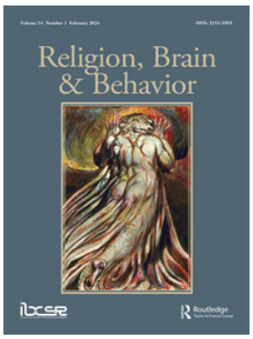

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Mapping the minds of spectators during an extreme ritual: a network perspective

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ABSTRACT

We study the mental maps of spectators using psychological network models during a large naturally occurring extreme ritual. Our aim was to identify the psychometric network structure of psychological reactions to an extreme ritual, and to investigate the core features of ritual cognition among its spectators. Participants who observed the Nine Emperor God (or Vegetarian) Festival ($N = 1041$ Taoist-Buddhists) completed measures of social, affective, behavioral and uncertainty cognitions. Applying undirected psychometric network models, we found that: 1) cognitions clustered in a small set of communities, and were 2) organized along two major dimensions (positive . negative valence, uncertainty beliefs 'vs.' uncertainty management). We argue that our study is an important step in theory building efforts, and that our findings offer insights for integrating theories of ritual. Thus, our study points towards new directions for theories of ritual by mapping the interdependence of psychological reactions and identifying the core cognition of a ritual.

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authenticity; awe; dysphoria; need for closure; network; perceived signals; ritual; social bonding

What happens in the minds of people attending large collective rituals? Current theory predicts that rituals regulate: a) social connections, b) emotions, and c) serve important goals of active participants, explaining their survival despite the time and effort costs involved (Hobson et al., 2018; Legare & Nielsen, 2020). Experimental studies have successfully isolated individual features of rituals and their psychological correlates (Hobson et al., 2018). Significant attention has also been paid to the effects of so-called extreme rituals on performers who engage in high ordeal acts, such as fire-walking, blood-letting, or public piercings (Kapitany et al., 2020). Extreme rituals are fascinating theoretically because they appear to invoke costs to the performer, and can include potential injury or poisoning, and/or heavy food restrictions, as well as temporal investments, without immediate apparent benefit. Performances such as bodily mutilation, bloodletting or fire walking have created much discussion about their evolutionary utility and function (Barker et al., 2019; Fischer & Kruekaew, 2020; Henrich, 2009; Irons, 2001; Singh et al., 2020; Singh & Henrich, 2020; Sosis, 2003); importantly, however, the majority of participants in many of these rituals are not active performers, but instead are individuals who observe the performance and participate by praying or asking for favors from performers (throughout this article we refer to individuals in this role as spectators). Spectators may experience rituals differently than performers (Bulbulia et al., 2013; Fischer et al., 2014), an observation

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Figure 1. *Spectators reactions during extreme ritual.* While past research has examined ritualistic effects on high ordeal performers & their closest kin (center panel) (e.g., Konvalinka et al., 2011; Xygalatas, Mitkidis, et al., 2013), little is known about the cognitive and emotional reactions of observing participants in response to the ritual (left and right panel).

which calls for greater attention be paid to the psychological states of spectators, including the information they receive and process in the context of the ritual (see Figure 1).

Rituals communicate information about participants, the community, and the larger belief system (Barker et al., 2019; Rossano, 2012), hence information about the ritual and its participants must be received and decoded by observers (Shannon & Weaver, 1949). Moreover, the communicative signals sent during a collective ritual by participants are often multimodal and multiplex; that is, they vary along a number of conceptual and performative dimensions (Power, 2017). This multi-modality creates problems for decoding, and for the effectiveness of any information exchange (Shannon & Weaver, 1949). A number of authors have recently highlighted that contemporary research on ritual has focused on a narrow set of variables that may be communicated, and argued that previous research studied these costly signals in isolation, while a wider range of potentially relevant variables may have been overlooked (Barker et al., 2019; Power, 2017). Building on information theory and work on ritual that has begun to investigate how rituals are perceived (Barker et al., 2019; Power, 2017), we here explore how spectators of a complex high-ordeal ritual react and process information inherent to ritual. Our first major contribution is to focus on the psychological organization of reactions by spectators who do not engage in the central activities of the collective ritual.

Because of the multimodal and multiplex nature of rituals, research on the psychology of ritual perception ought to measure a broader set of psychological reactions in context, because: a) remembered emotions and cognitions may not correspond to psychological states experienced during the ritual (Xygalatas, Schjoedt, et al., 2013), and b) rituals may simultaneously affect various psychological states (Boyer & Liénard, 2020; Hobson et al., 2018) through c) complex and non-linear relations.

It has long been known that survey reports do not necessarily correspond to actual behavior and retrospective survey responses may actually capture conceptually distinct processes or dynamics (Bradburn et al., 1987; Fishbein & Ajzen, 1975; LaPiere, 1934; Robinson & Clore, 2002; Stone et al., 1999; Sudman & Bradburn, 1973). A number of remedies have been suggested, such as collecting data as closely as possible to relevant events, using daily reconstruction methods or repeated sampling from the same participants (for applications in research on ritual, see Fischer et al., 2014; Piven et al., 2022; Shaver et al., 2021; Singh et al., 2020). An open question is whether and how psychological processes activated during a ritual might be related in the minds of the individual (Legare & Nielsen, 2020; Tinbergen, 2010). Rituals are likely to affect cognitions in three different areas (Hobson et al., 2018):

1) they increase social connection among participants and communities (Reddish et al., 2014, 2016; Xygalatas, Mitkidis, et al., 2013),
2) they regulate emotions (Atkinson & Whitehouse, 2011; Fischer et al., 2014; Kapitany et al., 2020; Kavanagh et al., 2019; Páez et al., 2015; Whitehouse et al., 2017) and

3) they modulate task and performance orientations (Gelfand et al., 2020; Mogan et al., 2019; Reddish et al., 2013).

Researchers have tended to focus on one or two of these areas and analyzed ritualistic effects in isolation in order to test specific theories. For example, seminal experiments (Bastian, Jetten, and Ferris, 2014; Wiltermuth & Heath, 2009), and longitudinal field studies (Singh et al., 2020; Snodgrass et al., 2017) have demonstrated that ritual behaviors increased social connectedness and emotional reactions, but crucially, the associations between these two outcomes of social connectivity and emotional responding were not examined. Therefore, it is of critical importance to investigate the extent, and the specific pattern, with which various reactions co-occur when attending an extreme ritual (extending preliminary work in this area by Power, 2017). Our empirical observation documents the cognitive structures in spectators that are invoked by rituals, which can then be questioned further for plausible mechanisms.

The attempt to arrive at causal analysis requires adequate mapping of the empirical evidence as a first step (Pearl & Mackenzie, 2018). Previous field studies have used a selected set of variables and used causal reasoning about how the selected variables may be related, testing these theoretical hypotheses via regressions or some form of a general linear model (e.g., *t*-test, ANOVA). Because field studies do not allow a random allocation of participants, the evidence is still observational and correlational. Recently developed psychometric network analyses, however, are ideal tools for understanding the conceptual relationships between constructs and they allow bottom-up insights into the mental representations of individuals in response to real-world phenomena. By providing both graphical and statistical insights into the mental maps of cognitions, it becomes possible to integrate and extend theory without superimposing ontological relationships onto observational data using causal models with restrictive assumptions (as is commonly done with general linear or latent variable models). Network structures are ideal tools to take one step back and illustrate how individuals perceive and react to rituals and how these cognitive reactions are connected with each other. Instead of forcing an implicit causal model onto the data, we here use a bottom-up approach to outline the connectivity of cognitions, or the "mental maps" of the rituals in the minds of spectators.

Psychometric networks contrast with typical approaches that test whether a single variable (e.g., pain, dysphoric affect) is connected to another variable (e.g., social connection, mental health). Here, by examining all pairwise conditional dependencies between variables, we simultaneously examine all possible measured links together, revealing the organization of cognition (Borsboom et al., 2021; Borsboom & Cramer, 2013). As Borsboom et al. put it: "network models can be used to generate causal hypotheses, as they represent statistical structures that may offer clues to causal dynamics; for instance, networks that represent conditional independence relations form a gateway that connects correlations to causal relations" (p. 1; see also Haslbeck et al., 2021). This approach addresses a central point of recent studies that highlighted the multimodal and multiplex nature of rituals (Power, 2017) and called for more research to distinguish the diverse perceptions and cognitive reactions relevant to rituals as an important contribution to theory building (Barker et al., 2019).

We thus advance current understanding of ritual by focusing on a) spectators of a widely celebrated extreme ritual, b) measuring the reactions to the ritual via a broader set of emotions and cognitions *in situ* and c) constructing the network structure of how individuals experience and perceive the ritual, in order to identify more central and peripheral cognitions. We thus shift the focus away from testing isolated theoretical predictions based on limited sets of variables and instead focus on how a broader set of information is perceived and organized. We argue that ours is a vital first step in theory building efforts.

The importance of the ritual spectator

Much recent research on ritual has focused on (high-ordeal) performers (Fischer & Kruekaew, 2020; Konvalinka et al., 2011; Xygalatas, Mitkidis, et al., 2013), which leaves an open question:

what is the role of spectators during an extreme ritual? High-ordeal performances are likely only functional if perceived by others; i.e. when socially relevant information, and/or group relevant information, is being transmitted about desirable qualities of the performer (Henrich, 2009; Power, 2017). Without spectators, there can be no communication (Shannon, 1948; Shannon & Weaver, 1949). Importantly, the presence of the spectator is also a signal to the performer that reinforces and sustains the efforts exerted. Hence, human behavior always contains information for others, in line with the famous dictum "one cannot not communicate" (Watzlawick et al., 1967). Any information that is transmitted during ritual needs to be decoded, requiring the availability of structured belief systems that allow the efficient decoding of information of relevance within the specific social context. Rituals can contain vast amounts of information, but only certain types of information are relevant and meaningful for individuals to pay attention to, evaluate, and remember (Barker et al., 2019). Conscious experience requires culturally shared top-down priors that structure and organize sensory input (Clark, 2013; Fischer & Tasananukorn, 2018). For a ritual to be understood and maintained, information about the ritual needs to be integrated into a coherent meaning structure and narrative that is both shared and understandable by community members. Therefore, participants, independent of their role as high-ordeal performer or spectators, need to share some basic understanding for the ritual to take place and to coordinate the respective roles of performer and spectator. The typical human reaction to intervene in case of harm (e.g. stopping a performer from self-harming by piercing their body tissue with a sword) would interfere with the performance of an extreme ritual. Similarly, the presence of the spectator provides the context and therefore the justification for the performer to continue with the ritual.

Additionally, meaning systems are learned (Bandura, 1971) and the observation of ritual performance is one of the most efficient ways for transmitting culturally shared meaning systems (Rossano, 2012). Considering the important role of socialization for the maintenance of culture, including ritual systems, future performers are current spectators. Similarly, spectators who may have performed these acts in previous rituals provide validation to the current performers and by doing so contribute to a continuation of the ritual. Therefore, the role of the spectator is quintessential in many complex collective rituals as observation provides the learning opportunities and the inter-generational validation for the cultural maintenance of rituals.

Finally, spectators are not passive recipients of information, but are also evaluators and judges of the spectacle. Authenticity and the efficacy of ritualistic performance and the supernatural status of the performer are often of major concern for participants (Chan, 2006; Erekosima & Eicher, 1981; Wang, 1999). For example, does the ritual follow culturally validated and consensually recognized forms that mark its performances as correct, true and authentic, therefore marking it as effective (Legare & Souza, 2012)? This final point connects to those earlier – spectators may validate the ritual performance through their presence and their emotional and behavioral reactions, which in turn justifies the continuation of ritual. Put simply, in the absence of spectators there will soon be nothing to spectate.

In summary, our work focuses on the psychological reactions of participants observing an extreme ritual. We focus on variables that carry information about the ritual, the performers, and the spectators along dimensions related to three of the assumed major regulatory functions of ritual: social connection, emotion and performance regulation. The key question for our study is: how do individuals perceive this ritual and how are these perceptions and cognitions related to each other? As we have outlined above, previous research has typically focused on a narrow set of specific variables in relative isolation – we shift the focus on a broader set of perceptions during ritual and investigate their possible underlying structure. A psychological network approach to the perception of ritual allows us to identify central nodes (variables), their mutual connections (edges) and communities of nodes (clusters) (Costantini et al., 2015; Epskamp et al., 2018; Golino & Epskamp, 2017). By detecting such community structures, we can identify core variables within the lived experience of human rituals.

In the current study, we measured variables that tap into a number of regulatory functions (see the Supplement for further information, in particular Figure S1 and Table S2) during a large Buddhist/folk-Daoist ritual attended by over a million spectators annually (Cohen, 2001; Fischer & Kruekaew, 2020) (see the supplementary material for an ethnographic description of the ritual). This ritual is one popular expression of folk religions that are widespread throughout Southeast and Southern Asia. Employing a large sample in this non-Abrahamic religious context, the emergent psychological networks ("mental maps") of participants can allow us to examine plausible cognitive mechanisms that are activated during an extreme ritual.

Method

We studied the Nine Emperor God (or Vegetarian) Festival performed by Sino-Thai communities in Southern Thailand and which takes place during the ninth lunar month each year. During the festival, approximately 10,000 individuals perform high ordeal rituals, but close to a million people participate as spectators (for a more detailed ethnographic description, see the supplement, Table S1 and Figures S2–S15). The origins of the festival trace to 5000-years-old pre-Chinese Shaman rituals and variations of these rituals, which are widespread throughout contemporary South-eastern and Southern Asia (Chan, 2006). During the festival, rituals are performed at shrines that involve high ordeal performers (spirit mediums) in trance states during which they are believed to receive powerful spiritual warriors and gods. Once in trance, these high ordeal performers perform extreme acts of self-mortification, including cutting, profuse bleeding, piercings to the face and upper body with large objects, burnings, fire-walking, and/or sword climbing (see Figures S2–S5). During the rituals, observing participants can ask high ordeal performers to cure ailments, divine the future, protect people, communities, and business against evil forces. (see Figures S6–S11).

In 2015 we collected data from 1041 spectators (Mean age = 30.28, SD = 12.48; 54.3% females; 21.7% with low occupational status [street vendors, cleaners, etc.], 45.6% of participants occupying governmental or professional jobs).

There are currently no clear guidelines for power calculations of network models, therefore we aimed to reach comparable sample sizes and variable-to-sample size ratios as used in network tutorials (Costantini et al., 2015). Individuals were approached by local research assistants at various shrines in Kathu and Phuket town on Phuket Island (a traditional center of the festival) and HatYai (Songkhla province, an emerging ritual center). The largest numbers of responses were collected from rituals organized by Juitui shrine ($N = 368$), Kathu shrine ($N = 364$, both on Phuket island) and Sey Deng shrine in HatYai ($N = 118$); the remainder were collected at smaller shrines in HatYai. Local research assistants approached potential participants during and immediately after rituals and asked whether they would be willing to participate in a short survey. Participants verbally agreed before receiving a survey, and returning the completed paper and pencil survey was taken as consent to be included in the study. Some individuals preferred to answer questions in an interview setting (with research assistants reading out the questions). Due to the logistics of fieldwork, no records of no-response were collected. All participants were Thai nationals and attended the ritual for spiritual purposes. The study design has been approved by the School of Psychology Human Ethics Committee under delegated authority of Victoria University of Wellington's Human Ethics Committee (#0000020925).

Measured variables

Here we provide a brief overview of the key variables. More detailed information on translation and validation procedures in pilot tests and ethnographic fieldwork are provided in the supplement, together with a theoretical description of relevant theoretical frameworks that can be linked to

each set of measured variables. Data, material and analytical code are available on the OSF: https://osf.io/wyzbm.

Social connection. We measured identity fusion with four adapted items (Gómez et al., 2011), see Figure 2 for item content ($\alpha = .92$). This scale has been used in a variety of contexts (Bortolini et al., 2018; Gomez et al., 2011; Kavanagh et al., 2019) and a visual version of this scale has been validated for this context (Fischer & Kruekaew, 2020).

Social identity responses were measured with three items capturing social connectedness to different referent groups (Harb & Smith, 2008). We asked whether individuals felt socially connected (linked) to family and friends and spirit mediums and other believers that are not present at the moment ($\alpha = .71$).

Emotional responses. Affect was measured with a total of seven items adapted from the Positive and Negative Affect Scale (Boonyarit et al., 2013; Watson et al., 1988) and aesthetic experiences scale (Zentner et al., 2008), using a five-point Likert scale. Positive affect (four items, $\alpha = .84$) and negative affect (three items, $\alpha = .81$) exhibited good reliability. Awe was measured with two items, asking spectators to indicate how much they felt "awe" at the ritual today and whether they "felt small and insignificant today". A Visual Analog Scale anchored by 0 (no pain) and 10 (worst pain imaginable) was used to measure both subjective pain and perceived pain in spirit mediums (Xygalatas, Mitkidis, et al., 2013).

Meaning-systems & Uncertainty Management. Authenticity and efficacy beliefs were measured with four items, adapted from (Morhart et al., 2015; Napoli et al., 2014) and based on extensive field work by the first and second author (see Figure 2, $\alpha = .89$).

We adapted four items from the ambiguity subscale of the revised need for closure scale (Roets & Van Hiel, 2011), which were measured on a five point scale from 0 to 4 ($\alpha = .78$).

Behavioral indicators. To measure behaviors related to performance regulation, we asked respondents yes/no questions on whether they had consulted: a) spirit mediums (high ordeal performers) during the Vegetarian Festival, b) at other occasions outside the Vegetarian Festival and c) whether the respondent had placed a table outside their home or business to receive the blessings of spirit mediums (high ordeal performers). For behaviors indicating social connection, we asked whether the spectator had walked with the spirit medium and whether the spectator had donated money to the shrine. Items were based on previous ethnographic work (Fischer & Kruekaew, 2020; Fischer & Tasananukorn, 2018).

Analytical strategy

We computed an undirected network using psychometric network models for psychological data (Costantini et al., 2015; Epskamp et al., 2018; Golino et al., 2020), which is ideally suited to uncover possible relationships between constructs in observational research (Borsboom et al., 2021; Borsboom & Cramer, 2013; Cramer et al., 2010, 2012; Dalege et al., 2016). A network maps observed indicators, such as items in a survey, as nodes, and the relationship with other nodes as edges. A psychometric network approach maps observed indicators (nodes) and the relationship with other nodes (edges). Due to the highly interconnected nature of psychological systems, networks modeled on psychological data tend to be fully saturated, including many edges (capturing correlations between observed indicators) that are close to but not exactly zero. We used the *Extended Bayesian Information Criterion Gaussian Least Absolute Shrinkage and Selection Operator* (*EBICglasso*; Foygel & Drton, 2010) because this regression-based approach has been shown to more faithfully represent the overall network while preserving parsimony by constraining close to zero edges to exactly zero. We used the default options (gamma = 0.5) (Friedman et al., 2008) as a more conservative parameter which reduces the likelihood of including spurious connections (Epskamp, 2017)

We report the smallworldness index (Humphries & Gurney, 2008; Watts & Strogatz, 1998) as computed via the *qgraph* package (Costantini et al., 2015; Epskamp et al., 2022) which provides

an index of the overall clustering of the network. We also report centrality strength, which is the sum of the absolute values of the weights on the edges connected to a node, and can be interpreted as a measure of overall connectedness within the network (for a more critical discussion of other centrality indicators, see Bringmann et al., 2019). We tested the stability of the network as well as the centrality indices via non-parametric bootstrapping using both node and case-wise dropping bootstraps (1000 replications for each run). The full results and additional information are available in the supplement.

We tested the distinctiveness of network clusters with Exploratory Graph Analysis (Golino & Epskamp, 2017) across 1000 bootstrap samples (Epskamp & Fried, 2018) and a walktrap algorithm (Yang et al., 2016). This method is superior to other methods for identifying optimal number of clusters (Golino et al., 2020). To overcome potential instabilities and accuracy problems in sample specific solutions, we bootstrapped the EGA results using 1000 samples. We examine both the dimension stability (number of clusters) and structural consistency (placement of each node within communities) to provide evidence of the stability of the clustering solution. Full results are reported in the supplement. To represent the optimal solution and aid interpretability of node positions, we ran a multidimensional scaling analysis assuming ordinal data on the network data and used the resulting coordinates to plot the EGA network solution, which allows a direct interpretation of the distances between nodes in the MDS-representation of the network. In other words, the node positions and their mutual distances are interpretable in this two-dimensional representation.

We also calculated the extent to which individual nodes within communities identified in the EGA link to other nodes in other communities (Jones et al., 2019). We report bridge strength, which is calculated as the sum of the absolute value of all edges that exist between a specific node within a community and all nodes that are not in the same community as the focal node. In other words, it reports which node within a network community is most strongly connected overall to any other communities within the network. We also report bridge expected influence (2-step), which includes both direct and indirect effects that a given node within a community has with other communities, either directly (e.g., node 1-> node 3) or indirectly through other nodes (e.g., node 1 -> node 2 -> node 3). Bridge expected influence accounts for the direction of the effect. For example, a specific negative mood (sadness) may decrease positive feelings (happiness) but also activate nodes within in a social connection cluster (feel closer to friends & family). Therefore, these bridge network statistics can provide important information on the nodes that connect network communities.

Finally, we tested the redundancy of variables in our network (Christensen et al., 2020). We used partial correlations as input, GLASSO and a thresholded model (using the default of $r = .35$). We then repeated the computation of the community clusters and influence statistics. Full results are included in the supplement.

Results

Our network had 31 nodes with 176 non-zero edges out of a total of 465 possible edges (37.8%), suggesting a reasonably parsimonious network. Of these non-zero edges, 148 were positive (84.1%). A case-drop bootstrap analysis showed that the edges in our network were stable (edge stability = .75) and above the recommended threshold of .70 (Epskamp et al., 2018).

We calculated the smallworldness index, which characterizes the overall clustering of the network. For our network the smallworldness index S was 1.14, which is above the recommended threshold of 1 (Humphries & Gurney, 2008; Watts & Strogatz, 1998), suggesting small world properties of ritualistic cognitions. A small world network implies high clustering and short average path lengths; i.e., a highly dense and interconnected psychological network structure with a small number of clusters connected via few key nodes.

In terms of node strength (direct links of a node with other nodes weighted by edge importance), “feeling happy”, “fear”, “believing that spirit mediums care for the welfare of participants,”

"believing that spirit mediums have supernatural powers" and "feeling connected to spirit mediums" were the five most central nodes in the network. This implies that emotional responses (both positive and negative) and belief in the spirit mediums, as well as a strong social connection to the spirit mediums, are the most central components of the mental map during the ritual. A bootstrap analysis showed that node strength was stable (see Figure S16).

Focusing on the clustering within the network, the EGA analysis found five clusters (see Figure 2). Cluster 1 consisted of authenticity beliefs, positive emotions, and awe, Cluster 2 included social connection (including fusion and social identity), Cluster 3 contained negative emotions and pain, Cluster 4 featured petition/ritualistic behaviors, and Cluster 5 was comprised of all need for closure items. A bootstrap analysis with 1000 resamples found five clusters in 32.1% of the samples, six clusters in 54.1% of the samples, seven clusters in 11.9% of the samples and eight clusters in 1.6%. These alternative structures indicated five clusters as the most coherent and parsimonious solution, and are discussed further in the supplement. When combining variables that were identified as empirically redundant, cluster 5 (need for closure) and cluster 3 (negative emotions and pain) merged into a single cluster, but the relative position of the combined need for closure items was retained. The overall similarity of the coordinates of the full vs. reduced network were $r = .86$ for dimension 1 and $r = .91$ for dimension 2.

Dimension 1 captures positive vs. negative valence, differentiating positive emotions and belief systems from negative emotion and pain. The second dimension distinguishes uncertainty cognitions (need for closure) from behavioral activities that are geared towards managing uncertainty (asking for blessings and advice). Social connection nodes are located within the center of the

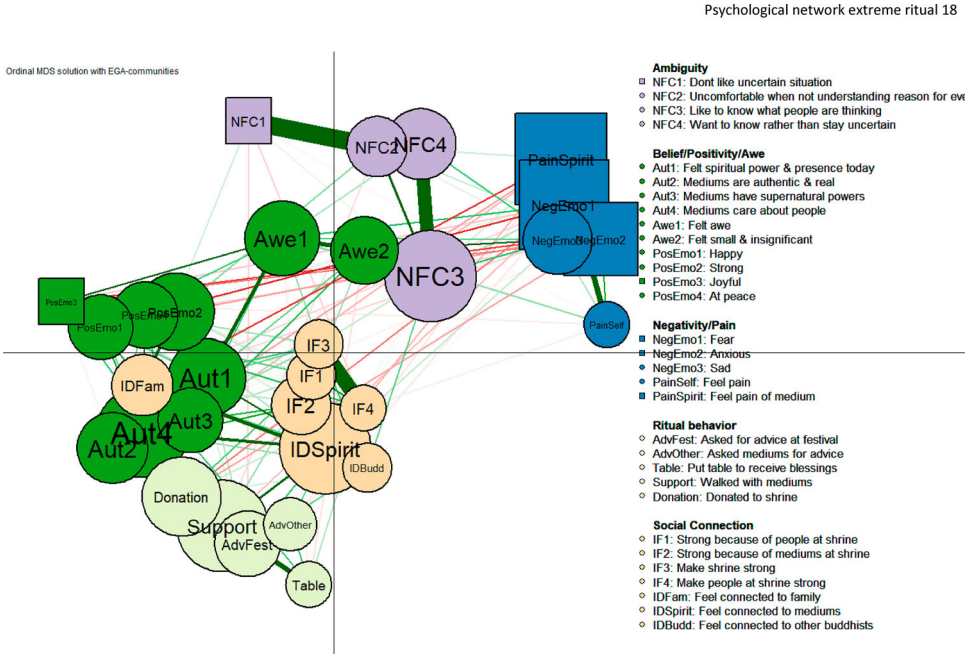

Figure 2. Network structure of psychological reactions during an extreme ritual. Overall network structure based on *Extended Bayesian Information Criterion Gaussian Least Absolute Shrinkage and Selection Operator* (EBICglasso; Foygel & Drton, 2010) network analysis and bootstrapped *Exploratory Graph Analysis (EGA)* (Epskamp & Fried, 2018) using a walktrap algorithm (Yang et al., 2016) with 1,000 bootstrap samples. Node colors indicate community membership according to EGA (see the right-hand legend). Node size indicates the expected influence (2-step, including indirect influence) on communities outside the node's community, while node shape indicates direction of expected influence (circle – positive, square – negative). Green lines indicate positive edges between individual nodes, and red edges indicate negative edges between individual nodes. MDS stress = .13. For interpretation purposes, the axes are rotated 15° anticlockwise. Full statistical information is provided in the supplement (see Tables S3–S7).

network, which supports their centrality in overall network. Examining the spatial positioning in a bit more detail, the behavioral items are placed in close proximity to social connection and beliefs. Donations to the shrine and providing support to spirit mediums were positioned near the belief nodes, implying that belief and group focused actions are closely related. Family connections were located in proximity to belief and positive emotion. At the upper end of Figure 2, awe was positioned closest to ambiguity and with links to negative emotions.

Examining the most important bridging nodes between communities (top 20% of the bridging nodes), within the social connection cluster "feeling connected to family and friends" (see the size of the shapes in Figure 2; for full details, see Table S7) and "feeling connected with spirit mediums" showed the strongest overall connectedness to other communities. The identity fusion item, "feeling strong because of spirit mediums at the shrine" also had a strong expected influence on other communities. It is noteworthy that these nodes exhibit some of the strongest bridge parameters in the network. Focusing on behaviors, donations had the strongest absolute connection with other communities, but "walking with spirit mediums" during the festival had the strongest positive indirect influence on all other communities. Concerning the emotion-focused clusters, among the positive emotion/authenticity/awe community, the belief that "mediums care for people" had the strongest absolute connections and indirect influence on other communities. Feeling "happy" had strong absolute links to other communities, but feeling "strong" had the strongest positive indirect influence on other network communities. Among the negative emotions cluster, feeling "sad" was well connected to other communities, but the relative influence was comparatively weak. The uncertainty cluster was relatively weakly connected to other network communities. The node "like to know what people are thinking" showed the strongest absolute connectivity and relative influence. Finally, the relative influence of the individual nodes was preserved when examining the reduced network ($r = .76$).

Discussion

Sampling responses from over a thousand participants, our study maps the psychological network representations of the spectators of a large extreme ritual attended by more than a million people each year. Our findings link a broader set of cognitions, emotional states and behaviors and hope to contribute to a better understanding of how various psychological states are mentally connected in the minds of spectators during ritual (Barker et al., 2019). We argue above that this approach is a vital step in theory building efforts, and Table 1 describes our findings and their implications for current major theories.

For example, our results suggest that social connections were centrally located and well connected throughout the network, highlighting the importance of community building effects of the ritual on spectators. Recent debates have focused on the relative compatibility and distinctiveness of costly signaling versus credibility enhancing displays (Brusse et al., 2022; Singh & Henrich, 2020). One distinguishing feature is that the former is often interpreted as communicating cooperative intent of performers whereas the latter is more concerned with the communication of sincerity of belief, independent of cooperative intent itself. A study of shamans on a small island in Indonesia found support for both theoretical models, but found stronger evidence in favor of belief effects; i.e., credibility enhancing display theories (Singh & Henrich, 2020). Here, we found the strongest connections of these social cognitions to a second cluster of salient religious beliefs. The strongest node connecting the social connection cluster with other cognitions, in particular the adjacent belief cluster, was the feeling of being connected to the spirit mediums. The spirit mediums are the focal point of the ritual; hence, the attention towards, and the feeling of being connected to ritual performers, is central for social bonding. The strong links to beliefs that spirit mediums have supernatural power, and that supernatural powers are channeled to protect the welfare of all, suggests the compatibility of signaling and credibility enhancing beliefs, and furthermore the broad applicability of a signaling approach

Table 1. Main findings and implications of the network findings in spectators for ritual theory.

Main findings	Theoretical implications
Five network communities were identified	Cognitions during a ritual appear clustered around core psychological functions: 1) belief/positive emotions/awe: clustering of emotional and belief cognitions implying some joint activation of meaning systems and positive emotional responses, highlighting the importance of positive emotional responses and its connection to meaning systems; clustering of awe with beliefs supports the importance of awe for ritual performances (Keltner & Haidt, 2003; Shiota et al., 2007; Valdesolo & Graham, 2014); 2) negative emotions & pain: confirms negative valence of pain displays; 3) Social connection: identity fusion with the shrine & high ordeal performers, social identification with kin & other beliefs at the festival and elsewhere show a single cluster, implying that fusion and social connection are closely linked (Bortolini et al., 2018); family ties connect to broader social cognitions (superordinate identity) during ritual (Konvalinka et al., 2011; Singh et al., 2020); 4) Need for closure/ambiguity cognitions (supporting the centrality of uncertainty dynamics); 5) Behavioral clusters: behavioral nodes indicating support for spirit mediums & shrine merged with behaviors focusing on controlling uncertainty.
Two major dimensions underlie the network: a) **valence** & b) **uncertainty beliefs vs management**	**Valence**: a clear distinction of positive vs negatively valenced cognitions is evident, highlighting the emotional complexity of extreme rituals, greater attention to positive valence in particular is needed (Xygalatas, 2014); **Uncertainty**: Uncertainty is a core organizing principle of cognitions during ritual, separating ambiguity and negative emotional dynamics associated with pain and fear at one end from active behavioral acts that are geared towards controlling uncertainty (asking for advice, blessings & divination) at the opposite end, supports uncertainty mechanisms for ritual (Henrich et al., 2019; Hogg et al., 2010; Snodgrass et al., 2017).
Identification of **bridging nodes** between cluster communities (strongest nodes per community): a) Belief that spirit mediums protect (care); feeling happy, feeling strong, feeling awe; b) Donating to shrine, walking with spirit mediums; c) Feeling connected to spirit mediums; feeling connected to family; feeling strong because of mediums (identity fusion); d) Like to know what other people are thinking; e) Feeling sad, feeling fear (negative links).	Bridging nodes offer insights into how activation of cognitions rituals during ritual spreads and therefore may induce greater efficiency of ritual functions: a) Belief nodes that focus on benefits and focus on empowering positive emotions show greater connectivity across communities – supports the importance of transmission of belief systems via credibility enhancing displays & empowerment via social emotions (Henrich, 2009; Kok et al., 2013; Singh & Henrich, 2020), links of awe to negative emotions & social connection supports the complexity of awe experiences & the importance of awe for ritual functioning (Bortolini et al., 2021; Keltner & Haidt, 2003; Shiota et al., 2007; Valdesolo & Graham, 2014); b) Behavioral nodes that signal commitment to the religious system show stronger links throughout the cognitive network, supporting the importance of signals of commitment to the group & belief system (Power, 2017; Sosis, 2003) and providing support for costly signaling theories that emphasize cooperative intent (Brusse et al., 2022; Singh & Henrich, 2020); c) Social connection to both high performers and kin (family) are centrally connected to other cognitions, highlighting the importance of social connection during collective ritual; d) Epistemic uncertainty, especially concerns about the minds of others are important cognitions that activate & spread to other cognitions during extreme rituals; e) Experiencing fear appears to be an important emotional response to extreme displays & distinguish believers from non-

(*Continued*)

Table 1. Continued.

Main findings	Theoretical implications
	believers; unexpectedly, feeling sad shows some connection to other nodes (may indicate lack of social connection; see also the non-redundancy of sadness in supplementary material).

(Brusse et al., 2022). Although our study points to the compatibility of the two approaches, several possible future studies may help to differentiate between these two frameworks. For example, it may be possible to isolate the specific costs for performers and examine the reactions of spectators towards performers in terms of the pay-offs to different ritual behaviors by performers, as well as how these may vary among spectators (Singh & Henrich, 2020; Soler et al., 2014).

The strong connectivity of beliefs is also noteworthy given that beliefs function as cultural priors that make the world understandable (Clark, 2013). We focused on authenticity as one important cognition that we expected to be of central concern to observers, and is one which has received relatively little empirical attention in the evolutionary and experimental study of ritual. Much recent focus has been on bottom-up functional features of ritual characteristics, such as pain or synchrony that explicitly remove any meaning component (Bastian, Jetten, & Ferris, 2014; Fischer, 2021; Mogan et al., 2017). By studying a broader set of perceptions that are contextually relevant, it becomes possible to understand how various sets of variables relate to each other, outlining the interconnectedness of processes that are typically studied in isolation. By focusing on these meaning-relevant cognitions, we can also start to link bottom-up and top-down processes in ritual (see Hobson et al., 2018).

One of the two major dimensions underlying the network was differences in positive vs. negative emotional valence. The strong differentiation of positively vs. negatively valenced cognitions is noteworthy, in particular because many of the core variables that are linked to social connection were closely positioned to positive emotions. Atkinson and Whitehouse (2011) have previously raised questions about the relative roles of positive vs. negative emotional experiences in ritual. In the ritual we examined, positive emotional reactions are closely connected to social connection in the minds of spectators. In other words, positive emotional states (and not negative emotional states) are tightly interlinked with how close people feel to others at the ritual. This also aligns with more clinical and experimental work. For example, health intervention studies using elements of ritual (Kok et al., 2013) have demonstrated that the induction of positive mood causally influences other cognitions and behaviors, shifting how individuals process information and behave. Inducing positive mood appears to be crucial for social bonding. These findings, in combination with the cross-sectional associations in our study, highlight the role of positive affect for social bonding and for ritual more broadly (Kapitany et al., 2020). Furthermore, the observation of key connections in our network, such as the associations of "feeling strong" point to efficacy and empowerment effects: observing a "powerful" ritual empowers individuals and strengthens connectedness.

Work on fading affect bias suggests that negative events tend to fade faster in memory and over time are misremembered as more positive (Skowronski et al., 2014). Previous research has also indicated that highly dysphoric rituals can create positive reactions in both performers and spectators (Fischer et al., 2014). Future research ought to examine positive and negative emotional experiences of ritual longitudinally. We hypothesize that high-ordeal displays create strong initial memories because of the combination of both positive and negative emotional reactions, with negative reactions helping to initially boost memory processes, but over time, these negative memories then fade out more quickly as predicted by fading affect bias, resulting in overall more positive memories. Nonetheless, these emotional dynamics clearly need greater attention and exploration in future research.

Extreme rituals often invoke both strong positive and negative emotional reactions (Kapitany et al., 2020). Interestingly, we found that awe was part of a positively valenced belief cluster, but was also connected with negative experiences and uncertainty cognitions (especially concerns about thoughts of others). These patterns are in line with the noted complex nature of awe that precluded easy classification into larger emotional systems in recent studies (Cowen & Keltner, 2017; Shiota et al., 2007). Experiences of awe during extreme ritual performances may be the conduit between emotional reactions during ritual, linking ritual observation to epistemic needs about certainty. The performance of self-mutilations and apparently superhuman feats during this multi-day ritual are believed to symbolize the annual visit of supernatural forces to the community. However, the experiences of awe were found only weakly and indirectly related to social connections within the cluster, further highlighting that although awe may facilitate social affiliation (Bortolini et al., 2021), these effects may be driven by strong emotional reactions (Takano & Nomura, 2022), moral concerns (Graziosi & Yaden, 2021), or a sense of a diminished self (Seo et al., 2022). Our findings point towards awe as a central affective experience in response to the performances that connect and bridge belief and emotional reactions, but require further exploration.

We also identified a clear secondary dimension in our network differentiating uncertainty concerns (ambiguity) from ritual behaviors that are focused on predicting and controlling uncertainty. Behaviors focusing on obtaining blessings, healings, or fortune telling that are performed to divine the future, or control one's fate, were closely connected to social connection and belief clusters, highlighting that uncertainty management mechanisms (Hogg et al., 2010) may be tightly coupled with social functions. This finding is consistent with recent observations that every-day behaviors geared towards uncertainty reduction (e.g., prayer) and social dynamics such as mutual commitment of social partners to one another are closely coupled (Fincham & Beach, 2014). Overall, our data suggest that uncertainty management through the observation of ritual behavior (but not so much uncertainty cognition) is closely associated with social connection dynamics (Henrich et al., 2019).

Taken together, our findings highlight that researchers interested in the cognitive and evolutionary study of ritual should devote more attention to the perceptions of spectators in ritual. Our contribution to the current literature is an exploration of the patterns of reactions by spectators, and points to a variety of interconnected responses that "vibrate" in relative unison during ritual. As noted in recent contributions of psychometric network models across different areas of behavioral sciences (Borsboom et al., 2021; Borsboom & Cramer, 2013; Cramer et al., 2010, 2012; Dalege et al., 2016; Fischer & Karl, 2020), a return to asking open-ended questions about the patterning of responses to behavioral phenomena is an important step of the research process, and is one which can reveal novel insights that may have been missed previously.

Limitations

The current study was ambitious in measuring a large number variables of relevance to a number of different theoretical accounts in a naturalistic context using a large sample. The conditions of the field study, together with low levels of education (e.g., literacy, and familiarity with rating scales) among some of our participants limited our ability to use more extensive standardized tests. At the same time, our scales showed adequate reliability and were carefully validated by academic experts and local informants. A major distinguishing point of network analysis that helps to alleviate some of these problems is that even single nodes can provide meaningful information in the context of a larger network, making them ideal for mapping complex natural experiences.

A further limitation is that we were not able to differentiate possible network differences based on the experience of spectators with the ritual. For example, based on our ethnographic observations, it is not uncommon that spirit mediums from other shrines frequent particular rituals. Such participation typically is interpreted as showing respect and validating the ritual

performance. However, it means that we may have had a small number of individuals in our sample who also have experience as spirit mediums. It is an open question whether cognitive network structures differ by expertise (Schvaneveldt et al., 1985; Siew & Guru, 2022) and this is an important avenue for further research. Another interesting question is whether and how network structures are influenced by some of the core features that have been the focus of recent evolutionary research on ritual, in particular the extent of ordeal or synchronization. Would we find a different cognitive structure if the individuals observed a synchronized display of relatively low ordeal performances (theater or dance performances or collective chanting)? Furthermore, costs can be subjective, and may depend upon the perceptions used to evaluate costs. They can appear less costly, neutral or even beneficial depending upon prior cultural experiences (Henrich, 2009). It raises the question whether cognitive structures depend upon, for example, the relative cost in time and preparation (e.g., a Sunday church service vs. a daylong chanting event). Or would the structure change if the ritual was relatively high ordeal (e.g., sports events that involve a high likelihood of accidents or injury such as rugby or mixed martial arts), but the ritual itself had some objective finality (e.g., win or lose) and involved some personal stakes in the outcome of the performance (e.g., being a supporter or not)? These are some of the interesting questions that we were unable to address by focusing on a single ritualist context, but that can be explored in future research.

Conclusions

We are the first to report a broad exploration of reactions by spectators in one of the largest extreme rituals in the modern world. Our results highlight that: 1) ritual cognitions are clustered into 2) five robust clusters emerge, that 3) can be organized along two major dimensions (positive vs. negative valence, uncertainty beliefs vs. uncertainty management). These findings of a clustering of reactions are compatible with a number of theories, and suggests that theoretical integration, rather than heated arguments, is probably often warranted. The network structure we found also points towards the importance of positive emotion, even in a ritual that seems incredibly dysphoric to outsiders. These results thus suggest that culturally constructed meaning systems are important to consider when examining the emotional reactions to a ritual, because they seem to influence how individuals interpret the behavioral signals that have been the focus of much of recent research, especially those on extreme rituals.

Supplementary material

The supplement contains a description of the history and structure of the ritual, ethnographic descriptions of key events during the ritual, an exploration of key theories and how these theories may relate to the variables measured in our study, detailed information on the validation of the measured variables in the study context and statistical information on the network analysis and network properties.

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Author contributions

RF conceived and designed the study, wrote the manuscript, analysed the data. RF, PT and KS prepared the material, reviewed the design, collected the data. JK provided theoretical input and statistical expertise for data analysis and edited manuscript drafts. All authors have read and agreed to the final version of this manuscript.

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Publishing ethics

This manuscript is our own original work, and does not duplicate any other previously published work; all listed authors know of and agree to the manuscript being submitted to the journal; and the manuscript contains nothing that is abusive, defamatory, fraudulent, illegal, libelous, or obscene.

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. Ethical approval for the study protocol was obtained from the School of Psychology Human Ethics Committee under delegated authority of Victoria University of Wellington's Human Ethics Committee (#0000020925). Institutional Review Boards in Thailand responsible for evaluating social science and humanities research were only introduced in 2017, two years after this study was completed. At the time of planning our study, we sought ethical approval but because our research was not of a medical nature and no intervention was implemented, it was not considered. To assure that we complied with the local ethical norms, we presented all study material to the relevant shrine authorities in Kathu, Phuket town and HatYai. The shrine committees examined our study protocol and agreed for us to approach participants during the festival.

Research transparency and reproducibility

All data, materials and scripts are available on the OSF: https://osf.io/wyzbm.

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