Ritual Behaviour and the Origins of Modern Cognition

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This article argues that ritual behaviour was a critical selective force in the emergence of modern cognition. The argument is based on the following observations: (1) Upper Palaeolithic Cro-Magnons exhibited unprecedented levels of social complexity and there is evidence to suggest that this complexity may have begun even earlier in Africa, possibly connected with the Toba eruption. (2) Creating larger, more complex social arrangements, especially those that cut across traditional within-group boundaries, would have required more elaborate and demanding social rituals. (3) Ritual behaviour requiring focused attention and the inhibition of pre-potent responses places demands on areas of the brain known to be associated with working memory. (4) An enhancement of working-memory capacity was very likely necessary for the emergence of modern cognition. (5) The social rituals of traditional societies, which provide the best window on the social rituals of our ancestors, are highly demanding in terms of maintaining focused attention and inhibiting pre-potent responses. (6) Those of our ancestors best able to successfully engage in ritual behaviour would have accrued fitness advantages from increased access to resources, status enhancements and psychophysical health effects. (7) Larger working-memory capacity was very likely a characteristic of these more ritually-capable hominins.

A pre-view of the argument

> [Tiger] Woods has become the exemplar of mental discipline. After watching Woods walk stone-faced through a roaring crowd, the science writer Steven Johnson, in a typical comment, wrote: 'I have never in my life seen a wider chasm between the look in someone's eye and the surrounding environment' (David Brooks, Op-Ed column *NY Times*, 6/17/08).

The ability to willfully focus attention on a selected signal in the face of powerful competing signals may be the key to uniquely human cognition. This article proposes a model for the evolutionary origin of uniquely human (i.e. modern) cognition based on two lines of evidence that converge on the conclusion that ritual behaviour was an important selective force filtering hominins for the enhanced working-memory capacity necessary for modern cognition. Furthermore, this force was probably in place sometime prior to the Upper Palaeolithic.

The first of these two lines of evidence stems from archaeological and comparative data indicating that (a) late Middle and Upper Palaeolithic modern humans had more extended social networks (which included inter-group trade alliances) compared to Neanderthals, and (b) creating and maintaining this unprecedented level of social sophistication would have required an expanded repertoire of social rituals. The second line of evidence stems from cognitive neuroscience and cognitive archaeological data indicating that (a) ritualized behaviour activates areas of the brain associated with working memory and inhibitory control, especially the dorsolateral prefrontal cortex (dlPFC) and the anterior cingulate cortex (ACC), and (b) a modest but significant enhancement of working-memory capacity was very likely key to the emergence of modern cognition.

Ethnographic evidence brings these two lines together by indicating that the social rituals prevalent among traditional societies for creating intra- and inter-group cohesion are often physically and psycho-

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logically demanding, placing great stress on working-memory capacity, focused attention, and the ability to inhibit pre-potent responses. Given that the ritual behaviour of current traditional societies provides the best window onto the social rituals of our ancestors, this leads to the conclusion that ritual competence would have become an important selection pressure in the period sometime after 100,000 years before present (years bp) and this pressure would have selected for hominins with the increased working-memory capacity necessary for modern cognition.

The article will take up each of these points, reviewing evidence relevant to each. The discussion will raise the possibility that ritual selection may have created a Baldwinian selection environment where the ontogenetic pathway of modern humans was altered raising the probability of a genetic mutation affecting working memory capacity.

The greater social sophistication of modern humans

The Upper Palaeolithic (beginning about 35,000 years bp) record provides evidence of greater social sophistication among European Cro-Magnons compared to the Neanderthals. First, Cro-Magnon campsites are larger, more frequent, more intensely used and occupied and more spatially structured compared to those of Neanderthals (Bar-Yosef 2000; Dickson 1990, 84–92, 180–89; Hoffecker 2002, 129, 136; Stringer & Gamble 1993, 154–8). Second, many of these sites show evidence of seasonal aggregation, larger group size, and other signs of social complexity and stratification (Hayden 2003, 122–31; Mellars 1996; Vanhaeren & d'Errico 2005).

Third, while there is evidence of long-distance inter-group trading networks among Cro-Magnons (Adler *et al.* 2006; Taborin 1993) similar evidence is lacking in Neanderthals (Feblot-Augustins 1999; Stringer & Gamble 1993, 210–11). For example, a recent comparison of Cro-Magnon and Neanderthal hunting strategies in eastern Europe found that while hunting tactics did not substantially differ, Cro-Magnons often enjoyed greater access to resources due to more extensive social networks (Adler *et al.* 2006). Gamble's comparison of the relative 'social landscapes' of Neanderthals and Cro-Magnons reinforces this point by demonstrating that Cro-Magnon raw-material exchanges occurred across significantly longer distances compared to Neanderthals (Gamble 1999, 360–62, 382–3). While isolating social factors apart from technological or ecological ones is always problematic, this body of evidence suggests that whatever advantage Cro-Magnons may have had over Neanderthals, the social aspect of it was very likely paramount relative to other factors.

The increased social sophistication of anatomically modern humans (AMH) may have had it origins prior to their expansion out of African around 60,000 years bp. Ambrose (2002, 22) argues that a 'troop to tribe' transition was already taking place among African AMH at around 70,000 years bp as a reaction to the ecological stress brought on by the Toba eruption. The non-local nature of the raw materials composing the Howieson's Poort and Mumba tool industries combined with the emergence of shell beads in the archaeological record at this time raises the possibility that an inter-group gift-giving practice similar the hxaro tradition of !Kung San was in place (Ambrose & Lorenz 1990; Henshilwood *et al.* 2004; Vanhaeren *et al.* 2006). While the direct impact of the Toba eruption is unclear (e.g. Petraglia *et al.* 2007), rapid climate changes resulting in resource stress were not uncommon in the late Pleistocene (from about 100,000 years bp on; see Alley 2000, 118–26 or Gamble 1999, 184–92). That these stressors may have impelled increases in social complexity among African AMH does not seem improbable (McBrearty & Brooks 2000).

Ritual behaviour and social life

In the current context ritual refers to a rule-governed and generally invariantly sequenced pattern of behaviour that is attention-getting and formalized (Bell 1997, 138–69; Rappaport 1999, 24). For example, consider a common ritual used for social bonding among male baboons called 'scrotum-grasping'. Two males wishing to signal friendship will momentarily allow the other to hold his testicles (Smuts & Watanabe 1990; Whitham & Maestripieri 2003). This ritual is especially effective given that grabbing and ripping at the genitals is common when primates fight. Thus, the 'scrotum-grasp' can be understood as a ritualized version of this fighting action. However, the 'scrotum-grasp' is a formalized or more restricted form of the action (i.e. a momentary grasp rather than aggressive 'grabbing and ripping'). The act itself is undoubtedly attention-getting (it is hard to ignore someone handling your genitals), and it follows a rule-governed, relatively invariant sequence: one baboon strides up to another using a rapid, straight-legged gait. As he approaches, he looks directly at the other baboon making affiliative gestures such as lip-smacking, flattening the ears back and narrowing the eyes. The other responds in like fashion, and then after a quick hug they each present their hind-quarters to the other and allow the other to momentarily fondle their genitals.

Building increasingly complex social arrangements, especially where it involves establishing relationships with wary out-group members, undoubtedly stressed many aspects of late Pleistocene hominin social life. In confronting this challenge, there are good reasons to believe that our ancestors would have turned to ritual behaviour as their primary mechanism of social bonding. First, ritual behaviour is widespread across the animal kingdom, especially where cautious communication is required (de Waal 1990; Guthrie 2005, 68; Silk 2001). For example, among many mammals aggressive males are as much a threat to females as a benefit. How then for a male to get close enough to a female for mating purposes without scaring her off? Among deer, elk and moose, a stereotypic male approach ritual — the low stretch — signals unthreatening intentions (Guthrie 2005, 68). The low stretch involves the male emulating a calf's nursing request behaviour. By approaching in calf-like fashion, the male signals his non-aggressive intent and gets close enough to a female to detect the presence of estrus odours.

Second, social rituals designed to build trust, promote group harmony, and reinforce social relations are common among primates (de Waal & Lanting 1997; Goodall 1986; van Roosmalen & Klein 1988, 515). The aforementioned scrotum-grasp ritual of male baboons falls into this category. Others examples abound: when chimpanzee, bonobo and spider monkey foraging parties reunite, they engage in ritualized acts of welcoming and social re-affirmation including mutual embracing, kissing, group pant-hooting and grooming (de Waal & Lanting 1997; Goodall 1986; van Roosmalen & Klein 1988, 515). Gelada baboons use rhythmic back-and-forth approach vocalizations to signal benign intent during close-quarter feeding sessions. These vocalizations allow two baboons to peacefully feed near one another without threat (Richman 1987). Chimpanzees also have a discrete set of behaviours used to signal the desire for reconciliation (de Waal 1990). If a loser between two combatants wishes to make peace, he will often approach the victor with submissive bows and vocalizations, holding out his hand in a begging gesture. By embracing and kissing the supplicant, the victor signals his acceptance of the loser's peace offering. This reconciliation ritual signals something of a *quid pro quo* on the part of the former combatants: the subordinate acknowledges the dominant's higher status (with bows and vocalizations) and the dominant assures the subordinate that hostilities will cease (with hugs and kisses).

Third, specific rituals appear necessary for certain categories of social interaction. For example, the scrotum-grasp ritual is typically restricted to older male baboons who often need to form strategic alliances against younger, stronger males in order to secure mating opportunities. It is noteworthy that younger males usually fail to complete this greeting ritual and are less likely to form social alliances than older males (Smuts & Watanabe 1990). Thus, put simply — no scrotum-grasping, no social alliances.

Fourth, the ability to utilize ritual effectively is affected by upbringing and observation. For example, rhesus macaque monkeys generally do not reconcile after conflicts, while stumptail macaques do — using what is called the 'hold-bottom' ritual where one stumptail puts both hands on the other's hips. The higher frequency of post-conflict reconciliation is one factor that produces a generally less combative social world among stumptails compared to rhesus. De Waal & Johanowicz (1993) showed that juvenile rhesus monkeys would gradually adopt the stumptail pattern of frequent post-conflict reconciliation if they were housed for several weeks with stumptails. The rhesus monkeys maintained their stumptail-like levels of reconciliatory behaviour for several months after being transferred to a same species social group. This research provides evidence that socialization can produce individuals who display greater competence in using ritual signals to manage within-group conflict.

The wealth of social rituals present among our primate cousins indicates that our hominin ancestors were pre-adapted for using ritualized behaviour as a means of social bonding and could call upon a rich repertoire of them in their everyday social life. Thus, faced with the challenge of managing larger social groups and communicating carefully and effectively to suspicious out-group members, our ancestors would have naturally turned to a mechanism with a deep history of facilitating social bonding: ritual.

Ritual's effectiveness in building social relationships can be traced to two important functions: (1) ritual focuses attention on a particular behavioural or sensory signal at the exclusion of other competing signals, and (2) ritual inhibits pre-potent defensive responses long enough to allow social emotions and social-bonding mechanisms time to operate. For example, dominate female monkeys use certain vocalizations, grunts and gurneys, when approaching subordinates to signal them of non-threatening intentions, forestalling the subordinate's natural tendency to flee (Silk 2001). A successful approach can lead to another common social ritual among primates: grooming. Grooming causes the release of endogenous brain opiates helping to bring about a mental state conducive to affiliation (Keverne *et al.*1989). In this

sequence then, one can see how successfully executed ritual can focus attention on a relevant signal (the approach grunt), inhibit defensive emotions (fright in the subordinate) and allow time for social-bonding emotions (associated with grooming) to operate.

As social complexity and inter-group interactions increased in the late Pleistocene, ritual took on increasing importance as a mechanism of intra- and inter-group social bonding. Ethnographic evidence (to be reviewed later) strongly suggests that these rituals very likely became increasingly elaborate and demanding, requiring that attention be sustained on the ritual signal despite powerful distractions such as pain, fatigue or impending danger. Furthermore, the ability to inhibit pre-potent defensive responses was very likely stressed to unprecedented levels as rituals increasingly involved extremes of deprivation, danger, and fear.

Ritual, working memory and inhibition

To my knowledge there are no studies that have directly tested the connection between ritual behaviour and working-memory capacity. However, there are a number of studies consistent with the hypothesis that the demands of ritual behaviour tax working-memory capacity, especially where it involves the inhibition of pre-potent responses. Numerous studies have linked working memory and attentional control to areas of frontal lobe, especially the dorsolateral prefrontal cortex (dlPFC) and anterior cingulate cortex (ACC: Curtis & d'Esposito 2003; d'Esposito *et al.* 1999; Duncan *et al.* 2000; Gray *et al.* 2003). Studies specifically addressing the issue of inhibitory control have also implicated the dlPFC and ACC along with other structures in the inferior parietal (Hester *et al.* 2004; Kelly *et al.* 2006) and inferior frontal cortices (Brass *et al.* 2005; Derrfuss *et al.* 2004; Kelly *et al.* 2006). All of this supports the contention that the dlPFC and ACC are central to the ability to engage in willful actions, such as when consciously focusing attention or directing controlled behaviours (Ingvar 1994).

A number of recent studies have demonstrated increased activity in the dlPFC and ACC when subjects are actively engaged in the suppression of pre-potent responses. For example, Beauregard *et al.* (2001) monitored brain activity while subjects viewed erotic films. Not unexpectedly, they found that the films increased activity in areas of the brain known to be associated with sexual arousal such as the amygdala and hypothalamus. However, subjects who were given specific instructions to inhibit any sexual response were found to have increased activity in dlPFC and ACC while only baseline levels of activity in the amygdala and hypothalamus. This was interpreted as an example of top-down inhibitory control over a naturally elicited response.

A second example of this can be found in studies looking at brain responses to inter-racial stimuli. Olsson *et al.* (2005) have shown that faces of racial out-group members serve as evolutionarily prepared fear-stimuli in a manner similar to snakes and spiders. Indeed, fMRI studies of both African- and Caucasian-American subjects show automatic activation of the amygdala when other-race faces are shown (Lieberman *et al.* 2005). However, this increase in amygdala activity is attenuated when subjects are given extended time for increased conscious processing of other-race faces and this attenuation is concurrent with increased dlPFC and ACC activity (Cunningham *et al.* 2004; Richeson *et al.* 2003).

Finally, depressed patients have been shown to have increased amygdala activity and decreased prefrontal activity, which has been interpreted to represent an inability to modulate negative emotions associated with unpleasant stimuli (Davidson *et al.* 2003). However, one effect of treatment has been to significantly increase the amount of prefrontal activation in these patients, a result associated with an increased capacity for the inhibitory control of negative emotions. These studies are consistent with a growing neuroscience and neuropsychological literature showing that the dlPFC (especially on the right side) is critical to the ability to filter out competing signals, inhibit immediate emotion-based responses, and exercise conscious self-control (Knoch & Fehr 2007; Sanfey *et al.* 2003; Stuss *et al.* 2002).

What these studies demonstrate is that areas of the brain associated with working memory are important in the inhibitory control of pre-potent responses. Recent work by Kelly, Hester and others (Kelly *et al.* 2006) has further defined the association between working-memory capacity and inhibitory control. Their work shows that increases in working-memory capacity allow greater resources to be dedicated to inhibitory processes. This improves the efficacy of those processes making it more likely that the subject will successfully maintain attentional focus on current task demands. The effect of practice therefore is to increasingly automatize the controlled aspects of a task, freeing up more cognitive resources for inhibitory control.

Ritual behaviour directly relates to the willful direction of action and the suppression of pre-potent responses. Based on the ethnographic evidence to be reviewed shortly, the social rituals used by our ancestors to create more complex social groups and

to establish inter-group trust and trade would have required considerable self-control, focused attention and inhibition of pre-potent responses. The repetitive elements of ritual behaviour would have also provided opportunities for practice effects, whereby working-memory capacity could have been 'freed up' for greater inhibitory control. Finally, those who were more successful at engaging in ritual behaviour would have achieved fitness advantages in the form of greater access to resources (via reciprocal arrangements), enhanced status and psychophysical health benefits.

Modern cognition, enhanced working memory and social complexity

Working-memory capacity may be the key to modern cognition. In a series of recent articles, Coolidge and Wynn (2001; 2005; Wynn & Coolidge 2003; 2004) have built a compelling case that the emergence of uniquely human cognition resulted from a slight but significant increase in working-memory capacity. This increase made AMH better able to hold information in mind, especially information about behavioural procedures and intended goals, in spite of competing signals or response competition (Kane & Engle 2002). Thus, when confronting cognitive challenges, AMH were better equipped to resist mental sets and other prior habits of thought and behaviour. This ability, Wynn & Coolidge (2004) argue, was essential for exploring novel relationships, engaging in cognitive innovation, and ultimately creating and using symbols.

Similarly, increased working-memory capacity is very likely necessary (though maybe not sufficient) for what Tomasello and colleagues (2005) call shared intentionality. Shared intentionality is the uniquely human capacity for sharing emotional, cognitive and attentional states and coordinating actions relevant to those states. Examples of shared intentionality range from simple coordinated actions such as holding a conversation to more sophisticated collaborative efforts such as performing a symphony or preparing an elaborate meal. Tomasello *et al.* (2005, 680–81) claim that coordinated actions such as these require complex representations in working memory. Participants must hold in mind not only the shared goal being pursued by both (or all) parties, but also the role (or action plan) of each participant. Shared intentionality, they argue, is the foundation upon which all uniquely human cognition arises. Sharing mental states provides the basis for constructing shared meanings (symbolism), creating shared communicative symbols (language) and imputing mental states as causal forces behind behaviour (theory of mind).

Shared intentionality lies at the heart of the human capacity for culture. This fact may prove decisive. A recent analysis found evidence for increasing behavioural and technological complexity and innovation in Neanderthals from 160,000–40,000 years bp (Langley *et al.* 2008). This finding led the authors to argue that cultural differences, more so than cognitive ones, were likely responsible for whatever advantage AMH may have had over Neanderthals. Culture and cognition, however, need not be orthogonal. It may be that a modest cognitive difference — such as a slight but significant enhancement of working memory which allows for a greater capacity for shared intentionality — accounts for a cultural difference. Furthermore, a difference in culture can provide greater support for more complex forms of cognition (Barnes 2000).

It is noteworthy that recent neuroimaging studies of brain activity during both Oldowan and Acheulean tool-making have failed to find activity in those areas associated with working memory such as the dorsolateral prefrontal cortex (Stout & Chaminade 2007; Stout *et al.* 2008). By contrast, social complexity and working-memory capacity have been directly connected in a recent study where it was found that individuals with greater social engagement performed significantly better on tests of cognitive performance including working-memory capacity (Ybarra *et al.* 2008). This reinforces the notion that social factors, more so than technological ones, were likely responsible for the working-memory enhancement that ultimately produced uniquely human cognition.

Social rituals among traditional societies

The evidence presented thus far indicates that the social world of our late Pleistocene ancestors was growing increasingly complex and very likely included unprecedented inter-group trade alliances. The construction and management of this social world would have required more demanding social rituals. This section reviews ethnographic evidence outlining the most likely character of those rituals. Looking across a range of traditional societies, three types of social rituals are common when it comes to enhancing within-group social cohesion and building between-group alliances: rituals of trust-building and reconciliation, rituals of initiation, and shamanistic rituals of community and individual healing. Of course the degree to which these ritual practices can be unalterably projected into our ancestral past is unclear. However, they provide the best starting point for understanding past rituals, and a consistent feature of them is physical and psychological rigour.

Rituals of trust-building and reconciliation

As inter-group interactions became more frequent, rituals for establishing trust between different groups and for maintaining cohesion within groups very likely rose in salience and important. Examples of these rituals from traditional societies show that they frequently 'ritualize' the expression of the explosive emotions that must be contained if trust and reconciliation are to be achieved. By exhibiting these dangerous emotions in ritual form while controlling their effects, participants signal their willingness and ability to let longer-term group-level interests direct their actions rather than short-sighted, self-interested inclinations.

Disputes among the Ammassalik of Greenland are often addressed using a traditional 'drum match', where the aggrieved parties drum and sing about how the other has injured them. These matches represent a highly stylized extension of the wider practice of singing and drumming for pleasure. Tradition governs nearly every element of the match including the tone, expression, and movement of the participants. This, however, does not eliminate the tension inherent in the ritual (Mirsky 1937). As they face, the singer uses mocking tones to detail the other's personal and familial faults. Even as the confrontation escalates with the singer occasionally butting heads with the listener, the listener remains frustratingly indifferent to the singer's taunts and accusations. When the singer is done, the roles reverse. Matches are rarely settled in one round, but may be continued for months or years.

An even 'edgier' example is the peace-making ritual of the Yanamamo, a traditional people of the Amazonian jungle (Chagnon 1968). The party requesting a truce invites its enemies to a ceremonial feast. As their adversaries arrive, the host warriors recline unarmed in hammocks. With weapons drawn, the 'guests' taunt their hosts with insults and intimidating gestures. But the hosts remain calm and unaffected by the threats. In time, hosts and guests trade places and the threats and insults begin anew. Only when each are satisfied as to the other's peaceful intentions does the feast begin, which includes the exchanging of gifts, the forging of new alliances and the arranging of marriages. Of course, the situation could easily turn back into violent conflict if either side senses treachery or mistakes simulated hostility for the real thing. But as long as the ritual is respected, explosive emotions are constrained and trust emerges.

Finally, among the Maring-speaking people of New Guinea, a traditional pig feast, the kaiko festival, serves as the forum for establishing or reinforcing martial bonds among warriors of different camps. When the visitors enter the host's grounds they do so aggressively — singing, dancing, and charging onto the feast venue with axes brandished (Rappapport 1999, 79). But the 'attack' is only apparent. An invitation to 'help dance' at kiako is understood to involve a pledge to support the hosts in battle. The aggressive dancing demonstrates the guests' ability and willingness to fight along side their hosts. Though dancing is used to signal solidarity, there is an undeniable competitiveness to it. It is not hard to imagine the festival degenerating into a riotous frenzy where inter-group alliances are spoiled rather than strengthened. But as long as the ritual is allowed to regulate the emotions, the alliance is safe.

Our late Palaeolithic ancestors' rituals of trust building and reconciliation may not have been as elaborate as these. However, even the most mundane ritual of this type requires some level of self-control. A handshake is only modestly removed from a swinging fist. Those of our ancestors unable to inhibit their aggressive or defensive inclinations long enough to allow for ritual-based trust and reconciliation to take hold very likely found themselves social outcasts, separated from the reciprocal benefits of within and between group alliances.

Rituals of initiation

Adolescent rites of passage occur in over 70 per cent of traditional societies studied (Alcorta 2006; Lutkehaus & Roscoe 1995). The severity of these initiations varies and tends to increase where ecological or external threats are greater (Hayden 2003, 104–5; Sosis 2006, 82; Young 1965). Among aboriginal societies in Australia, for example, the most severe initiation rites are found among tribes living in the driest, harshest conditions (Hayden 2003, 104). This is consistent with predictions from costly signalling theory where such rituals serve as indicators of group commitment (Sosis 2006). Greater commitment would be required in more demanding conditions where survival depends on the effort and cooperation of others.

If Ambrose (1998; 2002) is correct regarding the magnitude of the Toba crisis, then this event would have put unprecedented resource and social stress on ancestral groups. Even apart from Toba, rapid climate changes resulting in periods of drought and deprivation would not have been uncommon at this time (Alley 2000, 118–26). Maintaining social stability during these periods and establishing inter-group relations would have undoubtedly led to heightened social tensions. Though neighbouring groups would

have been essential for material trade and information exchange, the xenophobic nature of humans in general and of tight-knit traditional societies in particular, would have made these interactions a constant source of tension and unease. Group interactions almost always entail an elevated degree of group competition. Thus, it is not unreasonable to conclude that initiation ceremonies may have either arisen or intensified in the late Pleistocene as the social world became more complex. There is some archaeological evidence consistent with this speculation.

Hand and footprints of children and adolescents are not uncommon at many Upper Palaeolithic deep cave sites (Clottes 1992), suggesting that they may have been involved in rituals there. Indeed, there is considerable evidence that many deep cave sites were ritual venues (see summary in Hayden 2003, 148–50). Ethnographic evidence confirms that among traditional societies, children and adolescents are commonly involved in initiation ceremonies where isolation, altered states of consciousness, and encounters with sacred spirits occur (Owens & Hayden 1997; Pettitt 1946). 'Vision quest' initiations among native American tribes, where a young person is isolated at a sacred site in order to receive spiritual guidance, is a prototypical example of this. Thus, the hand and footprints found at Upper Palaeolithic deep cave sites could indicate the presence of adolescent initiation rites extending as far back as about 30,000 years bp.

A recent discovery may push the evidence for ritual back even further, tying it chronologically with the Toba eruption. What appears to be a ritually-modified snake-rock was recently found in a cave in the Tsodilo Hills of Botswana (Minkel 2006). Dated to around 70,000 years bp, the six-metre-long rock seems to have been intentionally modified so that in the firelight of the cave the 'head' and exterior surface make a chilling snake-like spectacle. Presumably this would have intensified any ritual experience. It is impossible to know exactly what type of rituals these might have been, but the setting is consistent with ones involving an altered state of consciousness, commonly a part of vision quests.

Adolescent rites of passage can be trying events. Where they are severe they require the young person to endure isolation, deprivation, physical pain, and psychological stress. For example, female initiation ceremonies among many traditional societies in southern Africa involve forced seclusion, bloodletting, genital cutting and rigorous training in ceremonial dances (Knight *et al.* 1995; Power 1998, 122–5). Deprivation, beatings, exhaustive physical exertion, exposure to harsh elements, genital mutilation, ritual scarring, tooth removal and forced dancing and chanting are among the torturous trials included in many male initiation ceremonies among Australian aborigines, native Americans, New Guinea tribes, Pacific Islanders, and many African tribes (Catlin 1867; Glucklich 2001; McCauley 2001; Whitehouse 1996). Possibly the most dramatic of these initiations was the famous Mandan Indian Sun Dance ceremony where new warriors were suspended from the top beam of a large ceremonial enclosure with ropes attached to skewers embedded in their chests (Catlin 1867). They might remain there for hours or days as dancing and chanting went on below them.

With regard to modern cognition, the important point is that the capacity to endure such rituals required a degree of mental control over reflexive responses that only humans have mastered. It is hard to know how severe our Pleistocene ancestors' earliest initiation rituals may have been. But current ethnographic models indicate that to some degree they would have required initiates to inhibit natural pre-potent responses in order to signal their commitment to the tribe. The ability to do this would have been an exercise in conscious mental control over automatic, defensive behaviours. This ability, according to Coolidge & Wynn (2005), is a critical hallmark of the enhanced working-memory capacity necessary for symbolic thinking. Furthermore, those initiates best equipped to pass these tests very likely achieved higher status within the tribe and with it greater reproductive success.

Shamanistic healing rituals

The ubiquity of shamanistic practices among traditional societies coupled with possible evidence of shamanism in the archaeological record suggest that it is humanity's oldest form of religion (Hayden 2003; Guenther 1999; Lewis-Williams 2002; Townsend 1999; Vitebsky 2000; Winkelman 1990; 2002). Archaeological evidence traces shamanism to at least the Upper Palaeolithic and probably earlier. Some Upper Palaeolithic cave art appears to reflect the experiences and rituals of early shamanism (Dowson & Porr 2001; Hayden 2003; Lewis-Williams 2002; Winkelman 2002). Therianthropic images (human/animal chimera) such as the 'sorcerer' image from Les Trois Frères or the 'bird-man' image at Lascaux, are consistent with the shamanistic theme of 'soul flight', where in the midst of trance, the shaman's soul leaves his/her body and unites with that of a spiritually powerful animal (Dickson 1990; Townsend 1999; Vitebsky 2000). Furthermore, the acoustic properties of many deep cave sites,

the lack of evidence for routine use, and the symbolic imagery often present there, all support the notion that these sites were used for consciousness-altering rituals (see review in Hayden 2003, 143–5, 148–51).

Two recent finds push the origins of shamanism to before the Upper Palaeolithic. A 35,000 years bp image of what appears to be a person in the antlered headgear of a shaman was recently uncovered in the Fumane cave of northern Italy (Balter 2000). The aforementioned 70,000-year-old Tsodilo Hills snake rock may also indicate the presence of shamanistic rituals involving altered states of consciousness (Minkel 2006).

The shaman is a community's spiritual emissary who, through the use of ritually-induced trance, communes and communicates with supernatural powers in order to cure illness, manipulate natural forces and reduce suffering and social strife. Shamanistic rituals typically involve sensory deprivation, the ingestion of psychoactive substances, rhythmic drumming, dancing and chanting often by hypnotic firelight, all designed to produce altered states of consciousness. As the spirit world's messenger, the shaman plays a critical role in binding supernatural authority to social norms, thereby strengthening community and discouraging deviance.

Along with its role in strengthening social cohesion, McClenon (2002) argues that in our evolutionary past, shamanism would have been our ancestor's primary means of healing. Indeed, considerable research shows that ritual healing practices involving altered states of consciousness can be effective for maladies where a significant psychological factor is present such as: chronic pain, burns, bleeding, headaches, skin disorders, gastrointestinal disorders, debilitating emotional states and the discomforts and complications of childbirth (Katz 1982, 49–55; for review see McClenon 2002, 46–67 or Newberg & Lee 2006, 50–51). Recent research has shown that meditative practices affect levels of beta endorphins, serotonin and melatonin, all of which are implicated in immune system function, pain reduction and subjective well-being (Newberg 2006).

The Kalahari !Kung conduct 'healing dances' about every two weeks, where shaman healers dance about frenetically, laying hands on and transmitting healing power to all present. These dances are considered essential to the health and vitality of the !Kung, both individually and as a community (Katz 1982). It is not hard to imagine our late Pleistocene ancestors engaging in similar rituals around a blazing campfire. At times these rituals may only have involved group chanting, dancing or hypnotic silence before the flames (the benefits of which should not be casually dismissed). At other times they may have involved intensely dramatic shamanistic ceremonies where soul flight, supernatural encounters, and 'miraculous' healings took place. Shamanistic healing rituals such as those of the !Kung always involve techniques designed to bring about a health-enhancing altered state of consciousness. In our ancestral past those most able to achieve this state would have had a selective advantage over others by virtue of its positive physical and psychological effects.

The connection between shamanistic rituals and modern cognition lies in the fact that techniques for altering consciousness are known to activate those areas of the brain associated with working memory and focused attention. Recent neuroimaging and EEG studies examining a wide range of meditative practices show consistent activation in the dorsolateral prefrontal cortex and anterior cingulate cortex — both regions critical to working memory and attention (Lazar *et al.* 2000; 2005; Lou *et al.* 1999; Lutz *et al.* 2004; Newberg *et al.* 2001; Wallace *et al.* 1971). Furthermore, studies have shown that meditative practices can produce long-term changes in both brain structure and attentional capacities, and that they increase levels of arginine vasopressin (AVP) which has important functions in learning and memory (Carter *et al.* 2005; Lazar *et al.* 2005; Newberg 2006; Slagter, *et al.* 2007). The shamanistic practices of our ancestors may not have been as formal or rigorous as current meditative techniques; however, even relatively mundane tasks requiring focused attention (such as determining if a current visual stimulus matches a previously presented one) are known to activate areas of the prefrontal cortex involved in working memory (Smith & Jonides 1994).

The proposed model

The model being proposed can be encapsulated in a single sentence: sometime between roughly 100,000 and 40,000 years bp ritual behaviour became an important selective force among our hominin ancestors and this force selected for hominins with expanded working memory capacity. The model is built upon the following observations:

1. Upper Palaeolithic Cro-Magnons exhibited unprecedented levels of social complexity and there is evidence to suggest that this complexity began much earlier in Africa in response to ecological stress possibly associated with the Toba eruption.
2. Creating larger, more complex social arrangements, especially those that cut across traditional

within-group boundaries would have required more elaborate and demanding social rituals.
3. Ritual behaviour that requires focused attention and the inhibition of pre-potent responses places demands on areas of the brain known to be associated with working memory.
4. An enhancement of working-memory capacity was very likely necessary for the emergence of modern cognition.
5. The social rituals of traditional societies, which provide the best window on the social rituals of our ancestors, are highly demanding in terms of maintaining focused attention and inhibiting pre-potent responses.
6. Those of our ancestors best able successfully engage in ritual behaviour would have accrued fitness advantages from increased access to resources, status enhancements and psychophysical health effects.
7. Larger working-memory capacity was very likely a characteristic of these more ritually capable hominins.

Along with the evidence just reviewed, there is an additional reason why ritual should be considered an important piece in the cognitive evolutionary puzzle. Ritual plays a critical role in ontogeny. All of the elements of ritual (attention-grabbing, formalization, rule-governance, invariant sequencing) are present in the social exchanges between mothers and their infants (Bruner 1975; Trevarthen 1979; Tronick *et al.* 1979). These social exchanges, including such things as protoconversations and 'social games' (e.g. peek-a-boo), have proven to be crucial to an infant's social and cognitive development (Greenspan & Shanker 2004; Hobson 2002; Tomasello *et al.* 2005).

This raises the very intriguing possibility that as adult social rituals became increasingly demanding, this translated into mothers who were better able to sustain ever-more extended and complex ritualized social exchanges with their infants, enhancing their social/cognitive development. Put another way, adult ritual behaviour may have altered child-rearing practices producing more intelligent children. If so, then this would have created a Baldwinian selection environment raising the likelihood that a genetic mutation enhancing working-memory capacity would emerge (Jablonka & Lamb 2005; Kirshner & Gerhart 2005).

Testing the model

There are implications of the model that open it up to testing. For example, the model clearly views modern cognition as resulting from a selection pressure unique to AMH — that is, unprecedentedly demanding social rituals. This claim is falsifiable. Suppose, for example, that evidence of inter-group trade networks comparable to those of Cro-Magnons is found among Neanderthals. Two possibilities arise from this finding: (1) Neanderthals engaged in complex social rituals without achieving modern cognition, or (2) Neanderthals created inter-group trade networks without complex social rituals. Either of these implications is damaging and potentially falsifying to the current model. A corollary to this would be that among traditional societies, where more extensive inter-group relations are noted, more sophisticated and demanding social rituals would also be present.

A second implication of the model is that ritualized behaviour serves as an effective mechanism for freeing up working-memory capacity, which can then be allocated for greater inhibitory control. If so, one would predict that ritual improves performance under conditions of high-stress. There is already evidence supporting this prediction in at least two areas: athletic performance and academic performance for children diagnosed with ADHD. In athletic performance, a number of studies have demonstrated that ritual behaviour, in the form of pre-performance routine, leads to better performance in a number of different sports (Czech *et al.* 2004; Gayton *et al.* 1989; Lobmeyer & Wasserman 1986; Lonsdale & Tam 2007; Southard & Amos 1996). For example, basketball players who maintain their established pre-free-throw routines have been found to be significantly more accurate on subsequent free-throws compared to those who deviate from their routines (Lonsdale & Tam 2007). This difference has been attributed to the fact that pre-performance routines serve to eliminate distractions, reduce anxiety and build confidence by focusing attention on a series of well-rehearsed, productive cues and away from performance-disrupting thoughts (Boutcher & Crews 1987; Lidor & Singer 2000; Weinberg & Gould 2003).

Brain-imaging studies comparing novice sports players to experts have revealed significant differences in the brain areas activated during pre-performance routines (Kim *et al.* 2008; Milton *et al.* 2007). Specifically, areas associated with emotions such as the posterior cingulate and the amygdala were significantly more active in novices, whereas the anterior cingulate along with areas in the temporal and parietal lobes were more active in experts. The authors of these studies argue that these patterns indicate that the experts possess a superior ability to maintain attentional focus (as indicated by increased ACC activity) while inhibiting detrimental emotional responses (as

indicated by significantly reduced response in the posterior cingulate and amygdala). Although not measured in the brain-imaging studies, a reasonable assumption would be that part of the experts' success is due to their ability to more effectively execute their pre-performance rituals compared novices.

Children with attention deficit/hyperactivity disorder (ADHD) represent another population where attentional focus is a serious challenge. A recent assessment has demonstrated that deficits in executive functions connected to working memory (e.g. directing goal-relevant behaviours, task monitoring, inhibiting task irrelevant activities) represent a significant component of this disorder (Biederman *et al.* 2004). Structured environments and behavioural routines are commonly employed to help improve learning and academic performance among ADHD children (Trout *et al.* 2007). However, with ADHD children the challenge is not just in establishing a behavioural routine but in keeping children aware of the routine and their progress through it. Training in self-monitoring has proven effective in keeping ADHD children on task and in improving academic performance (Harris *et al.* 2005; Shimabukuro *et al.* 1999).

For example, Harris and colleagues (2005) had ADHD children engage in a six-step study sequence for learning spelling words that involved (1) looking at the word, (2) closing one's eyes and spelling the word out loud, (3) studying the word again, (4) covering the word, (5) writing the word three times, and finally (6) checking the written words for correct spelling. ADHD children heard intermittent tones while studying that cued them to record on a tally sheet whether or not they were engaged in the study routine. Results showed that the self-monitoring procedure increased both on-task behaviour and spelling accuracy. This study demonstrates that by increasing a child's awareness of a routine behaviour, the ability to stay on that routine increases and their task outcome improves.

These lines of research reinforce the connection between ritual and working memory — a connection that was very likely exploited by our ancestors as their social world became increasingly complicated.

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