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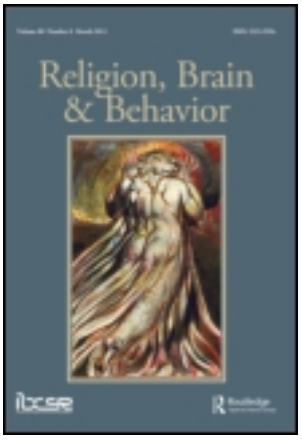

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Ritual and acquiescence to authoritative discourse

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TARGET ARTICLE

Cognitive resource depletion in religious interactions

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We explore the cognitive effects of three common features of religious interactions: (1) demand for the expressive suppression of emotion; (2) exposure to goal-demoted and causally opaque actions; and (3) the presence of a charismatic authority. Using a cognitive resource model of executive function, we argue that these three features affect the executive system in ways that limit the capacity for individual processing of religious events. We frame our analysis in the context of a general assumption that collective rituals facilitate the transmission of cultural ideas. Building on recent experiments, we suggest that these three features increase participants' susceptibility to authoritative narratives and interpretations by preventing individuals from constructing their own accounts of the ritual event.

Keywords: resource depletion; predictive coding; ritualized behavior; emotion regulation; authority

Introduction

Framing the problem

It is a widely held view among scholars who study religion that religious practices, especially collective rituals, constitute an ideal setting for the transmission of religious ideas. While the details of individual theories differ, most hold that transmission effects are amplified and consolidated because collective rituals orchestrate collective acts, which symbolize religious knowledge and myths (Durkheim, 1912/1995; Eliade, 1969; Geertz, 1973/1989; Rappaport, 1999; Turner, 1967). The symbolic-transmission hypothesis is consistent with observations that collective rituals are both pervasive and ancient; no culture lacks collective rituals. Although the symbolic-transmission hypothesis is persuasive for social-functional accounts of ritual, little remains known about the cognitive mechanisms that mediate this transmission function at the level of proximate explanation. Indeed, few researchers have proposed plausible cognitive models that explain how, at the level of cognitive processing, specific aspects of ritual affect participants' susceptibility to collective ideas.

The absence of explanatory models has exposed the transmission hypothesis to pressure from cognitive researchers, who argue that rituals are the evolutionary by-products of more general cognitive and behavioral traits (Boyer, 2001; Boyer & Liénard, 2006). Indeed, attention has been drawn to the fact that many characteristic features of collective rituals appear neutral or even counterproductive to the transmission of ideas (Sperber, 1975; Staal, 1979). For example, many rituals are

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characterized by incomprehensible actions rather than by actions with clear goals and causal structures. If rituals function to communicate meaning, why don't participants perform a meaningful drama or simply use oral communication instead? Recent studies suggest that perceiving the goal-demoted and causally opaque actions that characterize ritualized behaviors demands precious cognitive resources, which would otherwise be available for processing symbolic content (Boyer & Liénard, 2006). If the goal of ritual is to transmit knowledge, then we might predict that rituals would optimize the capacity for complex learning rather than divert attention to basic action perception. Another ostensible weakness of the transmission model is that collective rituals frequently impose strong regulation of emotion on their participants. For example, initiates in rites of passage are frequently expected to appear courageous in the face of frightening and painful stimuli, such as ritual piercings. Efforts to suppress expressions of emotion, however, have been shown to divert attention from external input to internal, detracting from the capacity to retain memories (Richards, 2004; Richards & Gross, 2000). If rituals are designed to produce rich episodic memories of important symbolic content (Whitehouse, 1992, 2004), why do they include features that severely impair memory formation?

In this paper we propose a resource model of ritual cognition in which collective rituals limit the cognitive resources available for the individual processing of religious events in order to increase participants' susceptibility to collective ideas. The resource model offers an alternative interpretation from most evolutionary by-product models by claiming that features which appear neutral or counterproductive to transmission are actually those that render such events effective transmitters of collective ideas. Rituals directly suppress and channel default cognition in order to facilitate the construction of collective memories, meanings, and values among ritual participants. The resource model is perhaps particularly interesting because it renews credibility, at the level of proximate mechanisms, for a general social-functional theory of collective rituals. However, our model does not necessarily support a functionalist account of ritual over a by-product account at the level of evolutionary explanation. It does not automatically follow from this article's insights that ritual practices have been the targets of selective processes in order to enhance the collective fitness of human societies. Nor does it support a by-product account of ritual. We do not argue for or against any evolutionary model of religious rituals. Our purpose is to identify and analyze the cognitive effects of important proximate mechanisms in religious interactions.

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The executive system and cognitive resource depletion

We begin with a basic explanation of how the brain processes information at the level of integrative processing in the executive system. This level of analysis is appropriate for at least two reasons. First, a narrow focus on low-level cognition and task-specific processing, taken in isolation, does not afford sufficient sensitivity to the dynamic nature of culture–brain interactions. Second, to aim for a complete analysis of the highly distributed and computationally complex processes that underlie complex meaning systems is far too ambitious in light of the current understanding of brain function. The executive system, positioned somewhere between these two poles, is where multiple streams of low-level cognitive processes are integrated into functionally orchestrated behavioral and cognitive responses. We acknowledge that the "executive system" is a problematic concept in itself — there is no discrete

neurocognitive entity that this term names but the integrative processes to which the term refers are known to rely on specific regions of the brain, including the so-called frontal executive network, which consists of the dorsolateral prefrontal cortex, the medial prefrontal cortex, and the anterior cingulate cortex (Alvarez & Emory, 2006; Miyake et al., 2000).

Most neural networks, especially the frontal executive network, are recruited for widely different tasks depending on context and situation. The dorsolateral and medial regions of the prefrontal cortex and the anterior cingulate cortex are all critically involved in attention, working memory, cognitive control, and inhibition (D'Esposito et al., 1995; Engle, 2002; Engle, Conway, Tuholski, & Shisler, 1995; Fuster, 2003). These frontal regions also appear to play a central role in various higher-order cognitive functions such as emotion regulation (Damasio, 1994; Goldin, McRae, Ramel, & Gross, 2008), volitional control of thought and movements (Hallett, 2007), conflict monitoring (Carter, Botvinick, & Cohen, 1999; Carter et al., 1998), action perception (Zalla, Pradat-Diehl, & Sirigu, 2003), autobiographical memory (Svoboda, McKinnon, & Levine, 2006), and decision-making (Bechara, H. Damasio, & A.R. Damasio, 2000).

Because executive functions and attention recruit the same frontal regions, these regions have been found to compete for cognitive resources in critical situations (Engle et al., 1995; Fuentes, 2004). This corresponds with a resource model of executive function in which a dramatic increase of cognitive load from attention detracts from executive processes because it depletes a common pool of resources. For example, increased attentional load on the frontal networks has been shown to impair performance in executive control tests such as the Stroop task (Engle et al., 1995; Garavan, Ross, & Stein, 1999). We term this phenomenon *cognitive resource depletion*.

One way to conceptualize the effects of cognitive resource depletion in more general terms of brain function is through the principle of predictive coding, which has recently emerged as the dominant paradigm for understanding perception and cognition (Bar, 2009; Friston & Kiebel, 2009; Frith, 2007). According to this principle, the way the brain makes sense of the world is by constantly generating predictive models. The brain generates predictions about the world (top-down models) which are continuously compared and updated according to input from the sensory apparatus (bottom-up models). The brain is constantly monitoring its predictions for errors. If the brain detects a mismatch between its own predictions and the sensory content of a situation, the predictions are updated accordingly. At a neuroanatomical level, both prediction error monitoring and model updating (e.g., in Stroop tasks) have been associated with the same brain regions and attentional resources that are involved in processing other executive functions (Carter et al., 1999; Carter et al., 1998; Engle et al., 1995; Frith, 2007). From this perspective, cognitive resource depletion in the frontal executive network may also negatively impact the brain's capacity for error monitoring and for updating relevant top-down models according to input from the sensory apparatus. Predictive coding is assumed by theorists to work at all levels of perception and cognition, from basic sensory perception to more complex cognitive tasks (Bar, 2009; Frith, 2007). At the level of complex social interactions, the effects of cognitive resource depletion may disrupt individuals' attempts to adjust their perceptions of a situation based on sensory information.

The possibility of cognitive resource depletion (henceforth simplified to "depletion") highlights the powerful impact of context on information processing.

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For example, if a situation were to strongly increase the cognitive load on one executive function, this would impair the performance of other executive functions. This insight seems important for the study of religion because many collective rituals create situations that necessitate extraordinary cognitive demands on executive processing. In the following sections we demonstrate how collective rituals include features that exaggerate the demand for attention and executive processing such that other executive functions are likely to suffer as a result of depletion.

The effects of culturally orchestrated depletion are particularly interesting from the perspective of attribution theory. If, for example, the cognitive resources involved in updating participants' perception of a situation are depleted in religious rituals, then individuals' attempts to understand the event and construct episodic memories that make narrative sense of the experience may consequently suffer. As a result, prior expectations and post-ritual interpretations may become more important for participants' understanding of the ritual than their actual perceptions of the ritual context. Under normal circumstances the individual would have enough resources available to attribute meaning and value to events as they happen, especially when such events include features that effectively motivate such attributions. Intense emotional experiences, and massive investments of effort common among certain ritual trials, contain elements that are known, quite generally, to motivate meaning and value attribution in individuals (Aronson & Mills, 1959; Cooper, 2007; Festinger, 1962; Gerard & Mathewson, 1966). In the context of depletion, however, individuals may be prevented from making their own attributions during the ritual event, creating an attributional gap which may be filled by shared attributions after the event. Indeed, it has been demonstrated that cognitive resource depletion enhances participants' susceptibility to suggested memories and narratives (Balgrove, 1996; Otgaar, Alberts, & Cuppens, 2012). The powerful suggestions and meaningful narratives that are provided by religious authorities and traditions therefore seem likely to thrive in the wake of events that cause depletion.

Assuming that the resource model is theoretically interesting for ritual cognition, what evidence supports this account? In the following sections we use the resource model to explain the effects of three common features in religious interactions. These are: (1) demand for the expressive suppression of emotion; (2) exposure to goal-demoted and causally opaque actions; and (3) the presence of a charismatic authority. None of these features are unique to religious interactions, but all three appear exaggerated in collective rituals.

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Evidence for the resource model

Expressive suppression in high-arousal rituals

The first feature we explore is the demand for expressive suppression in high-arousal rituals. Many religious interactions, especially rites of passage, involve high degrees of arousal (Bettelheim, 1954; Morinis, 1985; Turner, 1967; Whitehouse, 1992). Anthropologists have long hypothesized that arousing and painful stimuli in rituals facilitate the internalization of religious values and meanings (Durkheim, 1912/1995; Turner, 1967). Adding to the general observation that physiological arousal promotes meaning and value attribution (Schachter & Singer, 1962), cognitive researchers have recently conjectured that episodic memories are an important mediator of this effect (Whitehouse, 1992, 2004). Arousal is thought to facilitate the encoding of flashbulb

memories (Brown & Kulik, 1977; Conway, 1995), which consist of especially vivid perceptual memories of ritual performances. Ritually induced flashbulb memories are hypothesized to last for a lifetime and to enable individuals to continuously engage in spontaneous exegetical reflections over the meaning and value of the ritual (Whitehouse, 2004). Against this memory-as-mediator conjecture, however, recent studies show that individual memories of intense emotional experiences are fraught with inaccuracies, suggesting that the vivid details in flashbulb memories may be constructed and elaborated upon after the event (Talarico & Rubin, 2003). Building on these insights, we use the resource model to provide a more realistic account of the dynamics of arousal and memory in rituals. The model explains how arousal and memory combine to facilitate the transmission of collective narratives by taking into consideration the effects of emotion regulation.

For most high-arousal rituals, arousal comes with a high degree of emotion regulation. Ritual subjects who receive painful stimuli in puberty rites, for example, are often expected to appear calm or courageous and to suppress their anxieties and fear throughout the ordeal (Morinis, 1985). Such efforts to suppress expressions of emotion in response to arousing stimuli have been found in the laboratory to impair memory retention (Richards, 2004; Richards & Gross, 2000). These experimental insights point to a mechanism by which depletion arises from efforts to suppress emotional expressions, creating a gap in memory. Assuming a prediction model of perception and cognition, individuals who spend their cognitive resources on emotion regulation may be prevented from updating their models of the situation according to its *idiosyncratic* details, because their attention to external sensory information is limited. This gap in memory allows for the insertion of culturally shared schemas during a post-ritual consolidation phase. The question is, do the effects observed in the laboratory also exist in high-arousal rituals? A recent field study suggests that they do.

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Preliminary findings from a Spanish firewalking ritual

We examined arousal and memory in a Spanish firewalking ritual. By obtaining heart-rate and video recordings of the firewalkers along with short-term and long-term reports on episodic recall (Xygalatas et al., 2012, in press), we were able to test how levels of arousal during the ritual affected memory formation after the event. Heart rate data showed that the firewalkers exhibited extreme physiological arousal as they crossed the glowing coals (an average of 179 beats per minute). The firewalkers, however, subsequently reported being calm during the ritual. The discrepancy between measures of physiological arousal and subjective accounts indicates a desire to appear unaffected by the arousing event. Indeed, our interview data revealed a strong social desire in the participants to appear calm. This desire was further supported by anthropological data describing the popular opinion that getting burned was considered an indication of weakness or the lack of divine protection.

Remarkably, in the structured as well as the open interviews immediately after the ritual, the firewalkers reported almost no episodic memories for the event. On the contrary, some reported complete amnesia while others only remembered emotional states, indicating a focus of attention to internal states rather than on the external features of the event. Consistent with the resource model, these findings suggest that a social desire to suppress expressions of fear and pain may have diverted attentional

resources from memory formation to emotion regulation. The cognitive price of coping with the firewalking situation was the cost of encoding contextual details. Importantly, in the structured questionnaires collected two months after the ritual, the firewalkers not only showed a tendency toward more episodic memory details of the event compared to their memory accounts immediately after the ritual, but also a confidence rating by independent coders revealed that a significantly higher number of episodic details were spoken of with confidence in the later accounts (for a detailed analysis, see Xygalatas et al., 2012, in press). Compared with the video recordings, however, the new details that were inserted later were mostly inaccurate. This finding — of greater confidence in a larger number of false memories — is consistent with other studies showing that memories of intense emotional experiences are imprecise reconstructions rather than highly precise episodic memories (Talarico & Rubin, 2003). Moreover, this finding is consistent with broader theories of episodic memory, according to which socially mediated expectations shape autobiographical recall (Berntsen & Rubin, 2004).

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Implications for the transmission hypothesis

If the purpose of arousal in rituals is to produce rich and accurate episodic memories, then why do rituals so commonly combine arousal with a strong demand for expressive suppression, drawing attention away from episodic details? Our data demonstrate that the classical model of flashbulb memory from an arousing ritual does not accurately capture the dynamics of memory in high-arousal rituals. Notably, firewalkers failed to encode or retrieve any detailed episodic memories immediately after the ritual. Moreover, firewalkers subsequently elaborated stereotypical memories for the event.

The resource model, however, is consistent with these findings. According to this model, demanding efforts to suppress emotion should reduce participants' capacity to update their perceptual models based on external sensory information. This prevents them from encoding rich idiosyncratic memories. We suggest that this initial suppression of memory formation facilitates collective meaning and value construction among participants after the event, because it prevents the participants from constructing their own accounts during the event. Indeed, the firewalkers' accounts two months after the ritual showed an increase in false memories and higher confidence in those memories, indicating post-ritual memory construction based on schematic knowledge and social negotiation, rather than on individual episodic memories (Xygalatas et al., 2012, in press). Thus, whereas previous models of memory in rituals suggest that arousing features alone mark rituals as memorable and therefore transmissible, the resource model suggests that arousing features combine with expressive suppression to impede this very function. This effect, we propose, creates attributional gaps in individuals that motivate the search for meaningful narratives after the ritual, which may ultimately facilitate the alignment of individual accounts to collective narratives.

Goal demotion and causal opaqueness in rituals

The second feature we explore is a particular kind of behavior sometimes referred to as ritualized behavior (Boyer & Liénard, 2006; Liénard & Boyer, 2006). Scholars generally agree that most rituals include a set of distinct features that separate them

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from other types of behavior. Such features include formality, repetition, redundancy, stereotypy, invariance, causal opaqueness, and goal demotion (Rappaport, 1999). These features have collectively been understood as a specific mode of symbolic expression (Leach, 1968) and performative utterance (Tambiah, 1973/1985), which may be important for the transmission of religious knowledge. Cognitive studies, however, reveal a more complex story. In this section we investigate the effects of two central aspects of ritualized behavior: goal demotion and causal opaqueness. We distinguish between causal opaqueness and goal demotion because they belong to different hierarchically related levels of action perception. Causal opaqueness, which is the decoupling of an action sequence's causal dependency structure and determination, belongs to the level of concrete psycho-physics of an action, which is accessed through mechanisms of perceptual causality and therefore quite early in the processing hierarchy of dynamic stimuli. Goal demotion, on the other hand, is less perceptually accessible and targets the demotion of an action sequence and its purported goal, which belongs to the level of animacy and intentional specification. Using the resource model we propose that exposure to ritualized behavior prevents individuals from forming causally and intentionally meaningful representations of religious interactions. We suggest that exposure to causally opaque and goal-demoted actions limits the capacity for action comprehension by means of resource depletion, which in turn allows the post-ritual construction of meaningful action representations.

We begin with the assumption that the perception of ritualized actions recruits the same cognitive systems as ordinary action perception (Boyer & Liénard, 2006; McCauley & Lawson, 2002). Humans generally process actions in a hierarchical system by parsing them into discrete low-level units which are then integrated into coherent action representations based on their intentional and causal specification (Sørensen, 2007; Zacks & Tversky, 2001). For example, "grabbing a cup," "lifting a cup," and "opening mouth" are low-level units that may be integrated into a coherent action sequence specified by the intentional goal of "drinking coffee." Research on the perception of ordinary actions suggests that we automatically link low-level units into a causally coherent sequence and predict the sequence goal without considerable allocation of attentional resources to low-level units (Zacks, Speer, Swallow, Braver, & Reynolds, 2007). Interestingly, ritualized behaviors that include obscure goals and causal structures seem to obstruct this automatic linking of low-level units and goal prediction because the lack of sequence coherence is incompatible with ordinary action perception (Boyer & Liénard, 2006; cf. Zacks & Sargent, 2010). We therefore suggest that during ritualized behaviors, participants increase their attention to low-level perceptual detail and psycho-physics, which makes it difficult to form intentionally meaningful representations.

By introducing behavioral features that induce causal opaqueness and goal demotion, ritualized behavior appears to transform ordinary actions with relatively low attentional loads on basic action perception into less predictable behavior with a much higher attentional load (Boyer & Liénard, 2006, 2008; cf. Zor et al., 2009). Because basic action perception uses the same attentional resources as the top-down integration into action narratives in the executive system and corresponding frontal networks (Zalla et al., 2003), participating in or observing such actions may cause depletion and limit participants' capacity to construct their own narrative accounts of the event. In the broader framework of predictive coding, we suggest that inducing a chronically high rate of prediction error in participants may disrupt the updating of

the brain's top-down models of a ritual action to the extent that the construction of coherent action structures is hampered.

Preliminary findings on action parsing in ritualized behaviors

We investigated the cognitive effects of goal demotion and causal opaqueness in a series of behavioral studies (Nielbo & Sørensen, 2011) which used a variation of the event segmentation paradigm, in which participants segmented filmed action sequences into units by means of a response button (Hanson & Hirst, 1989; Newtson, 1973; Zacks, 2004). The participants were instructed to segment two sets of action sequences into meaningful action units which were either functional sequences (i.e., actions that were causally integrated and had a transparent goal structure) or non-functional sequences (i.e., actions that were not causally integrated and lacked a transparent goal structure). We found that exposure to non-functional actions resulted in an increased segmentation rate compared to the functional action sequences, suggesting that these types of actions increased their attention to low-level action parsing. In a second experiment we probed the effect of familiarization, because participants often practice the same ritual on a regular basis and therefore may learn to parse rituals more easily (Nielbo & Sørensen, 2011). Interestingly, we found that familiarization had no effect on their action segmentation, as the participants still demonstrated a chronically high segmentation rate. We note that it remains controversial whether familiarity effects even exist in response to ordinary functional actions (cf. Nielbo & Sørensen, in press; Zacks, Tversky, & Iyer, 2001). Nevertheless a chronically high segmentation rate in response to non-functional behavior independent of familiarity suggests that certain types of ritualized behavior, even when practiced with a high frequency, still increase the attentional load on low-level action processing.

Implications for the transmission hypothesis

Our results suggest that goal demotion and causal opaqueness make ritualized behavior less predictable than ordinary actions. One effect of this unpredictability is a chronically high segmentation rate, which seems to impair the normal functioning of action and perception in the frontal executive network (Kurby & Zacks, 2008; cf. Zacks et al., 2007). The recruitment of low-level, bottom-up processing is likely to decrease the allocation of resources to a top-down integration of the actions. Furthermore, this effect is found even in frequently rehearsed practices, as our data suggest immunity to familiarity effects.

Similar to our analysis on expressive suppression and memory, we suggest that religious interactions that include ritualized behavior prevent individuals from forming ordinary interpretations of ritual actions by depleting the cognitive resources required for such constructions. Depletion leaves participants with an inferential gap, which amplifies a search for meaningful interpretations of the ritual after the event. Thus, we propose that ritualized behavior, unlike ordinary instrumental actions, may use obscurity to increase participants' susceptibility to authoritative interpretations by religious experts. Rather than expressing a specific mode in which complex narratives are communicated, we suggest that ritualized behaviors facilitate the transmission of ideas because they prevent individuals from processing such narratives on their own.

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The presence of a charismatic authority

Charismatic authority introduces yet another mechanism that prevents participants from forming their own accounts of religious interactions. In many collective rituals, subjects participate as passive spectators or as recipients of actions performed by religious leaders and experts. In such practices, the participants' belief that the priest or shaman is endowed with special abilities is what separates effective rituals from meaningless actions. Most scholars of religion consider this recognition of abilities to be a central aspect in religious interactions (Barker, 1993; Dow, 1969; Turner, 2003; Weber, 1922/1968; Willner, 1984). Though universal and seemingly vital, little is known about how such attributions are cognitively supported. Nor is much known about how such attributions affect cognition in interpersonal interaction. In this section we discuss the results of an experiment that studied how participants' assumptions about religious experts affect processing in the frontal executive network. We here extend our resource model with insights from the neuropsychology of hypnosis.

Hypnosis research shows that the patient's prior belief in the practice of hypnosis and in the abilities of the hypnotist is critical for successful hypnotic induction (Kirsch, 1985; Sheehan & Perry, 1976; Spanos, 2001; Spanos & Barber, 1974). We suggest that religious participants' belief in the efficacy of a ritual and in the abilities of the ritual practitioner may have similar effects, with important consequences for participants' experience and understanding of that ritual. Studies have associated hypnotic induction with a decrease of attention to information that conflicts with the suggestions provided by the hypnotist. For example, successfully imagining a fly buzzing around one's face is possible only if the patient is able to disregard sensory input that conflicts with this suggestion. Neuroimaging studies have found this effect to correlate with inhibition in the frontal executive network including the anterior cingulate cortex, which is critically involved in conflict monitoring (Egner & Raz, 2007; Gruzelier, 2005, 2006; Gruzelier, Gray, & Horn, 2002; Jamieson & Sheehan, 2004; MacLeod & Sheehan, 2003; Raz, Fan, & Posner, 2005; Raz, Moreno-´Iniguez, Martin, & Zhu, 2007; Raz, Shapiro, Fan, & Posner, 2002). From the perspective of predictive coding, individual expectations that conflict with input from the sensory apparatus would normally elicit a prediction error signal to promote the correction and updating of that individual's expectations (top-down models). During hypnosis, however, highly hypnotizable patients appear to reduce this default monitoring, allowing expectations induced by the hypnotist to dominate their perception of a situation, e.g., imagined objects and events.

If there is merit to the analogy between religious authority and hypnotic authority, then we might predict that strong believers would decrease attention to sensory information that conflicts with the suggestions provided by the ritual expert. A strong belief in the efficacy of a ritual and in the abilities of the religious authority may enable believers to invest fewer frontal executive resources in the processing of potentially conflicting information in religious interactions. Rather than overloading the frontal executive network to prevent participants from processing idiosyncratic sensory input, the presence of a charismatic authority may simply reduce the amount of resources that participants invest in error monitoring and updating. Compared to emotion regulation and ritualized behavior, the effects of charismatic authority seem to follow an alternative pathway for resource modulation to achieve the same general effect, which is to limit the amount of resources invested by the participants in error

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monitoring and updating of a situation based on external sensory input. In the following we describe an experiment which investigates this hypothesis in a religious interaction.

Frontal deactivation in response to religious authority

We used functional magnetic resonance (fMRI) to investigate the activation of the frontal executive network in the context of a charismatic authority (Schjoedt, Stødkilde-Jørgensen, Geertz, & Roepstorff, 2011). fMRI measures the BOLD signal (blood oxygen level dependent), which is associated with blood flow and metabolism in the brain. Our design investigated how assumptions about the healing powers of praying speakers changed the evoked BOLD response in secular and Christian participants who received prayers of healing. The participants listened to prayers under three conditions of varying levels of speaker credibility: the speakers were either presented as (1) a non-Christian; (2) an 'ordinary' Christian; and (3) a Christian who was known for his healing abilities. Results revealed that Christian participants who believed in the healing effects of prayers and in the healing powers of charismatic healers down-regulated regions in the frontal executive system in response to the prayers performed by the speaker who was known for his healing abilities. Regions affected included the dorsolateral and medial prefrontal cortex and the anterior cingulate cortex. In an independent analysis, we found that this down-regulation was positively correlated with the Christian participants' ratings of the speakers' charisma and also with the intensity with which they subsequently reported having experienced God's presence during the prayers. Down-regulation in these regions predicted a more positive rating of the speaker's charisma and a stronger feeling of God's presence. Collectively, these findings show that assumptions about the praying speaker affect how believers experience interpersonal prayer sessions. In a broader framework, interacting with religious experts seems to allow believers to perceive religious practices in accordance with their beliefs and expectations. Interestingly, we found no differences in terms of brain activation or subjective ratings in the secular group, which may be explained by the fact that the secular group did not believe in the efficacy of prayer or in special healing powers, and therefore did not expect radically different experiences.

Our findings correspond well with insights on hypnosis, which suggest that a high level of trust in the practice and practitioner may relax believers' monitoring of information to the extent that hypnotically induced expectations are allowed to dominate their experience (Kirsch, 1985; Sheehan & Perry, 1976; Spanos, 2001; Spanos & Barber, 1974). The participants who down-regulated their frontal executive network also reported experiencing the healer as more charismatic and feeling God's presence more during the healing prayers. This effect of expert trust is probably not restricted to religion or hypnosis, but is rather important to any authority relationship, including those of doctor and patient, teacher and student, and parent and children (Schjoedt et al., 2011). People may generally spend fewer cognitive resources on vigilance and error monitoring when interacting with trusted partners or experts. If this interpretation is correct, strong belief in a religious authority may facilitate the transmission of ideas by limiting the amount of cognitive resources invested in error monitoring and updating among highly motivated subjects in charismatic interactions. Rather than depleting the frontal executive resources to increase participants' susceptibility to interpretations provided after the ritual, we

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suggest that authority reduces the amount of resources invested in error monitoring and updating during the ritual, which allows charismatic suggestions and expectations before the event to drive participants' experiences and their interpretation of the situation.

Implications for the transmission hypothesis

Our results offer preliminary evidence for the hypothesis that charismatic authority improves the transmission of collective ideas. In accordance with the resource model, charismatic interactions appear to prevent subjects from investing cognitive resources in the monitoring and updating of their religious expectations based on sensory input. This may allow participants' beliefs and expectations to dominate their subjective experience. The presence of a charismatic authority may therefore increase the probability of participants experiencing religious events according to religious beliefs and expectations induced by the religious system or by the authority's suggestions. Obviously, such an alignment of experience to the religious authorities may facilitate a rapid and potentially powerful transmission of shared beliefs, meanings, and values (Bulbulia, 2012; Bulbulia & Schjoedt, 2010). Although the cognitive pathway for this effect appears to be different from the depleting effects of emotion regulation and ritualized behavior, its functional outcomes are similar, limiting the believers' capacity for error monitoring and updating during religious interactions.

Discussion

In presenting a resource model for ritual cognition we have argued that expressive suppression, goal-demoted and causally opaque actions, and charismatic authority constitute an effective context in which participants are prevented from forming their own accounts of religious interactions. We propose that these characteristics produce attributional gaps in cognition, which facilitate the communication of collective propositions delivered before and after the event. The evidence we present suggests that there are multiple pathways by which rituals achieve this effect. Emotion regulation in high-arousal rituals appears to constrain the number of perceptual details that individuals encode, effectively removing participants' mnemonic foundation for idiosyncratic reflections of the event. Exposure to ritualized behavior seems to suppress action comprehension by diverting attentional resources away from meaning construction to low-level action perception. The presence of a charismatic authority appears to down-regulate regions in the frontal executive network that are involved with error monitoring and updating, allowing participants to experience rituals in accordance with authoritative suggestions, narratives, and interpretations. Obviously, more research is needed to support each of these hypotheses, but we believe that our three research examples represent important preliminary evidence.

In each of these examples, the resource model suggests that religious rituals operate on a "less is more" principle. The alignment of narratives and interpretations is made possible because religious activities and institutions actively and specifically suppress individual cognition. To exploit such gaps, religious institutions offer explicit narratives and interpretations both before and after the depleting regimes.

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Charismatic Christians, for example, may have read biblical stories about miracles and listened to healing testimonies of their born-again peers. They may already recognize the healer as endowed with special abilities, and prior to the point where miracles and mystical experiences are supposed to happen, the healer may provide powerful suggestions about what they are about to experience, while feedback from peers who express corresponding ecstatic behaviors may support these suggestions. Elements such as these provide an effective context for increasing the believer's expectations and motivations, and thus facilitate the desired experience (Luhrmann, 2005, 2011). According to the resource model, suggestions and interpretations by authoritative sources about mystical experiences, healing miracles, and magic are likely to thrive in ritual contexts that deplete and limit individuals' capacity for monitoring external information that potentially conflicts with these narratives.

Not all religious rituals, however, rely on prior narrative suggestion. In rites of passage, for example, the knowledge to be communicated is often kept secret until after the ritual climax, during which depleting regimes tend to be most active. Oral teachings by the elders often occur after the newly initiated have been exposed to ritualized actions and emotionally intense ordeals. Indeed, in a recent study using Gudjonsson's scale of interrogative suggestibility, participants showed increased susceptibility to suggestions about the content of a narrative in the context of cognitive resource depletion (Otgaar et al., 2012). Furthermore, to increase individuals' search for meaningful narratives after ritual participation, cognitive dissonance theory (Festinger, 1962), attribution theory (Schachter & Singer, 1962), and memory theory (Talarico & Rubin, 2003) all suggest that emotionally intense, strenuous, costly, and painful aspects of rituals automatically increase the search for attribution of meaning and value. The drive for effort justification (Aronson & Mills, 1959) and other cognitive biases such as loss aversion (Kahneman & Tversky, 1983), the sunk cost effect, and the endowment effect (Thaler, 1980) predict that if you have invested blood, sweat, and tears in some effort, you will likely consider your actions to be important in order to avoid the unpleasant feelings of loss and wasted efforts. This drive to justify that in which one has invested efforts may lead individuals to construct rich narratives that endow effortful events and invested objects with exceptional value and significance. The resource model suggests a particularly effective pathway by which such effortful activities may coordinate patterns of valuation among members of highly invested groups. Rites of passage, for example, may facilitate the alignment of participants' effort justification after the event, because depleting features obstruct their individual attempts to eliminate dissonance during the event. Individual effort justifications are deferred to the ritual phase, in which religious authorities offer elaborate explanations that easily compensate for the participants' ordeals. From this perspective, asking participants to invest a maximum of effort in a ritual, thereby allowing a minimum of individual attribution (by depletion) constitutes an optimum for producing uniform collective attributions of meaning and value to that ritual. This effect points to a "pure waste" hypothesis of ritual in which religions employ a host of technologies to create pure waste vehicles, which are expensive but useless objects and events available for religious authorities to imbue with religious value and significance (Schjoedt, 2012).

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Limitations of the resource model

Analyzing the cognitive effects of ritual at the level of integrative processing in the executive system has a number of advantages, but it also has its limitations. First, we need a clearer model for executive system functionality in order to construct more detailed accounts of the effects of integrative processing. Because the cognitive neuroscience literature offers no consensus on its operationalization of "executive system," much less in its explanation of frontal functioning, we have kept our theoretical assumptions about the functional architecture of this system to a minimum. Indeed, the features discussed in this article seem to operate by different cognitive pathways and to affect executive functions at different levels of integrative processing. For example, depletion from emotion regulation seems to remove the very foundation for perceptual memories by limiting the encoding of external perceptual information, whereas depletion from ritualized behavior diverts attention from high-level action comprehension to low-level action perception. Rather than overloading the executive system, charismatic interaction appears to reduce the amount of resources invested by the executive system in conflict monitoring. In all three instances, however, using a prediction model of cognition and perception offers one way to conceptualize how these features limit the capacity for processing religious interactions, by disrupting participants' error monitoring and updating of religious events based on external sensory information.

Second, in choosing this level of analysis we neglect the fascinating discussion on how specific cognitive inference systems select religious ideas and behaviors over the course of evolution. Exceptionally useful for understanding the importance of our genetic make-up, this line of research seems less useful for understanding the cognitive dynamics involved in actual culture–brain interaction. For this, we believe our level of analysis may represent a "sweet spot," as it focuses on the effects of processing multiple tasks specified by a given context. Third, our level of analysis does not afford a content-rich neurophenomenological account of believers' subjective experiences. Whereas modulations of the executive system seem critically involved in the subjective experience of religious interaction (Schjoedt et al., 2009, 2011), the exact identification of neurocognitive processes and anatomical regions that underlie specific experiential content lies beyond the scope of our analysis. A detailed account of such phenomena would require complex models of highly distributed networks in the brain and a deep understanding of how neurochemical processes interact. Although our current understanding of brain function is still very limited, especially in relation to religious thought and behavior (Schjoedt, 2009), recent work bodes well for the future of this kind of research (McNamara, 2009). None of the authors of this article, however, have sufficient knowledge to make this kind of analysis.

Conclusion

In spite of these limitations, we believe that the resource model is a useful tool for understanding the cognitive effects of religious interactions. In this article we have proposed that at least three common features in rituals limit the capacity of individuals to form their own accounts of religious events. Rituals are characterized by a set of features that modulate the amount of cognitive resources invested in the monitoring and updating of a situation. These effects impair individual attempts to

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construct episodic memories and meaningful narratives. We suggest that this disruption of individual sense-making during the ritual facilitates the transmission of collective ideas because it creates attributional gaps that make participants more susceptible to narratives and interpretations given before and after the depleting event.

Although each feature is likely to modulate the amount of cognitive resources used for understanding the ritual through different cognitive pathways, they all seem to target the same basic effect on perception and cognition, preventing participants from normal error monitoring and updating of their top-down models based on bottom-up sensory information. To what extent each of the features target the error monitoring function or the subsequent updating of models in the predictive coding process is an important question for future studies. At this point, we conjecture: (1) that emotion regulation diverts prediction error monitoring to internal visceral input resulting in less updating based on external input; (2) that ritualized behavior causes a chronically high level of prediction error that drains the resources required for top-down action integration; and (3) that the presence of an authority reduces the amount of resources invested by the believer in error monitoring as well as updating during charismatic interaction.

Our model points to a different understanding of the cognitive dynamics of ritual compared to the majority of ritual theories, which claim that features like arousal and ritualized behavior directly improve participants' acquisition of religious knowledge. According to the resource model it is the absence of sense-making in these contexts that makes ritual so effective for transmission when combined with authoritative narratives. Although this understanding of ritual has already been suggested by other researchers (Rappaport, 1979; Sperber, 1975; Staal, 1979), we offer a cognitive model for analysis and explain how it works at the level of individual cognition. Religions seem to employ a host of sophisticated technologies that exploit the limitations of human cognition in order to transmit collective ideas, norms, and traditions.

Finally, we call for more experimental research that systematically identifies, isolates, and investigates cognitive and behavioral components in religious interactions. Rather than focusing on selective pressures and corresponding evolved cognitive mechanisms to explain religious rituals, we believe that the priority should be identifying and analyzing the proximate mechanisms in rituals. A growing number of highly creative evolutionary and cognitive theories of religion have made empirical support and testing important for the integrity of the field. We have provided three examples of converging experimental research that appear to renew credibility for a general social-functional theory of collective rituals by identifying a few of its proximate mechanisms.

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COMMENTARY

Religious ritual and modes of knowing: commentary on the cognitive resource depletion model of ritual

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Introduction

Numerous scholars from Durkheim (1915/1969) to Rappaport (1999) have asserted that ritual plays a central role in communicating collective ideas and inculcating religious belief. Yet, the proximate mechanisms involved have yet to be empirically

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identified. The research presented by Schjoedt and colleagues empirically identifies several of these mechanisms. Their work offers evidence of ritual impacts on episodic memory, attentional load, and executive processing. More importantly, it identifies specific neural structures involved. These are significant advances.

Critique

What is much less compelling is the model of ritual constructed by the authors on the basis of these findings. The central flaw in this model is the implicit assumption that conscious, rational cognition is the principal form of knowledge transmitted through ritual. This is suggested by both the questions posed (e.g., "If rituals function to communicate meaning, why don't participants perform a meaningful drama or simply use oral communication instead?") and the executive function focus of the research. The authors view ritual's "absence of sense-making" as a "sophisticated technolog[y] that exploit[s] the limitations of human cognition in order to transmit collective ideas, norms, and traditions" (Conclusion). They argue that ritual achieves this by creating an "attribution gap" that provides fertile ground for charismatic authorities to plant the irrational beliefs of religion, although no evidence is provided for such a gap.

This focus on conscious cognition and executive function ignores mounting evidence that much of the mental processing that drives our decisions and behaviors is neither conscious nor logical. Many of our actions and choices are the result of subconscious algorithms and associational processing. Moreover, emotional valuation is critical to this process (Bechara, H. Damasio, & A. Damasio, 2000; Cardinal, Parkinson, Hall, & Everitt, 2002; Dehaene & Changeux, 2000; Hurlemann et al., 2010; Morris, Ohman, & Dolan, 1998). Emotions learned through past experiences weight our present choices (Bechara et al., 2000; Damasio, 1994; LeDoux, 1996). In the absence of these emotional valuations we may be able to accurately solve problems in the abstract, but we are incapable of applying the solutions to our own personal choices (Damasio, 1994). Understanding this critical role of subconscious associational processing in general, and emotional processing in particular, offers important insights into why ritual does, in fact, "make sense."

Symbolic Transmission Model of Ritual

Durkheim, Rappaport, and other symbolic transmission theorists did not consider the function of ritual to be simply the transmission of religious ideas. Durkheim viewed ritual as the mechanism for *creating* collective ideas. "[I]t is in the midst of these effervescent social environments and out of this effervescence itself that the religious idea seems to be born" (Durkheim, 1915/1969, p. 250). Rappaport described ritual as "the ground from which religion grows" (Rappaport, 1999, p. 26). He argued that "religion's major conceptual and experiential constituents, the sacred, the numinous, the occult and the divine, and their integration into the Holy, are creations of ritual" (Rappaport, 1999, p. 3). Clearly, for these scholars, ritual is not merely a mechanism for transmitting the cognitive schema of religion. Even Schjoedt and colleagues note that such transmission is more effectively achieved through explicit discourse, whether in "Sunday school," around a campfire with elders, or in a secular class on comparative religions.

Symbolic transmission theorists view ritual as a means of *creating* symbols with rich associational meaning. Cognitive schema are an essential component of this

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process, but it is the associational richness and emotional valuation of these symbols that *imbue* them with personal and social significance and invest them with motivational force. Ritual creates meaning through processes of conditional and associational learning that link somatosensory, motor, reward, emotional, social, and cognitive domains (Alcorta & Sosis, 2005). Ritual symbols are the nodes of these linkages. Like the paraphernalia of cocaine users (Dehaene & Changeux, 2000), these symbols themselves become "saturated with emotional quality" (Turner, 1967, p. 29) through association with the emotions evoked by the music, icons, psychological and physical ordeals, and other stimuli of religious ritual. From a logical perspective, it may be difficult to "make sense" of ritual, but from an associational perspective the music, settings, movement, sensations, and mystery of ritual make perfect sense. Sacred ritual symbols connect and condense many meanings in a single form, becoming themselves "stimuli of emotion" (Turner, 1967, p. 29).

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Roots of ritual

The cognitive resource depletion model of ritual comes up short from an evolutionary perspective, as well. Ritual is not specific to our own species; numerous non-human species engage in elaborate ritualized displays. Like religious ritual, these displays include expressive suppression (e.g., "bluffing" behaviors) and incorporate formality, pattern, sequence, repetition, stereotypy, goal demotion, and causal opaqueness (Laughlin & McManus, 1979; Smith, 1979). If the cognitive resource depletion model of ritual is correct, then these components of ritual should function to deplete cognitive resources in non-human species in order to enhance susceptibility to collective ideas also. Yet, no one would argue that fiddler crabs and bowerbirds engage in ritual in order to transmit abstract knowledge.

Laboratory experiments indicate that the components of non-human ritual are driven by receiver selection for reliable signals (Rowe, 1999). The formality, stereotypy, sequence, pattern, and redundancy of ritual alert and focus attention on sender signals and promote associational learning. These elements neurophysiologically prime participants for social appraisal and interaction. A parsimonious model of ritual requires that they serve similar functions in human ritual, as well.

Conclusion

While the cognitive resource depletion model of ritual proposed by Schjoedt and colleagues offers important insights into the effects of ritual on executive function, the cognitive bias of this approach precludes it from providing a comprehensive model of ritual. The down-regulation of executive function documented by the authors may be parsimoniously explained as a consequence of the up-regulation of emotional processing, rather than a mechanism for creating the postulated "attribution gap" which is unlikely to exist in traditional societies where religious beliefs are largely unquestioned. Alternatively, the attenuation of episodic memory, increase in attentional load, and down-regulation of executive function produced by ritual may shift cognitive processing from a predominantly logical to an associational processing mode. Since episodic memory is intimately connected with our sense of both place and time (Hasselmo, 2012), these effects may contribute not only to the creation of symbols that are dense with motivational force and associational meaning, but symbols that are also devoid of place and time; symbols both infinite and eternal.

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COMMENTARY

Religious ritual and the loss of self

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The target article's discussion of religious rituals emphasizes resource limitations. The authors place their focus on cognitive limitations, but one could arguably make the same case for resource limitations at other levels, since rituals tend to be very costly in terms of materials (regalia, foods, all kinds of props) and physiology (e.g., extended bouts of dancing and singing) as well (Alcorta & Sosis, 2005). But the focus here is on cognitive limitations. The authors argue that the depletion of cognitive resources (including the impairment of memory formation) favors the ultimate goal of ritual, namely the transmission of collective ideas.

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Most people would accept the idea that any highly complex and engaging activity — ritual or otherwise — takes hold of cognitive operations and leads to a depletion of attentional resources (e.g., driving a car in traffic, speaking a foreign language, learning to play a new piece on the piano). Few theories would argue that resource depletion is the *purpose* of these activities; most would say that it is an unavoidable outcome of the operations of any limited-resource system. However, the target article makes exactly this claim about religious rituals. The basic argument is that the depletion of cognitive resources enhances participants' susceptibility to collective — rather than self-generated — memories and narratives. In other words, there is a loss of self and a supplanting of the self by the collective. Memory impairments that arise from resource depletion allow for "the insertion of culturally shared schemas during the post-ritual consolidation phase."

This is certainly an original and provocative idea. However, I see problems with two basic aspects of the argument. First, I see the possibility of a conflation between cause and effect when it comes to cognitive depletion. The uncontroversial idea that demanding rituals place demands on cognitive resources is not the same thing as saying that this is their purpose. So, the article really rests on there being a *causal link* between resource depletion and "the insertion of culturally shared schemas during the post-ritual consolidation phase." The empirical evidence, however, is not as compelling as it could be. The fact that firewalkers have poor episodic memory for their experiences does not imply that amnesia is its major function. Evidence for memory suppression or goal demotion is not the same thing as evidence for the transmission of collectivist ideas. A much stronger causal link between cognitive depletion and the collectivist functions of ritual needs to be established. The case of the charismatic religious figure is qualitatively quite different in kind from the other cases mentioned. Interactions with such figures are specifically directed at indoctrination and the generation of religious beliefs and associated behaviors. There is nothing "non-opaque" about them. It should come as no surprise that these kinds of interactions increase collective beliefs; they are specifically focused on persuasion. But, in thinking about encounters with charismatic religious figures, we see the second half of the authors' model (collectivist beliefs) without the first half (cognitive resource depletion, such as impaired episodic memory).

My second issue with this cognitive model relates to what is "episodic" versus what is "semantic" (Tulving, 1972) about the memories that derive from rituals. The belief systems that are supposed to be driving religious rituals more properly fall under the domain of semantic memory, such as ideas about group myths, heroes, ancestors, historical events, and group norms. The goal of a ritual is not episodic per se. The episode is merely a vehicle for transmitting ideas that are more properly thought of as semantic. So, while emotionally charged rituals may generate flashbulb memories, this should not be seen as their function. The function is much more about generating semantic memories about the group as part of the socialization process. Again, the connection between the negative process of resource depletion and the positive process of post-episode semantic-memory generation is not well supported by the empirical evidence presented in the article.

What I do like about the model is its general focus on the loss of self as a mechanism by which rituals produce their cognitive effects and promote collectivist ideas. However, the emphasis is too much on negative processes, as evidenced by the very notion of "depletion." But aren't there positive processes that can produce similar outcomes? One important idea that comes to mind is that of pretense, and

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how people can voluntarily replace their identity with that of a character. A similar mindset characterizes the viewing of fictional narratives, such as when we watch films. People are very good at getting absorbed in fictional worlds, both cognitively and emotionally (Harris, 2000; Walters, 1989; Walton, 1990). Religious systems, while not fictional, are imagined worlds full of deities, myths, mystical props, and stipulated behaviors. Engaging in them requires that we suspend certain beliefs about the world and take on others, some of them highly counter-intuitive (Barrett, 2000; Boyer, 2001). Likewise, a charismatic religious figure is no different than a great actor in terms of their ability to take hold of people's attention and emotions. Instead of thinking about a negative process of resource depletion, we should perhaps look towards positive mechanisms in our psychology that allow us to lose ourselves, as we often do when we watch engaging dramas. Pretense, empathy, perspective taking, and related cognitive processes that allow us to actively immerse ourselves in imagined worlds are alternative mechanisms that allow us to lose ourselves and become absorbed in messages (such as collectivist religious messages) that are presented to us.

As mentioned, the target article presents an original and provocative model that, with further refinement and more compelling ethnographic evidence, could become stronger.

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COMMENTARY

Adding mist to the fog surrounding collective rituals: what are they, why, when and how often do they occur?

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The notion of cognitive resource depletion seems to be plausible. Indeed, high concentration and attentional focus while performing rituals could prevent the performer from diverting attention elsewhere. This is apparent, for example, for

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athletes or priests, who perform rigid intensive rituals during action play or rigorous prayer (Eilam, Zor, Szechtman, & Hermesh, 2006). Nevertheless, the arguments on which the depletion model rests in the target article are inaccurate and unsatisfying.

There are four outstanding questions regarding rituals: (1) What are they? (2) Why do they occur at all? (3) When do they occur? (4) How often do they occur? The target article focuses on a question-begging version of "why," while ignoring the other questions. To understand whence collective rituals (Liénard & Boyer, 2006), it is first crucial to understand what they are. While the global functions ascribed to rituals do not necessarily match the real motivations or understandings of their performers, we may use these labels as a framework for analysis, and, within the purported global goal, search for non-functional or causally opaque episodes and acts that constitute these rituals. For this, rituals must be first divided into their structural, temporal, and spatial components (Keren, Boyer, Mort, & Eilam, 2010; Zor, Keren et al., 2009). Once we identify the various acts, locations, and objects that are involved in the context of the ritual, it is possible to assess the necessity of each component of the ritual by its apparent frequency across participants. Specifically, the number of ritual performers exhibiting an act may serve as a reliable proxy for the relevance of that act for the ritual (Zor, Hermesh, Szechtman, & Eilam, 2009; Eilam, Zor, Fineberg, & Hermesh, 2012). Applying this methodology to compulsive rituals (Zor et al., 2010; Zor, Fineberg, Eilam, & Hermesh, 2011; Zor, Keren et al., 2009), normal motor tasks (Keren et al., 2010), and sport rituals (Keren, Boyer, Mort, Weiss, & Eilam, unpublished manuscript), we found that acts can be categorized into those performed by most ritual performers, and acts performed by only one or two individuals. The unequivocal result is that rituals comprise numerous idiosyncratic acts. A decrease in commonality and increase in idiosyncrasy render rituals their ostensible causal opaqueness and goal-demoted character. Altogether, a ritual may have an obvious function to the performer while some of its components are goal demoted or causally opaque.

The aforementioned analyses of ritual parsing and functionality provide solid ground for the conclusion that rituals constitute a predictable set of acts and episodes, performed with high concentration and attentional focus on accurate performance (Eilam, 2006; Eilam et al., 2006; Eilam et al., 2012; Keren et al., 2010; Keren et al., unpublished manuscript; Zor, Hermesh et al., 2009; Zor, Keren et al., 2009). This is in vivid contrast with the notion presented in the target article (wrongly referring to our studies) that "By introducing behavioral features that induce causal opaqueness and goal-demotion, ritualized behavior appears to transform ordinary actions with relatively low attentional loads on basic action perception into less predictable behavior." All in all, we do not dispute the claim that goal demotion does exist in rituals; however, the target article does not provide solid evidence for that, but rather focuses on subjective and hazy descriptions of this central feature of rituals.

The demand for expressional suppression is also flawed, overlooking religious rituals with overt emotional expression (joy in weddings; sorrow in keening). A more parsimonious explanation is that the emphasis on accurate performance, which is a conspicuous characteristic of rituals, depletes cognitive resources. Indeed, expressional suppression is not a prerequisite for ritual performance or for interpretations of the reason for the emergence of rituals. Similarly, even if the third demand of the target article — the need for charismatic authority — is a general truth for cultural transmission, it provides little insight into the specific characteristics or emergence of rituals. It is hardly a forgone conclusion that ritual participants, whether they are

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relatively passive observers or central actors, tend to form such complex and cognitively burdensome understandings of rituals regardless of their context.

Taking a broad view, hypotheses like the transmission hypothesis ought to be tested and consequently accepted or rejected. The target article, instead, simply accepts the transmission hypothesis. This is a weakness due to the dubious nature of that assumption and the shaky principles required to develop it, such as the reliance on "widely held" views exemplified by scholars who came prior to the cognitive revolution or explicitly denied its relevance. Their notions of "collective ideas" remains a troublesome one for cognitive researchers and even more so for evolutionary scholars. Despite this, such notions of collective ideas have been and remain popular. Boaz, Lévy-Bruhl, and Evans-Pritchard thrust "mental channels," "collective representations," and "cultural institutions" into the spotlight in order to promote relativistic stances (Mort & Slone, 2006). The recently touted cognitive science of religion, within which the target article is situated, maintains that spotlight (Sørensen, 2007). This, along with the target article's focus both on the transmission of "collective meaning and value construction" and the vague category of "religious rituals," contradicts the authors' claim that they do not espouse any particular evolutionary stance over another. It suggests that the authors are relying on the familiar less-than-parsimonious models which force the square religious peg through the round cognitive and evolutionary hole. McCauley and Lawson levied similar criticism against the artificial commitment of the modes of religiosity thesis on the Brown and Kulik "Now Print" mechanism (McCauley & Lawson, 2002). Furthermore, the target article's emphasis on the traditional anthropological central tenet of "meaning" (meaningful narratives, collective meaning, meaningful representations, etc.) is one that does not persuade. This article, while effectively explaining aspects of firewalking, does not present a satisfactory general explanatory model for rituals.

We wholeheartedly agree that there are cognitive resources relevant to ritual performance, and also agree that they undergo depletion, but after reading the target article we are still left with no means to qualitatively and/or quantitatively measure cognitive resources, the controlling executive system, and the proposed depletion. Therefore, the cognitive resource depletion model just adds mist to the fog surrounding collective rituals.

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COMMENTARY

Cognitive consequences and constraints on reasoning about ritual

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The target article adds to the growing body of empirical work supporting the proposal that collective rituals facilitate the transmission of cultural ideas in a number of interesting ways. We agree with the authors' proposal that the social stipulation and causal opacity of rituals are both important factors in preventing individuals from constructing their own accounts of a ritual event, and that they both enable rituals to effectively transmit cultural messages. However, we suggest that rituals, which are characterized as behaviors with high amounts of repetition, redundancy, stereotypy, and causal opacity, do more than simply open up space for authoritative interpretations of events. In addition to resource depletion, rituals have cognitive consequences rooted in the human capacity for causal reasoning that contribute directly to cultural learning.

Rituals behaviors, which we define as conventional, causally opaque procedures (Legare, Whitehouse, Herrmann, & Wen, in press), present a challenge to theoretical accounts of causal reasoning because they are both socially stipulated (Humphrey & Laidlaw, 1994) and not reducible to causal mechanisms (Bloch, 2004; Boyer & Liénard, 2006; Whitehouse, 2001). Even when rituals are explained in the context of a certain belief, there is often not an expectation of a direct causal connection between the ritual actions and outcomes (Sørensen, 2007).

We propose that rituals are unknowable from the perspective of physical causality because (1) they are not bound by the same kinds of intuitive physical–causal constraints that characterize non-ritualistic actions, and (2) they lack an intuitive causal connection between the specific action performed (e.g., synchronous dancing) and the desired outcome or effect (e.g., making it rain). Rituals intended to have particular effects (e.g., rituals promoting crop fertility or healing the sick) are not

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expected to do so by causal mechanisms that are transparent or even in principle knowable (Legare et al., in press).

In addition to the proposal by Schjoedt and colleagues that charismatic authorities socially stipulate ritual efficacy, we suggest that ritual efficacy is interpreted in light of intuitive causal beliefs about action potency. In particular, rituals used for problem-solving purposes reflect intuitive beliefs about causal reasoning and the efficacy of goal-directed action sequences. Consider Tambiah's (1979) classic definition of ritual as practice: "Rituals are patterned and ordered sequences of words and acts, often expressed in multiple media whose content and arrangement are characterized in varying degrees by formality (conventionality), stereotypy (rigidity) . . . and redundancy (repetition)." We propose that the characteristics of ritual described by Tambiah (1979) are the product of an evolved cognitive system (Atran & Norenzayan, 2004; Boyer & Liénard, 2006; Sørensen, 2007) of intuitive causal principles. Recent research on the evaluation of ritual efficacy supports this argument. Legare and Souza (2012) found that both Brazilian and U.S. adults rated problem-solving rituals as more effective when they contained more repetition and multiple procedural steps. These findings suggest that beyond ritualized actions' contribution to cognitive depletion, the ritualized actions themselves tap into a cognitive bias about the efficacy of causally opaque actions.

In addition, we argue that the causal opacity of ritualized behaviors acts as a signal to learners that the event being witnessed is conventional rather than instrumental, and ought to be learned as such. This work is rooted in the study of imitative behavior, and new developmental work on ritual provides converging evidence for this proposal. High-fidelity imitation in children has been linked to quintessentially social concerns, such as encoding normative behavior (Kenward, Karlsson, & Persson, 2011), affiliation (Over & Carpenter, 2011), shared experience (Tomasello, Carpenter, Call, Behne, & Moll, 2005), and fear of ostracism (Lakin, Chartrand, & Arkin, 2008; Over & Carpenter, 2009), rather than physical causal learning (Lyons, Damrosch, Lin, Macris, & Keil, 2011).

We propose that cultural learning in humans may involve a ritual stance (i.e., seeking out a rationale for actions based on social convention) in addition to an instrumental stance (i.e., seeking out a rationale for actions based on physical causation). Recent work by Legare and colleagues (in press) substantiates this claim. They presented children with action sequences that were either causally transparent or causally opaque and found that imitative precision was higher, and innovative actions lower, after causally opaque sequences. What distinguishes rituals from instrumental practices cannot be directly inferred from behavior, but rather is a matter of interpretation (see Humphrey & Laidlaw, 1994; Staal, 1990; Whitehouse, 2001). For example, the act of preparing a meal could be interpreted instrumentally (e.g., to appease hunger) or ritualistically (e.g., to present as an offering to a deity). Where such ambiguity exists, people may oscillate between ritual and instrumental understandings or use both.

Whereas the authors suggest that causal opacity leads to low-level action parsing, which in turn could account for imitative precision, Legare and colleagues (in press) claim that construing a causally opaque action ritualistically triggers imitative rigidity. A ritual stance is based on the attribution that an action sequence lacks a physical causal goal and can be triggered by a number of cues, such as start- and end-state equivalence and normative language (Legare et al., in press).

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The target article makes a valuable contribution to the study of ritual cognition by proposing that certain aspects of ritualized behavior leave the meaning of those events open to cultural construction, thereby allowing for the transmission of cultural conventions. We propose that, in addition, ritualized behaviors are constrained by causal cognition and give rise to a conventional interpretation of events, allowing for the transmission of culturally specific behavioral patterns. Together these different levels of analysis provide evidence for mechanisms supporting the transmission of causally opaque cultural conventions.

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COMMENTARY

What are we measuring?

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For Schjoedt and colleagues, religious rituals have features — emotion regulation, ritualized behavior, authority — that up- or down-regulate the cognitive system's

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monitoring of mind-generated predictive models of the world, and of prediction errors. In situations of emotion regulation or ritualized behavior, the modulation inhibits the encoding of rich episodic memories, hindering the creation of personal narratives bearing on those experiences, which in turn facilitates the participant's acquisition of religious ideas. In the authority condition, the modulation increases the effect of religious experts' suggestions on the participants' experience, hence facilitating the transmission of religious representations. By way of response we ask three questions: (1) How much do the participants' abstract thematic accounts tell about their memories of the ritual experience? (2) What are the contents of the religious representations whose acquisition is facilitated by religious rituals? (3) Is religious expertise special?

(1) Negative emotional arousal enhances the recall of themes of events with reduced memory for details from before, during, and after the event in participating and witnessing agents (Adolphs, Tranel, & Denburg, 2000; Bornstein, Liebel, & Scarberry, 1998; Christianson, 1992; Christianson & Hübinette, 1993; Wessel & Merckelbach, 1997). Efforts to suppress the expression of negative emotion, as shown in film viewing experiments, impair further memory for non-visual material (Richards, 2004; Richards & Gross, 2000). Schjoedt and colleagues suggest that such lessening of attention to contextual stimuli happens during high-arousal ritual in emotion-regulation conditions, leading to impoverished memories and susceptibility to religious representations during memory consolidation. If correct, that effect is probably unsystematic, as habituation to the emotion-laden stimuli is likely. For instance, it has been shown that habituation through exposure therapy successfully dampens the effects of high-arousal situations (Craske, 1998; Deacon & Abramowitz, 2004). Schjoedt and colleagues' 'blank-slate' type of argument would only account for exceptional situations, e.g., 'novices' struggling through rituals while engaged in emotion regulation. Thus in Schjoedt and colleagues' firewalking ritual, if first-timers go through situations that eventually impact episodic memory encoding, habituated others must have quite different experiences. Hence, if no discrepancy exists between first-timers' and others' reports, we should conclude that the contents of those accounts are probably not predicated on the participants' actual memories. We have no way of knowing, given the nature of the data provided. In any event, the firewalking findings thus far provided do not lend support to the exploratory model. Note too that the relationship between memory encoding, retrieval, and explicit report is not translational. More specifically, Schjoedt and colleagues do not take into consideration the likely involvement of a social desirability bias when interpreting the participants' accounts.

(2) Schjoedt and colleagues ground their analysis in a general assumption that collective rituals facilitate the transmission of cultural ideas. We would have welcomed examples of some representations that are transmitted primarily due to rituals. Schjoedt and colleagues speak of powerful suggestions and meaningful narratives. Are those *about* the religious events? Do those cultural representations interpret such events? The typical explanations bearing on rationales behind rituals are usually very 'literal' ("Doing *this* honors God"). In most cases of collective ritual, representations volunteered are typically focused on orthopraxis and less on theological elaborations. These representations are probably not what Schjoedt and colleagues understand by *suggestions* and *narratives*. So the ritual would be particularly suited

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for the transmission of vastly unrelated (to the specifics of the form and content of the ritual) representations. Do we have evidence of a particular association between rituals and such representations? Do we have evidence that the acquisition of such representations is disproportionately associated to ritual events and not to other transmission events that don't involve cognitive resource depletion? Do we have evidence that people grasp those representations in the context of ritual events?

(3) Schjoedt and colleagues argue that the typical involvement of charismatic authorities in religious events is another way of *preventing* participants from forming elaborate personal accounts of their religious experiences, which eventually leads to a greater susceptibility to religious stereotypical representations. Elsewhere, Schjoedt and colleagues make the additional claim that a strong belief in the abilities of a religious expert may *enable* believers to invest fewer cognitive resources in the processing of conflicting information (i.e., perceptual information conflicting with ritual experts' interpretations). By placing their trust in experts, agents spare themselves the burden of processing every aspect of situations for which they have no full mastery, freeing them to attend to particular facets of their religious experience. Furthermore, by their expertise recognition, agents acknowledge their limitations, allowing them to disengage themselves from the in-depth processing of conflicting stimuli. Finally, the discounting or shallow processing of conflicting stimuli driven by trust in the abilities of ritual practitioners makes the ritual experts' suggestions more salient and more likely to orient the overall understanding of the religious experience. It is a plausible model, but it seems not to be specific to religious interactions. In ordinary situations expertise seems to have a similar effect on non-experts. Research suggests that agents are readily susceptible to the influence of authority figures outside of religious contexts in ways that impact their interpretations of situations, their choices, decisions, and behaviors (Asch, 1951; Boyd & Richerson, 2002; Henrich & Boyd, 1998; Kuran, 1997; Milgram, 2009; Sperber, 2010). Unless a more radical claim is being made about what would be conceived as a *systematic* and *specific* association between religious authorities, rituals, and religious representations, we do not see what the model brings to the existing debate. At various places in their contribution Schjoedt and colleagues allude to the possibility of a specific and systematic association, while elsewhere they reject explicitly the view that their model would in any sense be an attempt to provide a functionalist account of religious interactions. In sum, if religious practices did not have any fitness impact at any point during their evolution, how could they ever be selected upon to the point that they *limit the cognitive resources available for the individual processing of religious events* in order to *increase participants' susceptibility to collective ideas* (our emphasis)?

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COMMENTARY

Functions, mechanisms, and contexts: comments on "Cognitive resource depletion in religious interactions"

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One sign of a field's growing maturity is when theories begin to rise from the bottom up in attempts to connect diverse empirical findings. Like many other areas of science, the cognitive science of religion (CSR) was born from high-level theorizing aimed at organizing and explaining relatively familiar phenomena about prominent religions and exhibiting at least some promise of managing somewhat less well-known religious materials from various small scale societies. To their credit, *all* of those theoreticians both welcomed attempts to test their hypotheses and did so themselves, whether by means of cultural or historical analyses and comparisons or by means of experimentation (Atkinson & Whitehouse, 2010; Barrett & Lawson, 2001; Boyer & Ramble, 2001; McCauley & Lawson, 2002). Such empirical investigation inevitably leads to the refinement or replacement of existing theories, to developing lines of research (for instance, the ongoing clarification and elaboration of the character and amount of counter-intuitiveness of religious representations), and to the generation of new, more exacting theories. Schjoedt and colleagues' cognitive resource depletion (CRD) hypothesis is an impressive

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example of the latter, born of some of the juiciest findings to arise from experimental work in CSR.

The authors argue that emotion suppression in high-arousal rituals, rituals' goal demotion and causal opacity, and charismatic authority deplete the cognitive resources participants bring to interpreting and remembering rituals, creating opportunities for imposing accounts proffered before or after ritual performances. After two comments about the theory itself, I raise three questions about the phenomena it aims to systematize, followed by an observation about resonances with my and Tom Lawson's proposals (Lawson & McCauley, 1990; McCauley & Lawson, 2002).

The authors' hypothesis takes inspiration from the predictive coding model of perception and cognition, which holds that human minds are constantly monitoring how well perceptual inputs tally with the brain's hypotheses about the current scene, in order, among other things, to update and improve those hypotheses. Alternative accounts exist (including proposals from evolutionary psychology that have motivated some CSR theorizing). In a chapter, "Bodies Talking to Bodies," Frans de Waal (2009) is but one more researcher who argues that much learning and *social* knowledge stem from simple motor mimicry and synchronization. No domain seems riper than *ritual* for such analyses. That may not speak to interpretation, but it would seem to bear on memory.

The authors envision at least two mechanisms behind CRD. CRD is born of *competition* for resources in emotion suppression and causal opacity. Charismatic authority, however, relies on resource *deprivation*. Their principal evidence for such deprivation is Schjoedt, Stødkilde-Jørgensen, Geertz, Lund, & Roepstorff's (2011) findings about "down-regulation" in the neural executive systems of believers in response to the prayers of perceived religious adepts. The authors note that this result might be a perfectly ordinary (and general) response to perceived expertise. All of this squares readily enough with our intuitions about how we frequently respond to experts, viz., we shut down our reflective faculties and follow their lead. But all of this raises the intriguing question about what the *neural* mechanism is that explains this deprivation. Competition is about swamping the executive systems. Deprivation is about starving them. Both will impede their functioning, but those different processes do not appear to constitute a natural kind at the neural level. This highlights the value of theorizing and experimentation about cognitive and psychological mechanisms. It also underscores the usefulness of functional analyses for providing integrated accounts of how religion works (McCauley & Lawson, 1984).

Various anthropologists' observations about interpretations (versus memory) of rituals and of high-arousal rituals, especially, occasion some questions. First, what is to be made of anthropologists' standard observation that most informants do not possess anything like interpretations of their ritual activities and have little or no idea what they mean (Boyer, 2001, pp. 232–233)?

Second, the authors mention both "institutions" and "authoritative suggestions, narratives, and interpretations." Functions do not rely exclusively on mechanisms; they also depend upon suitable contexts. Such comments suggest that the suitable contexts for these mechanisms to function are comparatively organized religions in literate, pluralistic, large-scale societies. These contrast with circumstances in non-literate, homogenous, small-scale societies, where memory and interpretation seem more up for grabs. In such societies collective memory-making sometimes occurs

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(Barth, 1987). But sometimes no interpretations, not even "collective" ones, are available. Among Melanesian groups such as the Baktaman, secrecy concerns *the rituals themselves*, not any putative meanings (Barth, 1975; Whitehouse, 2004). Do the roles that CRD plays in these latter settings differ substantially from those in institutional settings and, if so, what implications does that have for its contribution to "a general social–functional theory of collective rituals," which the authors seem to commend?

A third question concerns how the *inevitability* of theological incorrectness bears on both the impact of CRD on ritual understanding and on any larger, general social–functional theory (McCauley, 2011). The theological incorrectness findings suggest that *any* imposition of explicit, radically counter-intuitive interpretations about rituals or anything else has little influence, ultimately, in online cognitive processing (Barrett & Keil, 1996; Slone, 2004). One standard test of theories built from the bottom-up is to explore their ability to incorporate other well-established empirical findings. The authors, apparently, envision an encompassing account of both religious cognition and religious systems that, presumably, will accommodate the theological incorrectness findings too. How?

The authors' proposals comport in crucial respects with my and Lawson's account of religious ritual. For example, the authors' talk of "charismatic authority" obscures an empirical issue. Like Lawson and me (1990), the authors stress that "religious participants' belief . . . in the abilities of the ritual practitioner may have . . . important consequences for participants' experience and understanding of the ritual." Either of two paths might produce that outcome. One turns on practitioners' charisma and participants' resulting inclinations to attribute counter-intuitive properties to them. The other depends upon practitioners' ritual statuses in the religious system. Whether either or both suffice is an empirical question.

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COMMENTARY

Cognitive resource depletion and the ritual healing theory

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The authors argue that collective rituals facilitate the transmission of religious ideas, a process that involves emotion regulation, resource depletion, and charismatic authority. Rituals, coupled with charismatic authority urging emotional control, reduce the brain's capacity for error monitoring.

Can we test these assertions empirically? Can we define and measure cognitive resource depletion? The authors describe a Spanish study indicating that ritual firewalking impaired participants' immediate memories, resulting in false memories. They suggest that resource depletion involves hypnosis and charisma.

Some of these processes are described in the ritual healing theory (McClenon, 1997, 2002). I argue that ancient hominids used rituals to gain placebo and hypnotic benefits. Many well-controlled studies demonstrate that both placebos and hypnosis can have clinically significant impacts on health. The literature also indicates that hypnotic propensity has genetic basis. The ritual healing theory argues that genotypes allowing hypnotic suggestion became more prevalent over the many millennia that hunter-gatherers practiced shamanism. These genotypes facilitate spontaneous anomalous experiences governed by brain physiology. Universal experiences include apparitions, waking extrasensory perceptions, paranormal dreams, and out-of-body experiences. This theory makes no judgment regarding paranormal claims but argues that these episodes generate beliefs in spirits, souls, life after death, and magical abilities; the ideological foundations of shamanism. Shamanic performance includes out-of-body and paranormal perceptions (parallel to spontaneous experiences) and heat and pain immunity feats (such as firewalking). Shamanic rituals provide inferred and direct suggestions, generating survival benefits for those with hypnotic propensity.

Hypnosis is thought to be composed of absorption, dissociation, and suggestion. Although there is a lack of consensus regarding the mechanisms governing hypnosis, the process involves focused attention. Anthropologists and clinicians note patterns among dissociative, hypnotizable people. Both childhood trauma and socialization can contribute to hypnotic and dissociative propensities. Dissociative people who were raised in difficult environments tend to suffer from psychosomatic and psychological disorders. They often report anomalous experiences and adopt

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associated folk beliefs. They claim benefits from folk and ritual therapies. Those with performance skills (charisma) sometimes gain psychological health through attaining shamanic roles considered beneficial within their community. The ritual healing theory argues that such people became the first shamans.

I am uncertain regarding the role that cognitive resource depletion might play within the ritual healing theory. The authors argue that within the Spanish firewalking ritual, "a social desire to suppress expressions of fear and pain may have diverted attentional resources from memory formation to emotion regulation." This study lacks a control group, making conclusions uncertain. Resource depletion remains a valid hypothesis. I have taken part in more than a dozen firewalks in Japan (Buddhist), Sri Lanka (Buddhist and Hindu), Okinawa (secular), and the USA (secular; McClenon, 1994, 2002). I measured coal-bed and foot-bottom temperatures, seeking to explain firewalking mechanisms. I speculate that non-blistering involves a hypnosis-like process in which the body responds to inferred suggestion, preventing inflammation following exposure to excessive heat. This explanation does not explain all heat immunity feats. As the authors suggest, firewalking generates altered mental states (as do skydiving and other extreme sports). Firewalking is dangerous and varying percentages of firewalkers are burned. Belief in outside factors, such as spiritual forces, reduces risk (McClenon, 1994, p. 121). Rituals may facilitate performance by alleviating anxiety, allowing a graceful walking style which reduces foot exposure to coal-bed heat. Firewalking performances, like spontaneous anomalous experiences, shape folk beliefs.

I have also witnessed, and taken part in, spiritual healing rituals in Japan, Korea, Philippines, Thailand, China, India, Sri Lanka, and the USA (McClenon, 1994, 2002). Although some people claim anomalous cures, most benefits can be attributed to placebo, expectancy, and hypnosis. Many people report few or no benefits. The phrase *cognitive resource depletion* seems to emphasize dysfunctional characteristics (distortion of memory, reduction of error monitoring). In parallel fashion, rituals, placebos, and hypnosis can cause harm (damaging placebos are termed *nocebos*). In general, shamans spend greater effort in alleviating illness than in producing it. Excessive cognitive resource depletion (if it occurs), resulting in severe distortions of memory or reductions of error monitoring, would be labeled psychosis. Although shamanism and psychosis share features, the ritual healing theory hypothesizes that, over the millennia, rituals reduced mental disorder prevalence, providing survival benefits.

The target article advocates studies investigating factors associated with religious ritual. If we accurately specify spirituality's *phenotypes* (traits associated with corresponding genes), we can identify people with associated genotypes. This could facilitate locating spirituality alleles, leading to better theories regarding ritual.

Community surveys could contribute to this endeavor. Correlational clusters of phenotype variables suggest associated alleles. A recent survey in North Carolina identified variables most correlated with mental disorder symptoms (McClenon, 2012). Findings support the ritual healing theory. Childhood trauma variables, thought to switch on dissociative genes, were highly correlated with dissociation and absorption. These variables were highly correlated with propensity for anomalous experience and mental disorder symptoms, particularly psychosis. Respondents from a dissociative subsample described many anomalous experiences, folk beliefs associated with those experiences, and benefits derived from spiritual healing.

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Although dissociation, hypnosis, and spirituality have dysfunctional features, folk religious systems seem designed to derive benefits from these propensities.

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COMMENTARY

Problems for the cognitive-depletion model of religious interactions

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Schjoedt, Sørensen, Nielbo, Xygalatas, Mitkidis, and Bulbulia put forward a new cognitive model of religious interactions, which we depict in Figure 1. The model stresses three common features of such interactions: the requirement to suppress emotion expression, the exposure to ritualized behavior, and the presence of a charismatic authority (1).[1] These features have different cognitive effects, involving different sorts of cognitive-resource depletion (2). The regulation of emotion expression drives one's attention to inward phenomena, compromising one's ability to form episodic memories of the external, observable aspects of rituals. Ritualized behavior precludes the ordinary, means-end analysis of action and demands low-level action parsing. These two effects impede the interpretation of ritualized behavior or other observable aspects of rituals (3), which makes one susceptible to authoritative interpretive discourses (4), which in turn promote collective religious-symbolic interpretations (5). The presence of a charismatic authority has a third cognitive effect involving cognitive-resource depletion — lack of error monitoring concerning the evidence disconfirming an authoritative interpretation. Since a charismatic authority is an authority, it can play two roles: a conjoint one, by adding another force for the establishment of collective religious-symbolic interpretations (4/1 →2 → 5); and an independent one, by persuading individuals to align their interpretations of a ritual with the authoritative version (1 →2 →5). Thus, via cognitive-resource depletion, the three features contribute to the same effect, which constitutes their social function — to secure collective religious-symbolic interpretations. The remaining part of the model (5 →6 →1) completes a social-functional approach, qua an explanation of the occurrence of the functional features (Nagel, 1961).

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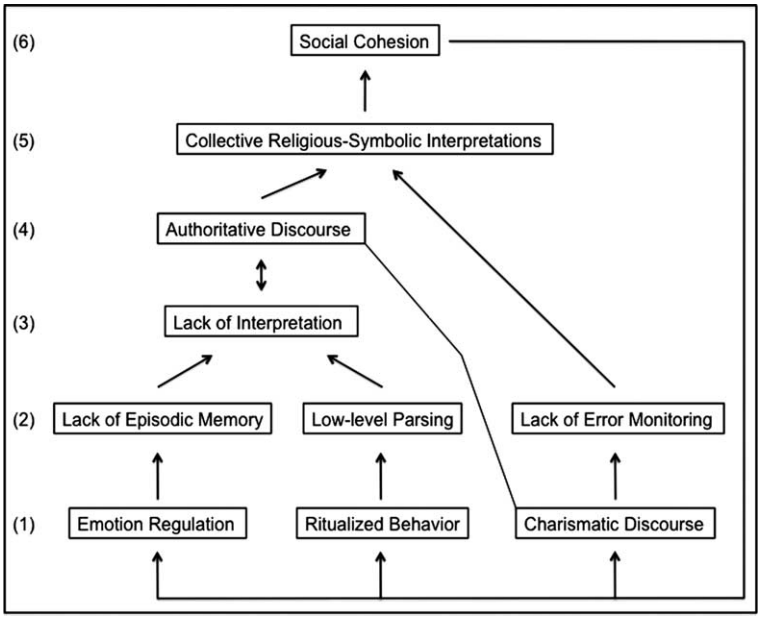

Figure 1. (Sousa & White). Cognitive-Depletion Model of Religious Interactions. Boxes refer to causes and/or effects; arrows refer to causal relationships; sequences of boxes and arrows refer to causal chains. Numbers (and their sequences) indicate the different parts of the model. Linked boxes indicate the possibility of a composition in causal role.

In this commentary, we identify the main problems regarding causal chains (1 →5). We do not evaluate causal chains (5 →6 →1) because the authors are ambiguous about them — sometimes they seem interested in effects simply as an effect, not as a function, as if eliminating these chains; sometimes they use the full language of social functionalism, as if supposing them.

There are two problems with the emotion-regulation causal chain. First, the preliminary evidence bears relevance to (1 →2 →3), but not to (3 →4 →5). The fact that two months later firewalkers recalled, less accurately and more confidently, more external details of the ritual than they had recalled just after it,[2] supposedly due to a process of authoritative social reconstruction, concerns the elimination of a memory gap in external details, not the elimination of an attributional gap in the religious-symbolic interpretation of these details. Second, it is doubtful that these findings generalize to other high-arousal rituals containing the emotion-regulation feature. These rituals often involve elaborate ordeals that last a long period of time (see Whitehouse, 1996), whereas the firewalking ritual operationalized in the field study seems comparatively simple and has a very short time span — for each firewalker, the ritual details to be remembered concerned simply the few seconds of the firewalk plus the period immediately before and after it (see Xygalatas et al., 2012, in press). Therefore, there are not many relevant external details to attend to; unsurprisingly, the study revealed quite poor external episodic memories, both following the ritual and two months later.

There is one problem with the ritualized-behavior causal chain. The preliminary evidence speaks to (1 →2), but not to (2 →3 →4 →5), since the studies showing low-

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level parsing of unfamiliar or familiar opaque behavior did not include dependent measures directly probing interpretive cognitive-resource depletion, and such depletion is not entailed by low-level parsing when interpreting others' ritualized behavior.

Contrary to what is assumed by the authors, there is no similarity in terms of cognitive-resource depletion between interpreting others' ritualized behavior and interpreting one's own. Interpretive cognitive-resource depletion occurs when one's interpretive capacities cannot be utilized because one's mental resources are overloaded with other tasks. There is such depletion in interpreting one's own ritualized behavior not because one cannot interpret it in terms of an ordinary, means-end analysis of action, but inasmuch as one has to carefully focus one's attention on the proper performance of its low-level units (Boyer & Liénard, 2006).[3] The simple impossibility of interpreting others' ritualized behavior in terms of an ordinary, means-end analysis of action does not entail depletion. It does not preclude non-ordinary interpretations, such as symbolic ones. In fact, it "calls" for them.

The authors insist that there is depletion in interpreting others' ritualized behavior because one's mental resources are overloaded with the excess of predictive error coming from parsing low-level units. However, ritualized behavior is often stereotypical and repetitive, which makes its low-level units totally predictable. In other words, the other properties of ritualized behavior overcome the predictive error related to the absence of ordinary parsing, and free one's mental resources for interpretation. Thus, the only interpretive problem posed by an exposure to others' ritualized behavior is the "freedom" of interpreting it in non-ordinary terms, which has nothing to do with interpretive cognitive depletion — if interpretations do not take place, it is due to an absence of motivation, not to the presence of depletion (coming from low-level parsing).

There are two problems with the charismatic-authority causal chains. First, the preliminary evidence is unrelated to these chains. The thrust of the authors' discussion concerns the role of charismatic authorities in establishing collective religious–symbolic interpretations of rituals, as we characterized. However, the praying evidence they cite is about establishing a belief in the causal efficacy of a ritual, namely, in the existence of effects beyond the scope of the ritual. Second, it is doubtful that religious authorities (charismatic or otherwise) play the exact role delineated in the model — while standardizing religious discourses may guarantee a good amount of uniformity in public representations, they often do not have this effect on mental ones (Sperber, 1996).

To conclude, we applaud the authors' attempt to build a new cognitive model of religious interactions. However, more empirical support is required for their model to become a strong contender to explain such interactions.

Notes

1. Numbers are related to Figure 1.
2. It is worth noticing that the numerical difference in external-detail recall wasn't statistically significant in any of the measures of the study (see Xygalatas et al., 2012, in press).
3. The other side of the story is a "recalibration" of the motor control system and its unconscious perceptual system (Jacob & Jeannerod, 2003; Wolpert & Ghahramani, 2000).

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COMMENTARY

Ritual and acquiescence to authoritative discourse

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Scholars have long recognized that participation in collective rituals can dull our capacities for independent thought and critical appraisal while increasing our susceptibility to indoctrination and deference to authority. Efforts to understand how rituals produce these effects have, until recently, lacked a solid scientific foundation, and in particular the use of carefully controlled experiments to study the psychological causes and consequences of ritualized behavior is still quite novel. Schjoedt and colleagues make a valuable contribution to this new wave of scientific research on ritual, but they also gloss over some recent theories and new evidence that could be of use to them.

Schjoedt and colleagues pose the question: "If rituals are designed to produce rich episodic memories of important symbolic content (Whitehouse, 1992, 2004), why do they include features that severely impair memory formation?" This citation of my work on ritual and its interpretation reveals a crucial misunderstanding. My claim is not that rituals *in general* "produce rich episodic memories of important symbolic content," but rather that those rituals involving high levels of dysphoric arousal tend to trigger long-term processes of independent reflection on questions of meaning and symbolism. (The question raised by Schjoedt and colleagues concerning whether enduring episodic memories for ritual ordeals are *accurate* is something of a side issue.) Independent reflection on ritual meaning is thought to have a cascade of downstream effects on group bonding, cooperation, and parochial altruism which, taken together, constitute the "imagistic mode of religiosity" (Whitehouse, 1995, 2000, 2004).

By contrast, routinized (i.e., frequently performed) collective rituals produce exactly the effects that Schjoedt and colleagues predict: susceptibility to authoritative doctrine and exegesis, and the suppression of individuals' independent interpretation

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of ritual meaning. My explanation for these effects is directly linked to the frequency issue. Frequent repetition of a collective ritual is typically associated with frequent exposure to authoritative exegesis, and this makes it easy to identify even minor departures from the standard interpretative canon. Not only is unauthorized innovation easier to detect when rituals are performed frequently, but the act of regular participation itself suppresses independent reflection on exegetical matters. To understand why, it is necessary to consider how procedural memory and explicit reasoning are related.

When a procedure, such as a ritual, is very frequently enacted, it no longer becomes necessary or even easy to represent the sequence of movements consciously. A commonplace example is riding a bicycle. Once learned, we manage the challenges of balancing, peddling, braking, and so on without conscious effort, and rely instead on implicit procedural memory to respond to changing features of the environment as we cycle through it. Once a procedural script has been encoded in this way we no longer reflect on *how* to do it, and this makes us less likely to reflect on *why* we do it that particular way. This principle applies to frequently performed rituals, effectively reducing our propensity to reflect on their causally opaque properties. But note that it is not the causal opacity that produces this effect. On the contrary, causal opacity in itself positively invites reflection on questions of meaning and symbolism. It is just that this is artificially suppressed in high-frequency rituals, *not in rituals generally.* And this combination of elements — easy detection of deviations and reduced levels of independent reflection — produces high levels of conformism, enabling the stabilization of beliefs and practices across large populations as part of the "doctrinal mode of religiosity" (ibid.).

Much of the evidence for these claims has been published (for a review of empirical research supporting the modes theory, see Whitehouse, 2012). From that perspective, I will offer a critical appraisal of Schjoedt and colleagues' efforts to connect ritual participation with acquiescence to authoritative narratives and interpretations.

Schjoedt and colleagues argue that three features of ritual *in general* serve to increase susceptibility to authority and reduce independent reflection: (1) suppression of emotion; (2) goal demotion and causal opacity; (3) charismatic authority.

The arguments concerning suppression of emotion are at times difficult to decipher. Is the claim that all rituals encourage the suppression of emotion? Such a view would appear to be unsustainable, since the ethnographic record is replete with examples of rituals in which emotional expression is strongly encouraged or even grotesquely exaggerated (Michaels & Wulf, 2012). Indeed, funerals, carnivals, weddings, sacrifices, initiations, and so on, often seem deliberately designed to maximize the intensity and diversity of emotional responses among participants (e.g., Bateson, 1936/1958; Huntingdon and Metcalf, 1979; Radcliffe-Brown, 1922/1964). The example of emotional suppression leading to a reduction in independent reflection among participants in a firewalking ritual is interesting, but we should be cautious about making generalizations from this one case. Indeed, Xygalatas has elsewhere presented compelling evidence of quite the opposite effects among firewalkers, showing that the more emotionally intense the ritual the greater the diversity of symbolic interpretations independently generated (Xygalatas, 2007).

If, on the other hand, the claim is that some (perhaps rather unusual) rituals induce strong emotions but discourage their expression, then this is a more interesting and potentially plausible proposal. In this case, we should ask what

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kinds of rituals do this and in which broader social and institutional settings. For example, where dysphoric rituals occur within larger doctrinal traditions they are often perceived by religious authorities to be somewhat subversive. This is precisely because such rituals generally provoke independent exegetical reflection leading to a diversity of interpretations, and also serve to bind together small communities that could potential oppose the larger doctrinal tradition and its authority structures. However, when doctrinal traditions compete and opportunities for defection are rife, their survival depends on the effective mobilization of recruitment and retention mechanisms. Emotionally intense rituals may play a valuable role in attracting new members and deterring defection, but such practices also promote local cohesion that could fracture the unity of the larger doctrinal tradition. In large religions, emotionally intense rituals must be carefully controlled and their downstream effects channeled. Perhaps this is why we find efforts to downplay the emotionality of the firewalking ritual discussed by Schjoedt and colleagues? It is also interesting that participants appear willing to bring their memories and experiences into conformity with a standardized narrative, apparently devaluing their more private, independent ruminations. Clearly, however, we need to know a lot more about this particular ethnographic situation before attempting to draw any strong conclusions on these matters.

The argument that goal demotion and causal opacity make us more susceptible to authority and less susceptible to independent innovation also has both promising and problematic features. Schjoedt and colleagues argue that causal opacity and goal demotion provoke puzzlement and thus "a search for meaningful interpretations of the ritual after the event." This seems entirely plausible and is consistent with much previous work on the topic (see Whitehouse, 2002, 2011). They go on to argue, however, that the propensity to seek meaning in itself makes ritual participants receptive to authoritative exegesis provided by trusted experts. One can appreciate why that may be so in doctrinal traditions where expert exegesis is available and levels of independent reflection are low (see above). But this argument is not applicable to rituals *in general*. Indeed, the ethnographic record is replete with examples of collective rituals that are not accorded an authoritative interpretation, or where exegetical knowledge, if it exists, results from idiosyncratic interpretation (e.g., Barth, 1987; Gell, 1975). This variability in the nature and origins of ritual exegesis cannot be attributed to causal opacity or goal demotion — features that are, of course, present in *all* rituals. The puzzling nature of ritualized action may prompt any number of responses of which acquiescence to authoritative exegesis is only one, and one that is largely confined to routinized religious systems.

Schjoedt and colleagues report some intriguing findings from a study of the mechanisms involved in attributing "charismatic authority." Their argument might, however, be more broadly applicable to the study of prestige bias in social learning. The core hypothesis is that people invest "fewer cognitive resources on vigilance and error monitoring when interacting with trusted partners or experts" (examples of which might include religious leaders and ritual officiators). Many tantalizing questions remain regarding the kinds of psychological cues and mechanisms that lead us to surrender executive control in this fashion, but Schjoedt and colleagues make an interesting and novel contribution to this complex topic.

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RESPONSE

The resource model and the principle of predictive coding: a framework for analyzing proximate effects of ritual

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Introduction

Cognitive science has proven to be a fertile ground for theorizing about religious ritual. Several recent theories compellingly identify the cognitive mechanisms underlying ritual, such as Hazard precaution (Liénard & Boyer, 2006), commitment signaling (Bulbulia & Sosis, 2011), action grammar (McCauley & Lawson, 2002), and routinization (Whitehouse, 2004); however, few attempts have been made to bring them together. Assuming that each of these mechanisms provides a missing piece to the puzzle of ritual cognition, a common theoretical framework is required for researchers to integrate them.

Admittedly, a theoretical framework that unifies all of the mechanisms of ritual lies beyond the scope of our target article. What we have attempted to contribute instead is a general cognitive framework that is grounded in cognitive neuroscience. We began

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with a general prediction model of perception and cognition to describe ritual cognition, and we used integrative processing in the executive system to analyze it. Within this framework, we focused on the cognitive resources required for successfully predicting the world. Briefly, we argued that at least three features of ritual limit efficient error monitoring and the updating of internal models that normally enable individuals to predict what happens in situations. We proposed that this effect might increase the probability of participants adopting culturally transmitted narratives.

Accordingly, our goal has been to provide a first step toward a more complete understanding of ritual that primarily focuses on its proximate effects rather than its ultimate explanation. For this reason we greatly appreciate the excellent commentaries from our commentators, which have forced us to sharpen and elaborate our model. Although most commentators expressed sympathy with our model, they agreed that three issues in particular have to be addressed. Thus, the following sections divide our response into three thematic areas of dispute: (1) the model; (2) the evidence; and (3) the other important mechanisms in ritual that our target article ignores.

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The model

With regard to the model, two important issues stand out and we would like to clarify them here. The first issue is whether the resource model of ritual represents a functional account. For instance, Sousa and White and Liénard, Martinez, and Moncrieff note that we simultaneously provide a functional interpretation but emphasize that our main interest lies in the proximate effects of ritual. To be clear, the resource model of ritual is not a functional model: it is strictly concerned with the proximate effects of ritual — that is, how rituals affect the executive functions of those who participate in them. However, the findings we report suggest that these effects — through different cognitive pathways — have comparable effects on the ability of participants to error-monitor and update their models of ritual events. We suggest that these effects agree with the general theory of rituals, which posits that rituals facilitate transmission of meanings and values (Durkheim, 1912/1995; Eliade, 1969; C. Geertz, 1973/1989; Rappaport, 1999; V.W. Turner, 1967). Yet the proximate effects to which we point are very different from the effects proposed by most functionalist theories of ritual. Thus, while the resource model itself is not functional, the effects we identify are consistent with functional interpretations.

Along the same lines, Eilam and Morte critically argue that we use the "widely held" view that rituals serve collective ends in our interpretation of data. Again, we do this because it seems like a relevant interpretation for the effects we study. Yet we are neither married to any one account of social functionalism nor committed to the view that rituals can be reduced to a few simple mechanisms. In fact, although we point to effects that could support social functionalism, we expect that religious rituals produce other effects that do not support it. Further, instead of presenting a strong functionalist model and then looking for specific mechanisms in favor of it, we do something different. We use a robust model of perception and cognition to generate hypotheses, from which we identify a host of proximate mechanisms regarding religious interactions.

Recognizing this, Liénard, Martinez, and Moncrieff provocatively state that our article actually brings nothing new to the debate unless we present the model as a functional account. We respectfully disagree. Combining the resource model with the principle of predictive coding both to describe and to analyze effects of religious

interactions is a novel approach, and we believe it will change how cognitive scientists research religious practices in the future. Indeed, knowing whether rituals serve collective ends remains an interesting question. However, it is perhaps less innovative than analyzing the different features of rituals and their effects in one cognitive network, which is the key contribution of our target article.

The second issue is how the effects we describe relate to one another. McCauley notes that the theory actually consists of at least two mechanisms: competition for resources and deprivation of resources, both of which affect predictive coding in radically different pathways. Generally, we like this division and we agree that a more sophisticated model is needed to flesh out the details regarding religious interactions and their effects on executive resources. In fact, we are currently working on such a study. In a general prediction model of religious experience, we identify components in religious interactions that use different cognitive pathways to increase the probability of believers reporting miracle healing, mystical experience, and magical causation (Schjoedt et al., 2012). Moreover, we use the principle of predictive coding to show how religious practices include several components that effectively tip the balance of normal perception to the extent that religious expectations are allowed to dominate participants' subjective experiences and interpretations. Cognitive resource depletion in response to expressive suppression and ritualized behavior is one example of this. Other examples include sensory deprivation and the down-regulation of attention in response to authority. Because we believe this theoretical framework is an excellent way to analyze the proximate effects of ritual, we are eager to put our general prediction model to the test in the lab and the field.

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Other issues

Alcorta makes the point that rituals do not communicate explicit meanings and suggests that our assuming it does is a central flaw of our interpretation. However, we suggest that low-level and automatic effects on the executive system create an implicit need for explicit narratives after the ritual. We agree with Alcorta — and Whitehouse, too — that ritual itself does not communicate explicit meanings, but rather makes explicit narratives attractive for ritual participants. In this regard, Brown notes that episodic memory is not the goal of ritual but is instead the means to produce collective semantic memories. As Alcorta suggests, while non-semantic processes are important in rituals, it is semantic memory that is central for the transmission of explicit narratives and interpretations. We agree, then, that rituals might function to generate semantic knowledge, but we suggest that resource depletion is an efficient way to make this happen.

In light of resource depletion, McCauley and Whitehouse note that not all rituals are followed by collective interpretations and ask how such instances might affect transmission. Based on our model, we conjecture that individual attempts to create meaning and value out of ritual make transmission more successful than otherwise. However, it is evident that participants in most rituals adopt culturally transmitted expectations prior to the ritual act. In such cases, depletion is still likely to affect the perception and interpretation of events, since it limits the ability of participants to error-monitor and update their internal representations. For example, those who carry the Kavadi in the Hindu festival Thaipusam are usually taught how trance occurs, what it feels like, and when it is likely to happen; and participants report experiences that correspond to these suggestions (Ward & Kemp, 1991). In cases

where narratives about the event are absent, we suspect that the ritual will be less efficient at transmitting collective narratives but perhaps more efficient at implying other important information, as suggested by Alcorta (we address this further in our final section).

Regarding ritualized behavior, Legare and Herrmann add to our model by suggesting that depletion from action parsing at low levels can be supplemented by a "ritual stance," where believers suspend their search for causal links between action and outcome. While we are sympathetic to this idea, the evidence on action perception suggests that low-level parsing happens automatically, and thus depletion cannot be avoided (see Zacks, Speer, Swallow, Braver, & Reynolds, 2007). Whether this remains the case at higher-order levels of action processing is something we are currently examining (Nielbo, Schjoedt, & Sørensen, 2012). Based on our work, we suspect that a "ritual stance" might occur in the context of authorities, where depletion from low-level parsing is supplemented by a down-regulation of error monitoring and cognitive updating. With religious authorities in mind, Liénard, Martinez, & Moncrieff ask whether such effects are specific only to the religious domain. Because our imaging studies fail to reveal any mechanism specific to religion (Schjoedt, Stødkilde-Jørgensen, A.W. Geertz, Lund, & Roepstorff, 2011), we argue that down-regulation results from a general trust mechanism that functions in unequal interpersonal relations, such as doctor and patient, teacher and student, parent and child, and so forth. Nonetheless, religious experts work in highly specialized domains such that their actions are opaque to participants unless those participants know what the causal link is between the ritual action and the expected outcome. This indeed makes religious practice unique insofar as it demands believers to assume certain things about religious authorities such as their inherent skills or divine powers (Boyer, 2001; S. Turner, 2003; Weber, 1922/1968; Willner, 1984).

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The evidence

In our target article we explore the effects of religious interaction in three studies. These studies were originally designed independently of one another to investigate the proximate effects of religious interactions by using various resource models for interpretation (i.e., expressive suppression of memory, chronically high prediction-error in action perception, and frontal down-regulation in response to expert authority). However, we decided to explore these observations in a common theoretical framework that uses one resource model and the principle of predictive coding. Accordingly, our target article represents an early step toward a more systematic and integrated investigation of ritual.

Because it is an early step, our article lacks the empirical studies designed to accurately measure the central aspects of the model itself, which several of our commentators addressed (e.g., Sousa & White). We thus agree with our commentators that two links need to be established to support our interpretation: (1) the causal link between depletion and susceptibility; and (2) the causal link between each of the ritual features and their proximate effects (e.g., expressive suppression, impaired memory, ritualized behavior, increased prediction of error rates, and decreased error-monitoring). In particular, we agree with Brown that evidence for the link between depletion and susceptibility in rituals is lacking. To the best of our knowledge, no studies have systematically studied this link in a religious context; but the relation has

been studied in other domains. For example, in our target article we reference Otgar, Alberts, and Cuppens (2012), who use the Gudjonsson Suggestibility Scale (Gudjonsson, 1984) to show that depletion increases people's susceptibility to authoritative narratives. Additionally, we are currently running a study that uses this relational paradigm to investigate similar effects from exposure to ritualized behavior. Regarding the link between depletion and ritual features, we have new evidence indicating that online schema construction is delayed by causal opacity due to increased attentional demands (Nielbo, Schjoedt & Sørensen, 2012). As for the link between authority and down-regulation of prediction error monitoring, we believe there is already sufficient evidence in hypnosis research to support it (see Egner & Raz, 2007; Kaiser, Barker, Haenschel, Baldeweg, & Gruzelier, 1997; Raz, Fan, & Posner, 2005; Raz, Shapiro, Fan, & Posner, 2002). Finally, to measure this link with accuracy in a religious context we are currently attempting to employ imaging technologies with high temporal resolutions such as EEG and MEG (Kaiser et al., 1997; Raz et al., 2005).

Based on our current model, Liénard, Martinez, & Moncrieff ask what kinds of knowledge rituals transmit. The short answer is this: rituals transmit narratives that provide sufficient meaning and value to the ritual events themselves. Whenever religious institutions effectively provide such narratives, they increase the likelihood of participants adopting them. For example, adolescents in Hopi initiation rituals are first exposed to painful and traumatizing ordeals, and only then told stories about how the world is organized and why the rituals are performed as such (A.W. Geertz, 2004). Still, culturally transmitted schemas and narratives may not be explicitly associated with religious institutions and worldviews. For example, in our fire-walking study we did not find specifically religious interpretations of the ritual, but rather a host of inaccurate memories that were schematized around what participants expected to happen during the ritual. Such schemas are most likely constructed through teaching, learning, or gossiping among family and peers. We have recently studied the memory effects of another high-arousal ritual in Mauritius to investigate what kind of schemas and narratives are used in accounts of another high arousal ritual.

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Other important mechanisms in rituals

Alcorta notes that many features in ritual, including those we identify as resource depleting, may in fact function as transmitters of value and meaning at the associative level. We agree that ritual performance may create associative effects that influence individual understandings of ritual. We also agree that rituals are often emotional experiences that can align the attitudes of participants toward religious institutions, objects, and events. However, when people share narratives about ritual events (e.g., when elders teach adolescents about the meaning and value of religious practices), feelings are often difficult to communicate. Moreover, explicit narratives are often necessary whenever groups negotiate canonical interpretations of ritual activities. In those circumstances, we suggest that depleting features may function to limit idiosyncratic exegesis of events to facilitate collective narratives.

Alcorta then asks why features that exist in animal rituals would function as depletions in human rituals. Although human rituals appear to share features with those of animals, they are different: Human rituals are not only orchestrated, structured, and transmitted through culture, but are subject to significant cultural

variation. Thus, we suggest that cultures modulate and exaggerate specific features of ritual to facilitate transmission.

Recently, Whitehouse (2002, 2004) has argued for a particular relation between memory and high arousal rituals. He states:

> [R]arely performed and highly arousing rituals invariably trigger vivid and enduring episodic memories [. . .] These memories can be so vivid and detailed that they can take the form of [. . .] flashbulb memories. It is almost as if a camera has gone off in one's head, illuminating the scene, and preserving it forever in memory.'' (Whitehouse, 2002, p. 304)

Building this into his commentary, Whitehouse argues that ''flashbulb'' effects only appear in dysphoric rituals. However, that remains an open question in light of recent evidence. For instance, our firewalking study demonstrates that the flashbulb hypothesis does not accurately reflect the general effects of high arousal rituals. Furthermore, literature on memory indicates that dysphoric events generate post-traumatic stress symptoms, including amnesia (see Bourget & Whitehurst, 2007; Brown, Scheflin, & Hammond, 1998; Joseph, 1999; Kikuchi et al., 2010; Loftus & Kaufman, 1992). We also have preliminary evidence that supports this phenomenon: Our field research on the Kavadi ritual in Mauritius shows that practitioners typically report long periods of amnesia after the event. However, participants also report flashbulb-like memories for parts of the Kavadi ritual. While we are currently studying the accuracy of these reports by using the same methodologies as our fire-walking study, we expect them to reflect culturally transmitted schemas and narratives rather than accurate episodic memories of the ritual.

Returning to the notion of a ritual stance, Legare & Herrmann argue that ritual features, such as causal opacity and redundancy, may have other effects on the causal reasoning and cultural learning of participants. We believe this line of thinking should be pursued. If ritualized behaviors deplete and activate a ritual stance, it would add further support to social functional theories of ritual.

As for ritual and healing, McClennon presents his own theory on healing practices rather than commenting on the resource model. In many ways, we are sympathetic to his ideas, as they seem particularly relevant for the study of charismatic authority. Specifically, we agree that hypnosis and placebo research provides important insights regarding the manners in which believers become susceptible to authoritative suggestions. However, we fail to see how McClennon's model relates to the resource model and our interpretation that collective rituals function to limit individual executive processing. McClennon seems to wonder about this as well: ''I am uncertain regarding the role that cognitive resource depletion might play within the ritual healing theory.''

Lastly, McCauley asks how depletion affects the natural tendency to make individual inferences by means of intuitive inference systems, such as theory of mind (Barrett & Keil, 1996; Norenzayan, Gervais, & Trzesniewski, 2012; Schjoedt, Stødkilde-Jørgensen, A.W. Geertz, & Roepstorff, 2009). This is an interesting question that needs further investigation. Rituals that successfully deplete should also limit the resources available for social cognitive processing, thereby reducing inferences about supernatural agents. Whether this effect is sufficient to prevent participants from making such inferences is uncertain. However, we suspect that ritual accounts will always be challenged by intuitive inferences — either

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before, during, or after the ritual — regardless of the extent to which rituals cause depletion.

Conclusion

We would like to thank our commentators, for our understanding of ritual has improved as a result of their contributions. We agree that the resource model requires more detail to analyze and describe the various effects of ritual on individual cognition. More evidence is clearly needed to support our functional interpretation of the observed data. We also agree that depletion is only one aspect of ritual and that depletion may also have other psychological effects, which serve as additional functions that need to be identified, described, and investigated. Furthermore, rituals include non-depleting aspects that may have completely different effects on individuals and collectives, which would entail different functions for both. It would be interesting to see how the framework of predictive coding and the resource model could be used to analyze other mechanisms and their effects. In sum, we hope that we have convinced our readers that using a resource model and the principle of predictive coding is an interesting approach for identifying and analyzing the proximate effects of ritual.

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