

Original Article

The cultural morphospace of ritual form[☆] Examining modes of religiosity cross-culturally

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Abstract

Ethnographic, historical, archaeological and experimental work suggests the existence of two basic clusters of ritual dynamics or ‘modes of religiosity’ — a low-frequency, high-arousal cluster linked to the formation of small cohesive communities (imagistic mode) and high-frequency, low-arousal cluster associated with larger, more centralized social morphology (doctrinal mode). Currently, however, we lack a large-scale survey of ritual variation on which to test such predictions. Here, we compile data on 645 religious rituals from 74 cultures around the globe, extracted from the Human Relations Area Files, revealing that the cultural morphospace of ritual form favours rituals that are indeed either low-frequency and highly dysphorically arousing or high-frequency with lower arousal and that these ritual dynamics are linked to group size and structure. These data also suggest that low dysphoric arousal, high-frequency rituals may have been tied to the advent of agriculture and subsequent emergence of the first large-scale civilizations.

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1. Introduction

Religious rituals show an enormous diversity of form and function across the globe, but this diversity is not unbounded. Various clusters of ritual features are hypothesized to co-occur cross-culturally as a result of both cognitive constraints on the range of possibilities and functional constraints on how features interact with each other and the broader social system. For example, different elements of ritual form have been associated with costly signalling (Irons, 1996; Sosis & Alcorta, 2003; Sosis, Kress & Boster, 2007), obsessive compulsive disorder and the human hazard precaution system (Boyer & Lienard, 2006), cognitive constraints on memory systems (Whitehouse, 1992), the

role ascribed to supernatural agency (McCauley & Lawson, 2002), modes of codification and transmission (Barth 1987; Turner 1974; Whitehouse 1995), and the scale and structure of religious communities (Gellner, 1969; Goody, 1986; Werbner 1977, 1989; Whitehouse 2000). To develop an understanding of the cultural evolution of religious rituals, these theories need to be tested in the light of evidence from a range of disciplines, including developmental and social psychology, cognitive neuroscience, behavioural economics and anthropology.

Central to this project is the characterisation of cultural variation itself. With few exceptions, (e.g., Sosis et al. 2007), the above theories tend to be derived from ethnographic, archaeological or historical case studies and field work, and are therefore vulnerable to the charge of cherry-picking: that is, focussing on bodies of evidence and experimental designs likely to confirm the theory. To avoid this criticism, a large-scale global database of ritual variation is needed. By systematically cataloguing cross-cultural variation in the dimensions of interest, hypotheses can be tested statistically and the cherry-picking criticism overcome. Such an

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undertaking is also in line with the recent suggestion by Hauser (2009) that, just as evolutionary biologists can gain insight into the forces shaping biological form by documenting the distribution of observed variants within a theoretical morphospace, social scientists can benefit from considering the morphospace of cultural forms. The existence of ritual clusters along certain dimensions can highlight possible adaptive peaks, perhaps favoured by cognitive biases, whilst gaps in the theoretical morphospace may suggest developmental, physical, historical or ecological constraints on the range of possible forms. These patterns can then feed back into the development of theory and serve to inform experimental work to establish the limits and drivers of human cultural variation.

Collecting cross-cultural data is time consuming and constrained by the available ethnographic evidence. A comprehensive catalogue of all the potentially interesting aspects of ritual variation is therefore not feasible in a single study. Here, instead, we take a first step towards characterising the cultural morphospace of ritual form by focussing on those elements of ritual relevant to the theory of ‘modes of religiosity’ (Whitehouse, 2004) — a relatively well-developed approach that applies cognitive theories to the comparative study of religious traditions to make a series of testable predictions about the sort of ritual variation we should expect to see.

The modes theory proposes that a crucial component of ritual variation arises from cognitive constraints imposed by episodic and semantic memory systems favouring two different cultural attractors or modes of religiosity — a ‘doctrinal’ mode and an ‘imagistic’ mode. The principal predictions of the theory concern the relationship between the frequency and emotionality of ritual performances. In order to maintain and motivate a cultural tradition, ritual elements must be preserved in the memory of participants. Put simply, the proposed doctrinal mode is seen as favouring high-frequency, low-arousal rituals, allowing large bodies of religious teachings to be stored in semantic memory, reproduced stably and spread efficiently as oral tradition. Conversely, the imagistic mode is seen as favouring low-frequency, high-arousal rituals that must evince strong emotions to etch themselves into episodic memory if they are to have an enduring impact on the religious imagination and to be remembered accurately. Research into the storage and vivid recollection of traumatic events in episodic memory (Conway, 1995) suggests that the relationship between frequency and arousal should be particularly strong for negatively valenced ‘dysphoric’ arousal, involving intensely unpleasant, perhaps traumatic, experiences.

The two modes are also thought to be associated with other features of the religious system and society in which they occur (Whitehouse, 2004). The doctrinal mode is based around frequently repeated teachings and rituals. High-frequency ritual performances allow complex networks of ideas to be transmitted and stored in semantic memory and give rise to generic identity markers ascribed to large-scale

‘imagined communities’ (Anderson, 1983). Much of the religious knowledge is codified in language and transmitted primarily via recognized leaders and authoritative texts. At the same time, routinization is thought to suppress certain kinds of creative thinking about the meanings of the rituals, which may be a necessary condition for the establishment of religious orthodoxies. It is also argued that the emphasis on verbal transmission facilitates highly efficient and rapid spread, through processes of evangelism and missionization. The emphasis on oratory and learning is taken to facilitate the emergence of venerable leaders and teachers: gurus, prophets and priests. Hence, the doctrinal mode is also thought to encourage the emergence of centralized ecclesiastic hierarchies, exerting influence over the content and organization of authoritative religious knowledge.

By contrast, the imagistic mode of religiosity is based on rare, climactic rituals — for instance, the hair-raising ordeals of initiation cults, millenarian sects, vision quests, and so on — typically involving extreme forms of deprivation, bodily mutilation and flagellation, and psychological trauma based around participation in shocking acts. Such practices are known to trigger enduring and vivid episodic memories for ritual ordeals (Whitehouse, 1996), encouraging long-term rumination on the mystical significance of the acts and artefacts involved (Whitehouse, 2002). Imagistic practices are likely to be much harder to spread than doctrinal traditions. A major reason for this is that the religious knowledge is created through collective participation in rituals rather than being summed up in speech or text. Traumatic rituals should create strong bonds among those who experience them together, establishing in people’s episodic memories who was present when a particular cycle of rituals took place. The expected tendency, then, is towards localized cults, based on patterns of following by example, and so it is not expected to generate the kind of scale, uniformity, centralization or hierarchical structure that typifies the doctrinal mode.

Beyond the religious system itself, ritual frequency and arousal are also thought to be linked to other social factors related to resource acquisition and control. Endeavours involving high risk and temptation to defect (e.g., military operations, hunting of dangerous animals, protection of moveable stores of wealth) are likely to recruit low-frequency, high-arousal rituals (e.g., hazing, painful initiation rites), both as a mechanism of bonding and perhaps as a form of costly signalling to demonstrate group commitment (Irons, 1996; Sosis & Alcorta, 2003; Sosis and Bressler, 2003; Sosis et al., 2007). By contrast, endeavours requiring regular input of relatively small but cumulatively large resources over much larger territories (e.g., exchange networks, tribute extraction, routinized manual labour, farming) are expected to recruit high-frequency, low-arousal rituals (e.g., ritualized expressions of nationalist pride, religious commitment, corporate identity) (Beardsley & McQuinn, 2009). In line with this dichotomy, recent work relating the modes theory to archaeological evidence from

the early Neolithic site at Catalhoyuk suggests that the emergence of a doctrinal mode may have been associated with the increasing reliance on agricultural production (Whitehouse & Hodder, *in press*).

Whilst the modes theory has received considerable attention in the last decade from historians, archaeologists, anthropologists and cognitive scientists (Martin & Whitehouse, 2005; McCauley, 2001; McCauley & Lawson, 2002; McCauley & Whitehouse, 2005; Whitehouse & Martin, 2004; Whitehouse & McCauley, 2005) and there is much to support it in the ethnographic record (Ketola 2002; Naumescu, 2008; Whitehouse & Laidlaw, 2004; Xygalatas, 2007), the above predictions about variation in ritual form have not yet been tested using a statistical framework and global sampling of cultures. Here, we construct a database recording frequency, arousal and contextual information for 645 religious rituals from 74 cultures around the globe, as documented in the electronic Human Relations Area Files (eHRAF). We seek to test whether some ritual features do in fact cluster together predictably along frequency and arousal dimensions and to investigate the cultural correlates of variation in ritual form. A crucial point to make about the hypotheses tested is that they are intended to be probabilistic rather than law-like. The two modes are envisaged not as a typology (nor even a specification of Weberian ideal types) to which religious traditions should be assigned. Rather, they constitute ‘attractor positions’ (Sperber, 1996; Whitehouse, 2004) around which the variables identified would be expected to cluster, given the availability of a sufficiently large sample of cases.

We therefore examine the following modes of religiosity hypotheses (Whitehouse, 2004):

1. Ritual frequency should be negatively correlated with levels of emotional arousal.
2. Ritual frequency should be most strongly negatively correlated with dysphoric (painful or unpleasant), rather than euphoric arousal, because of the effects of pain and trauma on the activation of durable episodic recall (Xygalatas, 2008).
3. The morphospace of ritual frequency vs. arousal should reveal two clusters — high frequency and low arousal vs. low frequency and high arousal.
4. Major world religions (e.g., classical religions and large regional religions) should have higher frequency and lower arousal rituals than small-scale or tribal traditions.
5. Highly arousing rituals should be more prevalent in societies that live in smaller groups.
6. Highly arousing rituals should be more prevalent in less hierarchical societies.
7. Highly arousing rituals should be less prevalent in societies that rely more on agriculture.

An alternative, though not necessarily incompatible, set of explanations for variation in *dysphoric* ritual arousal is

based on signalling theory (Irons, 1996; Sosis & Alcorta, 2003), since enduring pain or trauma can be a credible costly signal. Sosis et al. (2007) used cross-cultural data to test a number of potential signalling functions for male initiation rites and found that the most traumatic and painful male initiations, and those most likely to involve permanent scarring, occur in warring societies. We take advantage of our dataset to follow up this work on initiation rites by looking at the costly signalling hypotheses with regard to dysphoric arousal in rituals in general. Excluding those predictions that are relevant only to males, we sought to test three additional hypotheses based on costly signalling predictions outlined in Sosis et al. (2007):

8. Dysphorically arousing rituals should be more prevalent in cultures that live in larger groups (because of the increased need to guard against free-riders in all cooperative activities in the group).
9. Dysphorically arousing rituals should be more prevalent in cultures that rely more on foraging and less on agriculture (because increased likelihood of food scarcity requires sharing resources and is thus susceptible to free-riding).
10. Dysphorically arousing rituals should be more prevalent in cultures with higher rates of intergroup warfare (because there is a greater need for group members to signal commitment to the in-group).

Finally, we consider the effect of two other variables that recent work has shown may be important in the evolution of religion. Belief in moralizing high gods — defined as active in human affairs and specifically supportive of human morality (Swanson, 1960) — is associated with some indices of societal cooperation (Johnson, 2005; Johnson & Kruger, 2004; Norenzayan and Shariff, 2008; Snarey, 1996; Roes & Raymond, 2003), perhaps due to a supernatural policing effect. Moral high gods may be linked to the doctrinal mode of religion, and to the extent that moral high gods represent a proxy for larger, more hierarchical religious systems, the modes theory would predict that societies with such gods have rituals that are on average lower arousal/higher frequency. Likewise, we consider the adoption of writing, which has also recently been linked to stages of religious evolution (Boyer, 2005; Goody, 2004; Sanderson & Roberts, 2008).

2. Methods

Ritual data were compiled from eHRAF, a searchable database of ethnographies for over 180 cultures selected to provide a diverse sampling from around the globe. We focussed on a subset of 65 of the most well-attested cultures in eHRAF known as the ‘Probability Sample Files’ (PSF). Each of the PSF cases was randomly selected from one of a set of major culture areas around

the globe (Ember & Ember, 1998; Lagace, 1979). In addition to providing some of the most complete ethnographic information, the widely distributed sampling of the PSF minimizes potential for spurious results due to the well-known problem of non-independence between cross-cultural data points. To achieve a balanced sampling of society types from across the globe, we included 15 other eHRAF cultures from regions that were not otherwise represented in the PSF or where PSF cultures did not contain enough information to code rituals. Additional samples were selected from the best attested eHRAF cultures (as measured by quantity of material available) in different geographic regions to maximise diversity in our sample whilst avoiding sampling closely related cultures. Six PSF cultures contained no relevant information on rituals and so were excluded from the analyses. This produced a total sample pool of 74 eHRAF cultures comprising 175,000 pages of text.

We compiled a list of references to rituals in each culture, using eHRAF to search across cultures within the subject categories ‘religious practices’ and ‘ecclesiastical organization’. A ritual was defined as any conventional action sequence performed by two or more individuals where the physical-causal function of the act is underspecified or opaque. Although other features of ritual have been used as a basis for definitions (Bell, 1992; Bloch, 1974; Humphrey & Laidlaw, 1994; Leach, 1954; Staal, 1987), our focus on functional opaqueness is consistent with everyday classification of behaviour as ritual as well as with classifications typically deployed by anthropologists in practice. We ignored references where a ritual was merely mentioned and not described in any detail.

This produced a list of 645 rituals across the 74 cultures in our sample. For each ritual described, we recorded the typical annual frequency of ritual participation for members of the religious tradition (daily, daily-monthly, seasonally, annually, less than annual, once per generation) and the peak level of arousal for participants in each ritual. Due to the subjectivity of rating arousal levels, ratings were undertaken independently by one graduate student (Rater 1, male) and two undergraduate students (one male and one female) without specialist knowledge of the particular regions that might bias results. For each ritual, Rater 1 recorded the description of the ritual as given in eHRAF, paraphrasing longer descriptions where necessary. All raters were then given descriptions of each of the rituals in a randomized order in the absence of other contextual information related to the hypotheses being tested and asked to score the peak moment of emotional arousal on a Likert scale from 0 (*no arousal*) to 5 (*extreme arousal*). Emotional arousal was subdivided into positively valenced euphoric arousal (e.g., dancing, singing, shouting) and negatively valenced dysphoric arousal (e.g., pain, discomfort or trauma). Inter-rater reliability across both measures was high — Cronbach’s alpha was 0.88 for euphoric arousal and 0.96 for dysphoric arousal. The analyses

reported here are based on the mean arousal scores across the three raters. Fig. 1 shows the distribution of average dysphoric and euphoric arousal scores.

In order to account for the effect of other potentially confounding variables on ritual arousal levels, we also recorded additional contextual information on approximate ritual duration (<1, 1–6, 6–12, >12 h), gender of participants (all male, all female or mixed), ritual function [initiations, social transitions (other than initiations), attempts to manipulate this world, attempts to manipulate other worlds or the afterlife, divination, repeating doctrine, and other gatherings, such as trance dancing] and influence of classical religion. Influence of classical religion (Christianity, Islam, Hinduism, Buddhism) was divided into pre-classical (no contact with classical religion or contact but no record of ideas being adopted), mixture (some elements of classical religion mixed with indigenous beliefs and practices) or classical (classical religion is the indigenous religion or has been adopted by all or almost all in the culture). Every effort was made to ensure that all traits were recorded as accurately as possible. Cases where the correct coding could not be reliably determined due to inadequate information in the available ethnographies were coded as missing data. Whilst the coding is of course constrained by the quality of the available ethnographies, there is no reason to think that this will have biased our results with respect to the hypotheses being tested.

One advantage of using eHRAF is that, although relatively little work has been done systematically to assess ritual variation across the collection, other social variables have been coded for many of the cultures as part of the Ethnographic Atlas (EA; Murdock, 1967) project. Here we make use of this independently coded data by matching relevant social variables in the EA to cultures in our own database, so that we can test hypotheses about what might be driving cross-cultural variation in ritual form. The variables used in the present study are community size, local and regional jurisdictional hierarchy, agricultural intensity, writing and belief in a moralising high god. In line with previous work (Johnson 2005; Roes & Raymond, 2003), the last-named ‘high gods’ variable was also recoded as a binary variable representing the presence or absence of moralising high gods. To account for possible geographic non-independence, we also included the EA assignments to six geographical regions (Africa, Circum-Mediterranean, East Eurasia, Insular Pacific, North America and South America).

Finally, Sosis et al. (2007) also make use of the probability sample files to test hypotheses based on signalling theory and find that the prevalence of external warfare in a society is a significant predictor of costly male initiation rites. In order to test this and other costly signalling explanations for variation in ritual arousal in general, we included the binary variable of Sosis et al. coding the prevalence of warfare.

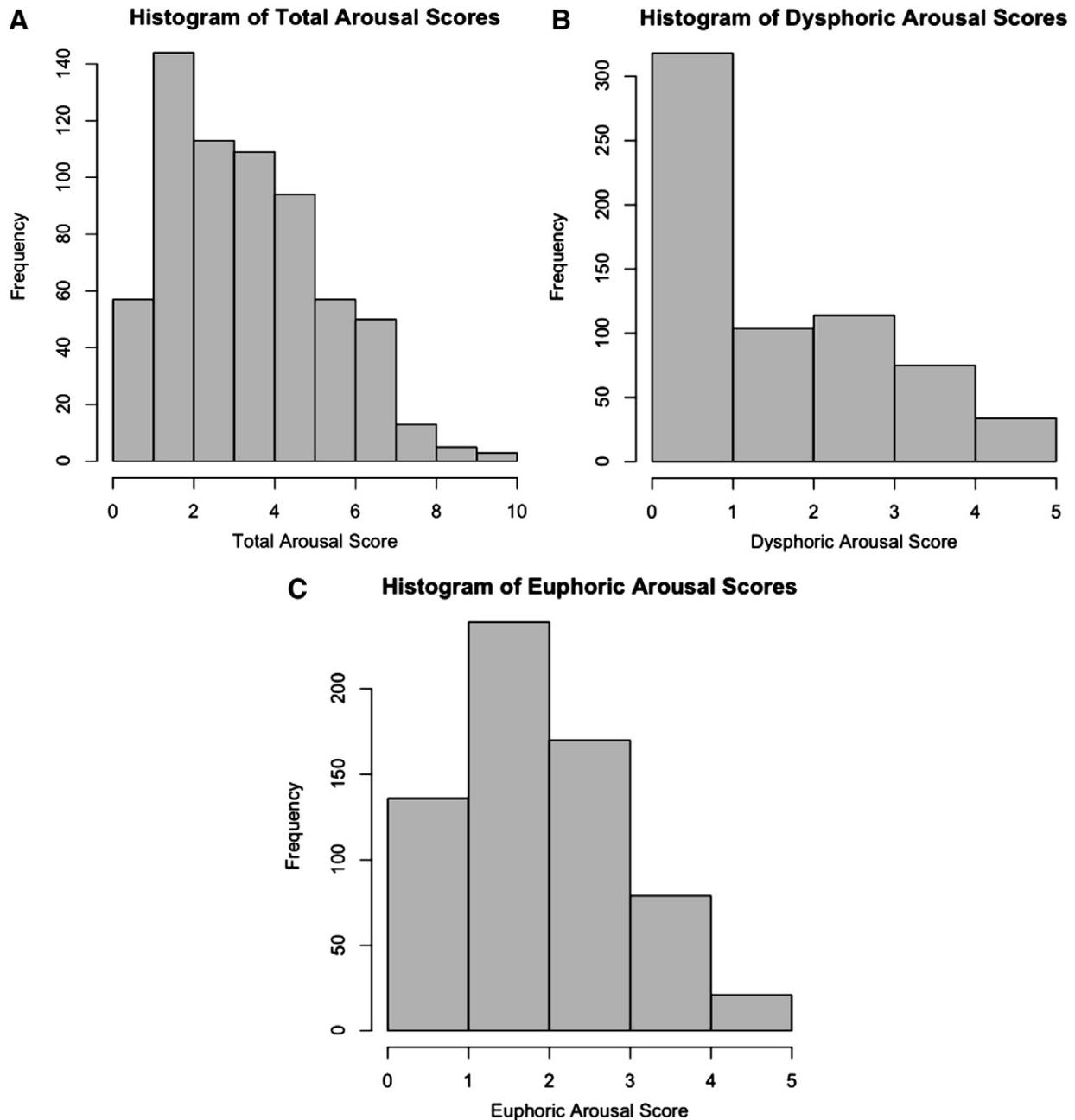


Fig. 1. Distribution of arousal scores ($n=645$). (A) Total arousal scores (summing dysphoric and euphoric arousal ratings). (B) Dysphoric arousal scores. (C) Euphoric arousal scores.

The individual ritual data and coding scheme is presented in [Supplementary Table 1](#). Cross-cultural data and coding scheme is presented in [Supplementary Table 2](#).

3. Results

As predicted, ritual frequency is negatively correlated with overall ratings of arousal ($\rho=-0.401$, $n=644$, $p<.001$; [Fig. 2A](#)). With the separation of euphoric and dysphoric arousal dimensions, ritual frequency is most strongly related

to dysphoric arousal ($\rho=-0.409$, $n=644$, $p<.001$), with a weak, though still statistically significant, correlation between frequency and euphoric arousal ($\rho=-0.08$, $n=644$, $p<.05$). [Fig. 2B](#) shows that whilst dysphoric arousal increases monotonically with decreasing ritual frequency, euphoric arousal peaks at the annual level and shows less variation with ritual frequency in general. The euphoric arousal relationship may be better described by a quadratic curve ($r=0.22$, $F_{2,641}=17.0$, $p<.001$). The same pattern can be seen in the heat maps in [Fig. 2](#), which provide a graphical representation of the distribution of arousal levels across

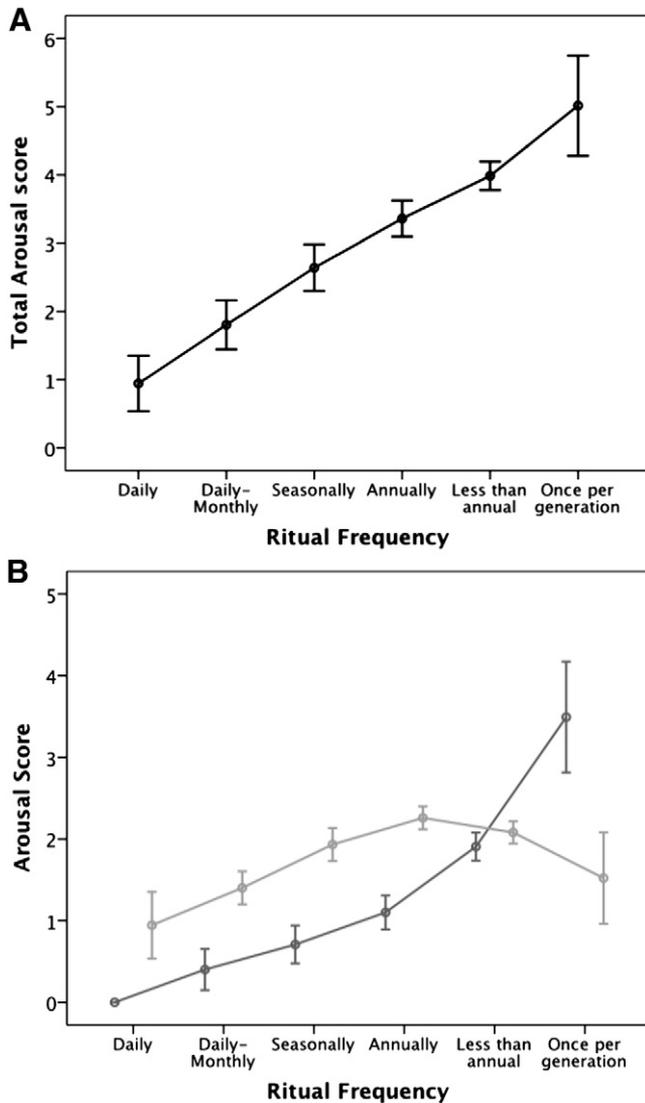


Fig. 2. (A) Total arousal scores (summing dysphoric and euphoric arousal ratings) by ritual frequency ($\rho=0.401$, $n=644$, $p<.001$). (B) Arousal scores by ritual frequency for euphoric (grey line; $\rho=0.08$, $n=644$, $p<.05$) and dysphoric (black line; $\rho=0.409$, $n=644$, $p<.001$) arousal.

different ritual frequencies. Cells are shaded according to the density of sampling of arousal levels across frequencies. This reveals the predicted clustering of rituals with low dysphoric arousal at high frequencies and high dysphoric arousal at low frequencies (Fig. 3A). Euphoric arousal does not show the same polar clustering (Fig. 3B).

Other contextual variables are also associated with arousal levels. Ritual duration was positively correlated with arousal ratings, with longer rituals tending to involve higher euphoric ($\rho=0.370$, $n=645$, $p<.001$) and dysphoric ($\rho=0.237$, $n=645$, $p<.001$) arousal (Fig. 4A). Ritual function also had a significant effect on both dysphoric and euphoric arousal levels (Fig. 4B). Dysphoric arousal scores were highest in initiations and other social transitions and lowest during repetitions of doctrine and other religious

gatherings. Euphoric arousal was also higher in initiations as well as in other religious gatherings. Regarding the gender of ritual participants, a Mann–Whitney test showed that there was no significant difference between arousal in all male and all female rituals [dysphoric: male/female, $U(110)=1447.5$, $z=-0.164$, $p=.869$; euphoric: male/female, $U(110)=1340.0$, $z=-0.815$, $p=.415$]; however, rituals involving either all males or all females showed higher dysphoric arousal scores than rituals involving both males and females [male/mixed: $U(575)=13563$, $z=-2.872$, $p<.01$; female/mixed: $U(553)=8713$, $z=-2.577$, $p<.01$]. Conversely, euphoric arousal scores were higher for mixed gender rituals than for all-male rituals [$U(575)=13419$, $z=-2.851$, $p<.01$], but did not differ from all-female rituals [$U(553)=9581$, $z=-1.598$, $p=.110$].

In addition to the above ritual-level factors related to the context of each ritual within societies, we can also examine societal-level correlates of ritual variation across the globe. A one-way ANOVA across societies reveals that between-society differences in ritual arousal ratings account for approximately 20–25% of the overall variation in ritual arousal (dysphoric: $r^2=0.251$, $F_{73,571}=2.628$, $p<.001$; euphoric: $r^2=0.220$, $F_{73,571}=2.21$, $p<.001$). Finding significant differences in ritual arousal levels between cultures means we can test predictions about population-level covariates of arousal. Table 1 shows the correlation between mean dysphoric and euphoric arousal ratings across cultures and our set of candidate predictors. Consistent with the modes theory, mean ritual frequency, community size and agricultural intensity all show highly significant negative correlations with dysphoric arousal. We find weaker negative correlations between dysphoric arousal and influence of classical religion and belief in a moralizing high god (both the standard and binary codings). Contrary to the predictions of the modes theory, levels of local or regional jurisdictional hierarchy are not inversely correlated with dysphoric arousal. Similarly, we find no effect of warfare or writing on dysphoric arousal. Mean euphoric arousal is also weakly negatively correlated with mean ritual frequency and influence of classical religion, but is not related to any of the other predictors.

The above relationships reveal associations between ritual arousal and a number of other ritual- and society-level variables; however, these variables are themselves known to co-vary. In order to establish which predictors remain significant holding other variables constant and hence which particular features may be driving differences in ritual arousal, we used a multilevel/hierarchical modelling approach that allows us to account for ritual-level within-society effects (such as ritual frequency and duration) and society-level effects (such as group size, high gods and agricultural intensity) in the same framework. We implemented this in the *lme4* package in *R* (R Development Core Team, 2008) using forward stepwise regression to identify predictors at both the ritual and society level that are important, after controlling for other variables in the model. All of the above ritual- and society-level predictors were

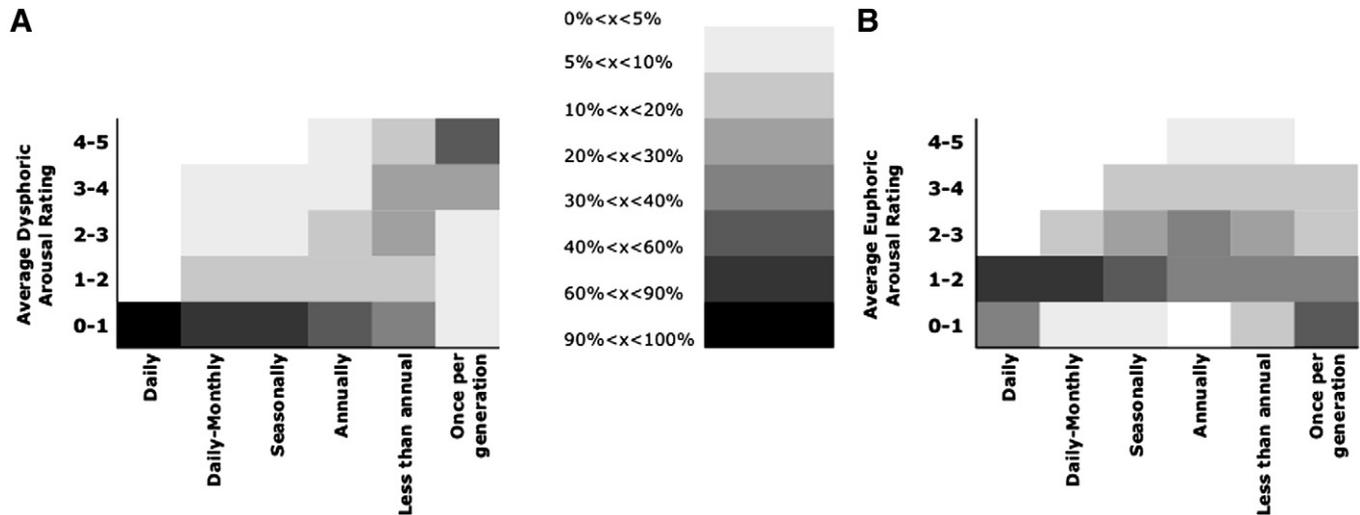


Fig. 3. Heat map of dysphoric (Panel A) and euphoric (Panel B) arousal score across ritual frequencies. Cells are shaded according to the proportion of rituals of each frequency falling within the corresponding arousal range.

evaluated in the model as fixed effects as well as a between-societies random effect. Based on Fig. 2B, for euphoric arousal we also included a quadratic frequency term in the model. This method is robust to deviations from the assumption of normality (Gelman & Hill, 2006), and residuals for both analyses showed only minor departures from normality. Levene's test for homogeneity of variances across societies was not significant (dysphoric: $F_{67,550}=1.190$, $p=.155$; euphoric: $F_{67,550}=1.301$, $p=.063$).

Tables 2 and 3 show the significant predictors from the stepwise regression model for dysphoric and euphoric arousal. The analyses reveal that, controlling for other variables, ritual frequency shows a significant inverse relationship with dysphoric arousal ($t=-7.161$, $p<.001$) and a curvilinear relationship with euphoric arousal (frequency term: $t=-4.858$, $p<.001$; frequency² term: $t=4.759$, $p<.001$). Dysphoric arousal is also predicted by ritual duration ($t=2.254$, $p=.024$), and across functions ratings are significantly higher for initiations ($t=6.151$, $p<.001$) and lower for other social gatherings ($t=-3.513$, $p<.001$). The only significant cross-cultural predictor of dysphoric arousal was agricultural intensity. Euphoric arousal is higher for rituals that are longer duration ($t=7.193$, $p<.001$), manipulations of this world ($t=1.968$, $p<.049$) and other social gatherings ($t=2.609$, $p<.009$). Across cultures, higher euphoric arousal is associated with less influence of classical religion ($t=-2.264$, $p=.023$).

Whilst the standard R^2 measure of variance explained does not apply to a multi-level model fit, one can get a similar measure by looking at the squared correlation between the fitted and observed values. Calculating this value for each analysis indicates that the models explain approximately 32% ($r=0.567$) and 28% ($r=0.525$) of the variation in dysphoric and euphoric arousal, respectively. Interaction effects for frequency and duration across societies and across agricultural intensity and influence of

classical religion were not significant and did not improve the fit of the model as measured by Bayesian Information Criterion (BIC).

Although the cultures in our database represent a deliberately diverse geographic sampling from around the globe, to investigate whether our findings could be an artefact of regional patterning among some ritual features, the above analyses were repeated, grouping societies into six geographic regions. Mean arousal scores were not found to differ significantly across geographic regions (dysphoric: $F_{3,72}=1.73$, $p=.170$; euphoric: $F_{3,72}=1.639$, $p=.189$), and adding region to the hierarchical model did not improve model fit as measured by BIC. There were no significant interaction effects between any of the main predictor variables and the six major geographic regions, suggesting the effects we report are consistent trends that hold across the globe.

4. Discussion

4.1. Variation within societies

Our findings support the existence and utility of 'cultural attractors' in the morphospace of ritual form (Hauser, 2009; Sperber, 1985, 1996). Consistent with the modes of religiosity theory, ratings of emotional arousal experienced by ritual participants are inversely correlated with ritual frequency, such that less frequent rituals tend to elicit higher emotional arousal ratings. This is the first demonstration of a correlation between ritual frequency and arousal from a global sample of cultures. Separating euphoric and dysphoric arousal ratings reveals that dysphoric arousal is driving the inverse relationship with ritual frequency. Unlike euphoric arousal, dysphoric arousal continues to increase as ritual frequency drops below the one ritual per annum threshold. A distinction between euphoric and dysphoric arousal is in line

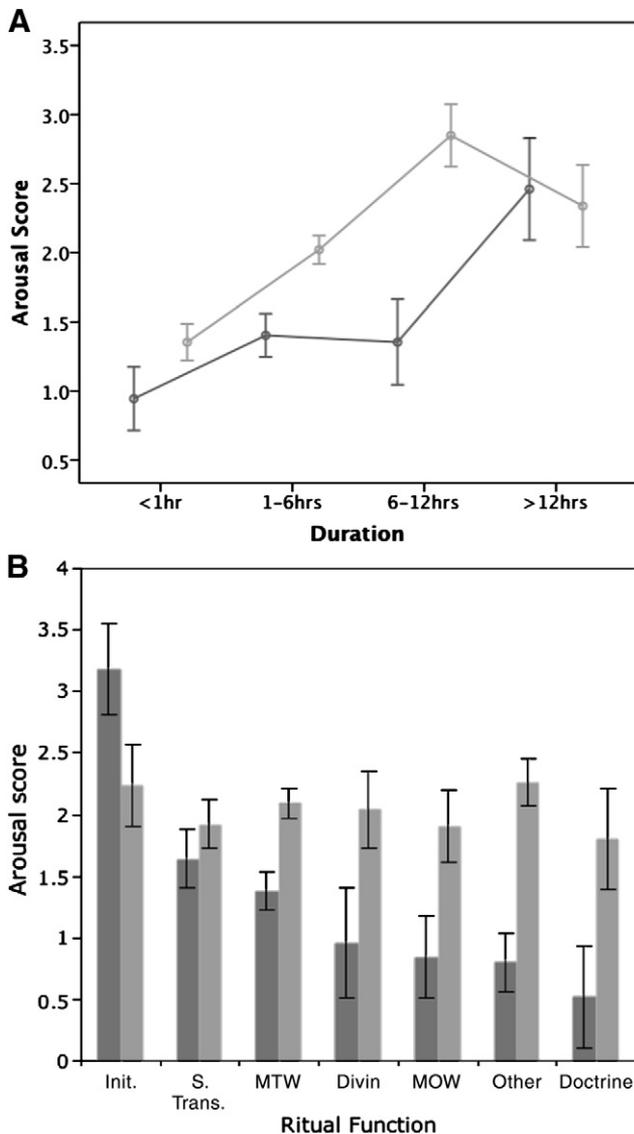


Fig. 4. Euphoric (grey) and dysphoric (black) arousal scores by different contextual variables. Error bars represent 95% confidence intervals for the mean. (A) Arousal scores by ritual duration (dysphoric arousal: $\rho=0.237$, $n=645$, $p<.001$; euphoric arousal: $\rho=0.370$, $n=645$, $p<.001$). (B) Arousal scores by ritual function. Init.=Initiations; S. Trans.=social transitions; MTW=manipulating this world; MOW=manipulating the afterlife or other worlds; Divin.=divination; Doctrine=repeating doctrine. Other=Other ritual gathering [dysphoric arousal: Kruskal–Wallis $\chi^2(7, n=645)=139.325$, $p<.001$; euphoric arousal: Kruskal–Wallis $\chi^2(7, n=645)=23.98$, $p<.001$].

with the predictions of the theory of modes of religiosity, supporting the argument that low-frequency rituals are less likely to persist in the absence of highly unpleasant or even traumatic experiences. This general picture is also supported by the two ritual clusters evident in the heat map of dysphoric (though not euphoric) arousal and ritual frequency in Fig. 3.

Controlling for other ritual- and society-level variables that may influence arousal, the hierarchical regressions reported in Tables 2 and 3 show the predicted inverse

relationship between ritual frequency and dysphoric arousal, and a curvilinear relationship between euphoric arousal and frequency. This indicates that the frequency effects we observe are not an artefact of other potentially confounding contextual variables. Indeed, frequency is the strongest single predictor of dysphoric arousal in the multi-level regression. In addition to frequency, ritual duration and function also have independent effects on arousal levels. Initiations, in particular, show high dysphoric arousal relative to other rituals, even given their low frequency, perhaps due to their proposed function as costly signals (Sosis et al., 2007). Importantly, however, because initiations are included as a factor in the model, the relationship we observe between frequency and arousal cannot simply be because initiations (or any other ritual type) have particularly high arousal and low frequency. Rather, the results suggest that low ritual frequency predicts high dysphoric arousal independently of the broadly defined function of a ritual.

There is considerable psychological evidence linking pain and trauma to the activation of durable episodic recall. The link between dysphoric arousal and ‘indelible’ memory for one-off events has been extensively demonstrated by research in the neurosciences, including studies of both humans and animals (Gold, 199; LeDoux, 1992; Mishkin & Appenzellar, 1987), and in psychological research, for instance examining recall for violent crimes (Yuille and Cutshall, 1986), one-off childhood traumas (Terr, 1979, 1983), war veterans, rape victims (Christiansen & Nilsson, 1989), and even the onset of the menarche in girls poorly prepared for the experience (Pillemer, Koff & Rierdan, 1987). A particularly rich literature on this topic relates to so-called flashbulb memory (Brown & Kulik, 1977), an especially vivid type of recall encoding the unique and emotional character of episodic experience. In a comprehensive survey of the literature on flashbulb memory, Conway (1995) concludes that the evidence overwhelmingly suggests that dysphoric emotion at encoding plays a crucial role in the formation of vivid, enduring episodic memory.

According to the theory of modes of religiosity, these memory effects are crucial to understanding why low-frequency rituals must incorporate elements of intense dysphoric arousal if they are to survive in the long run. More experimental work that explicitly addresses the proximate mechanisms driving ritual participation and recall is needed to establish whether and how individual psychology gives rise to the cultural patterns we observe. Recent experiments indicate that emotional intensity in one-off artificial rituals correlates directly with the longevity of episodic recall for ritual procedures and for the volume and conceptual richness of spontaneous reflection on the meanings of rituals (Richert, Whitehouse & Stewart, 2005). Pilot experiments also indicate that even low-arousal one-off rituals produce some reflexivity (albeit lower than for high-arousal variants), but that this effect disappears when rituals are repeated over a period of time (Whitehouse, 2004, pp. 83–84). This suggests that, as the need to reflect on how to

Table 1

Correlation (Spearman's rho) and *p* values relating mean dysphoric and euphoric ritual arousal ratings in each culture to the set of candidate cross-cultural predictor variables

Predictor	<i>n</i>	Dysphoric arousal		Euphoric arousal	
		rho	<i>p</i> value	rho	<i>p</i> value
Mean ritual frequency	74	−0.402	<.001***	−0.286	.014*
Community size	53	−0.446	<.001***	−0.196	.259
Local jurisdictional hierarchy	67	−0.031	.804	−0.107	.391
Regional jurisdictional hierarchy	66	−0.182	.143	−0.189	.129
Classical religion	74	−0.230	.048*	−0.264	.023*
Moral high gods	58	−0.260	.049*	−0.042	.753
Moral high gods (binary)	58	−0.294	.025*	−0.259	.233
Agricultural intensity	67	−0.415	<.001***	−0.266	.067
Warfare (Sosis et al. 2007)	55	0.214	.117	0.236	.083
Writing	34	−0.172	.332	0.001	.994

* *p*<.05.

*** *p*<.001.

perform a ritual is decreased (such reflection becoming unnecessary with the development of procedural familiarity and fluency), so active reflection on why one should do the ritual is decreased as well. These issues need to be investigated more systematically, however. For instance, low levels of reflexivity may be unproblematic in circumstances where religious identities are conferred for life, but more deleterious where defection is common (e.g., due to secularization or competition among rival traditions). In periods of religious renewal and reform we might expect heightened reflexivity on issues of ritual meaning and a reduction in the value of ritual performance for its own sake (e.g., iconoclastic tendencies). Where ritual exegesis functions as a marker of group identity, increased rigidity and belief resilience may ensue.

In addition to frequency effects, our results also raise a number of interesting questions about ritual arousal in general within societies that warrant further investigation. Why is euphoric arousal highest for annual rituals and is this linked to the function of euphoric arousal? How might gender affect euphoric and dysphoric arousal differently? Our 'other gatherings' category includes trance dancing, which has been linked to endorphin release and promotion of

Table 2

Results showing significant ritual- and society-level predictors in the stepwise multi-level linear regression predicting dysphoric ritual arousal

Predictor	Coefficient	<i>t</i> value	<i>p</i> value
Frequency	−0.408	−7.161	<.001***
Duration	0.141	2.254	.024*
Initiations	1.180	6.151	<.001***
Other gatherings	−0.507	−3.513	<.001***
Agricultural intensity	−0.100	−2.392	.017*

Log likelihood=−889.5.

* *p*<.05.

*** *p*<.001.

Table 3

Results showing significant ritual- and society-level predictors in the stepwise hierarchical regression predicting euphoric ritual arousal

Predictor	Coefficient	<i>t</i> value	<i>p</i> value
Frequency	−1.189	−4.858	<.001***
Frequency ²	0.154	4.759	<.001***
Duration	0.334	7.193	<.001***
Other gatherings	0.303	2.609	.009**
Manipulating this world	0.184	1.968	.049*
Classical religion	−0.182	2.264	.023*

Log likelihood=−881.6.

* *p*<.05.

** *p*<.01.

*** *p*<.001.

group bonding at times of internal conflict (Dunbar, 2009). How effective are such rituals at promoting group cohesion and cooperation?

4.2. Variation across societies

As well as variation in individual ritual arousal ratings within cultures, we find substantial and significant variation between cultures, accounting for >20% of overall variation in euphoric and dysphoric ritual arousal. Focussing on this cross-cultural variation, those cultures with higher mean dysphoric or euphoric ritual arousal scores tend to engage in ritual activity less frequently in general. Together with the analysis of variation across individual rituals, this supports the expectation of the modes of religiosity theory that both rituals and broader religious systems — to the extent to which they can be characterized by frequency and emotional arousal — tend to cluster into two modes. As predicted by the modes theory, those cultures with higher average dysphoric arousal ratings also have smaller community size, less influence of classical religion (and the absence of moralising high gods) and less reliance on agriculture. Average euphoric arousal ratings are also higher for cultures with less influence of classical religion.

With the predictors combined in the multi-level analysis, agricultural intensity was the only significant society-level predictor of dysphoric arousal, whilst influence of classical religion was the only significant predictor of euphoric arousal. The patterns we see both within and between cultures indicate that quite different processes may be shaping euphoric and dysphoric arousal, suggesting a possible future refinement of the modes theory. One productive line of enquiry here may be to integrate more general findings from psychology highlighting differences between the way we process positive, 'good', vs. negative, 'bad', information and events (e.g., Baumeister, Bratslavsky, Finkenauer & Vohs, 2001; Russell, Gobet & Whitehouse, in press).

Interestingly, we find no effect of local or regional jurisdictional hierarchy on either dimension of ritual arousal. This may be due to a lack of statistical power — in both cases the effect of jurisdictional hierarchy is in the predicted

direction. However, since the modes theory predictions actually relate to hierarchy in the religious system, a more satisfactory test of this hypothesis may require a more detailed coding system that examines hierarchical structure in the religious tradition itself. The jurisdictional hierarchy variables were chosen as a proxy for hierarchical structure in a society in general, but it is possible that jurisdictional hierarchy at the societal level is decoupled from local religious hierarchy. The influence of classical religion or the presence of high gods may be better indirect indicators of the degree of hierarchy in religious systems themselves, in which case, the significant negative correlation between these variables and arousal offers some support for a negative relationship between arousal and degree of religious hierarchy. However, the effect of classical religion on dysphoric arousal is not significant in the full multi-level model. Rituals that are influenced by classical religions are associated with lower arousal in general, but this relationship is mediated by other factors — classical religion appears not to affect dysphoric arousal independently. By contrast, influence of classical religion does show an independent effect on euphoric arousal, controlling for other predictors.

Previous work applying signalling theory to male initiation rites suggests that traumatic rites can be interpreted as costly signals of group commitment, which appear to be especially prevalent among warring groups (Sosis et al., 2007). However, it is more difficult to account for the variation we observe in dysphoric arousal across rituals in general (as opposed to male initiations, in particular) in terms of a costly signalling explanation. Agricultural intensity is related to dysphoric arousal as predicted, but the relationship between dysphoric arousal and group size is not significant in the multi-level analysis and is significant in the opposite direction to that predicted in the simple society-level analysis. Likewise, we find no relationship between dysphoric arousal and the presence of warfare. Sosis et al. (2007) also found the opposite to expected relationship between the costliness of initiation rites and group size. As they suggest, this may be due to the fact that other mechanisms are used to facilitate cooperation in larger groups. One possibility consistent with a costly signalling explanation is that larger groups may use time investment (in the form of high-frequency rituals) as a signal of commitment rather than rare but intensely painful or unpleasant rituals. Whilst our failure to find a relationship between dysphoric arousal and warfare could be due to a lack of statistical power, the effect of warfare is nevertheless weaker than for other variables examined. It is unlikely, then, that dysphoric ritual arousal in general is the result of a need to provide costly signals of group commitment under conditions of warfare, even if initiations do perform this role. Indeed, our individual ritual analyses provide evidence for the uniqueness of initiations, which show particularly high dysphoric arousal levels, even accounting for their low frequency. This does support the idea that initiation rites, much more than other

ritual types, could function to establish and signal group commitment via costly signalling.

One of the most striking results of our cross-cultural analysis is that reliance on agriculture is a key predictor of variation in dysphoric ritual arousal. Our hierarchical regression analysis shows that after accounting for the other variables, it is intensity of agriculture that best predicts dysphoric ritual arousal levels across cultures. This is significant for a number of reasons. First, it suggests that differences in dysphoric arousal are unlikely to be simply the result of recent influence from classical religions, but reflect underlying differences between groups' social or ecological environments. Second, the importance of agriculture to ritual has implications for our understanding of the link between religious systems and means of resource acquisition and distribution, as well as to debates about the drivers of the agricultural transition at the beginning of the Neolithic.

The main drivers of the great transition from small-scale hunter–gatherer societies in the pre-pottery Neolithic to the vast and complex civilizations of East Asia, MesoAmerica and the Fertile Crescent are still much debated (Rothman, 2001; Stein 1999). Doubts have been growing with respect to the explanatory power of technological innovation, and attention has been focused increasingly on changes in social and symbolic worlds (Hodder, 2006). The first appearance of the doctrinal mode in human prehistory would seem to presage the first appearance of large-scale, hierarchical political systems in Mesopotamia and Egypt. Was this seismic shift in social evolution driven by a change from imagistic to doctrinal practices (Whitehouse & Hodder, *in press*)? Although the question of causality cannot be determined here, the link between agriculture and relatively low-arousal, high-frequency rituals in our survey of contemporary societies offers support for this hypothesis. Whereas the exploitation of wild resources requires only sporadic group co-operation (e.g., in hunting larger game), the domestication of animals and plants fosters increasingly routinized forms of collaborative labour (e.g., clearing, planting, harvesting and building). In traditional societies such activities are typically punctuated by rituals (Leach, 1954), especially where the risks of crop failure or pestilence are keenly felt (Sorenson, 2007a; 2007b). If the emergence of agriculture drives an overall increase in the frequency of communal rituals, it also indirectly opens up opportunities for other features of the doctrinal mode to appear (see above), including the homogenization of regional traditions and in time the emergence of professional priesthoods. Domestication may impact not only the themes of cosmology and religion (Lewis-Williams & Pearce, 2005), but also the way religious traditions are codified, transmitted and organized (Whitehouse, 2000). How such a shift might have been brought about is not yet clear. Was it the advent of literacy, as some have argued (e.g., Boyer, 2005; Goody, 2004), or on the contrary did the doctrinal mode precede and give rise to systems of writing (Johnson, 2004; Mithen 2004)? Using a similar set of predictors to those used here,

Sanderson and Roberts (2008) found that mode of subsistence and writing were both important predictors of their measure of level of complexity in the religious system. How this relates to our findings is not clear. We find no effect of writing on ritual arousal; however, we have information on writing for only a subset of our sample. Clearly, further data are needed to answer these questions.

5. Conclusion

We have shown that the morphospace of ritual frequency and arousal supports key predictions of the modes of religiosity theory. If correct, the theory reveals some of the main causes and consequences of religious diversity, past and present. Of course, the results presented here are necessarily correlational and so do not allow causal relationships to be tested directly. Additional experimental work is required to determine whether the proposed proximate psychological mechanisms are able to generate the patterns we observe. For example, it should be possible to measure and directly manipulate subjects' arousal during simulated ritual participation and test how this is related to memory formation and recall, ingroup vs. outgroup attitudes and cooperation, and motivation to carry out rituals.

Variation across cultures also fits the predictions of the modes theory and suggests that the appearance of low dysphoric arousal, high-frequency religious rituals may have been tied to the advent of agriculture. If so, new rituals, rather than other technological factors, may most convincingly account for the changes in the scale and structure of human societies that presage state formation and the emergence of large-scale civilizations. However, the mechanisms generating these cross-cultural patterns remain unclear. High-frequency, low-arousal religious systems are likely to have spread to the extent that they could facilitate group cooperation and resource control. This could equally derive from individual psychological and cultural transmission biases within groups and/or cultural selection between rival groups. A recent article by Bell, Richersons and McElreath (2009) used cross-cultural survey data to quantify within- vs. between-group cultural variation. They found that differences between neighbouring groups accounted for roughly 8% of the variation in cultural traits. Whilst this indicates substantial within-group variation, 8% cultural variation measured between groups is much higher than the 0.5% of genetic variation observed between groups. This, they argue, speaks to the greater potential for cultural group selection as a driving force in human evolution. The ability of particular ritual systems to promote ingroup cooperation or control could have provided a powerful competitive advantage over rival groups. Whilst the sparse sampling of cultures in our dataset means we cannot compare neighbouring groups, the 20% between-group variation we find in ritual arousal levels suggests there is the potential for large between-group differences on which selection could act. In

order to test a cultural group selection explanation, synchronic cross-cultural evidence on a more local scale than we examine here needs to be combined with diachronic data from archaeology or longitudinal studies on group survival and changes in ritual dynamics through time. Such data will also allow questions about rates of spread and probability of adopting different variants to be examined in detail.

Cataloguing cultural diversity, like cataloguing biological diversity, is a crucial first step towards understanding the variation we see around us and has received less attention than it should have in recent years. Untangling the causal relationships shaping this diversity is a complex task that will require a consilience of evidence from across multiple disciplines. As the rate of cultural transformation and borrowing increases on a global scale, documenting the outcomes of long-term processes of cultural evolution is more important and urgent than ever.

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.evolhumbehav.2010.09.002](https://doi.org/10.1016/j.evolhumbehav.2010.09.002).

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