Ritual Morphospace Revisited: The form, function, and factor structure of ritual practice

Rohan Kapitany[1, 2], Christopher Kavanagh[2, 3] & Harvey Whitehouse[2]

1. School of Psychology, Keele University.
2. School of Anthropology and Museum Ethnography, The University of Oxford.
3. Department of Psychology, Rikkyo University.

All correspondence should be sent to Dr. Rohan Kapitany, School of Psychology, Dorothy Hodgkin Building, Keele University, Keele, Staffordshire, ST5 5BG, UK; rohankapitany@gmail.com

Abstract

Human rituals exhibit bewildering diversity, from the Mauritian Kavadi to Catholic communion. Is this diversity infinitely plastic or are there some general dimensions along which ritual features vary? We analysed two cross-cultural datasets, one drawn from the anthropological record, and another novel contemporary dataset to examine whether a consistent underlying set of latent dimensions in ritual structure and experiences were detected. First, we conducted a factor analysis on 651 rituals from 74 cultural groups, in which 102 binary variables were coded. We find a reliable set of dimensions emerged, which provide potential candidates for foundational elements of ritual form. Notably, we find that the expression of features associated with dysphoric and euphoric experiences in rituals appear to be largely orthogonal. Second, we follow-up with a pre-registered factor analysis examining contemporary ritual experiences of 779 individuals from Japan, India, and the US. We find supporting evidence that ritual experiences are clustered in relatively orthogonal euphoric, dysphoric, frequency and cognitive dimensions. Our findings suggest there are important regularities in the diversity of ritual expression and experience observed across both time and culture. We discuss the implications of these findings for cognitive theories of ritual and cultural evolution.

 Key words: Ritual, Cross-cultural, emotion, anthropology, ritual modes, cultural evolution.

Introduction

Social scientists, historians, and archeologists have recorded a great diversity of human rituals from around the world. And in so doing, have identified features common across rituals, such as stereotypy, repetition, causal opacity, goal demotion, normative prescriptions, and orthodoxy [1–10]. But to what extent do these aspects of ritual behavior vary in a systematic way cross-culturally, and how robust is the dimensionality of ritual generally? Here, we present two studies that seek to address whether similar underlying factors of ritual emerge from two distinct contexts: first, a coded database of ethnographic ritual accounts, and second, a contemporary dataset of ritual experiences collected from 779 respondents in India, Japan, and the US. In Study 1 we conduct a theoretically agnostic factor analysis on an existing database of 651 rituals from 74 cultural groups. In Study 2 -- informed by the results obtained in Study 1 which broadly conformed to the Modes of religiosity theoretical framework [4] -- we restricted our preregistered factor analyses to four key factors, examining whether they emerge from a survey of contemporary ritual experiences collected from individuals in India, Japan, and the US.

In using a factor analysis, there is no expectation that the results will produce a sensible factor structure, so our primary research question was whether the latent variables extracted will be distributed randomly or, as we expect, form clusters that can be interpreted sensibly in light of existing theories. Based on the results of study 1, in study 2 we aimed to address whether the factors extracted accord with those outlined specifically in Modes theory [4]. Our two studies address different time periods (recent history and the contemporary era) and approach ritual experiences at different levels of analysis; with study 1 focusing on analysis of second-order coding of recorded ritual accounts and study 2 focusing on self reported ritual experiences. This increases the potential that different factors will emerge between the two studies, but may also provide converging evidence reflecting core recurrent aspects of ritual morphology.

Ritual in the context of Tinbergen's Four Questions.

We understand ritual to be a special category of social action that includes a) predefined sequences of action characterised by rigidity, formality, and repetition, which is b) embedded in systems of meaning and symbolism, and which c) contains non-instrumental elements (that is, causally opaque and goal demoted elements) [9]. A full discussion of alternative definitions is beyond the scope of the present article but the definition we employ here (and most other definitions available) describe ritual at a level beyond that of concrete features. What we hope to do is to begin to describe the 'morphospace' of ritual form, which we construe as analogous to the phenotypic features common to the ritual 'family' of behavior, in which many diverse expressions

exist within respective 'genus' and 'species'[1]. In so doing, we hope to provide broader foundations upon which further empirical study can address the ontogeny, phylogeny, mechanism and adaptive features of ritual.

The level of coherence in the category of ritual is an issue that remains under dispute. Some scholars regard the category of ritual as too broad to be useful, see for instance Boyer and Leinard (in press; this issue) who argue that "*Ritual … is used to denote disparate forms of behavior, on the basis of a faint family resemblance*". Others, however, suggest there is a typology [11] and shared psychological components [9]. These are issues that are empirically tractable and upon which our present investigation can shed some light. In principle, a description of ritual focusing on the phenomenological morphology allows for a more fine-grained and complementary analysis of what ritual may be, the role it plays, and how it emerges. For example, also in this issue, Nielsen, Langley, Shipton, & Kapitany (in press; this issue) discuss ritual and ritualised action among *Homo neanderthalensis*, specifically addressing the phylogenetic and adaptive qualities of the phenomenon in the prehistoric record. But theirs, and indeed anyone else's, discussion of the ontogeny and life-history of ritual -- which in this case relate to an early emerging capacity for ritual cognition via the expression of over imitation [12] and the ritual stance [8,13–15] -- must be clear on what the concrete dimensions of the phenomena are.

Ritual morphology and theories of ritual form.

While the range of possible forms that ritual could take is potentially limitless, the forms that actually stabilize and are passed down through the generations in cultural traditions are shaped and constrained by features of human cognition, including intuitive biases, memory capacities and emotional systems [3,6,7,16]. Rituals are also constrained in various ways by the demands of wider social environments in which they form, often performing useful social functions ranging from the regulation of family life to the integration of entire political systems [17,18]. As a result of these shaping and constraining factors, rituals that survive and flourish in cultural traditions tend to cluster around discernible attractor positions in the morphospace of all possible ritual forms.

There are several well developed theories of ritual form, including 'modes of religiosity' [4], McCauley and Lawson's [19] 'ritual form hypothesis', Schjoedt et al's 'cognitive resource depletion' model [20], as well as anthropological theories associated with *collective effervescence* [21] and *communitas* [22]. Consider that McCauley and Lawson [19] argue that rituals are structured in such a way that agents and patients (respectively, those executing the ritual, and those being acted on by a ritual), objects, and actions must be delineated from ordinary people, objects and actions by way of 'S-Markers' indicating supernatural efficacy. For example, some rituals can only be correctly performed by a priest or a shaman who are supernaturally empowered to act; one

---

[1] We caution against an overly literal interpretation of this analogy, as culture and biology do not have a perfect correspondence. However, inasmuch as we might recognize that rituals within the islamic tradition share commonalities, or that weddings rituals from diverse faiths also share commonalities, the analogy is conditionally apt.

cannot simply swear on a book, one must swear on a holy book because of its supernatural properties. Our data ought to reveal whether cultural rituals require such special status items: that is, the latent factors which emerge might constitute specific categories of S-marked features, or, might a singular S-marker factor might emerge in which multiple s-marked objects load. Meanwhile, classic perspectives in anthropology suggest that rituals ought to generate 'collective effervescence' [21], which may be recognizable by way of social, physical, or psychological pageantry; factor analyses may reveal dimensions corresponding with one, or more, 'pageantry' factors.

'Modes of religiosity' is perhaps the most empirically well described theory to date, and it makes a structural claim about ritual form: rituals will trend towards high-arousal, low-frequency morphologies ('imagistic'), or low-arousal, high-frequency morphologies ('doctrinal') [4]. The former occurs infrequently (paradigmatically only once a lifetime, or once a generation) and are often intensely dysphoric (e.g. arousing considerable negative affect via painful or terrifying experiences). Doctrinal rituals, by contrast, are very frequent (sometimes occurring many times a day or a week, and at least as often as multiple times a year); they are also less emotionally intense than imagistic rituals and may even be quite tedious. This predicted ritual structure, however, is probabilistic rather than law-like and so -- while many confirmatory examples exist -- there are notable exceptions. Consider, for example, Pentecostal Christian traditions which are both [euphorically] intense and highly frequent [23]; while divinatory rituals [24], which may involve infrequent participation, arouse only low emotional responses. Thus, the modes theory of ritual form tends to describe two 'attractor positions' which account for ritual form at the aggregate level.

Atkinson and Whitehouse [5] curated a database of 651 rituals from the ethnographic record which were coded for 102 variables. The database was specifically designed to test the modes theory, but also coded for the presence or absence of over 100 other variables qualities). Correlational analysis found that ritual frequency is negatively correlated with measures of 'arousal' (rho = -.40), and that the relationship is stronger for dysphoric (rho = -.41) than euphoric experiences (rho = -.08)[2]. The data suggest two distinct relationships between dysphoric and euphoric arousal and frequency. Broadly speaking, there is an incremental increase in dysphoric arousal for each reduction interval in frequency with the rate of increase holding steady over daily, monthly, seasonal, and annual ritual events, thereafter, roughly doubling for less-than-annual, and doubling again for once-in-a-generation rituals. Euphoric arousal, on the other hand, displays a similar increase as frequency reduces from daily to annual rituals, but after that the trend reverses and arousal scores decrease for less-than-annual and generational rituals. Overall, the relationship between emotional arousal and frequency was consistent, with the most infrequent events, such as initiations, displaying highest arousal scores (for both euphoric and dysphoric dimensions), while more frequent rituals demonstrated lower arousal scores [5] (p. 55)

---

[2] All results discussed are significant unless otherwise indicated.

Study 1. A high resolution examination of ritual modes in the anthropological record.

In Study 1 we re-analysed the dataset created by Atkinson and Whitehouse [5] based on data from 74 cultures extracted from the electronic Human Relations Area Files (eHRAF) database. These rituals were drawn from the 'Probability Sample Files' (PSF), which have been specifically curated to avoid issues of non-independence in the data [25]. For full details on the nature of the data, see Atkinson and Whitehouse [5]. Each ritual was coded as belonging to one of 17 categories (a list is available in Table S9), and a total of 102 elements were coded for whether they were present/absent based on the anthropological record. Using only these binary values, we conduct a factor analysis to determine whether there is an apparent set of dimensions of ritual form that emerges from the cross-cultural ritual dataset.

Analysis

Factor analyses of binary data[3] requires a different approach than for continuous or ordinal data. Best practices and simulation studies show that polychoric matrices are most appropriate, as they produce the most accurate measures of correlation and loading values, but unavoidably produce suboptimal measures of fit [27–29]; equamax rotations maximises correct grouping of binary variables and minimises incorrect grouping [30]. Thus, we executed a factor analysis using a polychoric correlation matrix [27,29,31] with Equamax rotation with a loading threshold of .4. We attempted recommended factor extraction rules [32,33], but of all attempted analyses, these rules produced values that had the worst fit and explained the least variance (see: 34,35).

We analysed all data using R. Each of the 651 entries was randomly allocated to either an Exploratory or Confirmatory analysis dataset, a process known as cross-validation [36]. In total 325 rituals constituted the EFA dataset, while 326 constituted the CFA dataset. In some cases, instances of reported behavior were low in the complete dataset, and the randomization process created some variables that had zero-frequency in one of the randomized sets. For the sake of analytic assumptions, any variable that had zero-frequencies were omitted from both datasets. Within the data presented here, six variables were omitted (the number in parentheses is how many times these features showed up in the complete dataset): Short duration (n=0), scarification (n=1), sucking of

---

[3] Two instances of continuous data were were coerced into a binary form. The 4-level *'duration'* variable (short, medium, long, extended) was dichotomized into single variables - we noted no 'short' values, and so we created three mutually exclusive binary variables (e.g., medium = 1/0; long = 1/0; extended = 1/0). *'Typical Frequency as patient'* and *'... as participant'* (7-levels) was recorded into *'occuring once a year or less frequently'* (1), or *'more often than once a year* (0). The 4 measures of *average* and *peak* positive and negative arousal was recorded in a continuous/ordinal format, which we modified to simply reflect whether or not the *average* and *peak* arousal was either more euphoric (1) or dysphoric (0). All empty cells were imputed with a '0' (absent). The reasoning for this decision is that if the qualitative anthropological record failed to describe it, we can reasonably infer that it was not present, or not relevant in the judgement of expert anthropologists. Per a recent publication, [26], we do not belief Laplace's indifference principle can be applied here to sensibly arrive at a value between present and absent. We omitted all qualitative data.

patient (n=3), disgust (n=1), human sacrifice (n=4), a smoking taboo (n=2). Both the EFA and CFA dataset contained 96 common features of ritual[4].

Our approach identifies whether variables reliably load onto similar factors across the EFA and CFA, thus revealing whether the items have 'stability' [34]. However, given that the dataset was not compiled for this analytical technique explicitly, we conduct additional analyses to rule out other interpretations.

Results

The EFA suggested an 11-factor solution which explained .50 cumulative variance, in which the RMSR was .06 (lower than the .08 threshold), and the RMSEA was .117 (greater than the .08 threshold). The CFA was constrained to 11-factors. It explained .51 cumulative variance, in which the RMSR was .06, and the RMSEA was .118. While each model contained 11 factors, only the first seven had items common to both analyses. Figure 1 shows the proportional and total variance explained in both the EFA and CFA. Table 1 reveals which items were common, and their respective loading values (statistics for factors 8 - 11, and item loadings for all items, are reported in the supplementary material A). We conducted a range of follow-up analyses (available in supplementary material B) in which we tested for factor structure of 1) simulated datasets, 2) random samples of the present dataset, 3) by mode/frequency of the ritual, and 4) whether or not the factor structure was a consequence of the over-representation of particular category of ritual. The present model vastly outperformed all alternatives.

Figure 1. Proportional and total variance accounted for by factors with common loadings.

---
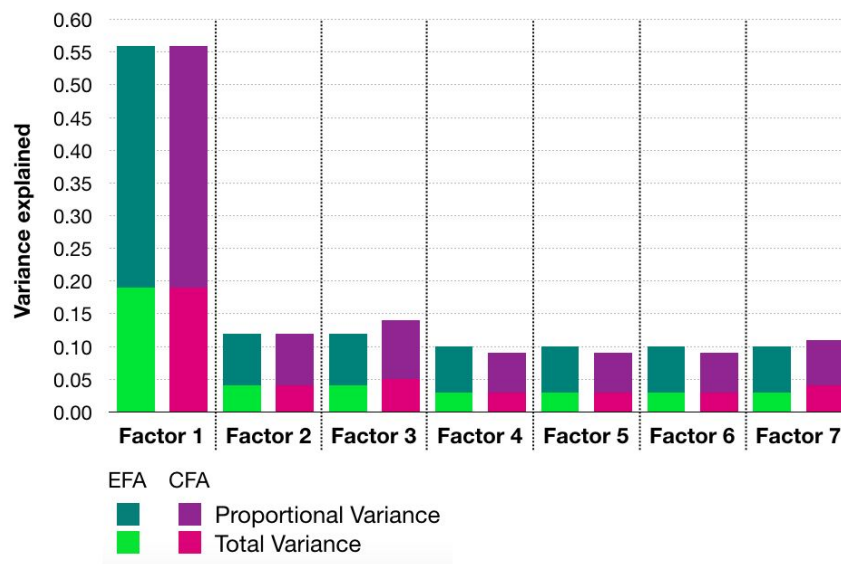
[4] Due to the random nature of allocation, these values may change between iterations.

Note: *Values in Figure 1 are stacked, not superimposed. Thus, the total variance explained by factor 1 in the EFA is .19, and the proportion of the variance explained in the model is .37 (not .56).*

Table 1. Factors and item loadings for items that loaded in common on both EFA and CFA datasets.

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
'Dysphoric Elements'	'Euphoric Elements'	'Pageantry - Physical'	'Viscera'	'Pageantry - Psychological'	'Frequency'	'Kin'
Other (catch-all) negative Humiliation The burning of participants, Tattooing, Vomiting, Laceration of sensitive areas, Mental ordeals, Piercing, Swallowing of objects (not eating), Large scale music & dance.	Average euphoria (.70; .75) Peak euphoria (.66; .82).	Dancing (.83; .61) Percussion (.72; .68) Intense music/dance (.46; .53) Singing (.46; .65).	Blood (.59; .66) Animal Sacrifice (.71; .63)	Burning Offerings (.51; .51) FireEmbers (.50; .47) Stimulants (.48; .54) Hallucinogen (.47; .54)	Annual participation (.69; .69) Annual (as patient) (.68; .64)	Extended Kin (.63; .72) Immediate Kin (.72; .45)

Note: Factor 1 had a total of 37 items common to the factor in both datasets (see table S1) for brevity's sake we list the 10 with the highest loadings in each dataset. All other factors are complete.

Discussion

We find support for the claim that rituals have a coherent underlying dimensionality as the factors extracted, are for the most part, interpretable. The extraction of dysphoric and euphoric factors and the amount of variance they accord for is in line with ritual theories that focus on emotional arousal and pageantry, especially Modes theory, or those that focus on costly signals [20,37]. Factor 1 contains items that arouse negative affect and are consistently dysphoric (and explains .19 of total variance explained), while factor 2 (which accounts for .04 of total variance) contains items related to positive affect that are generally euphoric in nature. Factor 3 - dancing, singing, percussion, and intense music - items are neither clearly positive nor negative, and may suggest that 'pageantry' does not skew valence in either direction but instead may serve as an intensity multiplier. Factor 5 appears to describe a kind of psychological pageantry associated with inebriation and altered states of consciousness - drug use and fire use are speculated to have played an important role in prehistoric rituals [38,39]. Factor 4, the 'Viscera' factor explains around .03 variance, and is somewhat like the pageantry factor in that is, a priori, neither clearly positive nor negative. Factor 7, which explains around .04 variance, relates exclusively to kin; here it is notable that group size variables (*2 - 3 people, < 15 people, less than half the community, more than half the community, and most of the community)* did not load on this factor.

We also note that some variables of theoretical interest did not appear to reliably load on any given factor (or weakly cross-load in any meaningful way), specifically elements that relate to semantic information or explicit

symbolism, such as the recitation of text(s), speechmaking, and the presence of holy texts or holy objects. This does not count as disconfirming evidence of McCauley and Lawson's hypotheses that rituals require S-Markers, however our data provides no support for this claim. We note however that only a few such special item variables were included in the database and therefore avoid drawing any strong conclusions.

The factor analysis suggests that negative and euphoric elements are not oppositional but orthogonal within rituals (the correlation within each ritual for intensity scores on *peak* euphoria and peak dysphoria across all rituals r = .01, *ns*; while the correlation within each ritual between *overall* euphoria and overall dysphoria is r = -.16, *p* < .001). This analysis indicates that while there is a weak negative correlation, rituals may contain both dysphoric and euphoric elements and that it is the relative proportions from each factor that may produce dysphoric or euphoric rituals. A wedding, for example, is frequently described by its participants and patients as being positive, though the participants also describe the experience of the event as provoking anxiety. Similarly, even dysphoric rituals (such as hazings or initiations) eventually give way to relief, and may be experienced, or evaluated in hindsight, as positive [40]. All of this is to illustrate the point that positive and negative affect can co-exist *within* a ritual and may in fact become more pronounced *after* the ritual as individuals reflect on their experience [40]. Atkinson and Whitehouse [5] demonstrated negative correlations between emotional arousal and frequency, but as previously discussed this relationship varied between euphoric and dysphoric arousal *overall*. Taken together, these findings suggest that any model that attempts to quantify rituals as expressed along a single axis of emotional arousal (where dysphoric and euphoric affect are treated as oppositional poles) is underspecified. This relates to an ongoing debate amongst emotion researchers (see: 41–43) as to whether negative and positive affect are bipolar or independent [44,45]. Our results align with the summary presented by Schimmack (2008) that positive and negative affect "are clearly separable components of affective wellbeing, although they may not be strictly independent" (p. 113; 46].

Our analysis suggests the presence of seven factors, which broadly accord with prominent theories related to the dimensionality of ritual form. It was possible, prior to analysis, that several alternative structures might have been revealed (see supplementary material B for additional alternative analyses). One was that euphoric and dysphoric elements would negatively load on the same factor (which would support a unitary, bipolar conception of arousal). A second possibility was that each factor might generally correspond with a given ritual type, such a wedding-factor, a funeral-factor, an initiation-factor, and so on. Third, it was also possible that such an analysis might not reveal any sensible structure, and that dimensionality and morphotype of rituals as relatively unconstrained and arbitrary. Instead, we observed distinctive valence factors, and factors that correspond to physical and psychological pageantry. Alongside their correspondence with recent cognitive models of ritual, these factors also relate to classic anthropological frameworks that focus on rituals' ability to generate *collective effervescence* [21] or *communitas [22]*. The viscera and kin factors are intriguing but do not immediately appear to correspond with existing frameworks.

Overall our findings suggest that the form of ritual cross-culturally is canalized by cognitive and potentially environmental and social constraints and that therefore the 'morphospace' of ritual form is constrained along meaningful joints, including notably dysphoric elements, euphoric elements, as well as physical and psychological pageantry. While we acknowledge that factor solutions are imposed structures, and may not necessarily correspond with the 'true' structure of the phenomenon, we suggest that the empirically revealed factors including those of 'pageantry', 'viscera', and 'kin' ought to be considered worthy of future investigation (weighted for their relative contribution to the overall model), and we encourage other authors to incorporate these dimensions of ritual structure in future theorizing.

Study 2. An examination of contemporary ritual accounts?

Study 1 examined ritual structure using an unconstrained factor analysis that identified seven components among ethnographic accounts of ritual morphology. In Study 2 we apply a similar analysis to contemporary accounts of collective ritual experiences in three countries: the US, India, and Japan. These countries were selected as they are geographically and culturally distinct with ritual traditions that revolve predominantly around Christian, Hindu and Buddhist/Shinto traditions, respectively. Pragmatically, they also have urban populations that are easily accessible via online data collection platforms. The samples represent a mix of population contexts with US participants providing a mix of non-religious and religious, Indian participants predominantly representing Hinduism, and Japanese participants demonstrating an orthopraxic mix of non-religious and Buddhist/Shinto. Although there is inevitably some overlap and cultural cross-fertilization between these countries, including in seasonal ritual celebrations (for example: Diwali in the US, Christmas in Japan), we anticipated that broadly they represent a diverse collection of ritual environments. Moreover, we concur with the anthropologist Roy Rappaport's declaration that "no society is devoid of what a reasonable observer would recognize as ritual" (p. 31; [47].

Sampling from such diverse environments we collected self-generated collective ritual accounts and asked people to rate the experiences they described on a variety of self-assessment metrics (described below). To increase the diversity of experiences described and to capture both infrequent and common rituals we asked participants the same sets of questions in relation to 1) the most memorable collective ritual they had experienced and 2) the collective ritual they perform most frequently. We focused on *collective* rituals to try and decrease the amount of idiosyncratic personal routines described.

Given the findings of Study 1, the significant existing empirical work on Modes theory and the framing of our ritual prompts around frequent and memorable rituals, in this study we imposed an anticipated structure on our factor analysis specifying four factors that accord with the theoretical model of Modes theory but also relate to the 'Cognitive resource depletion in religious interactions' [20], and McCauley and Lawson's 'ritual form hypothesis' [19]. We preregistered our expectations for the factors that would emerge which we categorised as:

1) dysphoric (negative affect), 2) euphoric (positive affect), 3) frequency, 4) cognitive (a factor pertaining to semantic knowledge or ritual exegesis in line with the prominent theories of ritual cognition indicated above). In line with Study 1 we expected euphoric elements to load onto a separate factor from dysphoric elements, rather than to load in a n oppositional manner on the same factor.

Methods

Study 2 was pre-registered. We aimed to collect data from at least 200 individuals in three different countries - the United States, Japan, and India (for a total minimum N=600) to serve as a contemporary dataset that we could compare with the ethnographic data examined in study 1. Participants were recruited on Amazon Mechanical Turk (US/India) and lancers.co.jp (Japan) which are both online crowdsourcing platforms in which anonymous participants complete short tasks for payment. Participants were asked to provide demographic information and were prompted to define - in their own terms - what a 'ritual' is, and to self-generate a list of five rituals. We then asked participants to report on two of their own ritual experiences: 1) the most memorable *collective* ritual they had experienced and 2) the *collective* ritual they perform most frequently[5]. We avoided any reference as to the emotional valence of the ritual experiences, but our questions did weakly orientate responses along an axis of frequency (although, notably, we did not prescribe that the memorable ritual ought to be infrequent or intense). Participants then provided ratings of each experience on 27 focal variables, including items that related to procedural details, emotional response, frequency of performance and levels of reflection. All quantitative measures were collected on a 100-point sliding scale (full methods and pre-registration file are available in the supplementary material C).

Results

Three datasets (one from the US, Japan, and India) were collected. We over-sampled, anticipating the need to remove participants who failed to complete the task in sufficient detail. In each location respectively, a total of 417 (US), 378 (Japan), and 339 (India) individuals began the survey. The cleaning process was the same for each dataset. First, participants who did not complete at least 85% of the survey were removed (total participants removed for insufficient data, US: 104; Japan: 94; India: 88), then participants who completed the survey in less than 10 minutes were removed (US: 15; Japan: 0; India: 54; the expected duration of the survey was 25 minutes). After removal of the fastest participants the mean duration in the US was 27.73 minutes, in Japan it was 31.05 minutes, and in India it was 35.58 minutes. The final dataset contained 779 individuals (US: 298; Japan: 284; India:

---

[5] We note that by allowing participants to select rituals based on their own understanding of the term that we ended up collecting data in which participants reported some events, like family meals or drug-taking, as rituals. The vast majority of responses describe weddings, funerals, initiations, and cultural events. We have not excluded responses that seem less definitionally ritualistic, as they constitute only a minority of responses, and that if the participant suggests categories such actions as being ritualistic, then they likely share consequent features and cognitions associated with rituals. Our data is available for review.

197). The US dataset contained 162 females and 134 males (2 undisclosed), and the mean age was 35.8 years. The Japan dataset contained 142 females and 141 males (1 undisclosed), and the mean age was 39.1 years. The India dataset contained 60 females and 132 males (5 undisclosed), and the mean age was 32.3 years.

We used attention checks not as an exclusion criteria but as an indicator that the responses should be checked for the quality of responses, as previous research suggests they are an unreliable indicator of overall quality. In the US 78 (of 298) failed a single attention check, in Japan 54 (of 284) failed a single attention check, and in India 48 (of 197) failed both attention checks[6], and 90 failed one of the two attention checks. We examined whether those who failed the attention check varied from those who passed in systematic ways. Thus, we categorized all responses as belonging to either the imagistic or doctrinal modes per the question prompt. We conducted an ANOVA on the following key variables for each mode, within each country: *Intensity*, whether the ritual was considered *routine*, how *consequential* the ritual was to the participant, how many *times participated*, and how well the participant *remembered* the experience. We used a corrected p-value of .003 for these 15 analyses for (as there are five analyses for each 'mode' for each country; though results do not change with an uncorrected value). Full results are available in supplementary material D, suffice to say here that we found no differences among US and Indian responses, respectively, and only one difference amongst Japanese responses (the 'routine' variables was significantly different between modes). Given that there was no systematic pattern to the observed differences between those who passed and failed attention checks, we have opted not to exclude participants (who surpassed more basic exclusion criteria).

Per our pre-registration (https://osf.io/m7hca), we constrained our analyses to four factors using an 'oblimin' rotation. Figure 2 shows the loadings of the 27 focal variables, and on which factor they loaded. Darker colours load above the threshold of .5 (or below -.5) and can be regarded as the revealed factor structure (a complete list of factor loadings are available in table S12 in supplementary material E). A parallel analysis indicated the appropriateness of a four-factor model as there were four values above the 1.0 threshold; the χ^2 = 3893.85, *p* < .001. The RMSEA = 0.096 (90%CI: 0.092 - 0.098) while the RMSR = .04. The model explains .50 total variance overall. The Euphoric and Cognitive factors correlate at .39, while all other correlations < .17 (absolute).

Our pre-registered hypotheses were largely supported however, contrary to our prediction, participant's evaluation of positivity (during the event and after the event, respectively 'then' and 'now') negatively loaded on the dysphoric factors. Despite this an independent euphoric factor still emerged (with drug use and inebriation also loading strongly; see table S12 for comprehensive values). The predicted frequency factor was observed, as was a cognitive factor, with the expected additional loading of memory quality. Intensity and Attention also co-loaded on the cognitive factor and not on the dysphoric factor as predicted. While we in no way are making a post hoc claim to prescience of this, these loadings are interpretable within the current findings. As with study 1,

---

[6] The US and Japan both included only one attention check, but the Indian sample included two.

we note that 'religiosity' did not reliably on any factor, and somewhat contrary to study 1, drug use and inebriation loaded on the euphoric factor.

Figure 2. *The revealed and predicted factor structure and item loadings.*
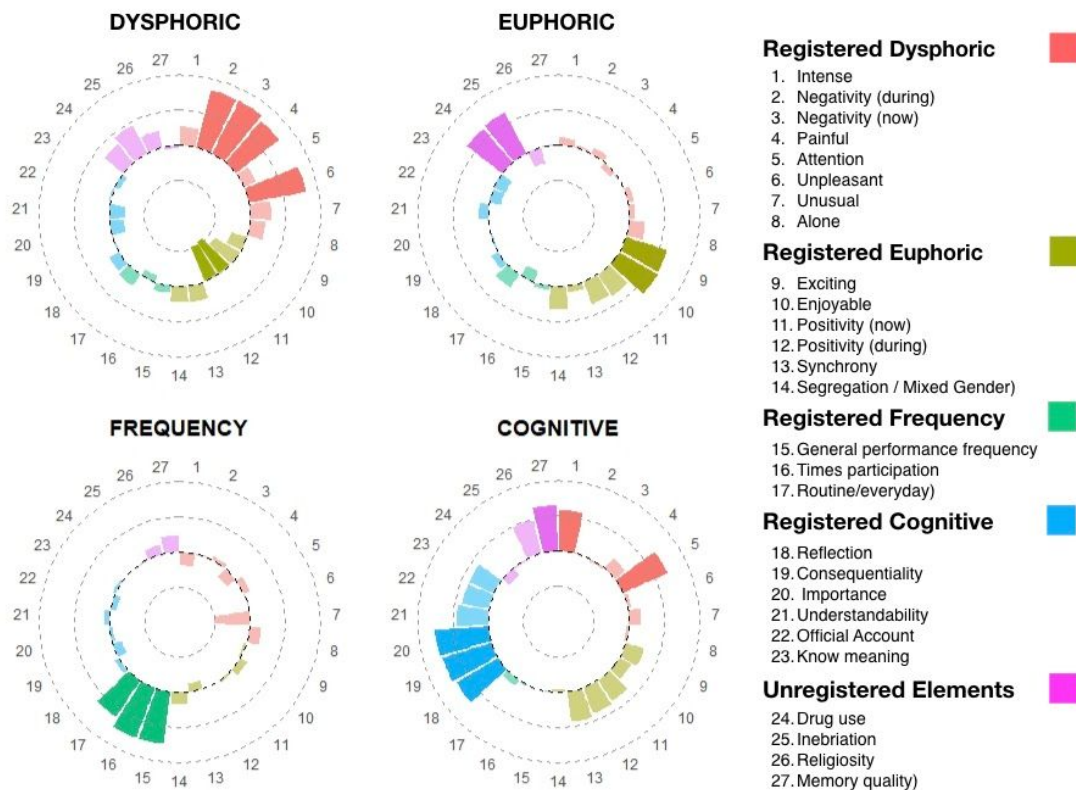
Note: The Dysphoric Factor explained .16 variance; the Euphoric factor explains .09 variance; The Frequency factor explained .16 variance; the Cognitive factor explained .08 Variance.

Discussion

We pre-registered the prediction that four factors would emerge; we predicted a euphoric and dysphoric factor, as well as a frequency factor, in line with the findings from study 1 and modes theory; we also anticipated a 'cognitive' factor based on modes and other prominent theories of ritual cognition (see: 19,20). Study 1 suggested that viscera, kin, and pageantry were relevant dimensions of ritual forms but we did not expect this pattern to emerge in study 2 due to the significant distinctions in cultural settings between the small scale tribal societies that are represented in the ethnographic data and the contemporary samples in this study being drawn from online, predominantly urban respondents. Rather, we anticipated and predicted the most empirically well supported

factors of ritual structure to emerge. In this regard we expected dysphoric and euphoric dimensions to emerge, as well as a dimension of frequency. We also included a fourth 'cognitive' dimension due to the emphasis placed on ritual reflection and meaning-making in prominent theories of ritual structure and function, whether 'spontaneous exegetical reflection' or semantic doctrinal knowledge as per Modes theory [4], an 'inferential gap' per the cognitive depletion model of religious interactions [20].

Two points need to be made with regard to the correlation between the euphoric and dysphoric factors (r = .4). First, study 1 used an equamax rotation - which maximises correct grouping of binary variables and minimises incorrect grouping [30] - which is an orthogonal method of rotation. Based on the nature of the data used in study 1 (collected ethnographic accounts which were systematically coded) we believe this decision was justified. However, the change in the level of analyses between coded elements of rituals accounts and the experience of rituals at an individual level meant that such an assumption is not tenable for the data in study 2. As such in study 2, we used an oblimin rotation which permits correlation between factors (though does not require it). The second point, is that the two factors are positively correlated. Broadly put, increasing scores on 'euphoric variables' positively predicts increasing scores on 'dysphoric variables'. This supports the view that both euphoric and dysphoric emotional arousal contribute in a mutually reinforcing manner to the overall level of emotional arousal of a given ritual.

General Discussion

 In our abstract we posed the following question: to what extent do aspects of ritual behavior vary in a systematic way cross-culturally, and how robust is the dimensionality of ritual generally? This is an important question as the level of variation across 'ritual' contexts can appear extreme, encompassing the bloody human sacrifices of the Aztecs in Mesoamerica and the intense piercing *Kavadi* rituals performed during Tamil Thaipusam festivals, alongside the solemn and subdued performance of Catholic communion and the silent daily performances of Islamic prayer (*salat*). We recognise each of these examples as 'rituals', but should we? Our results suggest that despite the diversity found in the expression of ritual morphology there are detectable structural features that are, at least to some degree, recurrent in both ethnographic and contemporary ritual accounts.

We show that by examining the features of a ritual (such as the presence or absence of 102 possible variables - including holy texts, fire, blood, singing, and various kinds of taboos) there is a dissociable set of latent structures in which euphoric, dysphoric, and frequency related elements aggregate with other similar variables. But also that there are dimensions of both physical and psychological pageantry which are related with classical anthropological ritual frameworks such as that of *collective effervescence* [21] or *communitas* [22], while dimensions associated with viscera, kin and cognition also emerge. However, we note that in both ethnographic and contemporary datasets it was the dysphoric factor that accounted for the largest share of variation in our

measures. This suggests that the emphasis placed on dysphoric rituals by Modes theory, costly signalling theories, and Automatic accrual theory is warranted [37,48,49]. Our results indicate that neither geography nor ritual function (such as marriages, funerals, initiations, and so on) provide a coherent explanation of the factor structure observed.

There have been many previous attempts to categorise rituals and many such efforts have focused on their social and psychological functions. Our findings do not contradict the utility of such frameworks but rather indicate that in future exploration of rituals it is important to give due consideration to the factors identified in study 1. This is not, however, to suggest that each of the factors identified will be equally relevant in all contexts. As the results of study 2 demonstrate, restricting dimensionality to a smaller number of factors can still produce meaningful outcomes. Our recommendation therefore is that researchers consider the dimensions relevant to the rituals they are examining. We do however recommend that across all contexts researchers should distinguish both dysphoric and euphoric features of ritual events (study 1) and euphoric and dysphoric dimensions of *subjective* responses to the ritual experiences (study 2). Our results, in line with other recent examinations of dysphoric ritual events, indicate that this is a crucial distinction even if positive and negative affect interact positively to establish overall emotional arousal ([5;50], Chapter 8).

However, the data examined are not without limitations and these are important to acknowledge. In study 1, the presence or absence of a given feature was extracted from the anthropological record. In the past,, anthropologists typically did not record what was absent (save for unique instances in which an absence was conspicuous, say, a wedding in which a bride was absent), while some features may have been present but not recorded, depending on the depth and breadth of the anthropologists work' research interests and the relevance of cultural features to their goals (e.g., if a fire was present for instrumental or tangential reasons it may not have been recorded). Thus, study 1 should be regarded as an agglomeration of *salient* features of ritual, acknowledging that the absence of a feature may not correspond with a real absence, but rather its diminutive or tangential role in the target of investigation. Moreover, the method of analysis in study 1 (known as cross-validation [36]) involves randomly splitting a large dataset into two parts, 'exploring' possible models in one dataset, and 'confirming' in the other. This terminology is misleading; we prefer to conceive of the findings as 'reliable', and given that we were looking for commonality of variables in specific factors across the two datasets (rather than attempting to clearly delineate variance accounted for) we recommend a cautious interpretation. Given also the size of the dataset, randomly splitting the data in half can produce datasets of unequal size, which may require cleaning (i.e., the removing of variables from both dataset if a variable has no instances in one of the two datasets), and as such, results may vary over iterations. Again, this leads us to recommend a cautious interpretation, and to regard the present results as requiring further verification. Additionally, while we claim that factor analysis is agnostic to theory, it is the case that the dataset we used was originally compiled to test hypotheses associated with modes theory and this likely skewed the variables examined. That said, given that 102 variables were coded, we judge the

list of features examined to be overall quite comprehensive, but invite interested scholars to examine the relevant items and judge for themselves if any significant feature was overlooked .

Additional limitations are apparent for study 2. Data were collected from a total of 779 individuals from Japan, the US, and India - across 27 variables - and were analysed according to a pre-registered plan. We acknowledge that there was a degree of correlation between the factors, and that the explicitly euphoric factors ('positive then' and 'now') also loaded negatively onto the dysphoric factor (though the 'euphoric' elements still better constituted a separate 'Euphoric' factor). It is also possible that the factor structure observed is not unique to ritual contexts, but rather a function of the specific items measured: that is, it could be argued that there are euphoric, dysphoric, frequency, and cognitive dimensions to most experiences. We acknowledge this issue and encourage ritual researchers, when possible, to examine theoretical models in non-ritual 'control' contexts. We recognise this to be an aspect missing from the current paper but hope that our dataset may be useful as a comparison for other researchers. We also note that while rituals represent an interesting category of social action, it is not the case that they are entirely distinct from all other kinds of social action, indeed rituals are often embedded in larger social contexts. Yet despite this there are important distinctions and we have no reason, for example, to imagine that the emotional intensity of a ritualistic ballet performance of *Swan Lake* should be inversely related to its frequency of performance. Nor do we have good theoretical motivations to anticipate that *Swan Lake* performances will generate predictable responses in terms of reflection and group bonding. Thus, although the dimensions identified may represent a generalized set that relate to social action broadly, we argue that they apply more specifically to ritual settings.

Future direction of this line of enquiry may involve examining exactly how rituals - either at the level of individual rituals, or the level of ritual-category - cluster within the morphospace. Herein, we have shown that there is likely dimensionality to rituals, but analytical work mirror that of [51], who demonstrated how four categories of song (Dance, Healing, Love, and Lullaby) common to 86 cultures not only exhibit a reliable structure along three dimensions (analogously corresponding to the seven dimensions of ritual presented here), but that those songs cluster in possibility-space in such a way that they are commonly closer to same-category songs than songs from other categories. We have laid the ground work for such analyses, and hope that more tailored datasets can be generated, and such analyses may be conducted.

In conclusion, our results acknowledge the existence of dimensions of ritual structure - dysphoric and euphoric arousal, physical and psychological pageantry, viscera, and kin which provides us with a better understanding of the 'morphospace' of ritual form. Having provided this tool, we hope that researchers may be better equipped to focus on addressing questions of ritual ontogeny, phylogeny, mechanism, and adaptiveness in a more calibrated manner. Put another way, we hope to have offered a complementary diagnostic tool that describes the features of ritual at the taxonomic level of the 'family', allowing for a diversity and categorisation of

ritual expressions at the analogous levels of 'genus' and 'species'. Our data and code are made public for reviewer and reader inspection (https://osf.io/undx8/).

References

1. Legare CH, Souza AL. 2012 Evaluating ritual efficacy: evidence from the supernatural. *Cognition* **124**, 1–15.

2. Nielbo KL, Sørensen J. 2016 Attentional resource allocation and cultural modulation in a computational model of ritualized behavior. *Religion, Brain & Behavior*. **6**, 318–335. (doi:10.1080/2153599x.2015.1087420)

3. Kapitány R, Kavanagh C, Whitehouse H, Nielsen M. 2018 Examining memory for ritualized gesture in complex causal sequences. *Cognition* **181**, 46–57.

4. Whitehouse H. 2004 Modes of Religiosity and the Cognitive Science of Religion. *Method & Theory in the Study of Religion*. **16**, 321–335. (doi:10.1163/1570068042652310)

5. Atkinson QD, Whitehouse H. 2011 The cultural morphospace of ritual form. *Evol. Hum. Behav.* **32**, 50–62.

6. Boyer P, Liénard P. 2006 Why ritualized behavior? Precaution Systems and action parsing in developmental, pathological and cultural rituals. *Behav. Brain Sci.* **29**, 595–613; discussion 613–50.

7. Boyer P, Liénard P. 2006 Precaution systems and ritualized behavior. *Behavioral and Brain Sciences*. **29**, 635–641. (doi:10.1017/s0140525x06009575)

8. Kapitány R, Nielsen M. 2015 Adopting the ritual stance: The role of opacity and context in ritual and everyday actions. *Cognition*. **145**, 13–29. (doi:10.1016/j.cognition.2015.08.002)

9. Hobson NM, Schroeder J, Risen JL, Xygalatas D, Inzlicht M. 2018 The Psychology of Rituals: An Integrative Review and Process-Based Framework. *Pers. Soc. Psychol. Rev.* **22**, 260–284.

10. Hobson NM, Gino F, Norton MI, Inzlicht M. 2017 When Novel Rituals Lead to Intergroup Bias: Evidence From

Economic Games and Neurophysiology. *Psychol. Sci.* **28**, 733–750.

11. Rossano MJ. 2012 The essential role of ritual in the transmission and reinforcement of social norms. *Psychol. Bull.* **138**, 529–549.

12. Hoehl S, Keupp S, Schleihauf H, McGuigan N, Buttelmann D, Whiten A. 2019 'Over-imitation': A review and appraisal of a decade of research. *Developmental Review*. **51**, 90–108. (doi:10.1016/j.dr.2018.12.002)

13. Wilks M, Kapitány R, Nielsen M. 2016 Preschool children's learning proclivities: When the ritual stance trumps the instrumental stance. *Br. J. Dev. Psychol.* **34**, 402–414.

14. Watson-Jones RE, Legare CH. 2016 The functions of ritual in social groups. *Behavioral and Brain Sciences*. **39**. (doi:10.1017/s0140525x15000564)

15. Wen NJ, Herrmann PA, Legare CH. 2016 Ritual increases children's affiliation with in-group members. *Evolution and Human Behavior*. **37**, 54–60. (doi:10.1016/j.evolhumbehav.2015.08.002)

16. Liénard P, Thomas Lawson E. 2008 Evoked culture, ritualization and religious rituals. *Religion*. **38**, 157–171. (doi:10.1016/j.religion.2008.01.004)

17. Lowie RH. 1950 : The Web of Kinship among the Tallensi; The Second Part of an Analysis of the Social Structure of a Trans-Volta Tribe . Meyer Fortes. *American Anthropologist*. **52**, 253–254. (doi:10.1525/aa.1950.52.2.02a00170)

18. Malinowski B. 2014 Argonauts of the Western Pacific. (doi:10.4324/9781315772158)

19. McCauley RN, Thomas Lawson E. 2002 *Bringing Ritual to Mind: Psychological Foundations of Cultural Forms*. Cambridge University Press.

20. Schjoedt U, Sørensen J, Nielbo KL, Xygalatas D, Mitkidis P, Bulbulia J. 2013 Cognitive resource depletion in religious interactions. *Religion, Brain & Behavior*. **3**, 39–55. (doi:10.1080/2153599x.2012.736714)

21. Durkheim É. 2012 *The Elementary Forms of the Religious Life*. Courier Corporation.

22. Gilsenan M, Turner VW. 1976 The Ritual Process: Structure and Anti-Structure. *RAIN*. , 12. (doi:10.2307/3031914)

23. Richman NI. 2018 What does it feel like to be post-secular? Ritual expressions of religious affects in contemporary renewal movements. *International Journal of Philosophy and Theology*. **79**, 295–310. (doi:10.1080/21692327.2018.1434011)

24. Vollweiler LG, Sanchez AB. 1983 Divination: 'Adaptive' from Whose Perspective? *Ethnology*. **22**, 193. (doi:10.2307/3773462)

25. Ember M. 1997 Evolution of the Human Relations Area Files. *Cross-Cultural Research*. **31**, 3–15. (doi:10.1177/106939719703100101)

26. Beheim B *et al.* In press. Corrected analyses show that moralizing gods precede complex societies but serious data concerns remain. (doi:10.31234/osf.io/jwa2n)

27. Schumacker RE, Beyerlein ST. 2000 Confirmatory Factor Analysis With Different Correlation Types and Estimation Methods. *Struct. Equ. Modeling* **7**, 629–636.

28. Babakus E, Ferguson CE, Joreskog KG. 1987 The Sensitivity of Confirmatory Maximum Likelihood Factor

Analysis to Violations of Measurement Scale and Distributional Assumptions. *J. Mark. Res.* **24**, 222.

29. Rigdon EE, Ferguson CE. 1991 The Performance of the Polychoric Correlation Coefficient and Selected Fitting Functions in Confirmatory Factor Analysis with Ordinal Data. *J. Mark. Res.* **28**, 491.

30. Finch WH, Holmes Finch W. 2011 A Comparison of Factor Rotation Methods for Dichotomous Data. *J. Mod. Appl. Stat. Methods* **10**, 549–570.

31. Fabrigar LR, Wegener DT. 2011 Implementing and Interpreting Exploratory Factor Analysis. In *Exploratory Factor Analysis*, pp. 104–142.

32. Weng L-J, Cheng C-P. 2005 Parallel Analysis with Unidimensional Binary Data. *Educ. Psychol. Meas.* **65**, 697–716.

33. Cho S-J, Li F, Bandalos D. 2009 Accuracy of the Parallel Analysis Procedure With Polychoric Correlations. *Educ. Psychol. Meas.* **69**, 748–759.

34. Fabrigar LR, Wegener DT. 2011 Requirements and Decisions for Implementing Exploratory Common Factor Analysis. In *Exploratory Factor Analysis*, pp. 39–87.

35. Timmerman ME, Lorenzo-Seva U. 2011 Dimensionality assessment of ordered polytomous items with parallel analysis. *Psychol. Methods* **16**, 209–220.

36. Bandalos DL. 1993 Factors Influencing Cross-Validation of Confirmatory Factor Analysis Models. *Multivariate Behav. Res.* **28**, 351–374.

37. Henrich J. 2009 The evolution of costly displays, cooperation and religion. *Evolution and Human Behavior*. **30**, 244–260. (doi:10.1016/j.evolhumbehav.2009.03.005)

38. Guerra-Doce E. 2015 Psychoactive Substances in Prehistoric Times: Examining the Archaeological Evidence. *Time and Mind*. **8**, 91–112. (doi:10.1080/1751696x.2014.993244)

39. Insoll T. 2011 *The Oxford Handbook of the Archaeology of Ritual and Religion*. Oxford University Press.

40. Kavanagh CM, Jong J, McKay R, Whitehouse H. 2017 Positive experiences of high arousal martial arts rituals are linked to identity fusion bonds and costly progroup actions. (doi:10.31234/osf.io/cjvsa)

41. Watson D, Clark LA, Tellegen A. 1988 Development and validation of brief measures of positive and negative affect: the PANAS scales. *J. Pers. Soc. Psychol.* **54**, 1063–1070.

42. Tellegen A, Watson D, Clark LA. 1999 On the Dimensional and Hierarchical Structure of Affect. *Psychological Science*. **10**, 297–303. (doi:10.1111/1467-9280.00157)

43. Egloff B. 1998 The independence of positive and negative affect depends on the affect measure. *Personality and Individual Differences*. **25**, 1101–1109. (doi:10.1016/s0191-8869(98)00105-6)

44. Russell JA, Carroll JM. 1999 On the bipolarity of positive and negative affect. *Psychol. Bull.* **125**, 3–30.

45. Green DP, Goldman SL, Salovey P. 1993 Measurement error masks bipolarity in affect ratings. *J. Pers. Soc. Psychol.* **64**, 1029–1041.

46. Eid M, Larsen RJ. 2008 *The Science of Subjective Well-Being*. Guilford Press.

47. Rappaport RA. 1999 Ritual and Religion in the Making of Humanity. (doi:10.1017/cbo9780511814686)

48. Cimino A. 2013 Predictors of hazing motivation in a representative sample of the United States. *Evolution and Human Behavior*. **34**, 446–452. (doi:10.1016/j.evolhumbehav.2013.08.007)

49. Wildman WJ, Sosis R. 2011 Stability of Groups with Costly Beliefs and Practices. *Journal of Artificial Societies and Social Simulation*. **14**. (doi:10.18564/jasss.1781)

50. Whitehouse H. 1995 *Inside the Cult: Religious Innovation and Transmission in Papua New Guinea*. Oxford University Press on Demand.

51. Mehr SA, Singh M, York H, Glowacki L, Krasnow MM. 2018 Form and Function in Human Song. *Current Biology*. **28**, 356–368.e5. (doi:10.1016/j.cub.2017.12.042)

52. Xing C, Hall JA. 2015 Confirmatory Factor Analysis and Measurement Invariance Testing with Ordinal Data: An Application in Revising the Flirting Styles Inventory. *Communication Methods and Measures*. **9**, 123–151. (doi:10.1080/19312458.2015.1061651)

53. Hayes AF, Krippendorff K. 2007 Answering the Call for a Standard Reliability Measure for Coding Data. *Communication Methods and Measures*. **1**, 77–89. (doi:10.1080/19312450709336664)

54. Krippendorff K. 2004 Reliability in Content Analysis: Some Common Misconceptions and Recommendations. *Human Communication Research*. **30**, 411–433. (doi:10.1093/hcr/30.3.411)

Supplementary Material A.

Factor 1. The first factor in the EFA and CFA accounts for .19 total variance, and .37 explained variance in each dataset. Factors in red have strong cross-loadings on other factors. Items that did not load on the first factor in both analyses are listed at the bottom. We cautiously interpret this factor as 'Dysphoria'. It is notable that the direct measures of affect do not load on this factor.

Table S1. *Variables and their respective loading values on the first factor*

Variables	Loadings in EFA	Loadings in CFA
Beating	0.537387	0.523305
Burial Offerings	0.419585	0.560197
Burning Offerings	0.501631	0.583328
BurningParticipants	0.857948	0.632646
Circumcision	0.568947	0.547966
Confession	0.445413	0.846747
Dehydration	0.57851	0.628271
DramaticActs	0.514238	0.438677
Fear	0.592254	0.524004
FoulOlfaction	0.51443	0.657694
sexing	0.675982	0.485921
Fumigation	0.548844	0.452134
Games	0.476922	0.445099
Hallucinogen	0.602314	0.632078
Humiliation	0.842365	0.656303
Immobility	0.523126	0.656454
InterdictionHands	0.654402	0.660126
LacerationSensitive	0.86788	0.602129
LargescaleMusicDance	0.842089	0.563039
OtherEndurance	0.542664	0.6235
OtherMental	0.743207	0.71971
OtherNegative	0.743659	0.8741
PathogenicPossession	0.677995	0.424895
Piercing	0.598808	0.857983
Sedatives	0.469605	0.542484
Smoking	0.42274	0.455729
SorrowMusicDance	0.619661	0.70544
Spitting	0.489755	0.582202

StoryTelling	0.420922	0.485574
SwallowingObjects	0.734547	0.719129
TabooAlcohol	0.642534	0.749122
TabooTalking	0.743863	0.555318
Tattooing	0.72668	0.758526
Vomiting	0.877383	0.601129
WaterOffering	0.402936	0.414733
WoundingSignificant	0.488351	0.858967
AthleticFeats	0.486627	
Haircut		0.449247
Isolation	0.40836	
Naming		0.401601
OtherMental		0.868361
PerformanceTrance	0.467208	
SleepDeprivation		0.40425
Stimulants	0.467957	
Taboo Sex	0.552072	
WoundingSuperficial	0.462373	

Note: Factors in red have strong cross-loadings on other factors.

Factor 2. The second factor in the EFA and CFA accounts for .04 total variance, and .08 explained variance in each dataset respectively. The only common items between the analysis are the average affect and peak affect. We cautiously interpret this factor as 'Euphoria'. It is notable that the direct measures of affect do not load on this factor. These affect values was coded such that if the event had higher positive than negative affect it was coded as 1, while if it had higher negative than positive affect it was coded as 0. Thus, values positive load on this, denoting a degree of orthogonality between euphoric and dysphoric affect (as it was entirely possible that these values would negative load factor 1).

Table S2. *Variables and their respective loading values on the second factor*

Variables	Loadings in EFA	Loadings in CFA
AvPrimaryEuphoria	0.696604	0.752187
PeakPrimaryEuphoria	0.66128	0.823408
Blood	-0.43354	
Isolation	-0.7077	
WoundingSignificant	-0.42289	
Isolation		-0.45752

Joyful		0.479547

Factor 3. The third factor in the EFA accounts for .04 total variance, and .08 explained variance, and in the CFA it accounted for .05 total variance, and .09 explained variance. We tentatively interpret the third factor 'Pageantry - Physical'.

Table 3. *Variables and their respective loading values on the third factor*

Variables	Loadings in EFA	Loadings in CFA
Dancing	0.825115	0.6147
Percussion	0.72459	0.676113
IntenseMusicDance	0.46455	0.530293
Singing	0.462103	0.65009
NonRhythmic	0.420204	
Marching		0.445074
Weapons		0.415999
Outsiders		0.402884
OtherInstruments		0.39925

Factor 4. The fourth factor in the EFA accounts for .03 total variance in each dataset, and .07 explained variance in the EFA and .06 explained variance in the CFA. We tentatively interpret the third factor 'Viscera'

Table 4. Variables and their respective loading values on the fourth factor

Variables	Loadings in EFA	Loadings in CFA
SacrificeAnimal	0.7147	0.634046
Blood	0.591472	0.664887
OtherOffering	0.584451	
Weapons		0.420103

Factor 5. The fifth factor in the EFA accounts for .03 total variance, and .07 explained variance in the EFA and .06 explained variance in the CFA. We tentatively interpret the third factor 'Pageantry - Psychological'.

Table 5. Variables and their respective loading values on the fifth factor

Variables	Loadings in EFA	Loadings in CFA
BurningOfferings	0.51334	0.512471
FireEmbers	0.50227	0.472749
Stimulants	0.477117	0.53615

Hallucinogen	0.474447	0.543029
Marching	0.398611	
OtherInstruments	0.488432	
OtherPurify		0.471566
Vomiting		0.436079

Factor 6. The sixth factor in the EFA accounts for .03 total variance, and .07 explained variance in the EFA and .06 explained variance in the CFA. We tentatively interpret the third factor 'Frequency'. A reminder that the coding for the '*Typical Frequency as patient*' and '*... as participant*' was initially recorded with 7-levels, which for analytical reasons were dichotomized, such that '*occurring once a year or less frequently*' (1), or '*more often than once a year* (0). It shouldn't be particularly surprising that both measures of frequency would load together, but what is notable is that the values did not load on the *Dysphoria* (factor 1) or *Euphoria factors* (factor 2)*.* Modes theory suggests that as intensity increases, frequency decreases. Thus, these frequency values could have conceivable loaded onto either, or both, of these affect measures.

Table 6. Variables and their respective loading values on the sixth factor

Variables	Loadings in EFA	Loadings in CFA
AnnualPARTICIPANT	0.693711	0.687426
AnnualPATIENT	0.679473	0.643986
Washing	0.547185	

Factor 7. The seventh factor in the EFA accounts for .03 total variance, and .07 explained variance in the EFA; the same factor in the CFA accounts for .04 total variance and .07 explained variance (likely due to the additional variables that loaded on to it). We tentatively interpret the third factor 'Kin'. Two things are noteworthy. First, the negative loadings in the EFA. The valence of the loadings are essentially arbitrary, though it is the case that both kin values aggregate together. Second, as there are fewer items accounting for diminishing variance, we are seeing less stability between the EFA and CFA.

Table 7. Variables and their respective loading values on the seventh factor

Variables	Loadings in EFA	Loadings in CFA
ExtendedKin	-0.6332	0.442471
ImmediateKin	-0.71683	0.454215
Alcohol	0.425744	
PerformanceTrance		0.729825
ExecutivePossession		0.713227

PathogenicPossession		0.558804
MixedGender		0.524344
MockConflict	0.396486	

Subsequent factors. Variables loaded onto several other factors, but did not appear to load reliably between the EFA and CFA analyses. They are presented in Table 8.

Table 8. Variables and their respective loading values on the remaining factors

Exploratory Factor Analysis		Confirmatory Factor Analysis	
MR8		MR7	
Spitting	-0.39985	TextRecitation	0.657251
OtherDiscomfort	-0.42435	BurningParticipants	0.441185
PathogenicPossession	-0.42717	Speechmaking	0.437269
Sprinkling	-0.49098	OtherOffering	0.419185
variance explained	*Total = .03; Prop = .05*	*variance explained*	*Total = .03; Prop = .06*
MR11		MR8	
LargeCrowd	0.717866	Group50percent	0.607774
Group90100percent	0.498584	WoundingSuperficial	0.474768
Group15abs	-0.59885	Group15abs	-0.58718
variance explained	*Total = .03; Prop = .05*	*variance explained*	*Total = .03; Prop = .06*
MR7		MR9	
Extended_duration	0.528699	Long_duration	0.48265
Outsiders	0.524926	Outsiders	0.412506
variance explained	*Total = .03; Prop = .05*	*variance explained*	*Total = .02; Prop = .05*
MR10		MR10	
Medium_duration	0.790248	Alcohol	0.527252
Long_duration	-0.5968	LargescaleMusicDance	0.515766
variance explained	*Total = .03; Prop = .05*	HolyObjects	0.415624
		variance explained	*Total = .02; Prop = .05*

Supplementary Material B.

Follow up analyses

The factor analysis suggests that there may be a factor structure that applies to the dataset. However, given that the dataset was not compiled for this analytical technique explicitly, additional analyses ought to be conducted in order to rule out other interpretations. Moreover, factor solutions are simply imposed structures, and may not necessarily correspond with the 'true' structure of the phenomenon. As is the case here, the EFA was conducted in such a way as to find an acceptable structure on a random-split half of a dataset, then, this n-factor structure was applied to the other matched-half. In the absence of theory, this in no way implies that the structure described corresponds with reality. We did find, however, that the structure broadly conforms with existing theory, and may also accommodate other evolutionary principles (i.e., involvement of kin).

In order to check against the most egregious violations of false structure, we generated random datasets of binary values with 651 observations and 96 variables, we found that parallel tests revealed no meaningful factor solutions, and when we forced specific factor solutions on the data, the variance explained was less than .01 per factor with fit statistics hovering around .5.

We also attempted to analyse the invariance in order to determine whether the same factor structure was present within sub-populations (category). However, doing so with binary data is difficult [52]. A simple alternative for approximating invariance, at least with regard to our specific hypotheses, is to conduct reliability analyses within the categories in question. Krippendorff's Alpha [53] is a reliability metric that can help us determine an alpha value for the present dataset. We used the *'Irr'* package for R, and present the alpha values associated with specific categories. We found that for each category (i.e., funeral, weddings, liturgies, divinations, etc.) that reliability for the 96 items ranged between .235 and .375 well below the accepted threshold of .8 [54] (see Table S9 for specific values and the number of observations).

Table S9. *The number of observations and Krippendorff's Alpha value for each category of ritual.*

Ritual Category	Observations	Alpha
WorldyPursuit	269	0.279
Funerary	93	0.287
OtherPurpose	70	0.271
Initiation	69	0.293
OtherWorldyPursuit	45	0.262
NewBorn	36	0.316
Apotropaeic	33	0.289
Divination	28	0.296
Commemorative	26	0.272

Wedding	21	0.314
Liturgical	18	0.291
HouseDedication	11	0.326
OtherUnion	8	0.268
Ogather	8	0.235
Protection	6	0.274
Installation	4	0.375

In order to provide a benchmark alpha, we repeatedly randomly sampled 40 rituals from the dataset 15 times and conducted Krippendorf's reliability analysis on each. These 15 values ranged from .25 to .315. Thus, the values reported for each ritual are essentially indistinguishable from randomly sampling rituals from across categories. When the dataset was crudely split by frequency, approximately corresponding with each mode (i.e., rituals that occur less often than annually, and rituals that occur more often than annually), and were matched for having the same elements, we found that low frequency ('imagistic') dataset (n = 505) and high frequency ('doctrinal') dataset (n = 140) shared 75 common elements, and had internal alphas of .239, and .324 respectively. Indeed, the EFA (n = .325) and CFA (n = .326) datasets which were originally randomly determined, and which shared 96 common variables, had internal alphas of .287 and .274, respectively.

Supplementary Material C.

Methods

The following procedure was conducted in three countries: The United States, Japan, and India. In all cases the survey was administered on a computer, and participants were solicited through Amazon MechanicalTurk (US and India), and lancers.co.jp (Japan). In the US it was presented in English. In Japan it was presented in japanese. The Japanese survey was prepared by one of the authors (CK) and then quality checked by two native Japanese researchers. In India it was presented in Hindi. A native Hindi translator produced an initial translation from the English text, and this was back-translated and differences in meaning clarified by two additional native Hindi translators. The first examined the initial translation (which led to some minor changes), and the second checked the quality of the amended translation. The English, Japanese, and Hindi translations are available on OSF.io. The survey was expected to take 20 minutes, and we paid our participants at a rate corresponding to the legal hourly rate. All participants were offered $2US per hour. The mean duration of the survey in each location was 28.85 mins, 31.08 mins, and 37.05 mins, respectively.

Participants were asked to provide demographic information, and were prompted to list five rituals, and to define - in their own terms - what a 'ritual' is. Participants were then asked to spend not more than 2 - 3 minutes describing '*the most memorable collective ritual you have experienced during your life*' and the '*the collective ritual you perform most frequently'* (participants were informed that they could not advance the survey until at least 90 seconds had elapsed; the order of these questions was randomized). Participants then provided data on the 26 focal variables (as described in the pre-registration) as well as limited number of other variables (reported in table S10). All measures were collected on a 100-point sliding scale, with five written metrics. Each was a variation on the following: the 0-anchor was 'not at all', following by 'a little', 'moderate', and 'very', and the 100-anchor was 'extremely' (or 'constantly, or 'perfectly' depending on the question). Some questions were categorical.

Because participants provided self-generated examples of rituals on which to base their responses, we examined all written responses and coded for appropriateness (for the indian and japanese responses, the responses were translated by google translate[7]). Responses the described actions that were consistent with Hobson et al's. (2018) definition were coded as '2' (e.g., weddings, funerals, graduations, etc.), responses that were broadly ritualistic by lacked the broader symbolism and doctrine were coded as '1' (e.g., football chants, japanese ritualised business meetings, formal family dinners, etc.), and responses that lacked clear ritualistic elements, but were clearly habitual (e.g., reading to one's children before bed) or highly sentimental (e.g., a couple sharing a regular 'date night') were coded as '0'. The authors RK coded these. Responses that were coded as 0 by

---

[7] We recognize that this tool lacks nuance in many regards, however, since we were not interested in the specifics of their response, but rather that participants responses were broadly ritualistic, we found the tool adequate.

RK were excluded from analyses (41, 7, 44 ommission from the imagistic set; 72, 22, 62 omissions from the doctrinal set). Our final analysable dataset included 491 from US (with 280 imagistic and 211 doctrinal responses), 567 from Japan (with 287 imagistic and 280 doctrinal responses), and 300 from India (with 159 imagistic and 149 doctrinal responses). All raw data and R syntax is available at (https://osf.io/undx8/).

Pre-registration and analysis plan

We made the following predictions regarding the factor structure of the data (see Table S10). All predictions were for positive loadings. We predicted four factors, using a 'direct oblimin' rotation (as we anticipated some degree of correlation between factors). We will conduct a more exploratory factor analysis in order to determine whether the data suggest a superior fit for a number of factors other than 4. We will use standard evaluative techniques, including parallel lines and eigenvalues.

We will also measure whether drug use was involved in the ritual experience (including, but not limited to, alcohol). We make no specific prediction regarding the loading of 'drugs' onto any individual factor, but suspect it will cross-load moderately across multiple factors. Similarly, measures that signify explicit religiosity (i.e., sacred objects and places) did not reliably load in prior work. Here, we predict that evaluations of 'religiousness' will cross-load on multiple factors. Finally, 'memory quality' may load on factors A and B, as the qualities of those events are linked with the production of vivid, enduring, flashbulb like events, but may load on factor D, due to the cognitive nature of the measurement. See table S11 for summary of ambiguous variables.

Table S10. *Pre-registered factors[8].*

Factor A Dysphoric (8)	Factor B Euphoric (6)	Factor C Praxis (3)	Factor D Cognitive/ Doctrinal (6)
Intense Negativity (during) Negativity (now) Painful Attention Unpleasant Unusual Alone	Exciting Enjoyable Positivity (now) Positivity (during) Synchrony Segregation / Mixed Gender	General performance frequency Times participation Routine/everyday	Reflection Consequentiality Importance Understandability ~ Official Account Know meaning

---

[8] We have used letters rather than numbers to describe predicted factors, as we are not strictly attempting to predict the variance explained by each factor, but simply its presence.

We also note of the following: Factor analysis is a statistical tool that describes data that *represents a thing*, and is not *the thing itself*. Regarding Factor D, we have included four measures that describe evaluations of a participants ritual experience (above), and also, reports of whether the ritual has an official meaning and whether the individual knows the doctrine (below). We hypothesise that these factors will load onto one factor, a 'cognitive'' factor. However, in the case of the first four elements of this factor, it is possible that they will load uniquely as those questions pertain to a kind of metacognition of the ritual experience, rather than a first order evaluation. It is possible this factor does not reveal anything meaningful about the ritual *thing*, but rather about the measurement tool applied to the *thing*.

Table S11. *Ambiguous variables*

Variable	Tentative Prediction
Drug Use / Inebriation	Multiple-Cross loadings
Religiosity	Multiple-cross loadings. Possibility of unique factor in alternative-n factor solutions
Memory Quality	Possible strong loadings of factors A and B. Possible dominant loading on factor D.
Official Account + Know meaning	May load onto a predominantly 'cognitive factor'. Possibility of unique factor in alternative-n factor solution.

Supplementary material D.

We used attention checks not as an exclusion criteria but as an indicator that the responses should be checked for the quality of responses, as previous research suggests they are an unreliable indicator of overall quality. In the US 78 (of 298) failed the single attention check, in Japan 54 (of 284) failed a single attention check, and in India 48 (of 197) failed both attention checks, and 90 failed one of the two attention checks. We examined whether those who failed the attention check varied from those who passed in systematic ways. Thus, we categorized all responses as belonging to either the imagistic or doctrinal modes per the question prompt. We conducted an ANOVA on the following key variables for each mode, within each country: *Intensity*, whether the ritual was considered *routine*, how *consequential* the ritual was to the participant, how many *times participated*, and how well the participated *remembered* the experience. We used a corrected p-value of .003 for these 15 analyses for (as there are five analyses for each 'mode' for each country).

Among US respondents, there was no significant differences in intensity (imagistic, $p = .935$; doctrinal, $p = .470$), routine (imagistic, $p = .722$; doctrinal, $p = .507$), consequentiality (imagistic, $p = .480$; doctrinal, $p = .953$), times participated (imagistic, $p = .977$; doctrinal, $p = .196$), and remember (imagistic, $p = .975$; doctrinal, $p = .684$).

Among Japanese respondents, there was no significant differences in intensity (imagistic, $p = .959$; doctrinal, $p = .470$), routine (there was an observed differences in imagistic, $p = .001$, but none in doctrinal, $p = .275$), consequentiality (imagistic, $p = .669$; doctrinal, $p = .119$), times participated (imagistic, $p = .168$; doctrinal, $p = .755$), and remember (imagistic, $p = .064$; doctrinal, $p = .72$).

Among Indian respondents, there was no significant differences in intensity (imagistic, $p = .938$; doctrinal, $p = .393$), routine (imagistic, $p = .766$; doctrinal, $p = .669$), consequentiality (imagistic, $p = .397$; doctrinal, $p = .583$), times participated (imagistic, $p = .593$; doctrinal, $p = .608$), and remember (imagistic, $p = .253$; doctrinal, $p = .791$). Given that there was no systematic pattern to the observed differences, we have opted not to exclude participants (who surpassed more basic exclusion criteria) based on failed attention checks.

Supplementary Material E.

Table S12. Full list of factor loadings

Item #	Element	Dysphoric	Euphoric	Cognitive	Frequency
3	Neg (now)	**0.84**	0.1	-0.03	0.06
2	Neg (then)	**0.84**	0.03	0.02	0.02
6	Unpleasant	**0.82**	0.08	0.05	0.02
4	Pain	**0.78**	-0.09	0.19	-0.14
12	Positive (now)	**-0.52**	0.34	0.39	-0.01
11	Positive (then)	**-0.54**	0.37	0.36	0.04
25	Inebriation	0.44	**0.65**	-0.03	-0.02
10	Enjoyable	-0.41	**0.63**	0.2	0.11
24	Substance Use	0.34	**0.63**	-0.13	-0.01
9	Exciting	-0.23	**0.62**	0.27	-0.03
20	Importance	-0.21	0	**0.76**	-0.05
19	Consequential	-0.01	-0.02	**0.72**	-0.13
5	Attention	0.19	-0.01	**0.69**	0.1
18	Reflection	0.16	0.1	**0.68**	0.07
27	Memory Quality	-0.04	0.01	**0.65**	0.24
1	Intensity	0.26	0.11	**0.58**	-0.18
16	Times Participation	-0.1	-0.17	0.02	**0.76**
15	Ritual Frequency	0.1	0.06	0	**0.75**
17	Routine	0.2	0.23	0.09	**0.62**
7	Unusual	0.31	0.08	0.17	-0.49
26	Religiousness	0.24	-0.23	0.49	0.14
13	Synchrony	0.24	0.1	0.43	-0.12
14	Sex Segregation	0.23	0.34	-0.04	0.17
8	Alone	0.22	0.23	-0.03	0.16
22	Official Meaning	0.02	-0.16	0.39	-0.08
23	Personal Meaning	-0.07	-0.18	0.38	0.04
21	Understanding	-0.22	0.13	0.45	0.07
	Proportional Variance	0.16	0.09	0.16	0.08
	Cumulative Variance	0.16	0.25	0.41	0.49