Ritual, Emotion, and Sacred Symbols

The Evolution of Religion as an Adaptive Complex

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This paper considers religion in relation to four recurrent traits: belief systems incorporating supernatural agents and counterintuitive concepts, communal ritual, separation of the sacred and the profane, and adolescence as a preferred developmental period for religious transmission. These co-occurring traits are viewed as an adaptive complex that offers clues to the evolution of religion from its nonhuman ritual roots. We consider the critical element differentiating religious from nonhuman ritual to be the conditioned association of emotion and abstract symbols. We propose neurophysiological mechanisms underlying such associations and argue that the brain plasticity of human adolescence constitutes an "experience expectant" developmental period for ritual conditioning of sacred symbols. We suggest that such symbols evolved to solve an ecological problem by extending communication and coordination of social relations across time and space.

KEY WORDS Adolescence; Costly signals; Emotion; Neuropsychology; Religion; Ritual; Symbolic thought

The evolution of religion and its possible adaptive function have been the subject of considerable recent investigation by a wide array of researchers with diverse theoretical and methodological approaches. Cognitive scientists and evolutionary psychologists have been prominent among these researchers (Atran 2002; Barrett 2000; Bering 2005; Boyer 2001; Bulbulia 2004a, 2004b; Guthrie 1993; Kirkpatrick 1999; Mithen 1996, 1999). They have primarily studied religion in terms of beliefs, uncovering the psychological mechanisms that produce supernatural agents in all cultures. With the notable exceptions of Bering (2005) and Bulbulia

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(2004a), these researchers have concluded that religion constitutes a by-product of cognitive adaptations selected for "more mundane" survival functions. Evolutionary anthropologists have also revitalized studies of religion over the past two decades (see Sosis and Alcorta 2003). In contrast to the cognitive scientists, however, these researchers have tended to focus on religious behaviors rather than beliefs. The primary debate among these investigators has centered on the relative importance of group selection and individual selection in the evolution of religious systems (Cronk 1994a, 1994b; Rappaport 1994; Sosis 2003a; Sosis and Alcorta 2003; Wilson 2002). Drawing on both ethological studies and a rich theoretical legacy beginning with Durkheim (1969), evolutionary anthropologists have proposed that religious behaviors constitute costly signals that contribute to social cohesion (Cronk 1994a; Irons 1996a, 1996b, 2001; Sosis 2003b). These theorists situate religious ritual within a broader, nonhuman evolutionary continuum related to socially adaptive behaviors. Costly signaling theory has received empirical support from the research of Sosis and colleagues (Sosis 2000; Sosis and Bressler 2003; Sosis and Ruffle 2003, 2004), whose work has demonstrated a significant and positive association between participation in religious ritual and enhanced cooperation. However, these researchers have yet to examine how the high levels of cooperation observed within religious communities (e.g., Sosis and Bressler 2003; Sosis and Ruffle 2003) translate into individual fitness gains.

Although not guided by evolutionary analyses, the cumulative findings of a third body of research that has emerged over the past two decades does provide evidence of individual benefits for religious practitioners. This work has been conducted by sociologists, epidemiologists, psychologists, and physicians, and has explored the health impacts of religion on adherents (Hummer et al. 1999; Levin 1994, 1996; Matthews et al. 1998; Murphy et al. 2000). Accumulating findings from this body of research show significant positive associations between religious participation and individual health. These studies demonstrate decreased mental and physical health risks, faster recovery times for a wide variety of disorders, and greater longevity for those who regularly attend weekly Western religious services, even when social and lifestyle confounds are controlled (Hummer et al. 1999; Matthews et al. 1998; Murphy et al. 2000). In association with ongoing neurophysiological research (Austin 1998; McNamara 2001, 2002; Newberg et al. 2001; Saver and Rabin 1997; Winkelman 1986, 1992, 2000), these findings suggest proximate mechanisms by which religious participation may impact psychoneuroimmunological systems and, thus, individual fitness.

FOUR FEATURES OF RELIGION

These various approaches to religion have provided significant insights, but individually each is insufficient for an evolutionary understanding of religion. A synthesis that encompasses religion's cross-culturally recurrent features and captures that which differentiates the religious from the secular is required. We propose that

religion may best be understood as an evolved complex of traits incorporating cognitive, affective, behavioral, and developmental elements selected to solve an adaptive problem. Here we focus on four cross-culturally recurrent features of all religions that we consider to be integral components of this complex. These are:

- Belief in supernatural agents and counterintuitive concepts;
- Communal participation in costly ritual;
- Separation of the sacred and the profane; and
- Importance of adolescence as the life history phase most appropriate for the transmission of religious beliefs and values.

These four elements emerge and reemerge throughout the anthropological and sociological literature and encompass cognitive, behavioral, affective, and developmental aspects of religious systems across a wide variety of cultures (Douglas 1966; Durkheim 1969; Eliade 1958, 1959; Malinowski 1948; Rappaport 1999; Turner 1967, 1969; Tylor 1871). Although each trait may be variably expressed across different socioecological systems, their recurrence in societies as diverse as totemic Arunta hunter-gatherers and Protestant American industrialists suggests that they constitute basic elements of religion.

In this paper we examine each of these traits in relation to an evolutionary theory of religion as an evolved mechanism for social cooperation. We posit that the critical element in the differentiation of religious from nonhuman ritual was the emergence of emotionally charged symbols. Drawing on the seminal insights of Durkheim (1969), Turner (1967, 1969), and Rappaport (1999), we propose proximate mechanisms by which religious ritual serves to invest stimuli with motivational meaning. The brain plasticity of extended human adolescence is examined as an "experience expectant" developmental period for the emotional valencing of emergent symbolic systems. Following Richerson and Boyd (1998) we conclude that the symbolic systems of religious ritual in early human populations solved an ecological problem by fostering cooperation and extending the communication and coordination of social relations across time and space.

Supernatural Agents and Counterintuitive Concepts

Belief in supernatural agents may be the most commonly offered definition of religion (see Sosis and Alcorta 2003). Durkheim (1969) was the first to propose that supernatural agents represent the reification of society itself and function to maintain social order. Although Durkheim's reification of society as a causal explanation for religion has largely fallen into disfavor, his observation that the type of agent represented in a society's religion reflects the social organization of that society has been subsequently supported by the work of Wallace (1966) and the cross-cultural analyses of Swanson (1960).

More recently, Guthrie (1993), and other cognitive scientists (Atran 2002; Barrett 2000; Boyer 2001; Kirkpatrick 1999; Pinker 1997) have reexamined the supernatu-

ral beliefs of religious systems and have concluded that such beliefs are merely a "byproduct of numerous, domain-specific psychological mechanisms that evolved to solve other (mundane) adaptive problems" (Kirkpatrick 1999:6). Rejecting any adaptive function of religious beliefs per se, these researchers view the conceptual foundations of religion as deriving from categories related to "folkmechanics, folkbiology, (and) folkpsychology" (Atran and Norenzayan 2004). Supernatural agents, similar to moving dots on computer screens or faces in the clouds, are simply the result of innate releasing mechanisms of agency detection modules evolved to respond to animate, and therefore potentially dangerous, entities (Atran and Norenzayan 2004). Likewise, the attribution of intentionality to supernatural agents is viewed as the application of folkpsychology mental modules evolved in response to complex human social interactions. For many cognitive scientists, supernatural agents, as well as religious beliefs in general, constitute little more than "mental module misapplications."

Anthropological and psychological evidence, however, suggests that supernatural agents of religious belief systems not only engage, but also modify, evolved mental modules. Moreover, they do so in socioecologically specific and developmentally patterned ways. Although agency detection modules probably do give rise to the human ability to imagine a broad array of supernatural agents, those that populate individual religions are neither random nor interchangeable. Whether supernatural agents are envisioned as totemic spirits, ancestral ghosts, or hierarchical gods is very much dependent upon the socioecological context in which they occur (Durkheim 1969; Swanson 1960; Wallace 1966). The types of religious practitioners present, as well as the nature of religious practices performed in a society, have been shown to be significantly correlated with measures of social complexity and integration (Bourguignon 1976; Winkelman 1986, 1992). The shamanic use of trance to communicate with totemic ancestors found among the Athapaskan hunter-gatherers of the Arctic would be very familiar to the desert-dwelling Arunta hunter-gatherers of Australia. Likewise, the presence of priests and hierarchical gods typifies religions of state-level agricultural societies from the Maya of Mexico to the Ashanti of Africa. Cross-cultural statistical research by Swanson (1960) and subsequent analyses by Roes and Raymond (2003) have shown that the presence of moralizing gods "who tell people what they should and should not do" is significantly and positively related to group size, social stratification, environmental resource levels, and extent of external conflict.

The supernatural beings of all these religious belief systems engage evolved mental modules of agency and intentionality, as noted by cognitive scientists. This, however, does not preclude the possibility that religion is an evolved adaptation. As we have argued elsewhere (Sosis and Alcorta 2004), evolution is opportunistic and necessarily co-opts existing traits to solve novel ecological problems. It is the modification of these traits through natural selection that constitutes evolution. The question to be posed, therefore, is not "Does religion incorporate preexistent mental modules?" Instead, the relevant question is whether there exists evidence of adapta-

tion of those modules to solve ecological challenges. Recent experimental work by developmental psychologists suggests that the answer to this question is "yes." The supernatural agents of religious belief systems incorporate attributes of agency and intentionality, but they also possess an additional attribute not shared with natural category agents. In contrast to natural category agents, the supernatural agents of religious belief systems are "full access strategic agents" (Boyer 2001). They are "envisioned as possessing knowledge of socially strategic information, having unlimited perceptual access to socially maligned behaviors that occur in private and therefore outside the perceptual boundaries of everyday human agents" (Bering 2005:419). Moreover, accumulating research indicates that humans exhibit a developmental predisposition to believe in such socially omniscient supernatural agents, appearing in early childhood and diminishing in adulthood (Bering 2005; Bering and Bjorklund 2004). Cross-cultural studies conducted with children between the ages of 3 and 12 indicate that young children possess an "intuitive theism" (Kelemen 2004) that differentiates this social omniscience of supernatural agents from the fallible knowledge of natural social agents (Bering 2005). As the child's theory of mind develops, parents and other natural agents are increasingly viewed as limited in their perceptual knowledge. Supernatural agents, however, not only remain socially omniscient, but are viewed by children in late childhood as agents capable of acting on such knowledge. This developmental predisposition to believe in socially omniscient and declarative supernatural agents contrasts with evolved mental modules of folkpsychology for natural categories. It also goes far beyond natural agency-detection modules to encompass socially strategic agents with behaviorally motivating characteristics.

Supernatural agents of religious belief systems also diverge from evolved mental modules for natural ontological categories (e.g., animate/inanimate; people/animals) in another significant way. Such agents do not uphold natural categories; they violate them. Totemic animals that can talk, dead ancestors who demand sacrificial offerings and visit the living, and incorporeal gods capable of being in all places at all times violate basic premises of natural ontological categories. Yet, these exceedingly unnatural constructs comprise powerful religious schema that elicit deep devotion and belief across traditional and contemporary cultures alike. If religious beliefs are merely by-products of mental modules evolved to deal with the "natural world," why do such beliefs consistently violate the basic cognitive schema from which they are presumed to derive?

In addressing this question, a number of cognitive scientists have noted that the counterintuitive concepts that characterize religious beliefs are both attention-arresting and memorable (Atran 2002; Boyer 2001; Kirkpatrick 1999). Experimental tests validate these observations (Atran and Norenzyan 2004; Boyer and Ramble 2001). Counterintuitive concepts, such as bleeding statues and virgin births, do grab attention. Atran and Norenzayan (2004) note, however, that the efficacy of counterintuitive concepts in engaging attention, improving recall, and promoting transmission is highly dependent upon the broader context within which these con-

cepts are framed. Comparing belief sets with intuitive and counterintuitive concepts, they found that the specific profile of the counterintuitive/intuitive concepts most frequently encountered in religious belief systems achieved the "highest rate of delayed recall and lowest rate of memory degradation over time" (Atran and Norenzyan 2004:723). Thus, the counterintuitive beliefs of religious systems not only violate natural ontological categories, they do so in a specifically patterned way that renders them maximally memorable and maximally transmissible. This suggests selection for such concepts.

Counterintuitive concepts have yet another important feature of significance for social groups. In addition to their mnemonic efficacy, they comprise almost unbreakable "codes" for the uninitiated. Most language distortions occur within ontological categories (Bartlett [1932] as reported in Atran and Norenzayan 2004). When distortions do cross ontological boundaries, they are most common from counterintuitive to intuitive concepts; distortions occurring from intuitive to counterintuitive concepts are extremely rare. For example, it would be much more likely for a listener to modify "talking horse" to "walking horse" than the converse. These findings indicate that counterintuitive concepts are not readily generated on the basis of intuitive concepts, and they suggest that the chances of spontaneously re-creating a preexistent counterintuitive concept are exceedingly low. This probability is lowered even further by embedding multiple counterintuitive concepts within religious belief sets. By incorporating counterintuitive concepts within belief systems, religion creates reliable costly signals that are difficult to "fake." They must be learned, and since such learning has been orally transmitted throughout the vast majority of human evolution, this also implies participation in religious ritual. As a result, religious belief systems serve as both costly and reliable signals of group membership.

Finally, the irrationality of counterintuitive concepts contributes to their efficacy as honest signals of commitment to a group who share that belief (Lee Cronk, personal communication 2002). Within a pluralistic context, adherents who propound counterintuitive beliefs risk censure. Early Christian belief in the resurrection of Christ constituted a potent signal to Romans, Jews, and other Christians. Only individuals knowledgeable about the religious tenets of Roman Catholicism would conceive of the transmutation of wine to blood, and only those initiated into the faith through the emotional conditioning of those tenets would truly believe that such a transmutation occurs during the sacrament of Communion. Through the eyes of nonadherents, such beliefs may be viewed as extraordinary and irrational. Such perceptions contribute to both the costliness and the effectiveness of religious signals.

In summary, neither the content nor the structure of religious belief systems supports the assertion that such beliefs constitute epiphenomenal "by-products." Although supernatural agents engage mental modules of agency and intentionality that evolved in response to "mundane" selection pressures, they modify these modules in specific and developmentally patterned ways. Cross-culturally, supernatural agents are integral elements of religious beliefs and they consistently reflect sig-

nificant socioecological relations within their respective cultures. The agents of religious belief are not natural category agents, as would be predicted if they were simply by-products of mental modules evolved to deal with such agents. They are instead counterintuitive agents that not only modify natural agency module parameters, but do so in consistently patterned and behaviorally significant ways. A developmental propensity to believe that such agents are not only intentional, but also socially omniscient, is indicated by accumulating experimental evidence (Bering and Bjorklund 2004). Although the predisposition to believe in such supernatural agents appears to be innate, the development of such beliefs is dependent upon cultural transmission. Religious cognitive schema exhibit structural elements that maximize transmission through the incorporation of minimally counterintuitive concepts that engage attention, promote recall, and insure exclusivity.

These features of religious belief systems provide ontogenetic lability for the construction of socially relevant moral systems across diverse ecologies, and they do so within a structure that is maximally transmissible and minimally invasive. Bering (2005:430) notes that "children are simultaneously immersed in unique cultural environments where morality is chiefly determined by socioecological conditions. Although there is likely a common 'moral grammar' underlying all children's development in this domain, the moral particulates of any given society are given shape by the demands of local environments." Bulbulia, too, argues that religion, like language, exhibits an innate grammar in which "development consists of fixing labels to preexisting cognitive structures" (J. Bulbulia, personal communication 2004). For both Bulbulia (2004a, 2004b) and Bering (2005), the idea of socially omniscient supernatural agency is a central component of this system. These researchers view the adaptive value of such agents to be the maintenance of group cooperation and cohesion across a broad spectrum of socioecologies. Atran, likewise, acknowledges religion's use of supernatural agents in "maintaining the cooperative trust of actors and the trustworthiness of communication by sanctifying the actual order of mutual understandings and social relations" but asserts that "religion has no evolutionary function per se"(2002:278–279). In contrast, we argue that religion's ability to promote cooperation is its evolutionary function, and that the costliness of religious ritual bears a direct relationship to the nature of the collective action problems faced. When individual costs are high, but the potential benefits of cooperation are great, costly religious ritual provides a reliable mechanism for minimizing free-riding and maximizing cooperation. We consider the cognitive schema of religious systems to be a fundamental evolved element in ensuring such cooperation. Both the ontogenetic and structural features of religious belief systems suggest evolved features. Yet, we also maintain that religious belief systems in isolation are incapable of "sanctifying the actual order of mutual understandings and social relations" (Atran 2002:278). It is certainly possible to be cognizant of religious beliefs without subscribing to them, as any schoolchild who has ever studied Greek mythology can attest. In order for religious beliefs to sanctify social relations, they must first themselves be sanctified. This is achieved through ritual.

Communal Participation in Costly Ritual

The pivotal role of communal ritual in religion has been noted by numerous researchers (Bloch 1989; Bourguignon 1973, 1976; Durkheim 1969; Eliade 1958, 1959; McCauley 2001; Rappaport 1999; Turner 1967, 1969). The formality, patterning, repetition, and rhythm of religious ritual have direct parallels in nonhuman ritualized display (Laughlin and McManus 1979; Lorenz 1965; Rappaport 1999; Rogers and Kaplan 2000; Smith 1979). In animal species such displays have evolved to serve intra- and inter-specific communication functions (Dugatkin 1997; Lorenz 1965; Rogers and Kaplan 2000; Rowe 1999). On its most basic level, nonhuman ritual constitutes "a process by which behavior specialized to be informative becomes differentiated from behavior that is informative only incidentally to its other functions" (Smith 1979:54). Ritualized displays represent but one end of a continuum in animal signaling systems that also includes simple indexical signals. Signal costs appear to be driven by both competition and receiver selection. Under conditions of ambiguity, or when signals can readily be faked, costlier signals may evolve to improve signal reliability. Ritualized displays are among the costliest of animal signals in terms of time, energy, and somatic resources required of the signaler. Zahavi (1975, 1981) has argued that such costly signals provide honest information for receiver assessment since only those who are sufficiently fit can bear the costs of such displays (Johnstone 2000; Zahavi and Zahavi 1997). Empirical research supports this hypothesis (Johnstone 2000; Zahavai and Zahavi 1997). Laboratory experiments indicate that the costliness of ritualized display is driven by receiver selection for reliable signals (Rowe 1999). The formality, sequence, repetition, and patterning that increase both time and energy costs of ritual also improve the ability of the receiver to assess the reliability of the message transmitted. These elements alert and focus attention, enhance memory, and promote associational learning (Rowe 1999). They neurophysiologically "prime" both the sender and receiver for action (Lewis and Gower 1980; Rogers and Kaplan 2000; Tinbergen 1965). The type of action that results is dependent both upon the receiver's assessment of the sender and upon the encoded "action releasers" embedded within the ritual display (Lewis and Gower 1980; Tinbergen 1965).

Animal signals and signal responses show considerable ontogenetic and socioecological malleability (Ball 1999; Lewis and Gower 1980; Marler 1999; Rogers and Kaplan 2000; Wingfield et al. 1999). Although some species-specific signals, such as the pecking response of herring-gull chicks to red dots, constitute relatively fixed, environmentally stable action-response sequences (Lewis and Gower 1980; Tinbergen 1965), others incorporate individually variant and ontogenetically learned patterns, as seen in the male courtship songs of various bird species (Ball 1999; Marler 1999). Signals of some species, including the esthetic nest constructions of male bowerbirds (Dissanayake 1995) and the friendship greeting rituals of baboons (Watanabe and Smuts 1999) show considerable malleability and high proportions

of environmentally variable behaviors. The continuum of simple to complex ritual signals clearly encompasses a broad range of "fixed" and "learned" elements.

Ritual signals communicate important information regarding the condition, status, and intent of the sender. The intensity of plumage coloration in birds, the pitch of croaking in frogs, and the stotting height of springboks constitute indexical signals that provide information regarding parasite load, size, and agility, respectively (Krebs and Davies 1984; Rogers and Kaplan 2000). Such signals may also convey information regarding intent. In many species, intent signals frequently involve the transference of behaviors from their original context to a ritual context. The incorporation of food begging displays in bird courtship rituals, and presentation of the ano-genital area by subordinate primates to dominants, both represent signals that have been emancipated from their original feeding and copulating behaviors and transferred to new contexts of courtship and social hierarchies. In both instances, affiliative responses eliciting approach behaviors are associated with the original function of the signal and the transferred signal intent (Lewis and Gower 1980). Transference of these signals from their original contexts to ritual communicates the intent of the sender by evoking the autonomic and neurophysiological state associated with the signal's origins. The incorporation of these intent signals in ritual derives from their preexisting motivational characteristics (Laughlin and McManus 1979).

Religious ritual, like nonhuman ritualized displays, is demarcated from ordinary behaviors and is composed of the same structural elements (Rappaport 1999). Formality, patterning, sequencing, and repetition are basic components of religious ritual, and signals of condition, status, and intent constitute "action releasers" embedded within that structure. Pan-human social signals of dominance and submission, such as bowing and prostration, are prominent components of religious ritual worldwide (Atran 2002; Bloch 1989; Boyer 2001; Leach 1966; Rappaport 1999). As in nonhuman ritual, these signals convey information regarding status and intent. Religious ritual also incorporates indexical and iconic signals. Masks, statues, and other "agent" representations are prominent elements in religious ritual across cultures. They engage innate mental modules evolved for mundane functions and potentiate human predispositions to autonomically respond to specific classes of stimuli, including animate agents and angry faces (LeDoux 2002). Incorporation of evocative, grotesque, and dissonant features further intensify such responses. Like the signals of nonhuman ritual, the signals of religious ritual clearly elicit neurophysiological responses in participants and influence the nature of social interaction (Lewis and Gower 1980; Reichert 2000; Rogers and Kaplan 2000; Sapolsky 1999). In contrast to nonhuman ritual, however, iconic, indexical, and ontogenetic signals are not the primary encoded elements of human religious ritual. The fundamental elements of human religious ritual are, instead, abstract symbols devoid of inherent emotional or cognitive meaning. Words such as "Allah," the geometric designs of Australian Dreamtime paintings, and religious beliefs do not, in and of

themselves, elicit any innate or ontogenetically derived neurophysiological response. Although, like language, religious systems across cultures appear to share a "deep structural grammar" that has an ontogenetic basis, the specific symbols embedded within that syntax are shaped by historical and socioecological parameters. In contrast to the signals of animal ritual, the meaning of abstract religious symbols must be created, both cognitively and emotionally. This important difference between nonhuman ritual and human religious systems not only requires that the abstract symbols of religious ritual be learned; it additionally requires that the emotional and behavioral significance of these symbols be learned as well. Whereas animal ritual elicits behavior through encoded signals, religious ritual elicits behavior to encode symbols. The creation of these symbols provides ritual tools for the shaping of social behaviors across space and time. Sosis (2003b) has argued that ritual participation generates belief among performers. He examined the psychological mechanisms underlying this process. Here we extend this argument to explain the interrelationship between emotions, symbols, and the sacred, and describe the neurological underpinnings of how ritual participation impacts belief.

Separation of the Sacred and the Profane

Religious ritual is universally used to define the sacred and to separate it from the profane (Douglas 1966; Durkheim 1969; Eliade 1959; Rappaport 1999). As noted by Rappaport (1999), ritual does not merely identify that which is sacred; it *creates* the sacred. Holy water is not simply water that has been discovered to be holy, or water that has been rationally demonstrated to have special qualities. It is, rather, water that has been *transformed* through ritual. For adherents who have participated in sanctifying rituals, the cognitive schema associated with that which has been sanctified differs from that of the profane. For Christians, profane water conjures associations of chemical structure and mundane uses; holy water, however, evokes associations of baptismal ritual and spiritual cleansing. Of greater importance from a behavioral perspective, the emotional significance of holy and profane water is quite distinct. Not only is it inappropriate to treat holy water as one treats profane water, it is emotionally repugnant. Although sacred and profane things are cognitively distinguished by adherents, the critical distinction between the sacred and the profane is the emotional charging associated with sacred things.

This distinction in emotional valence is created through participation in religious ritual. Sacred symbols have distinct cognitive schema, but their sanctity derives from their emotional meaning. It is the emotional significance of the sacred that underlies "faith," and it is ritual participation that invests the sacred with emotional meaning. The creation of religious symbols from abstract objects, and the imbuing of these symbols with attributions of "awe," "purity," and "danger" (Douglas 1966), are consistent and critical features of religious ritual everywhere (Douglas 1966; Durkheim 1969; Rappaport 1999; Turner 1969). Why is this so?

Emotions Motivate Behavior. Accumulating research indicates that emotions constitute evolved adaptations that weight decisions and influence actions. Emotions "rapidly organize the responses of different biological systems including facial expression, muscular tonus, voice, autonomic nervous system activity, and endocrine activity" (Levenson 1994:123) in order to prepare the organism for appropriate response to salient sensory stimuli. The ability of emotions to "alter attention, shift certain behaviors upward in response hierarchies, and activate relevant associative networks in memory" (Levenson 1994:123) directly impacts individual fitness. Since emotions are generated from limbic cortices that are outside conscious control, they are difficult to "fake" (Ekman et al. 1983). They, therefore, provide reliable communication signals among conspecifics. EEG patterns for simulated and real emotions are not the same, nor are the motor control areas for an emotion-related movement sequence and a voluntary act (Damasio 1994, 1998; Ekman and Davidson 1993). The somatic markers of emotion, including such things as pulse rate, skin conductance, pupil dilation, and facial expressions, differ from those under voluntary control. Emotionally motivated smiles engage different muscles from "Duchenne smiles," as do emotionally motivated frowns (Ekman 2003). As a result, emotions constitute powerful and honest cues of state and intent (Ekman 2003; Ekman et al. 1983).

Emotions may be elicited by sensory stimuli both internal and external to the organism. Predators, passing thoughts, and pulse rate are all capable of evoking emotional response. The emotional processing and appraisal of these stimuli engage widespread and complex cortical and subcortical systems within the brain. Initial unconscious processing of stimuli occurs in subcortical structures of the brain, including the basal ganglia, the amygdala, and the hypothalamus. This "first pass" level of processing appears to incorporate a superordinate division based on positive/approach and negative/withdrawal ratings of stimuli (Cacioppo et al. 2002).

Positive Stimuli Activate the Dopaminergic Reward System. The dopaminergic reward system constitutes "an emotional system that has evolved to motivate forward locomotion and search behavior as a means of approaching and acquiring rewarding goals" (Depue et al. 2002:1071). This system originates in the ventral tegmental area of the midbrain and projects to the nucleus accumbens of the ventral striatum. Its activation triggers the release of dopamine (DA), a neuromodulator which functions as a reward for the organism (Davidson and Irwin 2002). Stimuli intrinsic to somatic and reproductive success, such as food and sex, activate dopamine neurons within this system, and initiate goal-seeking behaviors. The potentiation of dopaminergic neurons induces a positive motivational state in the organism and simultaneously increases stimuli salience and locomotor activity (Pearson 1990). "Activation of this system has been shown to function as a reward, and animals will perform an arbitrary operant in order to self-administer stimulation of this pathway" (Pearson 1990:503). Drugs of addiction potentiate this system, as do subjec-

tively rated "pleasurable" activities (Cacioppo et al. 2002). Repeated potentiation of this system transfers "the ability to phasically activate DA transmission from incentive stimuli intrinsic to the goal to incentive stimuli extrinsic to it" (DiChiara 1995:95). This results in the assignment of a positive affective valence to stimuli perceived under that state (DiChiara 1995). Such "incentive learning" creates associational neural networks that link stimuli associated with rewarding experiences to behavioral motivators, thereby investing previously neutral stimuli with positive valence. For former drug addicts, the paraphernalia, settings, and even neighborhoods associated with drug use constitute such incentive stimuli capable of activating mesolimbic neural networks, as revealed through brain imaging studies (DiChiara 1995).

Negative Stimuli Activate the Amygdala. The amygdala is a subcortical collection of specialized nuclei located beneath the temporal cortex. A central function of the amygdala is the rapid appraisal of potentially dangerous and threatening stimuli. Activation of the amygdala initiates a cascade of specific neuroendocrine events that prepare the organism to respond quickly to threats and danger. These responses appear to be "hard wired" in the nervous system (LeDoux 2002). Animals with lesioned or removed amygdala lack a fear response, even when placed in highly dangerous situations (LeDoux 1996).

In humans, the amygdala is also pivotal in initiating fear responses. Humans exhibit an innate predisposition to negatively valence potentially harmful and threatening stimuli, including animate objects and angry or fearful faces. There is considerable evidence that such stimuli elicit a greater response than positive stimuli, particularly in relation to action tendencies (Ito et al. 2002). The amygdala also processes human facial cues in relation to social judgments of trust. This processing occurs both consciously and unconsciously by the left and right amygdala, respectively (Adolphs 1999, 2002a, 2002b; Adolphs et al. 1998; Dolan 2000; Morris et al. 1998; Oram and Richmond 1999).

While specific stimuli innately activate the amygdala, it is also possible for neutral stimuli to acquire negative valence through classical and contextual conditioning. Previously neutral stimuli that are present or otherwise associated with a negatively valenced stimulus that activates the amygdala may subsequently initiate such response themselves. Once such conditioning occurs, it is difficult to reverse. Extinction of such conditioning "is not a process of memory erasure, [but rather] involves cortical inhibition of indelible, amygdala-mediated memories" (LeDoux 2002:404). As a result of both the negativity bias in information processing and the indelible nature of emotional memory, amygdala-conditioned stimuli constitute powerful long-term elicitors of emotional response.

The amygdala is highly interconnected with sensory, motor, and autonomic output systems. These interconnections "provide an anatomical basis for adaptive responses to stimuli" (Dolan 2000:1117). Interconnections with the hypothalamus ensure rapid somatic responses to stimuli through a cascade of neuroendocrine events.

These events prepare the organism for behavioral response and provide feedback information regarding body state to the amygdala. Reciprocal interconnections with the nuclear basalis ensure amygdalar participation in cortical arousal and selective attention. Direct interconnections of the amygdala with the hippocampal formation allow affective modifications of spatial behavior (Cacioppo et al. 2002; Cardinal et al. 2002; Damasio 1994, 1998; LeDoux 2002). Specific reciprocal projections from the amygdala to other emotional processing regions, including the ventral striatum and brainstem nuclei, provide an important link between positive and negative affective systems (Dolan 2000; LeDoux 2002; Rolls 1998). It is, however, the direct interconnections between the amygdala and the prefrontal cortex that are of particular significance for human social and symbolic systems (Deacon 1997; Groenewegen and Uylings 2000; Rolls 1998).

The Prefrontal Cortex Plays a Critical Role in Decision Making. McNamara (2001, 2002) has convincingly argued that the self-responsibility, impulse control, and morality which religions seek to instill in adherents are frontal lobe functions. Ongoing research supports the pivotal role of the prefrontal cortex in social judgment and impulse control, as well as symbolic thought (Deacon 1997; Dehaene and Changuex 2000; McNamara 2001, 2002; Rolls 1998). The orbitofrontal (OFC) region of the prefrontal cortex is the area of the brain activated in anticipation of rewards and punishments. Injuries to this brain area affect the delicate calculus of personal interest, environmental contingencies, and social judgments that motivate and guide individual behaviors within a social group (Dehaene and Changeux 2000; Rolls 1998). The valuation of behavioral alternatives, particularly in relation to social behaviors, appears to be processed in the OFC. Impairments to this area correlate highly with socially inappropriate or disinhibited behavior (Anderson et al. 2002; Damasio 1994; Kolb et al. 2004).

The behavioral deficits of OFC impaired patients are also seen in individuals who have intact prefrontal cortices and intact amygdala but lack interconnections between the two (Damasio 1994; LeDoux 1996, 2002). These individuals perform well on abstract reasoning tasks but are unable to apply such reasoning to personal decision making (Damasio 1994; LeDoux 1996, 2002). The loss of emotion typical of OFC impaired patients is also a characteristic of these disconnect patients. For these individuals, the affective cues required for valuation of predicted outcomes are absent. In the absence of emotional input from the basolateral amygdala, the OFC lacks valuation information necessary for the prediction of reward/punishment outcomes. Recent laboratory experiments conducted by Schoenbaum and colleagues demonstrate that both the orbitofrontal cortex and the basolateral amygdala are "critical for integrating the incentive value of outcomes with predictive cues to guide behavior" (Schoenbaum et al. 2003:855). It is through the emotional inputs of the amgydala that "otherwise neutral cues acquire motivational significance or value through association with biologically significant events" (Schoenbaum et al. 2003:863).

Ritual, Emotion, and Sanctification. Religious rituals are biologically significant events. Ongoing research with ritual participants engaged in meditation and trance demonstrate changes in brain wave patterns, heart and pulse rate, skin conductance, and other autonomic functions (Austin 1998; Davidson 1976; Kasamatsu and Hirai 1966; MacLean et al. 1997; Mandel 1980; Newberg et al. 2001; Winkelman 2000). Meditation also alters neuroendocrine levels, including testosterone, growth hormone, and cortisol (MacLean et al. 1997). Although little research has been conducted on the neurophysiological effects of less intense religious participation, there is mounting evidence that participation in weekly Western religious services may impact blood pressure (Brown 2000; Dressler and Bindon 2000), adolescent testosterone levels (Halpern et al. 1994), and other neurophysiological systems (Levin 1994, 1996; Matthews et al. 1998; Murphy et al. 2000). Experiments suggest that some of these neurophysiological changes may be associated with the "rhythmic drivers" that characterize human religious ritual.

Music Is a Universal Feature of Religious Ritual. Human and nonhuman ritual share basic structural components of formality, pattern, sequence, and repetition. Human religious ritual further amplifies and intensifies these elements through the incorporation of "rhythmic drivers." Described by Bloch as "distinguishing marks of ritual" (1989:21), these elements, including music, chanting, and dance, constitute recurrent and important components of religious ritual across cultures. Although Bloch derived these features from ethnographies of traditional societies, the recent survey of U.S. congregations conducted by Chaves et al. (1999) found music to be a consistent feature of contemporary U.S. religious services, as well. Even in the most ritually constrained religions, music remains a key consistent feature (Atran 2002). Not only is music an important component of religious ritual, across traditional cultures it is inseparable from it (Becker 2001).

Music has important neurophysiological effects. As a "rhythmic driver," it impacts autonomic functions and synchronizes "internal biophysiological oscillators to external auditory rhythms" (Scherer and Zentner 2001:372). The coupling of respiration and other body rhythms to these drivers affects a wide array of physiological processes, including brain wave patterns, pulse rate, and diastolic blood pressure (Gellhorn and Kiely 1972; Lex 1979; Mandel 1980; Neher 1962; Walter and Walter 1949). This "coupling effect" has been shown to be present in humans at a very early age (Scherer and Zentner 2001). Music amplifies and intensifies this effect through the use of instruments, or "tools," thereby providing a means of synchronizing individual body rhythms within a group. Recent work by Levenson (2003) has shown that synchronized autonomic functions, including such things as pulse rate, heart contractility, and skin conductance, are positively and significantly associated with measures of empathy. The prominent role of music in religious ritual promotes such empathy.

Music also has demonstrated effects on measures of stress and immunocompetence. A significant negative correlation between exposure to "relaxing" music and

salivary cortisol levels was found in experiments conducted by Khalfa et al. (2003). Other research has demonstrated significant positive correlations between music and immunocompetence, as measured by salivary immunoglobin A (SIgA), with active participation correlating most highly with immunocompetence and no music exposure correlating the least (Hirokawa and Ohira 2003; Kuhn 2003). These associations between music and measures of stress and health may be mediated by music's ability to alter autonomic functions and evoke emotions. The capacity of music to alter skin temperature, muscle tension, cardiovascular function, respiration, norepinephrine, and brain wave patterns all have subjectively reported "emotion inducing effects" (Hirokawa and Ohira 2003; Scherer and Zentner 2001). The contour, rhythm, consonance/dissonance, and expectancy within a musical structure contribute to both the intensity and valence of the experienced emotion (Hirokawa and Ohira 2003; Scherer and Zentner 2001; Sloboda and Juslin 2001). Studies of subliminal facial expression demonstrate that musically induced physiological changes closely correspond with both involuntary facial expressions of emotion and subjectively described emotions evoked by particular types of music (Krumhansl 1997).

The capacity of music to entrain autonomic states and evoke congruent emotions in listeners provides the basis for creating and synchronizing motivational states in ritual participants. Although the communal songs and vocalizations of nonhuman species, including birds, whales, and wolves, may also function in social accommodation, only human music is capable of amplifying, intensifying, and modifying these effects through the use of "tools." The externalization of auditory signal production through the use of musical instruments fundamentally alters the signal/signaler relationship. The signal produced through the use of musical instruments is no longer indexical of either the signaler's state or condition. Two warriors can sound like twenty through the use of drums. Moreover, discrete sounds produced with musical instruments can be manipulated and juxtaposed to create emotionally evocative signals independent of the musician's state. Like the phonemes, words, and sentences of language, the use of musical instruments to produce sounds permits the combining of such sounds to create emotionally meaningful signals. These, in turn, can be arranged and rearranged within encompassing musical structures. The formality, sequence, pattern, and repetition of such musical structures themselves elicit emotional response through their instantiation of ritual. Music thereby creates an emotive "proto-symbolic" system capable of abstracting both the signals and structure of ritual. This abstraction and instantiation of ritual through music may well have established the foundation for symbolic thought in human evolution. It certainly provided a tool for the evocation of communal emotions across time and space.

Religious Ritual Evokes Both Positive and Negative Emotions. Cross-culturally, the emotion most frequently evoked by music in religious ritual is happiness (Becker 2001). In its most intense version, this may reach ecstasy. Such extreme joy "almost by definition involves a sense of the sacred" (Becker 2001:145) and is not unlike

that attained through use of various psychoactive drugs. Such drugs also constitute prominent elements in many religious systems. These components of religious ritual activate noradrenergic, serotonergic, and dopaminergic systems in the brain that heighten attention, enhance mood, and increase sociability (Regan 2001). These components of religious ritual elicit positive emotional responses in participants and engage the brain's dopaminergic reward system.

There are also numerous elements of religious ritual that evoke fear and pain rather than happiness and joy (Douglas 1966; Eliade 1959; Glucklich 2001; Turner 1967, 1969). Many ritual settings, including caves, caverns, and cathedrals, arouse vigilance by altering sensory perception through unpredictable illumination. Grotesque masks, bleeding statues, and fearsome icons engage innate "agency" modules that initiate emotional responses to danger and threat. Physical and mental ordeals inflict suffering and alter autonomic states. Vengeful gods and demons mete out punishment and demand painful sacrifices. Such negative stimuli comprise central elements of many religious systems and are particularly prevalent within the context of rites of passage (Eliade 1958, 1959; Glucklich 2001; Turner 1969). In contrast to the positive affect induced by ecstatic religious ritual, these components of ritual initiate responses related to fear and danger and evoke intense negative emotions in ritual participants.

The ability of religious ritual to elicit both positive and negative emotional responses in participants provides the substrate for the creation of motivational communal symbols. Through processes of incentive learning, as well as classical and contextual conditioning, the objects, places, and beliefs of religious ritual are invested with emotional significance. The rhythmic drivers of ritual contribute to such conditioning through their "kindling effects." Research on temporal lobe syndrome patients has shown that repeated neuronal firing of the amygdala can result in the conditioned association of arbitrary stimuli with heightened emotional significance (Bear 1979; Bear et al. 1981; Damasio 1994; Geschwind 1979). The increased religiosity characteristic of some temporal lobe epileptics has been attributed to this kindling effect (Bear 1979; Saver and Rabin 1997). Rhythmic environmental stimuli, including both music (Peretz 2001) and rapid, flashing lights, contribute to the rapid neuronal firing that results in such kindling (LeDoux 2002). Temporal lobe patients have a low threshold for such firing. EEG recordings have shown that the driving effects of ritual, such as music, drumming, and dancing, are capable of altering neuronal firing patterns in nonclinical populations, as well (Lex 1979; Neher 1962; Walter and Walter 1949). Elements of religious ritual that increase neuronal firing rates prime ritual participants for the conditioned association of symbols and emotions, both positive and negative, and create communal conditions for investing religious stimuli with these emotions (DiChiara 1995). The "ecstasy" achieved through the music and movement of Sufi dancing is transferred to the religious poetry with which it is associated. Likewise, ingestion of peyote by the Huichol Indians with its potentiation of the dopaminergic reward system provides a neurophysiological basis for investing the communal Peyote Hunt itself with sacred sig-

nificance (Myerhoff 1974). The negative emotional responses elicited by shadowed cathedrals, fearsome masks, and painful ordeals are heightened by drumming, music, and chants. The emotions thereby elicited and intensified become conditionally associated with the gods, ghosts, and demons that populate religious belief systems. Such symbols are not inherently pleasurable, but they are motivationally powerful and emotionally indelible. The use of communal ritual to invest previously neutral stimuli with deep emotional significance creates a shared symbolic system that subsequently valences individual choices and motivates behavior (Dehaene and Changeux 2000).

Most Religions Incorporate Both Positive and Negative Elements. The extent to which positive and negative elements are emphasized varies considerably both across the rituals within a given religion and among religions. Whether religious ritual predominantly incorporates positively or negatively valenced symbols appears to be correlated with both the political characteristics of the group and the risk-to-benefit ratio of their cooperative endeavors. We anticipate that when collective action issues are predominantly problems of coordination with few potential costs to individuals, positively valenced rituals will serve to promote affiliative cooperation. Such rituals engender empathy among participants and conditionally associate religious symbols with internal reward systems through incentive learning. When the predominant collective action issues faced by a group involve high individual costs but potentially great collective benefits, however, we expect increases in the costliness of religious ritual through the incorporation of negatively valenced stimuli to deter free riders. Since negatively valenced components of ritual are motivationally more powerful than positive stimuli, they provide a more reliable emotionally anchored mechanism for the subordination of immediate individual interests to cooperative group goals. In societies lacking a central political authority with police powers capable of subordinating individual interests to those of the group, intense and negatively valenced religious rituals address the inherent free-rider problems of collective action. The prominence of negatively valenced elements in religions associated with large, socially stratified, preindustrial societies (Roes and Raymond 2003) underscores this "policing" role of religion in motivating cooperation when a central secular authority is weak (Paige and Paige 1981). This is particularly pronounced in adolescent rites of passage in such societies (Eliade 1958; Glucklich 2001; Turner 1969). The incorporation of painful and dangerous elements in such rites is positively and significantly correlated with the incidence of warfare in preindustrial societies (Sosis et al., n.d.). These highly charged negative ritual experiences not only bond initiates, they also motivate intense cooperation and obedience under conditions of high individual risk and low central authority. The less powerful in such societies bear a larger share of the fitness costs of such subordination, but they may still gain greater benefits as members of a successful cooperative group than they would otherwise realize.

Yet, even when religious systems emphasize negatively valenced symbols, the

use of ritual to invest such symbols with emotional meaning necessarily incorporates positively valenced components that benefit ritual participants both psychologically and politically. Powerfully valenced symbols that motivate behavioral choices reduce cognitive dissonance, particularly under conditions of socioecological stress. Research by Bradshaw (2003) indicates that in contemporary Western societies, weekly worship attendance results in relatively greater decreases in psychological distress for the socioeconomically disadvantaged. The positive correlation of music and immunocompetence, and its inverse correlation with stress, suggests that ritual participation may differentially benefit group members facing the highest stress loads.

At the same time, joint participation in costly ritual creates empowering conditions. Ritual not only promotes more efficient and effective group functioning for politically and socially sanctioned endeavors, it simultaneously creates motivationally coordinated coalitions that can surmount existing in-group/out-group boundaries and provide a mechanism for social and political change (Bourguignon 1973). The Protestant Reformation of the sixteenth century, the role of African-American churches in the U.S. Civil Rights Movement, the contemporary importance of Pentecostalism in Latin America, and messianic movements in general, all illustrate the important role of religion in creating cooperative coalitions that have been instrumental in transforming existent social and political relationships.

Adolescence and Religion

Adolescent Rites of Passage. Adolescent rites of passage are one of the most consistent features of religions across cultures (Bettleheim 1962; Brown 1975; Lutkehaus and Roscoe 1995; Paige and Paige 1981; van Gennep 1960). In some societies, such as the Yamana and Halakwulup of Tierra del Fuego, such rites traditionally consisted of little more than oral transmission of sacred knowledge from elder to youth (Eliade 1958). In other cultures, such as the Ndembu and the Elema, pubertal initiation rites involved "kidnapping" of adolescents, months of sequestered seclusion, and ritual ordeals that included dietary restrictions, sleep deprivation, physical pain, and genital mutilation (Eliade 1958; Glucklich 2001; Paige and Paige 1981; Turner 1969; van Gennep 1960). In modern societies, adolescence also constitutes an important developmental period for religious training (Atran 2002; Elkin 1999; Regnerus et al. 2003). Although the intensity and duration of adolescent rites of passage vary from culture to culture, all share a common structure (Turner 1969; van Gennep 1960), as well as a common emphasis on the evocation of emotion and its association with symbols in the teaching of sacred things (Eliade 1958; Turner 1967, 1969).

The expressed purpose of rites of passage is to *initiate* particular categories of a society's adolescents into "the sacred." Initiates not only learn the sacred, they live it. The social and psychological death, transformation, and rebirth of the individual achieved through these rites not only train initiates, but transform them as well

(Turner 1967, 1969). Initiates enter as children but leave as adults invested with both social and reproductive rights, as well as the responsibilities entailed therein.

Through rites of passage initiates learn what things constitute the sacred. This requires the development of new cognitive schema for previously mundane things, whether words, images, or objects, involving the generation of new neural associative networks. More importantly, however, initiates directly experience the sacred. The separation; sleep and food deprivation; exposure to novel, dangerous, and terrifying stimuli; and subjection to physical and mental ordeals that are frequently an integral part of such rites evoke autonomic and emotional responses in initiates. Rites of passage purposefully engage unconscious emotional processes, as well as conscious cognitive mechanisms. The conditioned association of such emotions as fear and awe with symbolic cognitive schema achieved through these rites results in the sanctification of those symbols, whether places, artifacts, or beliefs. Because such symbols are deeply associated with emotions engendered through ritual, they take on motivational force. When such rites are simultaneously experienced by groups of individuals, the conditioned association of evoked emotions with specific cognitive schema creates a cultural community bound in motivation, as well as belief.

Adolescent Brain Development. Adolescence may constitute a neurophysiologically sensitive developmental period for the learning of abstract concepts and the conditioned association of such concepts with emotions (Kolb et al. 1998; Kwon and Lawson 2000; Plant 2002; Spear 2000). The human brain demonstrates great plasticity during development. Infancy, childhood, adolescence, and adulthood are marked by differentiated growth patterns in various brain cortices and nuclei (Casey et al. 2000; Giedd et al. 1999; Keshavan et al. 2002; Kolb and Whishaw 1998; Kolb et al. 1998; Kwon and Lawson 2000; LeDoux 2002; Plant 2002; Sowell et al. 1999; Spear 2000; Walker and Bollini 2002). The differential patterns of brain growth across the life course create sensitive periods for particular types of learning (Greenough 1986). Early childhood language acquisition is an example of such "experience expectant" learning (Pinker 1997). We propose that adolescence constitutes a second critical period of "experience expectancy" for the learning of emotionally valenced symbolic systems.

The Adolescent Brain Does Not Mature Uniformly. Whereas the preadolescent brain grows through an increase in cortical gray matter, during adolescence synaptic pruning eliminates as much as one-half of the number of cortical synapses per neuron (Spear 2000). Synapse elimination does not occur uniformly throughout the human cortex, however. Frontal and parietal lobes follow a similar developmental trajectory, with increases in gray matter up to a maximum occurring at 12.1 and 11.8 years, respectively, for males and 11.0 and 10.2 years, respectively, for females, followed by a decline, resulting in a net decrease in volume across adolescence. The growth of temporal lobe gray matter has also been found to be nonlinear, with maximum size reached at 16.5 years for males and 16.7 years for females, and

slight declines thereafter (Giedd et al. 1999; Sowell et al. 1999). Both frontal and temporal lobe maturation occurs late in development and is completed in early adulthood (Keshavan et al. 2002; Sowell et al. 1999). This heterochronous adolescent loss of cortical gray matter is accompanied by increased volume in amygdalar and hippocampal nuclei. Concurrent changes in white matter density facilitate the propagation of electrical signals and increase the speed of neural transmission (Keshavan et al. 2002; Walker and Bollini 2002).

These changes streamline brain function by eliminating irrelevant interconnections and enhancing those that remain. This ontogenetic sculpting of the brain results from differential activation of specific neurons on the basis of experience in the accommodation of environmental needs (Greenough and Black 1991; Kolb and Whishaw 1998; Kolb et al. 1998; LeDoux 2002). Kolb and colleagues note that "experience can alter different parts of neurons differently (and) . . . changes in synaptic organization are correlated with changes in behavior" (1998:156). As a result, "the environment or activities of the teenager may guide selective synapse elimination during adolescence" (Giedd et al. 1999:863). Emotionally evocative experiences that occur during adolescence may, therefore, actually shape neural networks in the maturing brain. This is particularly true for brain areas such as the temporal lobes and prefrontal cortices undergoing maturation.

The maturation of the prefrontal cortex that occurs during adolescence has important implications for abstract reasoning abilities and symbolic thought. The prefrontal cortex (PFC) is "essential for such functions as response inhibition, emotional regulation, planning and organization" (Sowell et al. 1999:860). The interconnectivity of the PFC with nearly all other brain regions uniquely situates this cortical structure in its ability to associate diverse stimuli (Groenewegen and Uylings 2000; Robbins 2000; Rolls 1998). Maturation of the prefrontal cortex during adolescence provides the neurophysiological substrate for social cognition, abstract reasoning, and symbolic thought (Adolphs 2002a; Deacon 1997; Robbins 2000).

There Is a Shift in the Dopaminergic Reward System during Adolescence. Significant changes in neurotransmitter systems occur during adolescence. Receptors for dopamine, serotonin, acetycholine and GABA (γ-aminobutyric acid) are pruned from their preadolescent over-production, and limbic areas, including the hippocampus, also undergo pruning of excitatory receptors. Hippocampal receptors for endogenous cannabinoids peak during adolescence at higher than adult levels (Spear 2000). Studies by Carlson et al. (2002) demonstrate increased long-term potentiation as a result of endocannabinoid production, suggesting enhanced memory functions during this period. Concurrent with the decline in excitatory neurotransmitter receptors during adolescence, a shift in dopamine balance from mesolimbic to mesocortical regions occurs. This shift impacts reward learning and has significant behavioral implications (Schultz et al. 2002). Dopamine inhibitory input to the prefrontal cortex is greatest during adolescence, whereas dopamine activity in the anterior cingulate cortex and other subcortical regions, including the amygdala, is

lowest. While dopamine activity in the anterior cingulate cortex is under inhibitory control of the amygdalar dopamine system, the amygdala is, in turn, tonically inhibited by prefrontal cortex activity. According to Walker and Bollini, "the enhancement of neuronal connection between the cortex and limbic regions may play a role in the integration of emotional behaviors with cognitive processes" (2002:18) during this time. The shifting dominance of amygdalar dopamine projections from anterior cingulate cortex to the prefrontal cortex during adolescence impacts both conditioned associations and the intrinsic reward system. In addition to cortical maturation during adolescence, MRI studies have shown differences in the activity of the amygdala in adolescents, as compared with adults. Human adolescents exhibited "greater brain activity in the amygdala than in the frontal lobe when engaged in a task requiring the subjects to identify emotional state from facial expressions, while adults conversely exhibited greater activation in frontal lobe than amygdala when engaged in the same task" (Spear 2000:440).

Adolescent Changes in Brain Function Have Important Implications for Learning and Behavior. The concurrent maturation of the temporal lobe and amygdala are relevant to facial recognition and social judgments (Adolphs et al. 1998). Studies indicate that the amygdala mediates judgment of other people's social behavior, particularly with regard to approachability and trustworthiness (Adolphs 2002a, 2002b; Cardinal et al. 2002). The shift in the dopaminergic reward system from mesolimbic to mesocortical dominance that occurs during adolescence provides a unique developmental window for the conditioned association of abstract symbols with intensely experienced emotions and for the integration of these associations with both social interactions and symbolic thought. Heightened adolescent sensitivity to stressors amplifies this process (Spear 2000). The synaptogenesis and neurotransmitter shifts occurring during adolescence intensify the impacts of environmental stimuli experienced during this developmental phase. This is particularly true for the late-maturing frontal and temporal cortices, and for such limbic nuclei as the amygdala and the hippocampus. The specific changes occurring in the adolescent brain render this a particularly sensitive developmental period in relation to social, emotional, and symbolic stimuli. These are precisely the type of stimuli of greatest importance in adolescent rites of passage.

Adolescent Rites of Passage Bombard Initiates with Environmental Stimuli that Engage Prefrontal, Temporal, and Limbic Functions. The ritual components of these rites optimize stimulus impacts while amplifying the kindling effects of the stimuli through rhythmic drivers, including music, chanting, and dance, all of which may be particularly salient for adolescents. Intensification of the stimuli through sleep and food deprivation, fear, physical ordeals, and drugs can be expected to increase the neurophysiological impacts in terms of memory, reward learning, and emotional charging of stimuli. The "breaking down" of initiates during the liminal phase of adolescent rites of passage engenders a common autonomic state among

initiates. The empathy and shared emotional charging experienced in rites of passage valence the cognitive schema associated with sacred things.

Not all schemata constitute equal candidates for sanctification. Accumulating evidence suggests a developmental propensity for schema incorporating socially omniscient and declarative supernatural agents (Bering 2005). Moreover, schema of religious belief systems exhibit consistent structural features. Dichotomies, inversions, and counterintuitive concepts are consistent elements of this structure (Atran 2002; Atran and Norenzayan 2004; Boyer 2001; Boyer and Ramble 2001; Levi-Strauss 1963). The cognitive schema of religious systems also consistently incorporate the salient socioecological features of the society in which they occur, yet they do so while transcending the momentary, individual, and specific attributes of those features. Both the abstraction of social relations and their transformation into eternal truths are the hallmarks of religious schema (Rappaport 1999). These schema leave no outwardly visible signs but instead carve their indelible mark on the very minds of initiates. Through adolescent rites of passage, "the abstract is made alive and concrete by the living substance of men and women" (Rappaport 1999:148).

THE EVOLUTION OF RELIGION

Many recent evolutionary studies define religion in terms of cognition, focusing on the beliefs rather than the behaviors of religious systems. From a cross-cultural perspective, however, it is ritual that lies at the heart of all religions (Durkheim 1969; Eliade 1958, 1959; Rappaport 1999; Turner 1967, 1969), and it is participation in ritual that creates believers (Sosis 2003b). In the absence of ritual indoctrination and practice, religious beliefs lack both emotional salience and motivational force.

Ritual in nonhuman species functions to communicate social information and to coordinate social behaviors through the use of species-specific signals evolved to elicit neurophysiological responses in participants (Dugatkin 1997; Rogers and Kaplan 2000; Rowe 1999; Wingfield et al. 1999). Although ritual displays may be costly in terms of time, energy, and somatic expenditures, they provide information to participants that can impact individual fitness. By providing reliable signals, ritual allows accurate assessment of conspecific condition and intent (Zahavi and Zahavi 1997). It also "primes" participants for social interaction. Ritual winners reap resource and mating advantages; losers, however, also benefit from reductions in conflict achieved through ritual. Within the context of social groups, ritual further functions to decrease individual stress through the stabilization of social organization (Sapolsky 1999) and provides a means of facilitating both group fission/fusion and the coordination of group activities (Dugatkin 1997; Goodall 1986; Laughlin and McManus 1979; Rogers and Kaplan 2000). The pre-hunt ritual of wolves represents such coordination, and the friendship rituals of chimps and baboons have been observed to facilitate cooperative alliances that force changes in

troop hierarchies (Goodall 1986; Watanabe and Smuts 1999). Among human groups, these same functions are apparent in the rituals of both sports and politics.

Religious ritual, too, functions to communicate and coordinate social behaviors and does so through the elicitation of neurophysiological responses. Participation in religious ritual results in empirically demonstrated effects on both cooperation (Sosis and Bressler 2003; Sosis and Ruffle 2003, 2004) and individual health and longevity (Hummer et al. 1999; Matthews et al. 1998; Murphy et al. 2000). Like the ritualized displays of nonhuman species, religious ritual is positively associated with decreased stress and improved immunological function (Murphy et al. 2000). Bradshaw (2003) has further found that decreases in psychological distress associated with participation in religious ritual may be particularly relevant for the relatively deprived. Under conditions of inequality, religious ritual may, thus, confer direct fitness benefits for participants while simultaneously providing a mechanism for cooperative action for political change. The parallels between nonhuman and religious ritual extend, as well, to the use of religious ritual in the reintegration of social groups across cultures, and the coordination of group endeavors. Nonhuman and religious ritual clearly share important structural and functional elements selected for their adaptive value in social communication (Rowe 1999). The two are, however, separated by a critical distinction. While nonhuman ritual encodes signals as neurophysiological primes for behavior, religious ritual encodes symbols created through the ritual process itself.

Although it is impossible to retrace ritual's evolution to a symbolic signaling system, the "distinguishing marks of ritual"—chanting, music, and dance—may provide important clues. As discussed above, all religions incorporate music in some form, and in most it is a dominant element. Music is uniquely adapted to instantiate the structure of ritual precisely because it incorporates the formality, sequencing, patterning, and repetition that define ritual. As a result, it is able to elicit the neurophysiological responses associated with such ritual in the absence of ritual behaviors. Music's direct impacts on autonomic function, its ability to enhance immunocompetence (Kuhn 2002), and its role in entraining ritual participants may all have led to its selection as a fundamental component of early hominid ritual. Ultimately, however, the most important evolutionary consequence of music may well have been its "proto-symbolic" attributes. The ability of music to abstract and codify ritual meaning over time and space may have been the critical first step toward symbolic thought. The introduction of such a symbolic ritual system introduced a new type of cognition in hominid evolution. The use of ritual to create associational neural networks linking symbolic, social, and affective systems provided social groups with a highly flexible tool for motivating individual behavior, forging inter-group alliances, and discriminating between friends and enemies. Individuals within such groups would have realized fitness benefits resulting from inter-alliance sharing of patchily distributed resources, as well as enhanced cooperation for in-group ventures, including hunting and warfare.

When symbolic behavior emerged in human evolution remains unknown. Some

researchers argue for the emergence of symbolic culture in early archaic populations (Bednarik 1995; Hayden 1993; Marshack 1990); others maintain that symbolic thought appeared in early *Homo sapiens sapiens* prior to migration out of Africa (Henshilwood et al. 2001; McBrearty and Brooks 2000; Watts 1999). Still others argue for a "big bang" theory of symbolic culture first appearing approximately 50,000 years ago in western European populations (Mithen 1996). All, however, associate the emergence of symbolic systems with ritual. Mithen notes that "the very first art we possess appears to be intimately associated with religious ideas by containing images of what are likely to be supernatural beings" (Mithen 1996:155). Watts (1999) also argues for a ritual origin of symbolic systems but maintains that such systems emerged some 100,000 years earlier than posited by Mithen. Watts (1999) argues that the ubiquitous presence of red ochre pigments at numerous African MSA (Middle Stone Age) sites indicates ritual activity. Noting a jump in ochre presence over time, he concludes that "the preoccupation with redness clearly indicates that ochre was primarily used for signalling" (1999:128) and argues that "the habitual nature of such behaviour from the MSA2b onwards strongly suggests that the signalling was symbolic rather than solely indexical or iconic" (1999:137). The MSA Blombos Cave excavations of Henshilwood and colleagues lend further support for symbolic behaviors in African MSA populations. These researchers recovered twenty-eight bone tools dated ca. 70,000 years ago exhibiting "formal" techniques of bone tool manufacture, as well as ochre pencils and objects bearing geometric designs. They note that "bone tools are . . . only one element of a range of techniques used at BBC during the MSA to produce practical and/or symbolic artefacts indicative of a complex technological society" (2001:668). The occurrence of pigment processing at numerous MSA sites, as well as the notching and incising of ochre, bone, and ostrich shell, are also interpreted by McBrearty and Brooks as evidence of symbolic behavior. These researchers note that "Despite the relatively small number of excavated MSA sites, the quantity and quality of evidence for symbolic behavior . . . far exceeds that known for the European Middle Paleolithic where the site sample is more than ten times greater" (2000:531).

The irregularly patterned and increasing use of red ochre pigment by African MSA/LSA populations suggests that ritual was of variant but increasing importance in human social groups throughout this period. The widespread occurrence of red ochre pigments has been interpreted by Dunbar (1999) as evidence of "badging." He argues that red ochre badging increased during the African MSA in order to mark and identify group members when both the size and the number of groups were increasing. Yet, Dunbar notes that "external badges encounter a common problem . . . they are easy to fake" (1999:202).

If, however, red ochre badging is viewed within a broader context of ritual, as Watts and others (Knight et al. 1995) have interpreted it to be, then both the costs and the reliability of these badges increase, as well. Participation in ritual entails time and energy costs which may deter free riders (Irons 2001; Sosis 2003b). More importantly, participation in communal ritual provides the context for the creation

and internalization of communally shared motivators. The use of ritual to emotionally charge badges and other selected artifacts would have added to the costs of such badges, but would have significantly increased their reliability as signals of motivational intent. This ritual transformation of signal badges to emotionally charged and positively valenced symbols of social relationships may have served to facilitate the creation of alliances under conditions of resource scarcity and conflict (Hayden 1987). The red ochre, beadwork, bone incising and regional stone- and bone-working styles evident in the archaeological record of the African MSA between 250,000 and 50,000 BP all indicate an increasing importance of ritual, an intensification of costly signals, and the emergence of symbolic systems specific to social groups. The emergence of dance, music, and even language may have their roots in this intensification process. Why did these changes occur during the MSA?

There is evidence of increasing population, increasing use of a fission/fusion social organization, and shared use of patchy resources within an environment of overlapping group ranges throughout the MSA. McBrearty and Brooks (2000) report that MSA sites in Africa are more numerous than those of the Acheulian and are found in previously uninhabited zones, suggesting both the need and the ability of MSA populations to exploit a wider range of habitats. Moreover, these sites provide evidence of deliberate foresight and planning in cooperative hunting strategies (Chase 1989), specialized tool use (McBrearty and Brooks 2000; Shea 1988), and in the transport of both water and materials across long distances (Deacon 1989). The development of technologies such as ostrich eggshell containers that permitted the transport of critical resources such as water opened up previously uninhabitable areas (Watts 1999). The appearance of blades, as well as retouched stone and bone points, indicates increasing technological sophistication, as well. McBrearty and Brooks (2000) have interpreted the diversification of MSA toolkits and the varying proportions of different artifact classes at different sites as evidence of regional tradition differences, as well as differences in extractive activities. These authors present compelling arguments for continuing intensification and scheduling of resource use throughout the African MSA into the LSA. Evidence of both selective, tactical hunting of large game and intensifying use of aquatic and small-scale resources is cited, as well as proliferation and geographic extension of trade networks. This intensification of extractive and hunting technologies, as well as expansion into previously unexploited habitats and increasing territorial sizes during the African MSA, have been viewed by McBrearty and Brooks (2000) as evidence of both population growth and environmental degradation.

The picture that emerges from the accumulating archaeological record for the African MSA is one of population growth, geographic dispersion, and technological intensification and specialization. Tactical hunting strategies for large game emerged. Simultaneously, the irregular distribution of critical items, such as water, and the regional distribution of other prized resources, such as obsidian, introduced increased inter-group interaction and competition for utilization of these patchy resources. The ecological context of human groups in the African MSA suggests

that the nature of hominid social groups underwent change during this period. Larger group sizes punctuated by seasonal fission/fusion, and the creation and maintenance of alliances in response to resource irregularity, are indicated. An increased reliance on cooperative subsistence strategies, including large game hunting and joint utilization of dispersed water sources, as well as increased competition between groups for patchy resources, can be surmised from the archaeological record. Red ochre pigments and decoratively incised stone and bonework suggest that these changes were accompanied by increases in ritual and the emergence of an abstract symbolic system.

It is likely that the incorporation of rhythmic drivers in human ritual preceded these developments. The drumming and "proto-dances" of chimpanzees suggest that precedents of music, chanting, and dance existed in common ancestral hominoids (Goodall 1986). Such behaviors may have originated as communication signals. The ability of these drivers to enhance positive affect would have rendered rhythmic ritual a useful tool in the reintegration of fissioned groups and in the creation of inter-group alliances. The use of rhythmic ritual to invest artifacts with symbolic, emotionally valenced meaning would have provided dispersed groups with a tangible and motivational symbol of the abstract social relationships codified through the ritual process. With increasing resource competition, however, there would also be increasing need to differentiate and cohesify groups in order to more efficiently and effectively extract and defend resources. These conditions would further promulgate in-group specialization and stratification. Under such conditions, negatively valenced religious symbols would assume increasing importance owing to both their greater motivational force and their signaling efficacy (Johnson and Kruger 2004).

In contrast to the indexical signals of animal ritual, which elicit congruent motivational states within an immediate time and space, the symbols of religious ritual afforded early humans a means of engendering congruent motivational states across space and time. And, although signals elicit neurophysiological responses that permit social interaction in the here and now, symbols extend the horizon of those responses to future activities, as well. Religious symbols, thus, provided tools for creating cooperative coalitions across time. In doing so, they introduced a new level of cognition and social organization in human evolution.

CONCLUSION

Religion is an important and unique human adaptation defined by four recurrent traits: belief systems incorporating supernatural agents and counterintuitive concepts, communal ritual, separation of the sacred and the profane, and adolescence as a preferred developmental period for religious transmission. Although the specific expression of each of these traits varies across cultures in socioecologically patterned ways, the belief systems and communal rituals of all religions share common structural elements that maximize retention, transmission, and affective en-

gagement. The roots of these structural elements can be found in nonhuman ritual where they serve to neurophysiologically prime participants and ensure reliable communication. Religion's incorporation of music, chanting, and dance intensifies such priming and extends the impacts of ritual beyond dyadic interactions. Music constitutes an abstract representation of ritual that can be recreated across time and space to evoke the emotions elicited by ritual. Human use of ritual to conditionally associate emotion and abstractions creates the sacred; it also lies at the heart of symbolic thought. The brain plasticity of human adolescence offers a unique developmental window for the creation of sacred symbols. Such symbols represent powerful tools for motivating behaviors and promoting in-group cooperation. Although religion evolved to solve an ecological problem by promoting group communication and cooperation across space and time, the symbols it created laid the foundation for a new adaptive niche in human evolution.

A number of empirically testable hypotheses emerge from this view of religion. We have posited that the adaptive function of religion is to ensure cooperation when individuals can achieve net benefits through collective action, and we have proposed that ritual serves to engender such cooperation through the motivational valencing of symbols. If so, religious ritual should be most pronounced within groups of individuals who are not genetically related and are pursuing high-cost cooperative endeavors, and least pronounced among kin groups pursuing individualistic subsistence strategies. Significant associations between ritual intensity, positive and negative symbolic valence, and age of initiation should also exist among these variables. We expect to find the highest intensity of ritual in groups encompassing unrelated individuals who must engage in intermittent, high-risk, cooperative endeavors, such as external warfare or long-term sharing of scarce and patchy resources. In contrast, the lowest levels of religious ritual should occur among non-cooperating groups of kin. We would further expect to find permanent, highly charged religious symbolic systems in non-kin groups engaged in high risk or widely dispersed cooperative endeavors. Based on emotion theory, we expect ritual systems to incorporate more negative affect in the emotional conditioning of symbols under conditions of large group size and political inequality. We have argued that adolescence constitutes an experience expectant period for the emotional valencing of symbols. We, therefore, anticipate adolescent rites of passage to be most intense and prolonged among unrelated adolescents in societies engaging in high-risk, cooperative activities. In addition, there should be a positive association between the duration/intensity of adolescent rites of passage and concomitant changes in both brain response patterns to religious symbols and individual cooperative behaviors. Music should be a particularly powerful elicitor of such responses.

Numerous research questions remain. If adolescence is an "experience expectant" period for the emotional valencing of symbolic systems, is adolescent development dependent on such valencing? In the absence of religious ritual, how is such valencing achieved? Does ritual participation impact adolescent health and behavior? Do adolescent rites of passage measurably alter neurotransmitter and

endocrine levels? Are there gender and/or status differences in the neurophysiological effects of ritual? Can we empirically demonstrate autonomic congruence in ritual participants? If so, is such congruence significantly associated with perceived empathy and increased cooperation? To what extent do the various components of ritual impact emotional charging of symbolic stimuli? Can we define socioecological parameters associated with the positive and negative emotional charging of religious symbols? Does the developmental propensity to believe in socially omniscient supernatural agents peak in adolescence? Are such agents a necessary component of symbolically charged belief systems, or can such systems instead achieve cooperation through the emotional charging of unfalsifiable non-agent schema, such as "liberty" and "freedom"? Finally, if religion is an evolved adaptation for cooperation, can humanity achieve such cooperation in its absence? This is among the most salient questions facing the world today. The answer must begin with a better understanding of religion as a specifically human adaptation.

Signals are necessarily bound to the moment; symbols, however, have existence and meaning that extend beyond the immediate to link the past, present, and future. They, thus, lay the foundation for creating and identifying groups, but also for motivating cooperation among the individuals within these groups across both space and time (Rappaport 1999). Far from being an evolutionary by-product, religion represents a critical adaptive complex evolved in response to ecological challenges faced by early human populations. Individual fitness benefits resulted both from participation in ritual itself, and from the cooperative activities it enabled. The use of music-based ritual to imbue group signals with emotional and motivational meaning gave impetus to a new system of social communication and a new level of human cognition.

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