

The evolutionary paths to collective rituals: An interdisciplinary perspective on the origins and functions of the basic social act

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Abstract

The present article is an elaborated and upgraded version of the Early Career Award talk that I delivered at the IAPR 2019 conference in Gdańsk, Poland. In line with the conference's thematic focus on new trends and neglected themes in psychology of religion, I argue that psychology of religion should strive for firmer integration with evolutionary theory and its associated methodological toolkit. Employing evolutionary theory enables to systematize findings from individual psychological studies within a broader framework that could resolve lingering empirical contradictions by providing an ultimate rationale for which results should be expected. The benefits of evolutionary analysis are illustrated through the study of collective rituals and, specifically, their purported function in stabilizing risky collective action. By comparing the socio-ecological pressures faced by chimpanzees, contemporary hunter-gatherers, and early Homo, I outline the selective pressures that may have led to the evolution of collective rituals in the hominin lineage, and, based on these selective pressures, I make predictions regarding the different functions and their underlying mechanisms that collective rituals should possess. While examining these functions, I echo the Early Career Award and focus mostly on my past work and the work of my collaborators, showing that collective rituals may stabilize risky collective action by increasing social bonding, affording to assort cooperative individuals, and providing a platform for reliable communication of commitment to group norms. The article closes with a discussion of the role that belief in superhuman agents plays in stabilizing and enhancing the effects of collective rituals on trust-based cooperation.

Keywords

Collective action problem, collective rituals, evolution, mechanism, religious system, selective pressure

Collective ritual behavior is a cross-culturally universal phenomenon ranging across time, space, and a wide variety of religious and secular contexts. At the same time, rituals pose a puzzle: why

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would people invest so much energy and resources into behaviors with no apparent function? Be it hours spent on regular Sunday church attendance, risking stampede and infection when bathing in the Ganges during *Kumbha Mela*, or burying gold and weaponry during the funerary rites of our ancestors, people abandon subsistence activities to join the rest of their community in what are often costly collective performances demanded by their gods or mythical ancestors. In contrast to instrumental social endeavors such as coordinated hunting or agriculture, rituals do not provide food, money, or any other apparent benefits.

The ubiquity of rituals and their puzzling cost-benefit nature offer an intriguing possibility for researchers to gain insights into the fundamentals of human social behavior and, at the same time, shed light on its underlying psychological and cognitive mechanisms. However, despite this potential, most psychologists of religion direct their interest at religious beliefs rather than rituals. Indeed, a simple search for the words “belief” and “ritual” in the flagship journal of the field (*Archive for the Psychology of Religion*) reveals 316 articles comprising the former term and 183 comprising the latter term. Similar results can be obtained from the *International Journal for the Psychology of Religion* (669/206) or *Psychology of Religion and Spirituality* (2441/144). This uneven representation has deep historical roots with belief being at the forefront of psychological research (e.g. James, 1889; Starbuck, 1900) while rituals were traditionally studied by social and cultural anthropologists (Durkheim, 1912/1964; Tylor, 1871). This situation has gradually changed over the past 30 years with the arrival of cognitively oriented approaches that started to explore some of the psychological mechanisms that underlie ritual performance (Boyer & Liénard, 2008; McCauley & Lawson, 2002; Whitehouse, 2000) and inspired further research into the psychology of rituals (for an overview, see Hobson et al., 2018; Watson-Jones & Legare, 2016).

However, while this upsurge in the psychological research of ritual is encouraging, I argue that to fully understand cultural phenomena such as collective rituals or religious beliefs, the psychological analysis should be enriched with the neo-Darwinian approach to provide rationale for the hypothesized functions and origins of collective rituals or religious beliefs (Alcorta & Sosis, 2005; Bulbulia, 2004; Kundt, 2018).¹ Without such a rationale, researchers might investigate myriads of hypothesized ritual effects that could nonetheless, be inconsistent with the principles of modern evolutionary theory. For example, previous research has found that performing ritual-like action sequences in the lab enhances consumption of chocolate, lemonade, and even carrots (Vohs et al., 2013). But would anyone expect that such a complex behavior as collective rituals would evolve to enhance consumption? In a similar fashion, why should rituals delay gratification (Rybanska et al., 2018)? Or why should synchronized movement during ritual performance enhance trust (Lang et al., 2017)?² While the effects reported in those papers are intriguing, a well-argued model of ritual behavior should aim to clarify not only the psychological mechanisms that facilitate a particular ritual effect but crucially, answer why rituals should cause such effects in the first place. Without a theoretical framework that would include answers to both “how” and “why” questions of ritual behavior and religious belief, experimental and survey data are merely a “butterfly collection” of various effects that do not follow from larger theoretical frameworks such as biological or cultural evolution, which explain human cultural complexity and its variation (Muthukrishna & Henrich, 2019; Pinker, 2015). Accumulating evidence in support of or against particular psychological models of religious beliefs and behaviors should follow only after providing an answer to the question “Why ritual behavior or religious belief should/should not have a particular studied effect?”

The pathways toward building a unifying model of complex cultural phenomena such as religious beliefs and behaviors were recently discussed in length in an article co-authored by Radek Kundt and myself (Lang & Kundt, 2019). Building on Richard Sosis’ (2017, 2019) work, we proposed to utilize the concept of religions as complex adaptive systems to build a comprehensive

model of religion in general, and ritual behavior in particular. The complex adaptive systems approach finds most applications in biological sciences although it recently gained popularity also in explaining macro-cultural events because this approach can capture and explain interesting dynamics of real-world phenomena (Holland, 1992; Lansing, 2003). The advantage of the systemic approach is that it helps determine the boundaries of a working system (e.g. the human immune system), its constitutive elements (B cells, T cells, etc.), and its main functions (detect and destroy antigens). Within such a specified system, researchers can identify the information and energy inflow to the system (B cell antigen detection informs the system about the need for action and increased metabolic rate supplies energy), how this information and energy are processed by the system's elements (multiply B cells and release antibodies), and how this processing leads to specific system outputs (destroy antigens). Importantly, while the system's constitutive elements might be studied in isolation to understand their functions, true insights into the workings of complex systems are possible only after accounting for the non-linear and often feedback-loop interactions between the individual elements (e.g. B cell and T cell interactions). Indeed, the fact that complex systems often produce emergent phenomena that are impossible to predict by simply summing the effects of individual elements attest to the importance of the interactive relationships (Bechtel, 2007). Finally, by examining the adaptive nature of complex systems, researchers can gain insights into the changing composition of the system that should reflect the changing socio-ecological conditions (e.g. functional differences between human and chimpanzee immune systems). In other words, complex systems are evolving, and to understand their current composition, one needs to understand their evolutionary history and explicate how the specific organization of individual elements helps promote the specific system outputs in the current environment.

Approaching religions as complex adaptive systems offers an opportunity to identify building blocks of the system and their particular functions that can be studied individually (e.g. ritual, myth, superhuman agents, taboo, or moral obligations; Sosis, 2019), but, crucially, also to understand how the apparent complexity of the system arises from non-linear interactions between the individual constitutive parts (e.g. rituals in concert with belief in superhuman agents). That is, researchers may identify religion's constitutive parts, study how these individual elements transform and process incoming energy and information, and create a model of their organization and operation that would account for phenomena observed on the level of the full system (e.g. how caloric input through rituals sustains moral obligation established by a religious community). This model thus affords the integration of the psychological effects of ritual behavior and religious belief within one broader framework of religious systems. Moreover, it is also possible to study how various religious systems evolved to thrive in their environments by promoting the positive effects on health, reproduction, and cooperation (Sosis, 2017) or how such systems deteriorated due to negative effects on health, reproduction, and cooperation. Returning back to the problem with the theory of religious beliefs and behaviors, modeling religions as complex adaptive systems enables researchers to make predictions about what functions (if any) the system's elements should and also should not facilitate, how these functions complement each other, and how these functions differ in various socio-ecologies.

Apart from providing a theoretical rationale for the effects that the researchers expect to find, another advantage of using such a broad theoretical framework is the mutual corroboration of the studied effects from various perspectives.³ Specifically, researchers might use a three-dimensional (3D) integrative approach (Lang & Kundt, 2019), in which the studied phenomenon is placed within a Euclidean space defined by three coordinates: temporal depth, mechanistic height, and contextual width. Each dimension provides a unique insight into the studied phenomenon. In the case of ritual behavior, these insights pertain to questions such as how collective rituals evolved and historically formed in various societies (temporal depth), how ritual behavior is

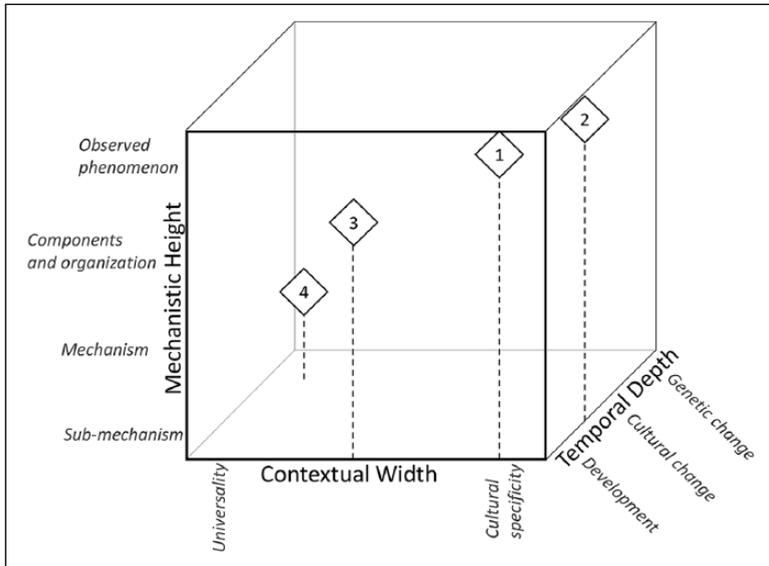


Figure 1. An illustration of the 3D integrative cube proposed by Lang and Kundt (2019). The cube is defined by three dimensions that direct researchers' interest: temporal depth, contextual width, and mechanistic height (with individual dimension items in italics). Researchers might choose to study their subject using various approaches afforded by the integrative cube. For instance, one may study the *Thaipusam Kavadi* ritual in a specific community (e.g. Tamil Hindus in Mauritius) and a particular year (e.g. 2014; point 1 on the cube); or one may study the cultural history of this ritual in the Tamil community in Mauritius (point 2 on the cube). Further insights into this phenomenon may be gained by identifying the universal features of *Thaipusam Kavadi* across various communities and studying the roles of those features in facilitating trust-based cooperation (point 3 on the cube). Finally, one may also study the evolutionary history of mechanisms, although those mechanisms would need to be relatively low on contextual specificity and mechanistic composition (point 4 on the cube). The present article moves roughly in the top-left-back corner, sliding along the mechanistic height and temporal depth dimensions.

carried by the human neuro-cognitive system and promoted by interactions with other elements of religious systems (mechanistic height), and how the form and content of collective rituals differ based on varying socio-ecological conditions (contextual width). Moreover, since this integrative model can be thought of as a 3D cube, one can also ask how the mechanistic composition that facilitates collective ritual behavior differs across contexts (combining mechanistic height and contextual width) or how this composition evolved (combining temporal depth and mechanistic height).⁴ See Figure 1 for illustration.

Research in the field of psychology of religion usually moves along the mechanistic height dimension, although contextual specificity is also reflected through cross-cultural psychology. The research on ritual's role in health management, anxiety regulation, and coping with life struggles may serve as an illustrative example. Frequent engagement in rituals has been shown to lower the mortality risk (Koenig et al., 1999; McCullough et al., 2000), and to consistently affect both psychological and physiological health (Chatters et al., 2008; Powell et al., 2003), even in the case of extreme rituals (Xygalatas et al., 2019). Moving down on the mechanistic height dimension, several interacting components of ritual behavior may facilitate these effects. For instance, collective rituals often provide social support in adverse life situations, decreasing the negative impacts of adversity (Bruce et al., 2014; Li et al., 2016). Praying to powerful and controlling deities may

provide comfort in uncontrollable and threatening situations (Kay et al., 2008; Lazar, 2015; Pieper et al., 2018; Sosis & Handwerker, 2011) and, on the lower mechanistic levels, may be deemed efficacious through magical thinking (Friedland et al., 1992; Lewis & Breslin, 2015) and spurious associations (Fessler, 2006; Matute, 1995; Rudski & Edwards, 2007). On yet a lower level, prayer and similar rituals may be effective due to their specific repetitive and rigid form. In our past work, we proposed that these ritual properties may help decrease anxiety by minimizing internal prediction error (Krátký et al., 2016; Lang, Krátký, et al., 2019) and showed that participants in anxiogenic situation spontaneously express ritualized behavior (Lang et al., 2015).

While necessarily simplistic, this brief illustration shows how one can move along the mechanistic height dimension from an observed phenomenon (rituals positively affect health) to very particular low-level mechanisms (ritualization decreases prediction error). In the present article, I aim to show how insightful it might be to also consider the temporal depth dimension (and leaving contextual width as yet another important step for future research). For example, the anxiolytic effects of ritual behavior may be inconsistent with the evolved function of the anxiety subsystem— anxiety serves to protect individuals from various threats and motivate precautionary behavior. In the first sight, anxiety reduction facilitated by ritual would thus be maladaptive and likely should not have this effect. Evolutionary models therefore need to show that the ritual decrease of anxiety is either (a) adaptive only under specific circumstances where it appears (Lang, 2018; Lang & Chvaja, forthcoming), (b) a by-product of other evolved mechanisms (Boyer & Liénard, 2006), or (c) a spurious finding in the psychological literature caused by confounding variables/poor methods. In either case, the mechanistic and temporal dimensions should be able to mutually corroborate each other and situate the individual empirical findings within a broader theoretical framework. To provide a more extensive illustration of the usefulness of the temporal dimension in the psychological research of religion, the following sections examine whether and how collective rituals, in interaction with religious beliefs, promote one of the three suggested adaptive outputs of religious systems, namely, cooperative and coordinated behavior.

The evolutionary approach

Before turning to the evolutionary analysis of collective ritual behavior, I will first describe the evolutionary approach taken in this article and differentiate it from some of the past approaches. Indeed, the idea that rituals evolve together with the rest of human culture dates back to the early authors in the social sciences and humanities. Early cultural evolutionists such as J. Lubbock, E. B. Tylor, W. R. Smith, and R. R. Marett put forward various progressivist theories on the stages of the evolution of rituals and religion in general (for an overview, see Kundt, 2015). However, rather than proposing testable evolutionary models, these authors engaged in speculative attempts to explain the process of human intellectual evolution while implicitly linking it with value-based concepts of progress (Kundt, 2015). In other words, these early authors did not correctly apply the blind and mechanical Darwinian principles of natural selection to the process of human evolution.

In contrast to these older approaches, current evolutionary approaches build on the neo-Darwinian principles of blind selection that affects both the long- and short-term evolutionary dynamics, expressed as the ultimate and proximate causes of individual behavior (Mayr, 1961). For example, in his seminal work, Mayr (1961) asked “Why did the warbler on my summer place in New Hampshire started his southward migration on the night of the 25th of August?” and offered two sets of explanations for the warbler’s migration: one dealing with proximate triggers of the evolved trait (weather conditions, daylight change) and one dealing with ultimate causes of the evolved trait (migration genetically encoded). This insight was further developed and popularized by Tinbergen

(1963), who proposed to analyze how are traits activated (causation) and how they develop during lifetime (ontogeny) as proximate causes; and why traits evolved as a response to environmental pressures (survival value) from existing structures and behavioral patterns during speciation (evolution) as ultimate causes. Returning to Mayr's question about warbler migration (assuming that the warbler is, for example, the American redstart), its migratory behavior was triggered by change in daylight (cause) to which was the warbler sensitized during its development (ontogeny), and the migratory behavior evolved to buffer seasonal fluctuation of feeding opportunities (survival value) during the speciation of the *Parulidae* family (evolution).

Analogically to Mayr's question about the warbler's migration, psychologists of religion may ask, for example, "Why did a Tamil Hindu in Quatre Bornes partake in the extreme ritual of *Thaipusam Kavadi* on the day of the full moon during Thai?" Applying Tinbergen's insights onto this question, the first set of studies should focus on illuminating how this behavioral trait was activated (causation), that is, what motivated the participant to engage in the collective ritual. Was it chronic illness (Xygalatas et al., 2019)? Or a need to enhance or reinforce cooperative affordances by demonstrating devotion to the god *Murugan* to whom the ritual is dedicated (Power, 2016)? The second set of studies should focus on explaining how the motivations for ritual participation developed during the individual's lifetime (ontogeny; Legare & Watson-Jones, 2015). For instance, did the participant's parents perform rituals related to *Thaipusam Kavadi* when the participant was a child, teaching the participant about the cultural appropriateness of such ritual behavior (Willard & Cingl, 2017)?

The third and fourth set of complimentary studies should elucidate the ultimate cause, that is, why the behavioral trait of participating in collective rituals exists in the first place? Specifically, what is the effect of collective ritual participation on individual survival value (if any), or, in the terms of the contemporary evolutionary theory, what is the effect on the reproductive success of ritual performer (Bateson & Laland, 2013; Strassmann & Gillespie, 2003)? Note that participation in such a ritual does not need to have direct reproductive benefits; rather, there may be other individual benefits (such as increased cooperative affordances) that sum into increased reproductive success for the genetically related circle of individuals around the ritual participant (Sosis & Bulbulia, 2011). Finally, is there a plausible evolutionary dynamic that leads to the evolution of collective rituals from pre-existent behavioral forms and cognitive machinery (evolution)? Answering this question means analyzing population-level behavioral patterns and cognitive machinery present before collective rituals and tracking the change in both as a response to changing socio-ecological pressures. This is a crucial step in the evolutionary analysis because despite finding that collective rituals have individual adaptive benefits, ritual practice may still be a by-product of various cognitive and behavioral processes that only later acquired its functions (a functional by-product rather than an adaptation),⁵ or the effects of participation in collective rituals may be just a spurious correlation resulting from the complex causal webs of human social behavior. For example, researchers might observe that rituals have anxiolytic effects, but without an evolutionary analysis of specific conditions under which ritualized behavior should be functional (Lang & Chvaja, forthcoming), such effects would not make sense because decreasing anxiety might be, in fact, maladaptive. A comprehensive model of collective ritual behavior needs to investigate all four questions and the answers should corroborate each other in order to avoid investigating phenomena that may contradict basic evolutionary principles.

To start building such a comprehensive model of collective rituals, the aim of the present article is to examine the purported adaptive functions that collective rituals may facilitate for individual participants within the religious system (Tinbergen's survival value) and establish whether these possible functions are evolutionarily plausible (Tinbergen's evolution), leaving the questions of causation and ontogeny for future research. To establish whether participation in collective rituals

has adaptive benefits for an individual (or is an evolutionary by-product or spurious correlation), I will review recent laboratory and field studies that examined the association between collective rituals and trust-based cooperation, which stand as a proxy for reproductive success in the present article. To examine whether collective rituals have a plausible evolutionary path, I will use a comparative method that contrasts similar traits in species closely related to *Homo sapiens*; however, before doing so, it may be useful to elaborate a bit more on the way that evolutionary scientists establish whether a trait is an adaptation or a by-product and what evidence is commonly used for that purpose.

According to Bergstrom and Dugatkin (2012), “An adaptation refers to an inherited trait that makes an organism more fit in its abiotic (nonliving) and biotic (living) environment, and that has arisen as a result of the direct action of natural selection for its primary function” (p. 98). Thus, to claim that collective rituals are an adaptation that helps to stabilize risky collective action for the benefit of participating individuals, two links need to be established: the first link is the existence of selective pressures in the hominin lineage related to collective action such as the existence of increased predation that required coordinated group defense or the existence of subsistence practices that relied on inter-individual cooperation. The second link is the existence of behavioral patterns and cognitive machinery that could be molded during the evolutionary process into the new adaptive trait, which enhances trust-based cooperation, because evolutionary processes build upon structures that are already available rather than designing traits *de novo* (Andrews et al., 2002). However, establishing these two links for collective rituals is convoluted by the lack of direct evidence pointing to the timeframe during which collective rituals might have evolved. This is due to the fact that collective rituals (and similar “fossil behaviors”; Tinbergen, 1963) usually do not leave direct material traces in the archeological record (Sterelny, 2017), at least not until the permanent Holocene settlements, in which collective ritual behaviors are inferred from architectural compositions of specific areas (Whitehouse & Hodder, 2010; but see Rossano, 2015).

A way out of this evidentiary cul-de-sac is offered by comparing human traits with closely related species such as chimpanzees, gorillas, or orangutans, who lack such a trait (Wrangham, 1987). If collective rituals would also be present in these species, one could infer that the evolution of collective ritual behavior took place within the socio-ecological pressures pre-dating the splits of the great ape lineage and was most likely also present in the last common hominid ancestor. However, since collective rituals (or religious beliefs for that matter) are most likely not present in the non-human great apes, or at least there are no observations of behaviors homologous in their complexity to human collective rituals, the focus of evolutionary analysis should be directed to the selective pressures and behavioral phenotypes present after the most recent split of hominins from the great ape lineage, that is, after the extinction of the last common ancestor between humans and chimpanzees.⁶ To this end, it is usual to compare the selective pressures and cognitive-behavioral phenotypes of wild chimpanzees⁷ and contemporary hunter-gatherer groups, assuming that the difference in the current selective pressures and cognitive-behavioral phenotypes sufficiently approximates the diversification of the two species (Chapais, 2017; Marlowe, 2005). However, since the time span of the period since the last common ancestor may be up to 7 million years (Besenbacher et al., 2019), a further nuance to this analysis can be added by including data provided by paleoanthropology and paleoclimatology, which elucidate the selective pressures and cognitive-behavioral phenotypes of australopiths and hominins who lived after the last common ancestor.

This phylogenetic comparison should afford tracking how the multi-layered mechanistic composition that gives rise to collective rituals emerged from the core behavioral and psychological mechanisms that humans share with their great ape cousins under differential selective pressure faced by australopiths and early hominins (Chapais, 2014). In other words, collective rituals are likely a product of hundreds of thousands of years of gradual evolution (but see Eldredge & Gould,

1972), which was building upon pre-existing structures in the process of exaptation during which the adapted trait acquires new functions (Andrews et al., 2002; Gould & Vrba, 1982).⁸ Eventually, collective rituals were incorporated into religious systems to play a key role in promoting cooperative outputs of the system.

In line with this dynamic evolutionary perspective, the current article hails from the assumption that collective rituals are an adaptation, an assumption supported by rituals' cross-cultural ubiquity, and deep historical roots (Sosis, 2009); however, this assumption needs to be tested against available empirical evidence. Furthermore, rather than aiming to establish collective rituals as a static adaptation with one main function, the present article investigates collective ritual behavior as an adaptive complex that gradually evolved to enhance individual benefits from collective action in response to changing socio-ecological pressures (similar to the research on the origins of religion, for example, Alcorta & Sosis, 2005; Sterelny, 2017). Congruently with the proposed 3D integrative model of complex adaptive systems (Lang & Kundt, 2019), I do not assume that the adaptive complex is carried by a single psychological mechanism or a single gene—quite the opposite: I expect that collective rituals are carried by and co-evolved with many psychological, cognitive, and neuro-hormonal mechanisms that are affected by various socio-ecological and developmental conditions, similar to other complex adaptations (e.g. see Boyd & Silk, 2009, Chapter 1). Finally, for the sake of simplicity, I remain agnostic about the ratio of genetic and cultural inheritance involved in the transmission of collective rituals, reverting to an assumption that the older and constitutional ritual elements will be likely encoded genetically, and the more complex symbolic elements transmitted culturally. The following sections describe the differential selective pressures related to collective action in the hominid lineage and show how ritual foundational structures that facilitate trust-based cooperation emerged from traits present in this lineage.

The collective action problem

As typically modeled by the evolutionary game theory, collective action that leads to stable interpersonal cooperation reaps the highest individual net fitness benefits (Maynard Smith, 1982). However, any such collective action is constantly at risk of defection or free riding, which threatens to destabilize interpersonal coordination and only maximize the defector's fitness benefits (Axelrod & Hamilton, 1981). Consider a simplified stag-hunt scenario as modeled by the evolutionary game theory (Bulbulia, 2012). If Jane, Paul, Cristina, and Mark could successfully hunt a stag, they would have enough resources to survive longer compared to a situation where each of them would individually hunt for a hare. However, stag hunting is a dangerous and complicated group endeavor that requires elaborate coordination patterns and absolute commitment to individual roles during the hunt. If Paul decides not to risk his life and go hunt a hare instead, the rest of the group will be ineffective and possibly at risk of serious injury.

While the stag-hunt model is hypothetical, real-world examples of collective action problems that necessitate trust abound. For instance, to protect their herds from risks such as drought, famine, and disease, Kenyan pastoralists ask other tribe members for cattle donations when one's herd is decimated, and return this favor when other tribe members are in need (Aktipis et al., 2011). This delayed reciprocity system helps to pool the risk among several bands, thereby minimizing the net individual loss in the long term. However, how can the donor be sure that in the case of their need, the others will reciprocate? Another example of a human collective action problem is communal field-irrigation (Bardhan, 2000). While even water distribution irrigates everyone's field just enough, allocating more water from the public supply to one's own field can significantly increase the field's yield. However, an increasing number of free riders will destabilize the communal irrigation system, which will eventually break down.

Even though these examples are centered on human collective action problems, this does not mean that collective action problems are specifically human. Quite the contrary, any socially living species faces similar problems. Nevertheless, the extent of collective action problems significantly differs between species according to a within-group genetic relatedness, inter-group aggression and predation, and dietary strategies. For instance, if a group comprises mostly related conspecifics, genetic closeness is a sufficient motivation to curtail free-riding tendencies because removing resources from kin decreases the reproductive chances of a similar genotype (Hamilton, 1964). However, in large cooperative networks of unrelated individuals (such as those observed in humans), additional mechanisms are needed to drive collective action. This article argues that collective rituals are exactly such a mechanism (among other mechanisms such as direct and indirect reciprocity, kin and affine structures, etc.), but to support this claim, it first needs to be demonstrated that our hominin ancestors faced more intensive collective action problems than the ancestors of related species in the great ape lineage, and that these pressures necessitated the evolution of social technologies such as collective ritual behavior. To support the thesis that early hominins faced increased collective action problems, the following paragraphs review the evidence for selective pressures in wild chimpanzees, contemporary human hunter-gatherers, and early hominins, focusing on three basic types of collective action problems related to (a) the structure of social groups, (b) inter-group aggression, and (c) dietary niche. Comparing evidence between the three species should reveal whether it is possible to assume sufficient selective pressures for the evolution of collective rituals.

Group size

Starting with the structure of social groups, chimpanzees live in communities that range from 20 to 150 individuals and are usually subdivided into smaller, male-centered parties (Muller & Mitani, 2005). The dynamic of chimpanzee communities is fission–fusion where parties and individuals feed on food patches with variable abundance and accessibility within their territory, and periodically re-join in communal gatherings (Aureli et al., 2008). Chimpanzee societies are patrilocal with female exogamy, so males exhibit increased sociality compared to females (Chapais, 2017). However, since chimpanzees are highly promiscuous, paternity certainty is usually low and genetic relatedness is recognized only between maternal brothers, resulting in most male–male cooperative exchanges being based on reciprocity rather than genetic relatedness (Wrangham & Benenson, 2017). In comparison, contemporary hunter-gatherers live in similarly fission–fusion societies, but their social structure is multi-level, usually organized around bands of 20 to 30 members that together with other bands comprise an ethnolinguistic tribe, which has on average 500 members (Wilson & Glowacki, 2017). In contrast to chimpanzees, humans form stable pair bonds, either monogamous or polygynous, that afford extensive kin and affine networks across bands, independent of their patri- and matri-locality (Chapais, 2017). Although these kin networks may facilitate trust-based cooperation with close kin from different bands, they would be insufficient to account for the increased number of interactions with unknown or less known individuals. Indeed, a survey of hunter-gatherer groups revealed that these kin networks are superseded by ritually established cooperative relationships between unrelated conspecifics, which are more frequent and intense compared to contacts with extended kin (Hill et al., 2014). The increased tribal interconnectedness observed today was estimated to originate during the late Middle Pleistocene in archaic *Homo sapiens* and *Homo neanderthalensis* (Aiello & Dunbar, 1993); accordingly, early hominins such as *Homo habilis* were estimated to have an intermediate network size between chimpanzees and modern hunter-gatherers.

Inter-group aggression

Regarding inter-group aggression, chimpanzees are known to form (predominantly male-based) small groups that patrol borders of their territory, searching for any intruders from competing groups. These border patrols sometimes invade another group's territory, looking for an easy victim (Mitani et al., 2010). If they encounter a lone juvenile or adult male from another group and have sufficient numbers to reduce any possible risk of injury, the invading group kills the lone individual (Wilson & Glowacki, 2017; Wrangham, 1999). However, when two patrols meet and there is no obvious imbalance of power, these meetings usually end with pant-grunts and power displays with no actual physical conflict that would hazard an injury (Muller & Mitani, 2005). Similar to chimpanzees, human hunter-gatherer groups are territorial with a defendable communal range (Willems et al., 2015). The battle raids of contemporary hunter-gatherers usually have similar emphasis on one's own safety and most raids take the form of an unexpected ambush (Wilson & Glowacki, 2017). Nevertheless, there are some records of intensive warfare where many members of both groups died, especially when defenders decided to fight back or the attackers were detected before the attack and massacred (Wrangham & Glowacki, 2012). Similarly, paleoanthropological data suggest early hominins were territorial (Willems et al., 2015), which together with meat dependency and assumed hostile inter-group relations could lead to inter-group aggression (Wilson & Glowacki, 2017). While this conclusion yet lacks direct archeological support, traumas observed in Neanderthal bones during the late Middle Pleistocene indeed suggest aggressive conflict (Churchill et al., 2009; Trinkaus, 2012), at least later in the hominin lineage.

Dietary niche

Dietary niche also significantly differs between chimpanzees and hunter-gatherers, especially in the case of hunting, which again poses a collective action problem. Chimpanzees are known to hunt various species of smaller primates (most often the red colobus monkey), duikers, bushbucks, and bushpigs (Wood & Gilby, 2017). It is mostly the red colobus monkey hunts that potentially require collective coordination and are risky to some extent (most often performed by males). Various authors speculated about different roles that individual chimpanzees play during the collective hunt like "drivers," "blockers," "ambushers," and "chasers," assuming that the hunted prey is subsequently shared (Boesch, 1994, 2002). However, later studies put forward an "impact hunter hypothesis," according to which hunts are usually initiated by frequent hunters who increase the chance of success for other additional hunters, creating a by-product mutualism rather than cooperation (Gilby et al., 2015). Moreover, the prey division is often forced by harassment rather than fair sharing (Gilby, 2006). Chimpanzees also do not hunt large game, most of their prey is less than 10 kg. In stark contrast, hunter-gatherers pursue large game such as giraffes or hippopotami that may weigh up to almost 2 tons (Wood & Gilby, 2017). Hunting large game requires detailed preparations, planning, and trust-based cooperation among the hunters because not only is the yield risky, but the hunt is also very dangerous (Alvard & Nolin, 2002; Bulbulia, 2012). Accordingly, meat is usually shared within the hunter-gatherer band to offset the division of roles and potentially unsuccessful hunts (Kaplan & Hill, 1985), although the meat-sharing rules cross-culturally vary (Gurven & Hill, 2009; Wood & Marlowe, 2013). Looking into the hominin evolutionary past, the oldest remains of large-game processing dates back probably to early hominins such as *Homo habilis* or *Homo ergaster* (Braun et al., 2010; Wood & Gilby, 2017). Cut marks on the bones of animals that were comparable in size to wildebeest suggest either cooperative hunting or at least cooperative power scavenging⁹ by these early members of the Homo genus. Further evidence

suggests that hunting was well under way during the Middle Pleistocene by *Homo heidelbergensis* and *Homo erectus*, as indicated by hafted hunting tools (Wilkins et al., 2012).

Summary

The reviewed differences between chimpanzees, contemporary hunter-gatherers, and early hominins suggest a variety of common selective pressures but generally more intensive collective action problems in the hominin lineage. Among the significant similarities between the three species are fission–fusion group dynamics with recurrent group rejoinders, primarily male engagement in territorial defense and expansion, and preference for safety during inter-group aggression. The major differences include larger and more interconnected social networks in hunter-gatherers, larger mortality risks during both inter-group warfare and during large-game hunting for hunter-gatherers, and the need for food sharing to re-distribute the high risk of unsuccessful hunt. In other words, the collective action problems stemming from the social organization, inter-group relationships, and dietary preferences require heightened within-group cooperation and coordination in hunter-gatherer bands. Possibly originating around the onset of early *Homo*, these selective pressures further intensified for the subsequent hominins due to the variable climate (Ash & Gallup, 2007) but also expansion out of Africa to new habitats (Parravicini & Pievani, 2016).

It follows from this summary that some fundamental ritual mechanisms, which enhance dyadic bonding and stabilize risky collective action, may have existed probably as long as from the last common ancestor between chimpanzees and humans, although collective rituals can be expected to have co-evolved with tool making, social norms, gestural communication, and psychological adaptations for social learning only in the genus *Homo*, starting around the Early Pleistocene (Henrich, 2016, Chapter 15). Moreover, with the onset of the Middle Pleistocene, paleoclimatology data suggest increased climate variability (and, therefore, harsher environments exerting new selective pressures; Ash & Gallup, 2007) and documents sometimes sharp shifts between glacial periods with arctic temperatures and warm interglacial periods. These shifts intensified during the late Middle Pleistocene where paleoanthropological records also document the first evidence of symbolic behaviors (McBrearty & Brooks, 2000) and where fully-fledged collective rituals should be expected.

Although speculative and built only on a limited amount of available data, this summary suggests that there were indeed substantial selective pressures for the evolution of mechanisms that would stabilize risky collective action, especially around the Plio-Pleistocene transition and during the Middle Pleistocene where frequently changing habitats pressured hominin groups to enhance their social life. However, before proceeding further, I would like to clarify one important caveat to this simplified account. The above description of selective pressures appears as if one could draw a simple causal arrow between novel selective pressures and the evolution of collective rituals; but it is important to realize that these selective pressures co-evolved with other adaptations, and besides environmental variability also reflect the evolution of a hominin-specific cultural niche (Fogarty & Creanza, 2017; Laland et al., 2016). For instance, early hominins were not pushed to hunt large game; rather, our ancestors developed an ability to do so because of the multiple benefits that this form of hunting entails and because they possessed a ready-made toolkit of weapons, hunting strategies, and cooperative mechanisms (cultural niche) that afforded such hunting. At some point, collective rituals became part of this toolkit and enhanced the ability to hunt cooperatively, rather than solving a need to hunt cooperatively that would arise *ex nihilo*.

Likewise, the expanded community size resulted from other selective pressures such as increased terrestrial time that was used to exploit resources inaccessible to other primates. Since increased terrestriality would also increase predation rates of our ancestors, larger groups were likely formed

to enhance defense from predation (as we see in other species). Yet, ritual bonding mechanisms might have allowed for even bigger groups (Dunbar, 2012) that were capable of better defense. The causal arrows of selective pressures and the resulting adaptive behaviors are tangled, often in feedback loops; hence, collective rituals are adaptive only given the already existing niche structures in which collective rituals were co-evolving. While the spatial constraints of the current article do not afford detailed elaboration of the co-evolving cultural niche (for more, see Norenzayan et al., 2016), this section hopefully illustrated the basic analysis of the selective pressures that explains why collective rituals might have evolved to serve the cooperation-enhancing function. In the following section, I will define the important features of collective rituals, review the empirical evidence on the effects of participation in collective rituals on trust-based cooperation, and use this evidence to support the supposition that collective rituals gradually evolved from fundamental mechanisms driving dyadic bonding to mechanisms stabilizing larger cooperative groups.

The adaptive benefits of collective rituals

As with the idea that collective rituals have evolved, the notion that rituals provide cooperative group benefits dates back to the founders of the social sciences. Starting with Durkheim (1912/1964), sociologists and anthropologists have long theorized that rituals carry a remarkable “secular utility” by forging communal bonds. In Durkheim’s view, religion functions to organize social life by instilling behavioral norms in their members through symbolic classification and through periodic, emotionally intense rituals. Following Durkheim, Mauss (1954/2002) claimed that ritualized gift exchange imposes obligations of reciprocity, which serves as a social bonding activity in societies that have not yet reached the state of individual contracts sanctioned by laws. Likewise, V. Turner (1969) suggested that by cyclically implementing ritual *communitas* (morally binding egalitarian units), which for a limited period of time equalize community members, the group is fostered along age, sex, and status roles. However, while speculating about possible adaptive benefits, these early theories often lacked supportive data on the socio-ecological predictors of collective action performance (Tinbergen’s causation) and on the process of forming the motivation for collective action performance during individual development (Tinbergen’s ontogeny). Furthermore, these older theories did not provide experimental data that would show the individual adaptive benefits in particular socio-ecologies (Tinbergen’s survival value) and did not employ a neo-Darwinian evolutionary perspective that could explain why rituals should facilitate social cohesion (Tinbergen’s evolution). As mentioned above, the following paragraphs will focus on Tinbergen’s survival value and evolution, illustrating the gradual acquisition of the functions of collective rituals, and leave the causation and ontogeny of collective rituals for future research.

To understand what ritual is and how it might facilitate the adaptive benefits, I now turn to the insights provided by one of the major ritual theoreticians, Roy Rappaport (1999). During his fieldwork among the Maring tribe in New Guinea, Rappaport (1999) noted that warfare between neighboring tribes was accompanied by particular collective rituals (pp. 74–80). To signify the start of the war, men hang fighting stones, prepare special charcoal that is applied to warriors’ bodies before combat, and everyone slaughters their pigs as a sacrifice to the spirits of deceased warriors. Importantly, the warriors are also subjected to strict taboos during the war period, which regulate sexual behavior and the consumption of particular food items. When the war is over and the group gathers enough resources to initiate further warfare, the *kaiko* ritual ensues. Potential allies from neighboring villages are invited to a feast, and the hosting warriors donate pigs to feed the visitors. When the feast is over, the hosts ask potential allies to “help them dance,” and accepting this offer indicates a willingness to fight as an ally in the ensuing war.

Based on this and similar observations, Rappaport (1999) suggested that collective rituals help stabilize risky collective action by materially anchoring symbolic communication in recurrent performative acts that express true commitment to cooperative collective action, which in the case of the Maring would be inter-group warfare. Ritual pig sacrifice, marking one's body with charcoal, or dancing at *kaiko* indicates the individual will to participate in warfare in coalition with other group members and bands. Although the potential allies could use symbolic communication (language) to express their cooperative intentions, such expressions might just be "cheap talk." Consider the stag-hunt example again. While all four actors might wish to cooperate and can coordinate using symbolic communication, they cannot be sure whether the symbolic messages communicated by others are true reflections of their intentions (Bulbulia, 2012). Using flexible symbolic communication is highly adaptive in ever-changing environments (affording elaborate coordination), but the same flexibility constantly threatens collective action because it only has minimal material anchors that do not guarantee signal reliability.

Collective ritual behavior, on the contrary, is performative and helps translate the intangible commitment expressions into tangible physical acts that require energy, material, and time resources, and often involve various forms of suffering. Indeed, the importance of the performative aspect of collective rituals is one of Rappaport's key insights. According to Rappaport (1999), ritual behavior is "the performance of more or less invariant sequences of formal acts and utterances not entirely encoded by the performers" (p. 24). While performance gives the communicated message a material anchor, the invariance of rituals secures that this message will be understood by the recipients. That is, ritual communication has to have rigid structures in order for the message to be meaningful ("we always sacrifice pigs before warfare"). Nevertheless, despite this crucial role of invariance, some ritual subparts are left unspecified so that performance could vary to allow individual participants to communicate self-referential messages within the perimeter of pre-defined invariant forms (how many pigs an individual warrior sacrificed as an index of his commitment to participation in the ensuing warfare). That is, individual performative variance communicates the participants' current states and intentions regarding the risky collective action in question.

To assure the reliability of such self-referential signals, they are carried by indexical communication whereby the *significata* are physically affected by signs. According to Rappaport (1999), this is how ritual "represents the incorporeal by the substantial" (p. 85). These indexical signs are shared with the rest of the animal realm and are one of the basic communication platforms (Krebs & Dawkins, 1984). For example, lowering oneself in front of another individual indicates submission. The deepness and loudness of a mammal roar during a dyadic aggressive encounter indicates body size and fighting ability. However, in contrast to non-human animals, humans harness the inherent reliability of natural indices to broaden the scope of potentially reliable signals by creating other indices through convention (Alcorta & Sosis, 2005). In contrast to animal signals, it is not immediately clear why the number of sacrificed pigs before warfare or the number of piercings in the performer's body during *Thaipusam Kavadi* should indicate a commitment to cooperative collective action. That is, while the physical anchoring of the sign gives the sign its reliability, signaling modality and *significata* are given by convention.

It follows that at some point during hominin evolutionary history, indexical messages had to be extended from indexical ritualized gestures to conventionally determined *significata* carried by physical indices, which afforded a broader scope of reliable commitment signals (Deacon, 1997). These signals eventually transformed into the communication of commitment to a particular symbolic system with sanctified normative structures: whereas kneeling indicates submission, kneeling in front of a statue of a goddess signals, by convention, the existence of and adherence to a sacred normative system that regulates risky collective actions.¹⁰ However, before the enlivenment of complex religious systems, the indexical ritualized communication had to be adaptive in order

to provide foundational structures for the more complex commitment signaling within religious systems; therefore, it should be possible to trace the foundational structures of collective rituals as they have evolved from chimpanzee-like ancestral communication starting during the Plio-Pleistocene transition and continuing to contemporary human collective rituals.

Several predictions about such foundational structures can be deduced from this evolutionary stance. First, since the transition from indexical to symbolic communication assumes the lack of fully developed human language (which is the prototype of symbolic communication), the archaic ritual signals should be carried by channels other than human language. Second, these channels should be predominantly based on visual cues because such cues afford the communication of emotionally charged messages via facial gestures, body postures, and so on and are highly developed within the hominid lineage (J. H. Turner et al., 2017, Chapter 6). Third, the reliability of visually transmitted signals should be enhanced by repetition, redundancy, and invariance (Rappaport, 1999). Finally, the foundational structures of collective rituals should enhance trust-based cooperation. In the following paragraphs, I will provide supportive evidence for the presence of the hypothesized foundational structures of collective rituals and, specifically, for the presence of similarity signals, coalitional signals, and costly signals of commitment, which might have facilitated the transformation from chimpanzee-like commitment communication to fully-fledged collective rituals.

Chimpanzee commitment communication

While ritualized communication abounds across the non-human animal realm (e.g. mating dances by Birds of Paradise), such communication rarely concerns a commitment to cooperative collective action between unrelated conspecifics. Chimpanzee coalitions are one of the exceptions (de Waal, 1982). Commitment to coalitional action is built mostly through social grooming when the individual initiating a bond cleans the fur and skin of another individual from debris and ectoparasites (Dunbar, 2010). Such social grooming results in the activation of the endogenous opioid system in the individual being groomed and, specifically, in releasing endorphins, which were shown to facilitate social bonding (Akil et al., 1984; Machin & Dunbar, 2011), a fact that I return to later in this section. However, social grooming is not the only coalition-building behavior. Due to the fission–fusion dynamics of chimpanzee societies, so-called greeting behaviors are used during group reunions to decrease tension and assure non-conflict ties between individuals that foraged apart (Luef & Pika, 2017; Okamoto et al., 2001). These greetings are often of a tactile nature such as kissing, hugging, or mounting, which in themselves make the signaler vulnerable because proximate contact between adult male chimpanzees frequently results in aggressive displays. Moreover, true to the coalition-building nature of these greeting behaviors, some of the affiliative behaviors are outright dangerous (Dal Pesco & Fischer, 2018) such as putting a finger into mouth of another individual (Byrne et al., 2019; Nishida & Hosaka, 1996) or presenting the genital area and letting other individuals to touch the scrotum (Bygott, 1974).¹¹ These risky behaviors are a direct index of the signaler's cooperative intention to the receiver that intensifies in frequency during times of stress (Arnold & Whiten, 2001; Wittig et al., 2008) and in other primate species may be highly repetitive (Dal Pesco & Fischer, 2018).

However, whereas social grooming and ritualized greetings present a rudimentary behavioral toolkit for coalition building that is based on non-verbal communication, it is also strikingly different from human collective rituals in two aspects: the number of signal receivers and the content of the signal. Chimpanzee coalitions are built bottom-up by summing dyadic relationships and so are the grooming and greeting practices—always building trust between two individuals. Although the chimpanzee community size affords such a bottom-up coalition building, this would not be

possible for the average human network size. Indeed, as argued by Robin Dunbar (1998, 2012), the need to cultivate a large number of social relationships pressured humans to evolve new grooming strategies, which would afford to “groom” multiple people at once, that is, increase the number of signal receivers. The performative aspect of collective rituals offers such a communication platform. Since collective rituals have rigid and repetitive nature, they afford to send the signals of similarity, coalition membership, and commitment to the group norms to multiple receivers simultaneously.

Similarity signals

Similarity signals can be transmitted through several channels during collective rituals, although joint music-making and dancing are the prime candidates for such a pre-symbolic communication that does not require language (Alcorta & Sosis, 2005). Recall that the *kaiko* ritual specifically demanded allies to “help them dance” as a commitment signal to joint warfare endeavor (Rappaport, 1999). A similar use of music-making and dancing were observed in other hunter-gatherer groups, supporting the coalition-building potential of these behaviors (Hagen & Bryant, 2003). On the contrary, while chimpanzees have been observed to drum on tree buttresses, this drumming is conceptualized as individual agonistic displays rather than rhythmic engagement of multiple individuals (McGrew, 2013). Several observations also suggested that chimpanzee juvenile play shows elements of rhythmic coordination but never to the extent of human rhythmic abilities (J. H. Turner et al., 2017).

The differences between modern humans and chimpanzees suggest that the capacity to drum and engage in coordinated interactions may have been present also in the last common ancestor and serve as a pre-cursor for the group rhythmic engagement evolved by humans; that is, a pre-cursor to synchronous entrainment of multiple performing individuals during collective rituals (J. H. Turner et al., 2017). Indeed, rhythmic music is tightly coupled with motor coordination and helps perpetuate synchronous movement (Lang, Shaw, et al., 2016). The synchronous motor activity of many individuals sends visual signals that are rigid and repetitive and create an impression of one cohesive body of agents. The impression of group cohesiveness is further perceived by both performers themselves and their observers (Fessler & Holbrook, 2016; von Zimmermann & Richardson, 2016). Importantly, collective synchrony has been shown to positively impact inter-individual entitativity (Reddish et al., 2013), liking (Hove & Risen, 2009), and cooperation (Reddish et al., 2014; Wiltermuth & Heath, 2009). There are multiple pathways whereby synchrony may promote these effects (Tarr et al., 2014), but for the sake of the argument, I will illustrate just one pathway, namely, signaling similarity between the synchronized actors.

When people engage in collective synchronous movement such as dancing or hand clapping, they recognize others as being more like themselves, and this recognized similarity may serve as a proxy of relatedness, which facilitates trust-based cooperation. The feeling of similarity is likely induced by an integration of the perception and action systems: the former system is responsible for encoding the movement of others onto perceivers’ motor cortices (Gallese et al., 2011) whereas the latter system facilitates movement preparation and performance. During collective synchronous activity, the same movements are perceived and performed, which may cause blending of self-generated and other-generated movements (Paladino et al., 2010), eventually leading to perceived similarity and relatedness. To test the effects of this mechanism, we designed a study where we asked participants to synchronize their movements with another person to a beat, simulating the synchronous dance experience (Lang et al., 2017). This other person was, in fact, a confederate who either synchronized perfectly (high-sync condition), made mistakes (low-sync condition), or was absent (control condition). After the synchrony manipulation, we asked participants to play an

economic trust game with the other participant (our confederate) to assess the effects of enhanced similarity signals on economic cooperation. The results showed that synchronous movement indeed positively influenced perceived similarity between participants and the confederate, an effect that mediated the positive effects of synchrony on participants' liking of the confederate. The high-sync participants also displayed the highest rates of economic cooperation in the trust game; nevertheless, this effect was not mediated by perceived similarity but by endorphin release during the synchronous activity (that we assessed as a pain-threshold increase). Recall that the endogenous opioid system (and beta-endorphins specifically) were implied in chimpanzee social bonding. Signaling similarity may perhaps activate such an old bonding mechanism, which helps stabilize risky collective action, albeit future research yet needs to establish such a connection because our design did not allow us to test such a causal claim.

Coalitional signals

While dancing and music-making support cooperative collective action through signaling similarity, Rappaport's (1999) crucial insight was that participation in collective rituals serves to communicate a commitment to social norms. That is, rather than committing to exclusive cooperation with each individual, participants in collective rituals commit to group-specific cooperative norms that are impersonal. Based on the exceptional hominin social-learning ability (Herrmann et al., 2007), norms evolved to regulate the multiplex social interactions that resulted from the increased network size, expansion into new environments, and the evolution of a cultural niche (Henrich, 2016). While signaling similarity is an important ingredient to stabilizing risky collective action, in complex and cluttered cultural niches, it is adherence to social norms that help solve the abundant collective action problems.

Nevertheless, the social-norm technology begs another question—how to recognize anonymous individuals committed to the same collective-action-regulating social norms (McElreath et al., 2003)? This problem again stems from the increased hominin network size. While chimpanzees usually hunt and patrol borders in groups comprised of only a few members (and up to 30; D. P. Watts & Mitani, 2001) that can be fostered by grooming relationships, battles of hunter-gatherers may involve 200 warriors on each side (Wrangham & Glowacki, 2012). Thus, the recognition of individuals committed to cooperative collective action becomes crucial during large-game hunting as well as during territory expansion and defense.¹² Recall again the Maring of New Guinea described by Rappaport (1999): in the pre-war ritual, the committed warriors applied charcoal to their bodies to signal their commitment to participation in the ensuing warfare, thus simplifying the recognition of cooperative individuals. In the ancestral populations, the most commonly found marker was red ochre; however, other markers might have been used (charcoal, flower/berry colors) that escaped detection by archeological methods and might have preceded the use of red ochre.

A recent experimental result from our laboratory suggests that people are indeed sensitive toward cues of norm-adherence adored by others (Shaver, Lang, et al., 2018). In a study conducted in the multi-ethnic and multi-religious society of Mauritius, we recruited participants from the local Indo-Mauritian (traditionally Hindu) and Afro-Mauritian (traditionally Christian) populations and presented them with a choice of monetary investment to 10 different people who could reciprocate the investment or keep the money for themselves (a version of the trust game). These potential investees were presented as photos displayed on a computer screen in random order and with a standardized background, clothes, and other possibly confounding cues. The only difference among the 10 potential investees was a photoshopped religious badge, which signals participation in collective rituals and commitment to the specific group (a Hindu ash mark on the forehead of

Indo-Mauritian faces and a Christian wooden cross around the neck of Afro-Mauritian faces). The results showed that participants' investments were significantly biased in favor of the faces adorning ritual participants, but interestingly, only for the religious badges that were congruent with the participants' religious affiliation. That is, Indo-Mauritians entrusted more money to faces with an ash mark while the wooden cross had no effect, and vice versa for the Afro-Mauritian participants. These results suggest that collective rituals provide visual cues whereby others assess the signaler's commitment to group-specific social norms that are ritually established.

Costly signals of commitment

Nevertheless, while such self-referential messages of norm commitment help in assorting cooperative individuals for collective action, these messages may be easily faked. Herein lies the problem of cooperative communication raised by Rappaport (1999): how can receivers be sure that the signal is truthful? As suggested above, the solution to this problem is to closely connect the unobservable trait with an observable physical signal (material anchor) and intensify the signal's strength so that the signal would be too costly to imitate for fake signalers. Referred to as a costly signaling theory (Irons, 2001; Sosis, 2003; Zahavi, 1975), this line of thought suggests that if both the signaler and the receiver benefit from trustworthy signals representing an unobservable trait, this signaler will incur such costs that it would not pay off for the low-quality signaler to imitate this signal (Bird et al., 2001).¹³ In the Maring case, while a male can apply charcoal to his body and collect short-term benefits (e.g. increased prestige from committing to warfare), he should not be willing to handicap himself by sacrificing pigs because that would result in net loss over the short term. However, for high-quality signalers committed to the warfare participation (and related social norms), sending self-referential commitment signals through conventional indices such as sacrificing pigs and observing warfare-related taboos will incur short-term costs (handicap) but yield individual net benefits in the long term through the group's increased coordination certainty.¹⁴

Note again the analogy to the chimpanzee greeting behaviors described above. Chimpanzee signalers make themselves deliberately vulnerable by offering sensitive parts of their body (fingers, reproductive organs), behaviors that may be seriously costly for the signaler if the mutual affiliation cannot be established. However, in contrast to human costly communication, chimpanzees communicate dyadic affiliation that corresponds to their typical collective action problems rather than their commitment to the whole group and its norms. Since the costliness of the vulnerability cost depends on the receiver reaction (e.g. exploit another's vulnerability to harm them; Bruner et al., 2017), it is again bound by the possible amount of signal recipients and the network size. In response to the new adaptive challenges, hominins have evolved intrinsically costly ritual practices that signal a general commitment to group norms (rather than to a specific individual) through various modalities such as self-harming, material offerings, or permanent marks (tattoos, scarification). Again, there is experimental and ethnographic evidence supporting the positive role of costly collective rituals in stabilizing risky collective action.

For example, returning to the Indo-Mauritian population, the local Tamil community annually organizes a costly collective ritual called *Thaipusam Kavadi*. Embarking on a 6-km long pilgrimage with home-made altars (*kavadies*) on their shoulders, participants pierce their bodies with needles, hooks, and rods, and/or drag car-sized chariots with hooks attached to their skin. We recently investigated the health risks of participation in this extreme ritual and found that some *kavadies* weigh as much as 30 kg and the most extreme participant taking part in our study had 400 needles piercing his body (Xygalatas et al., 2019). Looking through the lens of the costly signaling theory, enduring pain during *Thaipusam Kavadi* honestly indicates devotion to the Tamil religion

and the rules it stipulates thereby presumably deterring any potential free riders. Like the Maring pig sacrifices, *Kavadi* helps to translate an unobservable degree of commitment to sanctified social norms into detectable and measurable costly indices. Importantly, these costly indices indeed predict group commitment. After performing the *Kavadi* ritual, Xygalatas et al. (2013) asked the performers to fill out a survey and rewarded them with 200 MUR for their participation. The performers could then choose to anonymously donate part of this reward to the local temple. Compared to participants who only took part in the prayers and not in the costly ritual itself, *Kavadi* participants donated significantly higher amounts from their reward. These results were reinforced by subsequent studies where we showed that frequent participation in the *Kavadi* ritual predicts decreased cheating at the expense of anonymous co-religionists (Xygalatas et al., 2018) and that priming participants with music from the *Kavadi* ritual decreased dishonest reporting to obtain financial reward (Lang et al., 2016).

Other studies on costly ritual requirements showed that more frequent participation in a synagogue service predicted cooperation in a collective economic game in Israel (Sosis & Bressler, 2003) and similar results were obtained for the adherents of Candomblé in Brazil (Soler, 2012). A study of collective ritual practices in rural India further supported the costly signaling interpretation of collective rituals by showing that people frequently participating in rituals were seen as more devout and prosocial by other community members (Power, 2016) and actually provided others with all types of support (Power, 2017). Interestingly, as would be predicted by the 3D integrative model described in the introduction (Lang & Kundt, 2019), there is an important socio-ecological variation in costly collective rituals. Sosis et al. (2007) analyzed ethnographic data from 60 societies and coded extreme ritual practices together with other costly signals such as food and sexual abstinence. The results revealed that the frequency of warfare was the best predictor of ritual costs compared to community size, subsistence form, and polygyny.

However, the functional role of costly requirements in stabilizing risky collective action has an important caveat. In a study of the survival rates of 19th-century US communes, Sosis and Bressler (2003) correlated the number of costly ritual practices and requirements and the survival of religious and secular communes (30 and 53 communes, respectively). The results showed that while the number of costly requirements positively predicted the longevity of religious communes, the same requirements did not predict the survival of secular communes. A similar result was obtained in an experimental study where we tested the effects of costly requirements posed by various student groups on a US university campus (Shaver, DiVietro, et al., 2018). Specifically, we compared the frequency of costly requirements between fraternities, university clubs, and classes, and tested their effects on a trust-based cooperation. The results showed that while the members of both fraternities and university clubs trusted each other more than students in regular classes, there was only a small and insignificant difference between the fraternities and the clubs despite the former having more costly requirements for membership.

The studies by Sosis and Bressler (2003) and by Shaver, DiVietro, et al. (2018) indicate that while collective rituals (especially in their costly form) contribute to the stabilization of risky collective action, the interaction between collective rituals and belief is even more effective. As I proposed above, collective rituals evolved from rudimentary dyadic signals to reliable signals of commitment to group-specific norms. Since rituals were able to stabilize risky collective action, they were later integrated with a belief in superhuman agents and with cooperative norms that are sanctified by those agents to form religious systems. This integration may have further promoted the stabilization and persistence of collective rituals and the associated cooperative norms by shrouding the reasons for ritual performance and norm following in a “supernatural veil.” This veil protects rituals and associated norms from logical and empirical refutation (Rappaport, 1999) and decreases the perceived cost of ritual performance for devoted believers (Sosis, 2003). In contrast

to secular systems, sanctified rituals and cooperative norms are seemingly eternal and irrefutable, which facilitates their persistence in the population and helps spread the benefits of stable collective action. Moreover, superhuman agents often require ritual performance (Purzycki, 2016), which leads to an even stronger belief and locks beliefs and rituals in the form of a positive feedback-loop relationship (Lang, 2018; Purzycki & Sosis, 2013). Such a feedback loop may eventually bifurcate out of the original social function of public rituals into the performance of private rituals that serve a belief-enhancing auto-signaling effect (Rappaport, 1999; Sosis, 2003), again firmly interlocking the ritual–belief relationship.

Finally, as with collective rituals, the form and content of belief in superhuman agents itself are subjected to socio-ecological pressures, and it is possible to track the evolutionary history of religious belief (Peoples et al., 2016). Nonetheless, since assessing beliefs in non-human animals is much harder compared to observable behaviors, reconstructing the deep evolutionary pathways of religious belief would be much more challenging and speculative (e.g. see Sterelny, 2017). As a viable alternative, researchers might investigate how belief in superhuman agents changed in the face of more recent socio-ecological pressures such as the Neolithic revolution and the associated growth in societal scale that increased the rate of one-shot interactions between anonymous individuals (Botero et al., 2014). To stabilize such a risky collective action, religious systems likely re-organized to comprise belief in moralizing gods who care about the treatment of anonymous co-religionists, can observe this treatment, and punish any maltreatment (Norenzayan et al., 2016; J. Watts et al., 2015). Our recent test of this hypothesis across 15 small-scale societies supported this proposition: participants professing belief in moralizing gods (as opposed to local gods who care about normative conduct to a lesser extent) played two different economic games closer to the fair split of endowed money between themselves and anonymous co-religionists from a distant community (Lang, Purzycki, et al., 2019; Purzycki et al., 2016, 2018).

Conclusion

In this article, I argued that scholars of religion should aim to build unifying theoretical frameworks that would afford corroboration of a studied phenomenon from various perspectives, including the temporal depth, mechanistic height, and contextual width (Lang & Kundt, 2019). Since the mechanistic height dimension is likely familiar to the readers of the *Archive for the Psychology of Religion*, I only briefly touched on some of the mechanisms that underlie the effects of collective rituals on trust-based cooperation and dedicated most of the article to the evolutionary analysis (temporal depth), which I hope may prove inspirational for the readers. However, a detailed examination of the psychological and neuro-cognitive mechanisms that underlie the origins of ritualized signals and their perception by receivers would be of high interest to the current model and would provide additional corroboration/refutation of the assumed ritual function. Likewise, studying collective rituals along the contextual width dimension and focusing on differential roles that collective rituals play across various socio-ecologies (e.g. as in Sosis et al., 2007) would add an important nuance to the current model and significantly help augment our understanding of the most basic human social act.

By focusing on the temporal depth dimension (see Figure 1), I aimed to illustrate the importance of evolutionary analysis for understanding the purported effects of religious beliefs and behaviors and the workings of their underlying mechanisms. Without a proper explication of the changing selective pressures on collective action and the role that collective rituals have likely played in response to these pressures, it would not be possible to explain *why* scholars observe the various empirical findings regarding the positive effects of collective rituals on trust-based cooperation. Importantly, even if there would be reasons to expect a priori that the effects of collective ritual (or

any other religious phenomenon under investigation) are a by-product of other evolved mechanisms, the ultimate *why* question would still need to be answered to apprehend the empirical findings regarding ritual effects, albeit such an analysis should focus on the original adaptations and the way they give rise to the side effects (Boyer, 2003; Boyer & Liénard, 2006).

Finally, the evolutionary analysis is necessarily speculative and based on scattered and piecemeal data that do not afford clear and unambiguous interpretations. However, this does not mean that such an analysis is useless or a collection of “just-so-stories,” as some may object. Quite the contrary, the principle of corroboration helps to shed more and more light on the human past due to the massive interdisciplinarity and fact-checking across several disciplines. Likewise, these newly developed evolutionary theories help shed light on psychological mechanisms that facilitate religious beliefs and behaviors and their cross-cultural variation. It is my hope that psychologists of religion will take up such a challenge and contribute their knowledge to help build unified models of complex religious systems.

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Notes

1. Note that the proposed approach assumes that individual and social behavioral patterns are legitimate units of evolutionary analyses (Maynard Smith & Price, 1973) in a similar fashion as are, for example, bodily organs or psychological traits (i.e. all are phenotypes).
2. The same argument could be put forward regarding the studies on belief and similar psychological phenomena. For instance, why should spiritual experiences enhance well-being (Rudaz et al., 2019)? Or religiosity promote gratitude (Sharma & Singh, 2019; Tsang et al., 2012)? Also note that I am criticizing myself as much as others. The present article lays ground for what I perceive to be important steps for improving the future science of religion.
3. The corroboration of a particular finding from multiple perspectives/disciplines should be a cornerstone of any discovery process. As an analogy, imagine that while walking through a forest, you hear a series of high, clear piping sounds. You initially identify these sounds as woodpecker calls but to confirm your suspicion and classify the species of woodpecker, additional information is necessary such as the type of forest you are in, geographical area, elevation, season of the year, and so on. Visual information may add further specificity but again requires the knowledge of sexual dimorphism, ontogeny of plumage, seasonal variation, and so on. Together, the more information from different perspectives one has, the more confidence one can have in the particular finding.
4. Of course, other combinations are also possible. For instance, one can study the evolution of specific context in which collective rituals operate as the process of niche construction (Laland et al., 2016).
5. What Gould and Vrba (1982) would call a “non-aptive cooptation,” a term that did not enter the mainstream vocabulary of evolutionary scientists (Kundt, 2018). Nevertheless, this term points to an important

distinction that needs to be considered when discussing a trait's origins. Not all adaptive traits need to be adaptations (Sosis & Bulbulia, 2011), they may as well originate as a by-product of other functional structures and only later acquire beneficial effects. By-products may be also dysfunctional, in which case they would be selected against, or neutral, and spread due to the beneficial functions of other adaptations and human social-learning skills (Gould & Lewontin, 1979). For a discussion of the by-product view of religion and ritual, see Kundt (2018), Sosis (2009), and Sterelny (2017).

6. Hypothetically, the related species might originally have had collective rituals and then lose them after the split of the great ape lineage. While intriguing, I deem this scenario highly unlikely and will not elaborate on it further. However, future research may add comparisons with other great apes to strengthen this assumption.
7. It would be correct to also include wild bonobos in such an analysis. However, since there are not yet such rich data for bonobos as there are for chimpanzees, I am leaving this possibility for future research. See also Pilbeam and Lieberman (2017) for an argument why chimpanzees better approximate the last common ancestor than bonobos (cf. Duda & Zrzavý, 2013).
8. For instance, bird feathers are thought to be a primary adaptation for thermoregulation but during the course of evolution gained a new function—that of catching insects. Larger feathers were adaptive in insect catching and later were co-opted for flying (Gould & Vrba, 1982).
9. Power scavenging is a practice of stealing freshly obtained prey from the predator by chasing the predator away.
10. Note that there is another important product of this ritual form, namely, the establishment and perpetuation of convention. By invariably repeating group-specific acts encoded by ancestors or mythical agents, ritual participants communicate the existence of *the* group-specific social order (and not any other version) and perpetuate *the* established normative convention, which is seemingly eternal. While important, this effect relates more to the functioning of religious systems as wholes rather than the evolutionary roots of collective ritual behavior.
11. While I favor the interpretation that such behaviors signal trust and cooperative intention by making oneself vulnerable, the ethological context of these behaviors is not clear because males often perform testicle shaking on themselves and on the appeased individual (Arnold & Whiten, 2001).
12. Assuming that early hominin societies had rudimentary social norms, albeit pre-linguistic. While this assumption is quite speculative, the extent of technological complexity found in the early Middle Pleistocene hominins suggest large social networks galvanized by social norms (Henrich, 2016, Chapter 15).
13. Also see Henrich (2009) for an extension of the costly signal theory to cultural learning and prestige bias, and Chvaja and Řezníček (2019) for a comparison of these two theories.
14. In the original formulation of the costly signaling theory, Zahavi (1975) focused on mate selection and argued that costly displays are honest signals of fitness quality. While I emphasize costly displays related to group commitment, I do not deny that collective rituals and other religious behaviors also serve the mate-selection function (e.g. see Pazhoohi et al., 2017).

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