Topoi (2025) 44:1111–1129
https://doi.org/10.1007/s11245-025-10189-1

# One with Nature, One with Each Other? A Niche Construction Framework Linking Rituals, Social Media and Nature Connectedness

Ronald Fischer[1,2,3] · Johannes A. Karl[5,3] · Adam Daly[6] · Giovanna Bortolini[4]

Accepted: 5 March 2025 / Published online: 7 April 2025


**Abstract**
In this review, we bring together different strands of research focusing on rituals, social media and nature connectedness and interpret the intersection through a broad evolutionary niche construction lens. We argue that (a) humans have used rituals for a number of different purposes, with a particular emphasis on connecting human communities and managing emotional processes, (b) that these rituals were often centered around nature and seasonal cycles, and (c) that the runaway sociocultural niche construction driven by technological changes has disconnected humans from both the environment and traditional rituals, which has many unintended side effects and consequences. However, we also acknowledge the intrinsic importance of rituals for humans and the great potential of emerging rituals in the digital space to connect individuals with each other, to disseminate information on nature at scale and to link individuals and communities back to nature. We provide some speculation on how social media and digital technology could be used creatively by individuals and communities to connect them with nature again and therefore help to protect nature and identify areas for future transdisciplinary research and theory development.

**Keywords** Niche construction · Ritual · Wellbeing · Health · Nature connectedness · Seasonality

The human evolutionary history is unprecedented in evolution. One of the most salient features that sets humans apart from other animals is the creation of complex niches by altering the natural environment at a fundamental level. Over hundreds of generations, humans have successively moved from being deeply integrated and embedded into the natural environment to an increasingly restructured and modified environment through human-driven technological exosomatic adaptations. While this has been an ongoing process over humanity's existence, the pace of technological and associated lifestyle changes has rapidly accelerated over the last 300 years, pushing human behavior into collective behavioral patterns that are radically distinct from our long term ancestral environments in which foundational psychological processes have developed. There is an increasing disconnection from natural environments and a reduction in physical activity together with an increasing technological connectivity that leads to a disconnection from more direct physical and visceral experiences of life. These evolutionary mismatches between an ancestral environment that shaped human physiology, anatomy and cognition and contemporary living conditions have now been recognized to lead to multiple maladaptive conditions (Hoogland and Ploeger 2022; Li et al. 2018). One of the interesting side effects is that being disconnected from the natural environment may have negative mental and physical health effects (Browning et al. 2022; Frumkin et al. 2017; Rojas-Rueda et al. 2019; White et al. 2020). But even very subtle cognitive effects due to changed collective dynamics and shifts in social learning mechanisms have been documented (Bentley & O'Brien

✉ Ronald Fischer
ronald.fischer@idor.org

1 Cognitive Neuroscience and Neuroinformatics Unit, Institute D'Or for Research and Education, Av. Brigadeiro Luís Antônio, 5001, Jardim Paulista, São Paulo, SP CEP 01401-002, Brazil

2 IDOR Pioneer Science Initiative, RJ 22281-010 Rio de Janeiro, Brazil

3 School of Psychology, Victoria University of Wellington, Wellington, New Zealand

4 D'Or Institute D´Or for Research and Education, Rio de Janeiro, Brazil

5 Stanford University, California, USA

6 Dublin City University, Dublin, Ireland

2015). Further exacerbating the cognitive demands, individuals today are embedded in environments in which selected emotional and cognitive information is consistently shared via social media at an increasing rate and intensity and this information flow is constantly available, which may create problems for some individuals to disconnect or pause information flow from this network, especially during specific developmental periods (Haidt 2024; Twenge 2020; Twenge and Campbell 2018).

Here we bring these strands together and elaborate on how these various processes are interlinked, even though they are typically discussed in isolation. For example, a number of studies have demonstrated effects of nature exposure on human health. We briefly review this evidence and speculate on the pathways of such beneficial effects in modern environments, which show features that deviate from presumed ancestral states of our species (Li et al. 2018). One of the interesting questions to examine in future work is whether these presumed beneficial pathways for health in contemporary populations are triggered by the alterations in today's living environments. It may well be possible that changes in the natural environment that have reduced nature contact of humans in contemporary environments set in motion mechanisms that were not the direct result of evolutionary processes but may now increase fitness for some individuals or groups. To some extent, this may even imply that evidence of positive nature-exposure effects on health in contemporary environments via hijacked evolutionary processes are evidence of evolutionary mismatch dynamics, including runaway sociocultural niche construction dynamics (Ellis 2023) that may conceal negative fitness effects in environments that are most strongly modified away from ancestral conditions (Li et al. 2018).

We then shift our focus to collective rituals. We review a diverse line of research that suggests that collective rituals have evolved over our evolutionary past as a cooperative signaling platform, which connects individuals that are distant kin into well-organized and cohesive groups that can survive in often hostile natural environments. One point that we want to emphasize here is that many collective rituals were centered around seasonal cycles that required coordinated action (e.g., collecting, harvesting, migrating, hoarding) in order to survive and thrive. Therefore, collective rituals historically coincided around seasonal points when collective action needs are highest.

Bringing these lines back together, we speculate on the role played by the collective nature of seasonal rituals that directly connect individuals with each other and to a larger natural cycle, which are today substituted by constant virtual connectedness without shared physical presence and being disconnected from natural environmental cycles. We aim to bring these two strands of thinking which are typically discussed in isolation together via an evolutionary lens. Here, we speculate how the two processes of nature connectedness and collective ritual are intrinsically interwoven and have an amplifying impact both for better and worse for different aspects of human health and wellbeing. We then discuss how communities could harness social technology within this runaway sociocultural niche construction cycle (Ellis 2023) to bring out positive change. To ground our discussion, we first introduce basic principles of evolutionary dynamics.

Basic principles of evolutionary processes.

Evolution according to Darwinian natural selection principles is based on variability of behaviors, inheritance of features and differential fitness (Brown et al. 2011; Darwin 2003; Laland and Brown 2011). The most widely discussed form of evolution which emerged during the modern synthesis in the 1930s (Laland 2017; Laland and Brown 2011) is genetically driven evolution. Variability here refers to the differences found within individuals of a population, which are encoded in DNA sequences. Variability can be induced via spontaneous or environmentally induced mutations as well as genetic recombination during sexual reproduction. Variability is the most essential part of natural selection because without differences among individuals, there would be no traits for natural selection to act upon. Inheritance within this biological evolutionary model is embodied in DNA, which is passed down from parents to offspring. To the extent that behavioral traits are encoded in genetic information (specific genes), this information is inherited by offspring from their parents. The third principle that is necessary for any evolutionary processes to take place is differential fitness, which refers to the differing abilities of individuals to survive and reproduce, based on their traits. Individuals with traits better suited to their environment tend to have higher fitness, meaning they are more likely to survive and produce offspring (which implies that they can pass the information that helped them to survive to the next generation). Over time, these advantageous traits become more common within the population, as those individuals with higher fitness contribute more to the next generation's gene pool. To the extent that the environment remains stable, these traits should then become more frequent in the population.

Evolution via information passed on through genes is well documented but operates at relatively slow time scales. These genetically driven evolutionary processes, for example cannot explain the rapid evolution of humans over the last 50 thousand years. A second mechanism that has been used to explain these changes is cultural evolution (Creanza et al. 2017; Dawkins 2016; Richerson and Boyd 2010). Here the important information is passed through cultural transmission from one generation to the next. The three principles of natural selection are applicable. First, variability refers to the different types of information that informs behavior between both individuals and groups. Second, inheritance of cultural evolution happens via the information that is stored and passed on through formal or informal socialization processes in which offspring learn adaptive behavior within their local context. Third, the individuals and communities that are better able to survive and produce offspring are more likely to pass on their cultural information. Within the cultural evolution literature, a number of additional concerns have been focusing on the relative benefits of learning by trial and error vs. copying behavior of others, including questions on what models are worth copying (frequently observed behavior or behavior by highly prestigious individuals) (Creanza et al. 2017; Laland and Brown 2011).

In addition to genetic and cultural evolution, an additional evolutionary mechanism that has been increasingly recognized as important is niche construction (Laland and Brown 2011; Odling-Smee et al. 2003). Organisms are theorized to play an active role in shaping their environments, which in turn influences the evolutionary pressures they experience. Niche construction occurs when organisms alter their surroundings in ways that can benefit their survival and reproduction. The classic example are the dam building behaviors of beavers that transform forest streams into ponds, creating a habitat that offers beavers protection and access to food. This change in the environment can also influence other species, as the newly created pond may support different plants, fish, and insects than the previous stream. This view moves beyond the traditional assumption of organisms adapting passively to pre-existing environmental conditions and instead highlights how organisms actively modify, select, or create aspects of their niches (environments) in ways that can impact both their own survival and that of other species.

Through these modifications of their environments, organisms can create new selective pressures that affect not only themselves but also other species sharing the environment, which leads to organisms inheriting an environment that has changed what behaviors may be selected for or against. This modified environment affects the fitness of offspring, which means that differential behaviors then become beneficial for survival and reproduction, leading to complex interactive feedback loops. A classic example of human behavior is the invention of agriculture, with agricultural practices varying around the globe according to local ecological conditions, which in turn affected genes involved in extracting nutrients more efficiently from food sources that are locally available (e.g., lactose tolerance, ability to digest starch, see (Fan et al. 2016; Rees et al. 2020; Van de Vliert et al. 2018). The necessity to coordinate social groups to cultivate specific types of crops also leads to changes in social structures (e.g., rice wheat hypothesis, (Talhelm et al. 2014; Talhelm and Dong 2024) and may have been associated with self-domestication in humans, including changes in genetic make-up of contemporary humans compared to our pre-agricultural ancestors (Zanella et al. 2019). Therefore, niche construction recognizes that complex interactions across multiple systems can drive significant evolutionary changes by altering selection pressures across ecosystems and species.

However, when societies develop both the tools to alter their environments and the cultural adaptations to thrive within these altered settings, these transformations can speed up, creating a reinforcing cycle of "runaway socio-cultural niche construction." (Ellis 2023) Achieving a better future for both people and the planet will depend on steering this accelerating process toward positive outcomes. This requires redirecting humanity's most powerful force—our shared aspirations. To guide this force, cultural stories that inspire people with a vision of a better future are likely to be more effective than those focusing only on environmental crises and the dangers of technological change. Therefore, niche construction processes can lead to the emergence of complex ecological webs and evolutionary patterns that might not arise from passive adaptation alone and these processes might be steered through intentional cultural means.

## 1 Nature Relatedness and Human Health

Technological changes have transformed human social life in deeply profound ways. The independent emergence of agriculture around 10,000 years ago in several regions led to the emergence of large collectives that were less mobile and less intimate on average compared to previous hunter-gatherer communities. Our living arrangements have shifted dramatically from living in small bands of up to 200 individuals linked through shared kinship links (R. A. Hill and Dunbar 2003) to living in communities consisting of often thousands of unrelated strangers. Our contemporary living arrangements, especially in cities, also increase the distance to any living matter, with concrete walls, covered pavements and streets that reduce exposure to natural vegetation. Humans have likely shaped their living environment well before settling down and cultivating seasonal crops, horticultural and agricultural land use. For example, evidence from the southern Rift valley in Africa suggests that humans started using fire to manage landscapes around 90 thousand years ago (Thompson et al. 2021). There is some evidence that more diverse ecological settings may have favored early human settlement because greater ecosystem diversification increases availability of diverse food sources, options for shelter and access to valuable resources for clothing, housing or tool manufacture (Zeller et al. 2023). Any vegetation requiring constant water such as green forests or wooded grasslands also implied the presence of fresh water that is essential for human survival, possibly leading to cognitive resources being allocated to detection of green landscapes.

Historically, humans have spent a considerable amount of time managing and cultivating their natural environment. The most dramatic effect of this was the emergence of agriculture around 10,000 years ago in different places around the world, and to some extent independently (Scott 2017; Smith 1998). Humans began to radically alter the natural environment as they moved from a nomadic hunter-gatherer lifestyle to sedentary agriculture. Clearing land to make way for small fields led to the deforestation of large areas of forest. Such deforestation reduced biodiversity, changed soil composition and altered local and global climate by releasing stored carbon. Secondary effects included increased soil degradation, erosion and salinization from irrigation. The resulting decline in arable land led to further pressure to expand agricultural land and further deforestation. Other side effects that would accumulate over time included changes in river systems due to irrigation or water management, changes in local biodiversity, changes in microclimate and the spread of invasive species that further impacted and disrupted local ecosystems (Scott 2017; Zhao et al. 2020).

Managing the natural environment nevertheless seems to have had some immediate positive effects on our ancestors. One of the issues that may be overlooked when considering the impact of green nature today is that natural environments can be highly hazardous. For example, natural spaces can expose individuals to various types of allergens (e.g. pollen), predators, pathogens and diseases, and increase the risk of accidents (drowning, falls, disorientation, etc.) (Europe 2016). Landscape management can reduce these risks and thus improve the overall health of the population (Lõhmus and Balbus 2015). Indeed, the current evidence is that our human ancestors started managing their natural environment well before the emergence of agriculture (Thompson et al. 2021).

Yet, there is increasing evidence that exposure to natural environments today is associated with increased health benefits. Nature exposure has been related to a wide range of benefits from increased attention (Nguyen and Walters 2024), to increased pain management (Berry et al. 2021) and improved biological functioning (Bauer and White 2023). Current research on nature exposure on human health has focused on three major mechanisms or pathways to explain any positive effects (Browning et al. 2022; Rojas-Rueda et al. 2019; White et al. 2020). First, contemporary living environments, especially urban areas, are characterized by the presence of a large number of stressors, including pollution, noise and heat exposure due to increased heat capture in built up environments. Green spaces can help in absorbing some of the toxins and pollutants as well as reduce noise and heat levels. Second, available green spaces may build capacity via instoration, that is these spaces provide opportunities for greater physical activity and social interactions (e.g., parks, playgrounds, sports grounds) and thereby reduce stress and fatigue (Hartig et al. 1996; Korpela and Ratcliffe 2021). As a result, increased green spaces may help to reduce anxiety or restore attentional capacities, that is they act as points of restoration.

One of the mechanisms that has attracted research attention is that increased exposure to nature may increase immune function (Frumkin et al. 2017). One classic theory supporting this is the "hygiene hypothesis," which suggests that early, low-level exposure to certain microbes strengthens immune function and improves its ability to regulate inflammation over the lifespan. This concept evolved into the "Old Friends Mechanism," which posits that essential exposures are not merely common childhood infections but rather ancient environmental microbes that co-evolved with humans, fostering immune tolerance (Rook et al. 2015). Reduced interaction with these microbes has been linked with increased risks of asthma, allergies, and hypersensitivity diseases (Hanski et al. 2012; Ruokolainen et al. 2015). Mental health issues may also result as a downstream effect of these altered immune systems (Rook et al. 2013). In essence, these organisms are key to establishing immune-regulating mechanisms and immunological system cells. When this process is disrupted, susceptibility to chronic inflammatory diseases, cardiovascular conditions, and inflammation-related depression rises (Rook 2013).

These effects may also depend on interactions at the level of the human microbiome, a complex community comprising the entire genomic content of symbiotic, commensal and pathogenic microorganisms residing in various sites in the human body. The diversity of microbes in these communities depends on an individual's health status, genotype, diet, hygiene and it is partly regulated by the local environment (Dekaboruah et al. 2020). Factors associated with living in industrialized regions, such as heightened hygiene, smaller family sizes, increased misuse of antibiotics, and reduced exposure to natural food bacteria, contribute to a less diverse microbiota, mostly old friends microbes (Rook 2013). This reduction can negatively impact human health, as the microbiome is essential for inhibiting harmful microbes, aiding in digestion, and regulating immune responses, contributing to the prevention of diseases such as inflammatory, autoimmune, and neurological conditions. For example, microbiome colonization occurs primarily in early life, and disruptions during this period are linked to greater immune dysfunction later in life, including allergic sensitization and asthma (Bloomfield et al. 2016; Gilbert et al. 2018). In contrast, exposure to biodiverse environments, such as agricultural areas and green spaces that host a greater variety of microbes supports beneficial microbial growth, which is associated with reduced allergic sensitization and enhanced immune resilience (Buchholz et al. 2023; Campbell et al. 2015; Hanski et al. 2012; Von Mutius and Vercelli 2010).

In addition, there may also be natural substances produced by plants that exhibit antioxidant, anti-inflammatory, antimicrobial, and antiviral properties, specifically, volatile organic compounds (VOCs) like phytoncides, which are known to enhance immune function. Studies show that exposure to these compounds, especially during “forest bathing”, can reduce pro-inflammatory cytokines, increase NK (natural killer) cell activity, and improve respiratory health, suggesting a direct immune-boosting effect from inhaling these plant-emitted VOCs (Andersen et al. 2021). The impact of these volatile compounds found in forest air extends beyond respiratory effects. Once inhaled, these compounds are absorbed into the body and are thought to produce broader systemic benefits, particularly by positively influencing the nervous system with calming, anxiety-reducing, and mood-enhancing (antidepressant) properties (Antonelli et al. 2020).

There is some evidence that nature effects on health are stronger in more urban environments (Browning et al. 2022), which implies that nature exposure is more important for health of human populations that are less integrated into natural environments. These patterns involved in beneficial effects of nature point towards complex niche construction effects. First, as discussed above, the positive-effect-of-nature literature neglects that these effects are located within an **evolutionary highly unusual environment**, in which natural environments have been ‘tamed’ through technological advances and existential threats have been largely removed. This contrasts with much of human evolutionary history, in which often hostile natural environments have exerted significant evolutionary pressure on human evolution, representing a source of threat. These threats have been documented since antiquity (Pliny and Healy 1991) and come in a variety of forms, animal attacks, famine, and unexplainable outbreaks of pandemics such as the plague which might have been responsible for the repeated abandonment of neolithic cities and societal collapse (Doig 2022; Scott 2017). Similarly management strategies for these threats, especially pathogen threats which were essentially lacking a coordinated response beside quarantine (and even this was rarely sufficiently effective) until the rise of vaccines against diseases such as smallpox in 1796 and subsequent mandatory vaccination campaigns at the start of the 1800s in Bavaria and Denmark (Habicht et al. 2022). Second, not only are these positive effects studied in a highly modified environment, nature is also less omni-present in individuals’ lives as more have moved from nature rich rural environments (or at least nature adjacent, in the case of intensely agriculturalized environments) to largely built urban environments conflating the effects of nature exposure with exposure to complex novel environments (Morris 2013). Finally, historically individuals did not only have to master survival in these harsh natural environments, they also had to manage their emotional, cognitive, spiritual, and meta-physical relationship with these spaces as individuals and cultural units, which commonly happened in the context of ritual practice (Hutton 1996).

## 2 Rituals as Social Technologies

Rituals have been studied extensively in the social sciences (Fischer 2021). There is no consensus definition of the term, but researchers tend to agree that rituals are structured, often repetitive behaviors or practices that are typically performed in a prescribed sequence and are typically causally opaque (the actions performed are not necessarily causally effective in other contexts, e.g. folding one’s hands is not typically associated with improving the odds of winning a lottery), while at the same time these actions are often imbued with symbolic meaning (Fischer 2021; Lang and Kundt 2023).

Rituals are ubiquitous in human cultures (Brown 1991). Given that all known societies perform rituals, and that these rituals vary dramatically in form, structure, frequency and focus, this incredible diversity makes it difficult to describe specific characteristics and possible factors driving their performance.

Kapitány et al. (2020) analyzed observer-coded features of rituals and identified a small number of dimensions that varied mainly in terms of emotional valence, but also differentiated rituals somewhat in terms of the use of specific behavioral practices (e.g., singing, dancing, percussion) or substances (stimulants, fire, blood, etc.), who participates (kin vs. non-kin), and their relative frequency. An important feature of rituals is their professed sacredness; in many societies, what is part of the ritual is set apart from everyday activities (Bell 2009). Rituals are thus closely associated with religious or spiritual concerns and may have contributed to and preceded the emergence of organized religious movements and hierarchical group living (Lang 2024; Watts et al. 2016). A number of studies have examined possible predictors of the emergence of religious or spiritual beliefs and practices. In a large-scale study of 583 societies, belief in a moralizing high god (as a supernatural agent used to enforce cooperation among believers, (Botero et al. 2014) was more prevalent in contexts where the environment was poorer in resources and communities living in these contexts were exposed to more ecological stress. In addition, these beliefs were more prevalent in politically complex societies that allowed individuals to own animals (which can be stolen or ownership disputed). In other words, belief structures associated with moral high gods and requiring elaborate ritual practices are more likely to emerge under conditions of high environmental stress. The survival of societies with these collective ritual features suggests that these practices may be locally adaptive (Sosis and Bressler 2003). Related work also suggests that many of these rituals are performed seasonally or annually (Atkinson and Whitehouse 2011), most likely coinciding with significant seasonal variations in resource extraction or capture (e.g., hunting and foraging or planting and harvesting cycles, seasonal migration to better resource areas) (Graeber and Wengrow 2021).

There is now ample evidence that rituals serve three main functions(Hobson et al. 2018), including enhancing social connectedness, regulating emotions, and improving task performance. Rituals foster stronger social bonds between participants and within communities (Fischer and Xygalatas 2014; Irving et al. 2024; Reddish et al. 2013; Xygalatas et al. 2013, 2024), they help individuals and groups manage emotions effectively (Atkinson and Whitehouse 2011; Fischer et al. 2014; Irving et al. 2024; Kapitány et al. 2020) and shape task orientation and enhance performance (Mogan et al. 2018; Reddish et al. 2013).

Central to the social connection function of ritual have been actions that are coordinated between group members and often synchronous, that is behavioral actions or vocalizations that are timed to cooccur together in synchrony (Mogan et al. 2017). The phase synchronization of behavior has been shown to be highly effective in conducing cooperative behavior, even if this is costly to individuals (Fischer et al. 2013; Fischer and Kruekaew 2020; Mogan et al. 2017).

In addition to the community binding function, a further function may be the regulation of emotion. Originally proposed by Malinowski (1992), rituals may be beneficial due to their potential to reduce individual anxiety. A number of studies now have shown that (a) anxiety increases repetitive actions (Lang et al. 2015) and (b) in turn the increased repetitive action will reduce physiological arousal (Karl and Fischer 2018). The emerging evidence suggests that repetitive actions may play a key role in the anxiety-reducing effects of rituals.

Rituals typically last a few minutes to days or weeks. These more extended rituals were evolutionarily accompanied by daily interactions with most, if not all, community members (Wiessner 2014). Humans have lived in small groups of up to 200 members, with a distinct fission-fusion dynamic (Couzin 2006). During the day, groups would split up to forage, hunt, gather, plant or extract other types of resources in very small groups but would reunite in the evening for protection and security. Individuals would therefore have daily contact with most members of their community and would spend considerable time each day exchanging information face-to-face around a fireplace or other communal setting. Simple story telling has beneficial physiological and psychological effects (Brockington et al. 2021). Yet, the flow of information was highly variable depending on specific tasks and interaction partners, but typically involved immediacy of rich feedback and close physical proximity. These interactions were interspersed with periods of relative information paucity (e.g., nights with little light sources, waiting for game during a hunt).

## 3 Rituals and Natural Environments - Linking Rituals Back to Seasonal Cycles

Beyond rituals' role as social bonding and emotion regulation tools, rituals are also a common practice in relation to the natural environment. Rituals aid individuals in structuring their relationship with the natural environment both through providing an enacted meta-physical framework that places human and the environment into a coherent, meaningful relationship (Clarke 2009; Hill 2011). Rituals can also aid communities in passing on information and skills necessary for environmental mastery (Hill 2011) and structuring the natural environment (Clarke 2009), or reinforce the position of an individual who has honed such environmental mastery within a given social structure (Rossano 2012).

We propose that rituals were especially common around seasonal transitions (Hohm et al. 2024) as these herald important changes in the daily lives of communities (Lee 1973; Poudel 2020; Wengrow and Graeber 2015) and are partially driven by biological reactions to the changing environment (Harrison 2004; Hohm et al. 2024). There is some indirect evidence for this claim. First, many archaeological sites associated with possible ritualistic use are aligned around specific celestial cycles, suggesting the importance of observing natural cycles for our ancestors and constructing physical spaces in line with seasonal cycles observable in the sky (Hutton 1996; MacKie 2009). Second, seasonality has been shown to influence human behavior and cognition at profound levels, from physical activity to mating behavior and food preferences down to basic cognition and neural activation patterns (Hohm et al. 2024; Shephard and Aoyagi 2009; Xu et al. 2023). Furthermore, human life was strongly driven by seasonal cycles of food available during our hunter-gatherer stage. The necessity to track such seasonal cycles has been proposed to be one of the major drivers of cognitive evolution in primates (DeCasien et al. 2017), because tracking location of specific plants and their harvesting time were highly cognitively demanding. Individuals that were better able to remember high-food sources had greater fitness and were more likely to pass their genes on to the next generation.

These foraging cycles gave way to the emerging cycles of planting, tending and harvesting with the advent of agricultural practice. Seasonal demands for food and shelter required further planning and organization, especially as groups became larger and more sedentary. In some parts of the world, the cultivation of water-intensive crops depended on large-scale mobilization to coordinate access to water through the construction and maintenance of irrigation systems; in other parts of the world, the safe storage of food for the cold season required careful planning and coordination of community resources and the anticipation of possible predation or looting (Scott 2017; Talhelm et al. 2014). These seasonal cycles were typically marked by elaborate rituals to appease higher powers, predict auspicious times for sowing or harvesting, etc.(Graeber and Wengrow 2021).

Such rituals to control environmental factors can be found in many cultures around the world. In the past, without the advances of modern technology, the weather was a matter of life and death not only for individuals but also for communities (Linden 2007). To deal with this existential and essentially uncontrollable threat, communities tended to assert control through the creation of shared belief structures centered on the personification and deification of weather events (Bergmann 2020). Rituals associated with appeasing weather-related gods to ensure physical well-being by obtaining helpful weather and avoiding bad weather are deeply embedded in the culture of many societies, and have played a role in maintaining both communal (Pacheco 2019) and spiritual well-being (Ombati 2021), ensuring that groups would have enough food to last through the winter if they prayed hard enough (Jolly 2006), or that they would not be wiped out by drought if their shaman could please ancestral or natural spirits through dance (Gumo 2017).

As noted above, the anxiety induced by threat can be alleviated by ritual acts, which reduce anxiety and restore some emotional control to the individuals who perform them (Karl and Fischer 2018; Lang et al. 2015, 2020). The performance of these rituals has often been the role of specialists who have assumed roles of high importance in societies under environmental threat. Examples of these highly valued ritual roles have been reported for rain-making (Håland 2005), sun-dancing (Modaff 2014) and ritual worship of volcanoes to avoid eruptions (Chester et al. 2008). The "failure" of specialists to control weather events in difficult environments often led to community hardship and communal anxiety (Shaffer 2018). Therefore, ritual specialists assumed important leadership positions because, through ritual performance, they could temporarily alleviate anxiety and social tensions and coordinate actions that ensured the survival of the larger community (Soga 1931). In this way, ritual specialists were able to assert themselves as a ruling class because of their perceived power within these groups, often passing on genuine meteorological observation skills to descendants to ensure the continuation of a lineage of leaders (Gumo 2017).

Water was a particularly important resource for human survival, and communities were existentially threatened by the absence of rain. Rain has played an integral role in the general well-being of a community, both in hunter-gatherer communities and especially in agricultural communities that rely on rain for crop growth. Rituals focused on controlling rain can take many different forms, including prayer/worship, sacrifice, song or dance (Babane and Chauke 2015; Mendoza & Hansen 2024; Ombati 2021). The continued importance can also be seen in the changing forms of ritual during colonization and apartheid in South Africa (Comaroff and Comaroff 1986; Worden 2011). The original belief systems inherent in many rain-making rituals changed, shifting from communal rituals linked to the land to more abstract rituals that disempowered traditional structures (Mbaya and Mbaya 2024). Typically, lack of rain required a cultural adaptation by local communities to initiate rituals focused on controlling rain as a limited resource. Performed under stress, the rituals could temporarily relieve anxiety, and the performers took on high social status. Such was the importance that these rituals, because of their cultural significance to the well-being of these communities, were also used to cultivate power, first by tribal rainmakers and then by colonial religious institutions, ultimately shifting the source of this well-being away from the relationship with the land, community and rituals, and towards the power of particular religious figures.

Unfortunately, much of this richness of ritual in relation to seasonality and nature is currently unexplored in academic literature. For example, a Scopus search on November 8, 2024, showed a total of 56,390 entries for the search word ritual, but only 503 entries when searching for ritual combined with season, 293 entries when combining ritual with rain or a mere 202 publications when combining ritual and harvest. In other words, less than 1% of the research on rituals examines an ancestrally important context and function of rituals. To some extent, this disconnect demonstrates that contemporary lifestyles and research interests appear disconnected from central concerns of our ancestors. Others have previously noted that research on seasonal variation on human cognition and behavior is largely unnoticed and pales in comparison to other sources of variation (genetic, social, personality, etc.) because it is scattered across various disciplines and these effects vary due to cultural and geographical moderators (Hohm et al. 2024; Van de Vliert 2020).

## 4 Rituals in the Past and Emerging Rituals in a Social Media World

As we outlined above, rituals emerged as social technologies in our ancestral past and continue to evolve because of their important functions, including their ability to help individuals to form, maintain and signal group identities. Until very recently, identity construction and signaling identities in real-world face-to-face contexts were a core aspect of ritual behavior, which involved learning about rituals and their encoded messages followed by engaging in planned, repetitive, and meaningful actions and which then compel individuals to honor those messages and allowed individuals to embody their identity or incorporate it as part of a specific social group.

A paradigmatic example of this is our ancestral past are story-telling rituals, often conducted at the end of the day around a shared fireplace (Wiessner 2014). These rituals typically involved individuals learning through listening to a narrative (Cvorovic and Coe 2022). Historically, a large subset of stories that were told encoded information about the environment, how to treat nature, and the consequences of disrespecting natural forces, factors which would then contribute to social identities centered on stewardship of the environment (Fernández-Llamazares and Cabeza 2018). To take just one example, the Native Hawaiian stories of Pele (the goddess of volcanoes and fire) and Kamapuaʻa (a shape-shifting demigod who is associated with rain, fertile lands, and lush vegetation) detail how these two natural forces rival each other and can be disastrous but can also be formative and beneficial when kept in ecological balance (Beckwith 2024; Xiaojing 2009). These stories in particular detail how individuals must work to balance Hawaii's delicate ecosystem with present volcanic forces, as well as ensure that these areas are protected and not disrupted. Moreover, these stories were of such importance that the identity of environmental stewards has stayed with Hawaiians to this day, with ancestral knowledge facilitating sustainability (ʻĀina of Kaʻōnohi et al. 2023) and fostering resilience against ecological injustices (Ms et al. 2020). Similar stories exist throughout recorded stories the world over.

However, technology has advanced our control over and resilience to environmental threats, such as natural disasters (Krichen et al. 2024) and famine (Sasson and Vernon 2015). Nowadays, the market for stories is saturated and levels of boredom in a digital age with unlimited entertainment options have increased (Tam and Inzlicht 2024). Stories continue to center around environmental issues, but the focus has certainly shifted and may play into identity politics and consumer demands (Soutar and Wand 2022). The clearest example of this is Marvel's 'Infinity War" and "End Game" movies. The story of these movies is that Thanos, who is an extraterrestrial whose home planet was wiped out by unsustainable population growth and resource harvesting, is trying to wipe out half of the universe to prevent what happened to his home happening again on a wider scale (Bruther 2024). He initially succeeds however this is quickly fixed when Iron Man, a human with a technologically advanced suit, sacrifices himself to defeat Thanos and bring back all the individuals who died because of Thanos' actions. This provides a potentially interesting narrative message that with symbolic human sacrifice technology can overcome environmental catastrophes. In other words, a need for more sustainable practices and more stewardship of the natural environment are story tropes but fade into the background of a technological spectacle. The transformational potential for such narratives is undercut by promoting heroism, self-sacrifice, and redemption in combination with implausible technological solutions which do not directly deal with present environmental issues. The human story elements are recognizable and mirror core features of human myths and epics, but embedded and told within a technological environment that transforms our living conditions at a rate never seen before in human history.

Focusing on the identity processes of rituals in our digital age, we briefly discuss one example of feast/meat-eating rituals. Historically, feasting rituals were community centered and often involved the sharing of large animals which has been killed either from a successful hunt (Hawkes et al. 2001a) or from an individual's personal catalog of livestock (Vaiglova et al. 2018). Through these rituals, individuals were able to have a meal for a day, something which was not always guaranteed in communities with low food security (Plana et al. 2023) as well as provide a large amount of protein which some may be lacking (Hawkes et al. 2001a, b). Individuals celebrated themselves and their communities having access to a resource that benefited them as well, with the value of both being tied specifically to the environmental challenges that prevented them from regularly securing such a thing (Van Holt et al. 2010).

Contemporary living conditions have fundamentally shifted both our forms of eating and the ritualistic nature of food consumption. One interesting emerging trend that showcases how ritualistic practices of food that are essential to humanity are shifting is 'Girl Dinner'. Girl Dinner is an internet trend that revolves around the ritualized consumption of quick, easy, typically small, and indulgent meals by women (Karasik 2024). It began in 2023 and has since amassed over 300,000 posts with the associated hashtag on

Tiktok and 2.2 billion views on the same app (Culverhouse, 2023). Girl Dinner as a ritual is interesting because it taps into salient motifs of both simple family dinner rituals and community feast rituals, but in new ways within an overconsuming society. With the abundance of food on display in supermarkets and restaurants, Girl Dinner focuses on a small amount of food in favor of convenience. Similarly, instead of engaging with a smaller community in which food is shared directly (but often in gendered ways), Girl Dinner represents a chance for women to forge bonds digitally across time zones and engage with a broader community who reject perceived notions of 'what one should eat' which are projected onto them (Karasik 2024). Further emphasizing the issue of identity driven rituals in a digital age, the success of Girl Dinner has spanned other gender stereotype-reinforcing trends (e.g., Boy dinner focused on meat and other meals associated with masculinity meals such as eating entire rotisserie chicken).

From a ritualistic perspective, it is noteworthy how these online rituals simultaneously defy and reinforce stereotypes and both challenge and celebrate stigma around healthy eating (Sarkisova 2023). This example demonstrates how we have changed our rituals in the light of technology removing environmental risks (for some) to engage with broader communities and navigate intersecting expectations that come along with membership of such communities.

These brief examples serve to illustrate not how rituals have been replaced but rather how widely practiced rituals have changed and how new rituals have been created due to the variance in environmental conditions. Particularly, rituals have begun to shift away from focusing on increasing survival odds or decreasing the likelihood of a doomsday that often have been central to historically transmitted myths and epics driven by the unpredictability of the environment. This shows the transformative power of technology that it has tamed nature to the extent that its presence has shifted to the margins of contemporary concerns in many parts of the world. Technology has also afforded us the opportunity to engage in new ritual practices on a larger scale, on a more regular and accessible basis. At the same time, we need a better understanding of how these rituals shift due to changes in the environment and technology that also drive risk factors for the survival of humanity in the future (Togawa 1999). It is also important to emphasize that some of these online ritualistic activities have emerged very quickly, and the impact on people's lives, social relationships, and connectedness to nature has not been systematically studied (in part due to their very recent emergence and the long efforts that systematic studies typically require).

## 5 Beyond Doomsday Scenarios - Harnessing the Positive Potential of Modern Technology

The context in which we live and our relationship with our environment has changed dramatically since the creation of traditional harvest rituals, rain dances, etc. In past days, rituals provided a way for communities to bond together, coordinate around seasonal cycles, release stress and perceive a sense of control over the existential threats of the world. However, these points raise the question: What are rituals in the modern age where we have unprecedented control over the natural environment, and we are more connected than ever before, yet probably individually more isolated and lonely than ever before in human history (https://www.hhs.gov/sites/default/files/surgeon-general-social-connection-advisory.pdf)?

To some extent social media that is all around us connects 24/7 to the most distant corners of this world, but at the same time the connections are more superficial, often asymmetric and asynchronous (e.g., we are consuming messages sent by others sometimes a long time ago and we never provide direct and timely feedback to the sender). Therefore, we are connected but lack meaningful connectedness. There is a strong association between social media use and loneliness (O'Day et al. 2021), but it is hard to ascertain the causal direction of this association even in the presence of longitudinal links from social media use to loneliness and lowered wellbeing (Ferguson 2024; Pezzi et al. 2024).

At the same time, social media may also offer new opportunities for engaging with each other and connecting individuals to nature in new ways. Rituals emerged as a social technology probably deep in our evolutionary history (Lang and Kundt 2023) and it is almost certain that rituals change with the shifting needs of humans living within everchanging ecological niches (Heine & Prebish 2003; Laing and Frost 2014; Zainuddin 2023).

Social media has a unique ability to reach and inspire a wide audience, making it a powerful tool for fostering community connections and a deeper connection to nature. Although social media use can be associated with increased isolation and loneliness, as demonstrated by numerous studies (Haidt 2024; Twenge and Campbell 2018), it can also be used to build a shared sense of purpose and community (Verduyn et al. 2017). This also includes possibilities to develop technologically mediated collective rituals that connect individuals to nature. For example, sharing nature-related photos is associated with increased life satisfaction (Chang et al. 2020), and active sharing is associated with greater engagement with nature and better mental health (Flynn et al. 2022).

Indeed, one of the most powerful tools of social media and information technology is the ability to disseminate information on a scale and at a speed never before experienced by humanity (as a form of oblique one-to-many knowledge transfer, Laland and Brown 2011). This opens up exciting possibilities for sharing information that may have existed in small communities but can now be shared more widely. A second opportunity is the ability to communicate directly with individuals across time and space, including the ability to find like-minded individuals in other locations that an individual would never have been able to identify and connect with without the help of social media (as a form of horizontal peer-to-peer transmission, Laland and Brown 2011). A careful scaffolding of technological capabilities and opportunities around meaningful activities that occur in the offline real world between individuals and communities allows for interesting new forms of connecting individuals in new ritualistic forms, building new connections to the natural environment, and sharing relevant information.

In the following sections, we discuss some possible ways forward for engaging individuals and communities with nature through the ritualistic use of social media. These discussions are anchored around several key pillars, but we acknowledge that our discussion of specific activities is somewhat arbitrary, and different activities tap into more than one pillar. It is also important to emphasize (as one reviewer of our manuscript noted) that there is little empirical work on the actual effectiveness of some of these emerging activities and strategies. Our observations are presented with the goal of encouraging more systematic research on the links between ritual activity, social media, and nature and social connectedness.

In order to better understand the key characteristics of emerging technologies and how they relate both to ritual practice and to enabling social and natural connectedness, we list a number of key dimensions of technology that we think are worth exploring further in this broad area. The list also shows links to established research areas in the study of ritual, technology, and social cohesion, to help build bridges to more established research domains. This can serve as an initial guide for further theory-development and research.

## 6 Sharing of Real-World Activities

Social media allows sharing of images, videos, stories and information to a potentially unlimited number of others. If these activities were focused on aspects of the natural environment, such as the beauty, fragility, or power of nature and how individuals engage with nature in order to enjoy or protect it, this could have significant normative effects. Simple photos or written reports as well as more carefully edited visual story telling can encourage followers to appreciate and care for the natural world. At the aggregate level, a larger proportion of photos with plant-related labels has been found to correlate with higher nation-level life satisfaction (Chang et al. 2020), suggesting that online-sharing of nature-related activities can have positive wellbeing effects.

There is a robust research tradition that journaling or daily writing tasks can have therapeutic effects (Sun et al. 2020). These repeated ritualistic activities build around one of the central functions of rituals for managing emotions (Hobson et al. 2018). Historically, rituals have operated as opportunities for self-reflection, growth, and/or the removal of guilt within a religious or spiritual focus (Bybee and Quiles 1998; Demmrich and Wolfradt 2018). An example of this is Metta meditation, which stems from Buddhist traditions, whereby an individual, typically living a monastic lifestyle, meditates while focusing on the love that they have for others and extending it to the self and the broader world, allowing them to work towards achieving enlightenment through letting go of resentment and self-doubt (Bhikku 2024; Fredrickson et al. 2008). However, with the decline in monastic lifestyles, the lack of free time in modern-day lifestyles, and the global spreading of secularized practices it seems that many meditation rituals have been adapted to modern needs and be transformed into online contexts (Li et al. 2023). For example, daily affirmations are short-form media to provide emotional and spiritual support to individuals which is easily accessible and consumable (Dela Cruz 2023). Some forms of daily affirmation content may have a religious or spiritual character, but many have moved away from the original Metta meditation goal of self-actualization and instead more broadly aims to improve the positivity and well-being of others to help cope with modern life (Devos et al. 2023; Green 2024). This difference is particularly interesting considering the vast difference between monastic life and modern life, with monks afforded the opportunity to spend most of their days outdoors in contemplation (Hayashima 1962) as opposed to modern-day individuals who do not spend a lot of time outdoors (Beyer et al. 2018). Interestingly, in this case is that core aspects of the ritual and the message associated with it have been changed and in some benefitted from the introduction of technology, reaching a wider audience even if in a slightly different form and format (Connelly 2015).

Meditative events could also be centered around cyclical or seasonal activities such as sunrise/sunset or lunar cycle observations. For example, individuals could focus on watching the sunrise or sunset from their location, posting photos or reflections. This simple ritual can remind people of their connection to natural rhythms, while also allowing followers across different time zones to contribute to a shared experience. Building on the evidence of both meditation and writing exercises on mental and physical health (Fischer et al. 2020; Pennebaker 2018; Pennebaker and Evans 2014), individuals could reflect on the specific sensations that they notice as a form of mindfulness and careful attention (Karl and Fischer 2022), or individuals could focus on things in nature they are thankful for during a particular time of day (e.g., sunrise or sunset). This is central to many mindfulness interventions, getting individuals to commit to mindful observation activities where they are encouraged to spend a few minutes observing nature without any distractions (Karl et al. 2021) or to gratitude interventions (Diniz et al. 2023). They can then share a single observation or realization they had during that quiet time. Broadening this, individuals could also be encouraged to share one thing each week or month that they're grateful for as their participating in nature activities (e.g., #NatureGratitude). Such simple reflection can deepen appreciation for local ecosystems, and seeing others' gratitude posts can increase empathy for nature and encourage diverse perspectives. The work on mental health has demonstrated the benefits of regular reflective and writing activities (Fischer et al. 2020; Pennebaker 2018). This could be adapted for asking individuals to reflect on a regular basis on their level of nature engagement (e.g., prompts such as "What did you see that reminded you of the beauty of nature this week?" or "What's one sound from nature that stood out to you this week?"). Again, the real power of social media is that it becomes possible to take photos, videos and create written reflection.

These activities could also be built around specific days or months such as Weekly or Monthly Nature-Themed Challenges ("Nature Saturday" or "Wild Wednesdays") or season-focused themes (e.g., "May spring blossom", "Autumn leaves November", "Summer solstice skies") in which participants establish a recurring day each week, a specific month or natural event (Solstice, equinox) with nature-themed activities and share their experiences using a dedicated hashtag (e.g., #NatureSaturday). Activities could range from taking a nature walk to photographing local wildlife, plants, or landscapes to document flowers, leaves, fruits, or seeds, or simply reflect on the changing season. Making individuals aware of the cycles of nature can increase awareness and empathy (Djernis et al. 2019). At the end of each month, participants can share a snapshot or summary, building a collective gallery that showcases the diverse ways people experience and appreciate nature. Documenting and sharing impressions and lessons learnt from these events could help disseminate knowledge, build community identities through sharing and inspire others to join. Ideally this could be built around some real community groups (e.g., community meet ups, nature walking groups). In addition to linking to individuals and communities, technology features such as Micro-Stories (short, engaging stories on platforms like Instagram, TikTok, or YouTube Shorts) about daily nature interactions can inspire viewers to find their own local nature experiences.

## 7 Promoting and Encouraging Outdoor Activities

First, while new technologies can lead to disengagement from the natural environment, they can also provide new ways to encourage engagement with the outdoors and the natural environment. This can range from online groups and conversations that generate enthusiasm for the natural environment, to groups that pool resources to enable collective engagement with the environment. There is an impressive and growing variety of digital applications, games and community resources online (Andrachuk et al. 2019; Cord et al. 2015; Franken et al. 2023; Keshavarzi et al. 2023; Shrode 2012). These activities are well documented in English-speaking settings, but also appear to be effective in non-English-speaking contexts (Keshavarzi et al. 2023). Extensive work in the exercise and diet literature suggests that partnering is highly effective in inducing real-world behavior change (Burke et al. 2006; Irwin et al. 2012; Kerr et al. 2007; Lemstra et al. 2016; Rackow et al. 2015), even when the buddy is virtual or in a gaming context (Feltz et al. 2011).Combining the primary synchronous activities, the enhanced power of social media is that it allows asynchronous sharing of records of the events online with designated hashtags. These shared posts can in turn foster a greater sense of collective identity and further shared environmental responsibility. These activities can foster a range of benefits, from individual to collective enjoyment, that would be difficult to achieve without the rapid communication technologies that allow effective organization of dispersed individuals.

Second, communities can use digital communication technologies to create asynchronous content that is embedded in a broader group narrative of engagement with nature, which can encourage individual activity in nature. These activities can also take on the format of games, forcing individuals to move through physical spaces to earn points or rewards. The most famous of these is probably Pokemon Go, which has created a global craze and generated significant tourism activity (Hsiao and Tang 2021), but other games also encourage users to visit real-world spaces (Cord et al. 2015). Successful campaigns have created social media challenges (e.g. The Wildlife Trust's stay wild challenge (*Stay Wild| The Wildlife Trusts*, n.d.) that encourage participants to engage with nature on a daily basis, whether by going for a walk, observing wildlife or practicing environmentally friendly actions. Again, using social media to find buddies for these activities can increase the potential for behavior change (Emmerson et al. 2019).

These digital campaigns can range from single short-lived challenges to ongoing and persistent group activities, evolving their own norms and structures. Such as digitally connected bird-watching communities, communities centered around plant identification (Andrachuk et al. 2019; Shrode 2012) or communities around specific outdoor activities such as sharing individual running progress (Franken et al. 2023). However, as with many group activities, implicit norms may appear that can reduce their effectiveness (Franken et al. 2023). Nevertheless, the potential for these activities is probably not properly explored yet, especially when considering altered reality applications and games that might increase the individual and collective enjoyment and engagement with the natural environment. These altered reality applications and games range from games that include contact with nature as incidental products such as when users spend more time walking outdoors to altered reality games in which individuals can create specific opportunities to engage in new and novel ways with the environment. For example, as part of geocaching individuals can scout particular nature locations which they can encourage others to visit and engage with in a novel way by providing additional information or gamified features. As part of these visits, individuals can engage in community ritualized practices such as logging their visits and exchanging small memorabilia and coins. The exchange of coins adds a specifically interesting meta-layer as they can be tracked by users providing insights on the connection of the community and creating a sense of scale and cohesion (cord). Overall, this shows that technology can be a tool to increase individuals engagement with nature, both individually and in a group context which can lead to the emergence of new ritualized practices within communities through which the interaction with nature is mediated.

## 8 Knowledge Sharing

We have repeatedly hinted at another important aspect of digital technologies, which is the possibility to share knowledge. Online campaigns can amplify conservation messages and raise awareness about specific environmental issues, which can result in activism and changed behaviors (Knupfer et al. 2023). Through sharing relevant information on local flora, fauna, and habitats both individuals and organizations can share resources about local trails, parks, and hidden nature spots to make it easy for people to find nearby areas where they can connect with nature. We also already mentioned the possibility to disseminate tips for sustainable practices that help protect nature, such as reducing plastic use, conserving water, and supporting ethical brands.

The increasing available of citizen science apps and new journals (e.g., https://theoryandpractice.citizenscienceassociation.org/*)* provide new avenues for individuals to both engage in science to create new knowledge and document important information around wildlife, plants, or fungi (e.g., Internet of Nature initiatives - https://www.plataforma.edu.pt/inature*)*. Some wildlife trusts have started campaigns around seasonal change (see above), by asking individuals within online communities to document local flora and fauna in specific seasons. This can then be used to construct a collective map of nature, including spring blooms, migrating birds, or leaf changes and create valuable information on climate patterns.

Given the current volatile political climate, it is difficult to forecast how these trends will play out in the near future. At the time of writing, elections in several countries brought political parties to power that are science-skeptical and promised to roll back environmental protection, deregulate industries and disempower human communities in favor of large industries. The monopoly of social media firms used by most humans in the hands of a few individuals also raises further concerns and questions. Yet, a view over the evolutionary history of our species provides some optimism because of the adaptability, resilience and creativity that human populations have shown over the millennia. We can hope that we have enough time to use the creative potential of digital media to the advantage of humanity and hone age-old predispositions for ritual and social connection to activate communities to mitigate the damage that has been done to our planetary ecosystem.

## 9 Transdisciplinary Research Directions

In the previous section we focused on how rituals in a digital world can still help to connect people with nature. In Table 1, we outlined a number of possibly important dimensions within the digital environment that appear promising for further research. In this final section, we want to outline some transdisciplinary research directions that might help us better understand these interrelated dynamics at a more fundamental level.

First, the idea of runaway socio-cultural niche construction (Ellis 2023) needs further exploration. The idea of complex niche construction processes with feedback loops from human activities shaping our environment to genetic inheritance is a plausible hypothesis for which substantial evidence is accumulating for other species. For humans, however, some of these effects are still more speculative than supported by solid evidence. Transdisciplinary work

**Table 1** A preliminary taxonomy of major characteristics of technology and relevant research domains

| Dimension | Definition | Example | Relevance to existing research |
|---|---|---|---|
| Degree of synchronization | The extent to which behavior and information flow are instantaneous and synchronized or delayed and asynchronous | Making a video call vs. sending a text message that will be read later | Synchronization is central to the functionality of collective ritual (Mogan et al. 2017) |
| Anonymity of group members | The extent to which group members are individually identifiable to each other | Anonymous comments on social media vs. identified group chat participants | Anonymity and diffused responsibility can lead to suboptimal outcomes in group settings (Baltes et al. 2002; Bond and Titus 1983); establishing parasocial relationships online may influence subsequent behavior (Knupfer et al. 2023) |
| Activities are self- or other-guided | The extent to which activities require the presence of a facilitator or external stimuli (e.g., guided meditation, beepers) | Guided meditation apps vs. self-guided mindfulness exercises | The effectiveness of guided vs. unguided ritualistic activities on mental health (Fischer et al. 2020; Spijkerman et al. 2016) |
| Individual vs. group focused technology and activities | The extent to which any technology and associated activities are focused on individuals, groups or both | Individual learning apps vs. group games or social forums | Relative effectiveness of individual vs. group activities for inducing behavior change (Fischer et al. 2024; Rosendahl et al. 2021) |
| Active vs. passive ('lurking') engagement with online content | The extent to which individuals can only consume content or have the opportunity or are required to actively engage (comment, share, collaborate, etc.) | Passive consumption (YouTube) vs. active learning platforms (Duolingo) | Effectiveness of different learning strategies (Chi 2009; Prince 2004); active vs. passive ('lurking') effects of social media (Flynn et al. 2022; Verduyn et al. 2017) |
| Necessity to engage with real-world | The extent to which the technology requires interaction with the physical world (e.g., running or social games with real-world interactions) | Pokémon Go (real-world interactions) vs. YouTube (virtual) | Differential effectiveness of online and offline learning (Alarifi and Song 2024) |
| Virtual vs. physical reward for engagement | The extent to which an individual is reminded and incentivized, virtually or physically, to encourage continued engagement in a behaviour | Virtual log-in rewards vs. Store loyalty cards | The valuation of varying incentivization strategies to guide repeated behavior (Demoulin and Zidda 2008; Frommel and Mandryk 2022). |
| Authenticity of the online presentation | Extent to which nature engagement appears authentic vs. motivated by instrumental motives (e.g., click bait) | Nature conservation digital activists (authentic) vs. branding strategies (possibly inauthentic) | Effects of authenticity on behavior and attitudes (Yang et al. 2021, 2024) |

involving archaeologists, geneticists with expertise in ancient DNA analysis (Orlando et al. 2021), historians and digital scientists to explore subtle changes in textual sources (Du et al. 2023), economists to explore economic activity over historical time periods, and sociologists and psychologists interested in historical change (Muthukrishna et al. 2021) can generate new insights that transcend any single discipline. With a focus on contemporary populations, it is also essential to explore in more detail the effects of natural exposures on human health in different ecosystems (Frumkin et al. 2017). To date, most research has been conducted in limited ecosystems, making conclusions less clear, particularly for tropical and subtropical regions. There is a clear need for more diverse and representative research, covering the full range of ecosystems and human populations.

In this line of work, digital traces collected by mobile phones (e.g. GPS data), which can be linked to other data sources, such as epidemiological data on disease outbreaks or plant distribution captured by satellite images over different seasons, could be analyzed with machine learning tools to identify associations between exposure to nature, mobility patterns and health. Unobtrusive data from mobile phones has already helped change public policy to identify and address poverty (Aiken et al. 2022).

This can also help in identifying some of the implied mechanisms of the nature exposure effects that we introduced earlier. One of the frontiers for science in this area is a better understanding of the microbiome. Citizen science platforms and wearable devices can monitor individuals' interactions with nature and associated changes in the microbiome, as seen in projects like the American Gut Project (McDonald et al. 2018). By combining biological research with mobile sensors and social media, innovative research approaches can be developed to study and ultimately promote human health at a much bigger scale than can be done with traditional laboratory research.

## 10 Conclusions

We have brought together research from different traditions inspired by a broad evolutionary lens to argue that (a) humans have used ritual for a number of different purposes, with a particular emphasis on connecting human communities and managing emotional processes, (b) that these rituals were often centered around nature and seasonal cycles, and (c) that the runaway sociocultural niche construction driven by technological changes has disconnected humans from both the environment and traditional rituals, which has many unintended side effects and consequences. Yet, we also argued that human nature is built around rituals and emerging rituals in the digital space demonstrate that rituals continue to evolve and thrive. We have speculated on how social media and digital technology may be used creatively by individuals and communities to connect them with nature again and therefore help to protect nature. We also outlined a number of key dimensions that are worth exploring further for future theory and research development.

**Funding** This work was supported by the IDOR/Pioneer Science Initiative (http://www.pioneerscience.org) to the first and the fourth aut hor.

## Declarations

**Conflicts of Interests** The authors have no relevant financial or non-financial interests to disclose.

## References

Aiken E, Bellue S, Karlan D, Udry C, Blumenstock JE (2022) Machine learning and phone data can improve targeting of humanitarian aid. Nature 603(7903):864–870. https://doi.org/10.1038/s41586-022-04484-9

Alarifi BN, Song S (2024) Online vs in-person learning in higher education: effects on student achievement and recommendations for leadership. Humanit Social Sci Commun 11(1):1–8. https://doi.org/10.1057/s41599-023-02590-1

Andersen L, Corazon SS, Stigsdotter UK (2021) Nature exposure and its effects on immune system functioning: A systematic review. Int J Environ Res Public Health 18(4):1416. https://doi.org/10.3390/ijerph18041416

Andrachuk M, Marschke M, Hings C, Armitage D (2019) Smartphone technologies supporting community-based environmental monitoring and implementation: A systematic scoping review. Biol Conserv 237:430–442. https://doi.org/10.1016/j.biocon.2019.07.026

Antonelli M, Donelli D, Barbieri G, Valussi M, Maggini V, Firenzuoli F (2020) Forest volatile organic compounds and their effects on human health: A State-of-the-Art review. Int J Environ Res Public Health 17(18):6506. https://doi.org/10.3390/ijerph17186506

Atkinson QD, Whitehouse H (2011) The cultural morphospace of ritual form: examining modes of religiosity cross-culturally. Evol Hum Behav 32(1):50–62. https://doi.org/10.1016/j.evolhumbehav.2010.09.002

Babane MT, Chauke MT (2015) The preservation of Xitsonga culture through rainmaking ritual: an interpretative approach. Stud Tribes Tribals 13(2):108–114. https://doi.org/10.1080/0972639X.2015.11886717

Baltes BB, Dickson MW, Sherman MP, Bauer CC, LaGanke JS (2002) Computer-Mediated communication and group decision making: A Meta-Analysis. Organ Behav Hum Decis Process 87(1):156–179. https://doi.org/10.1006/obhd.2001.2961

Bauer A, White ND (2023) Time in nature: A prescription for the prevention or management of hypertension. Am J Lifestyle Med 17(4):476. https://doi.org/10.1177/15598276231165662

Beckwith M (2024) Hawaiian mythology. Left of Brain Books

Bell CM (2009) Ritual theory, ritual practice. Oxford University Press

Bentley RA, O'Brien MJ (2015) Collective behaviour, uncertainty and environmental change. Philosophical Trans Royal Soc A: Math Phys Eng Sci 373(2055):20140461. https://doi.org/10.1098/rsta.2014.0461

Bergmann S (2020) Weather, Religion and Climate Change. 1st edn. Routledge

Berry MS, Rung JM, Crawford MC, Yurasek AM, Ferreiro AV, Almog S (2021) Using greenspace and nature exposure as an adjunctive treatment for opioid and substance use disorders: Preliminary evidence and potential mechanisms. Behavioural Processes 186:104344. https://doi.org/10.1016/j.beproc.2021.104344

Beyer KMM, Szabo A, Hoormann K, Stolley M (2018) Time spent outdoors, activity levels, and chronic disease among American adults. J Behav Med 41(4). https://doi.org/10.1007/s10865-018-9911-1

Bhikku VK (2024) Meditation and Monasticism: Tracing the Historical Roots of Buddhist Practice. https://www.irjweb.com/Meditation%20and%20Monasticism%20Tracing%20the%20Historical%20Roots%20of%20Buddhist%20Practice.pdf

Bloomfield SF, Rook GA, Scott EA, Shanahan F, Stanwell-Smith R, Turner P (2016) Time to abandon the hygiene hypothesis: new perspectives on allergic disease, the human microbiome, infectious disease prevention and the role of targeted hygiene. Perspect Public Health 136(4):213–224. https://doi.org/10.1177/1757913916650225

Bond CF, Titus LJ (1983) Social facilitation: A meta-analysis of 241 studies. Psychol Bull 94(2):265–292. https://doi.org/10.1037/0033-2909.94.2.265

Botero CA, Gardner B, Kirby KR, Bulbulia J, Gavin MC, Gray RD (2014) The ecology of religious beliefs. Proc Natl Acad Sci 111(47):16784–16789. https://doi.org/10.1073/pnas.1408701111

Brockington G, Gomes Moreira AP, Buso MS, Gomes da Silva S, Altszyler E, Fischer R, Moll J (2021) Storytelling increases Oxytocin and positive emotions and decreases cortisol and pain in hospitalized children. Proc Natl Acad Sci 118(22):e2018409118

Brown DE (1991) Human universals. McGraw-Hill

Brown GR, Dickins TE, Sear R, Laland KN (2011) Evolutionary accounts of human behavioural diversity. Philosophical Trans

Royal Soc B: Biol Sci 366(1563):313–324. https://doi.org/10.1098/rstb.2010.0267

Browning MHEM, Rigolon A, McAnirlin O, Yoon H, Violet (2022) Where greenspace matters most: A systematic review of urbanicity, greenspace, and physical health. Landsc Urban Plann 217:104233. https://doi.org/10.1016/j.landurbplan.2021.104233

Bruther BJ (2024), June 11 'Was Thanos Right?': Mad Genius, Eugenics, and Popular Culture. North Meridian Press. https://thenorthmeridianreview.org/blog/essay-was-thanos-right-mad-genius-eugenics-and-popular-culture-by-bj-bruther

Buchholz V, Bridgman SL, Nielsen CC, Gascon M, Tun HM, Simons E, Turvey SE, Subbarao P, Takaro TK, Brook JR, Scott JA, Mandhane PJ, Kozyrskyj AL (2023) Natural green spaces, sensitization to allergens, and the role of gut microbiota during infancy. mSystems 8(2):e01190–e01122. https://doi.org/10.1128/msystems.01190-22

Burke SM, Carron AV, Eys MA, Ntoumanis N, Estabrooks PA (2006) Group versus individual approach? A meta-analysis of the effectiveness of interventions to promote physical activity. Sport Exerc Psychol Rev 2(1):13–29. https://doi.org/10.53841/bpssepr.2006.2.1.13

Bybee J, Quiles ZN (1998) Guilt and mental health. In: Guilt and children, pp 269–291. Academic Press. https://doi.org/10.1016/B978-012148610-5/50014-X

Campbell BE, Lodge CJ, Lowe AJ, Burgess JA, Matheson MC, Dharmage SC (2015) Exposure to 'farming' and objective markers of atopy: A systematic review and meta-analysis. Clin Experimental Allergy 45(4):744–757. https://doi.org/10.1111/cea.12429

Chang C, Cheng GJY, Nghiem TPL, Song XP, Oh RRY, Richards DR, Carrasco LR (2020) Social media, nature, and life satisfaction: global evidence of the biophilia hypothesis. Sci Rep 10(1):4125. https://doi.org/10.1038/s41598-020-60902-w

Chester DK, Duncan AM, Dibben CJL (2008) The importance of religion in shaping volcanic risk perception in Italy, with special reference to vesuvius and Etna. J Volcanol Geoth Res 172(3):216–228. https://doi.org/10.1016/j.jvolgeores.2007.12.009

Chi MTH (2009) Active-Constructive-Interactive: A conceptual framework for differentiating learning activities. Top Cogn Sci 1(1):73–105. https://doi.org/10.1111/j.1756-8765.2008.01005.x

Clarke PA (2009) Australian aboriginal ethnometeorology and seasonal calendars. History Anthropol 20(2):79–106. https://doi.org/10.1080/02757200902867677

Comaroff J, Comaroff J (1986) Christianity and colonialism in South Africa. Am Ethnologist 13(1):1–22. https://doi.org/10.1525/ae.1986.13.1.02a00010

Connelly L (2015) Virtual Buddhism: Online Communities, Sacred Places and Objects. In: S. D. Brunn (Ed) The Changing World Religion Map: Sacred Places, Identities, Practices and Politics, Springer Netherlands, pp 3869–3882. https://doi.org/10.1007/978-94-017-9376-6_204

Cord AF, Roeßiger F, Schwarz N (2015) Geocaching data as an indicator for recreational ecosystem services in urban areas: exploring Spatial gradients, preferences and motivations. Landsc Urban Plann 144:151–162. https://doi.org/10.1016/j.landurbplan.2015.08.015

Couzin ID (2006) Behavioral ecology: social organization in Fission–Fusion societies. Curr Biol 16(5):R169–R171. https://doi.org/10.1016/j.cub.2006.02.042

Creanza N, Kolodny O, Feldman MW (2017) Cultural evolutionary theory: how culture evolves and why it matters. Proc Natl Acad Sci 114(30):7782–7789. https://doi.org/10.1073/pnas.1620732114

Culverhouse CE (2023) Here's the bleak truth behind TikTok's "girl dinner" craze. Big Issue. https://www.bigissue.com/life/food/tiktok-girl-dinner-trend-cost-ofliving-crisis/

Cvorovic J, Coe K (2022) Storytelling around the world: folktales, narrative rituals, and oral traditions. ABC-CLIO. https://www.amazon.com/Storytelling-around-World-Folktales-Traditions/dp/1440872945

Darwin C (with, Huxley J (2003) The Origin of Species: 150th Anniversary Edition, 2nd edn. Penguin Publishing Group

Dawkins R (2016) The selfish gene, 40th anniversary edition. Oxford University Press

DeCasien AR, Williams SA, Higham JP (2017) Primate brain size is predicted by diet but not sociality. Nat Ecol Evol 1(5):1–7. https://doi.org/10.1038/s41559-017-0112

Dekaboruah E, Suryavanshi MV, Chettri D, Verma AK (2020) Human microbiome: an academic update on human body site specific surveillance and its possible role. Arch Microbiol 202(8):2147–2167. https://doi.org/10.1007/s00203-020-01931-x

Dela Cruz N (2023), August 16 Instagram and Tik Tok: Modern Platforms for Wisdom and Daily Affirmation. The Daily Scrum News. https://www.thedailyscrumnews.com/instagram-and-tik-tok-modern-platforms-for-wisdom-and-daily-affirmation/.

Demmrich S, Wolfradt U (2018) Personal rituals in adolescence: their role in emotion regulation and identity formation. https://doi.org/10.1163/15709256-12341373

Demoulin NTM, Zidda P (2008) On the impact of loyalty cards on store loyalty: does the customers' satisfaction with the reward scheme matter? J Retailing Consumer Serv 15(5):386–398. https://doi.org/10.1016/j.jretconser.2007.10.001

Devos S, Karsay K, Eggermont S, Vandenbosch L (2023) Whatever you do, I can do too: disentangling the daily relations between exposure to positive social media content, can self, and pressure. Communication Monogr 90(4). https://doi.org/10.1080/03637751.2023.2206472

Diniz G, Korkes L, Tristão LS, Pelegrini R, Bellodi PL, Bernardo WM (2023) The effects of gratitude interventions: A systematic review and meta-analysis. Einstein (Sao Paulo Brazil) 21:eRW0371. https://doi.org/10.31744/einstein_journal/2023RW0371

Djernis D, Lerstrup I, Poulsen D, Stigsdotter U, Dahlgaard J, O'Toole M (2019) A systematic review and Meta-Analysis of Nature-Based mindfulness: effects of moving mindfulness training into an outdoor natural setting. Int J Environ Res Public Health 16(17) Article 17. https://doi.org/10.3390/ijerph16173202

Doig A (2022) This mortal coil: A history of death. Bloomsbury Publishing Plc

Du AH, Karl JA, Fetvadjiev V, Luczak-Roesch M, Pirngruber R, Fischer R (2023) Tracing the evolution of personality cognition in early human civilisations: A computational analysis of the Gilgamesh epic. Eur J Pers 089020702311618. https://doi.org/10.1177/08902070231161869

Ellis EC (2023) The anthropocene condition: evolving through social–ecological transformations. Philosophical Trans Royal Soc B: Biol Sci 379(1893):20220255. https://doi.org/10.1098/rstb.2022.0255

Emmerson KB, Harding KE, Taylor NF (2019) Providing exercise instructions using multimedia May improve adherence but not patient outcomes: A systematic review and meta-analysis. Clin Rehabil 33(4):607–618. https://doi.org/10.1177/0269215518819706

Europe WHORO (2016) for. Urban green spaces and health, (WHO/EURO:2016-3352-43111-60341). Article WHO/EURO:2016-3352-43111-60341. https://iris.who.int/handle/10665/345751

Fan S, Hansen MEB, Lo Y, Tishkoff SA (2016) Going global by adapting local: A review of recent human adaptation. Sci (New York N Y) 354(6308):54–59. https://doi.org/10.1126/science.aaf5098

Feltz DL, Kerr NL, Irwin BC (2011) Buddy up: the Köhler effect applied to health games. J Sport Exerc Psychol 33(4):506–526. https://doi.org/10.1123/jsep.33.4.506

Ferguson CJ (2024) Do social media experiments prove a link with mental health: A methodological and meta-analytic review. Psychology of popular media. No Pagination Specified-No Pagination Specified. https://doi.org/10.1037/ppm0000541
Fernández-Llamazares Á, Cabeza M (2018) Rediscovering the potential of Indigenous storytelling for conservation practice. Conserv Lett 11(3):e12398. https://doi.org/10.1111/conl.12398
Fischer R (2021) Mapping the scientific study of rituals: A bibliometric analysis of research published 2000–2020. Relig Brain Behav 11(4):382–402
Fischer R, Kruekaew J (2020) Synchrony vs. Pain in males and females: an examination of differential effects on social bonding in a naturally occurring ritual. Relig Brain Behav 10(4):407–427
Fischer R, Xygalatas D (2014) Extreme rituals as social technologies. J Cognition Cult 14(5):345–355
Fischer R, Callander R, Reddish P, Bulbulia J (2013) How do rituals affect cooperation? An experimental field study comparing nine ritual types. Hum Nat (Hawthorne N Y) 24(2):115–125. https://doi.org/10.1007/s12110-013-9167-y
Fischer R, Xygalatas D, Mitkidis P, Reddish P, Tok P, Konvalinka I, Bulbulia J (2014) The fire-walker's high: affect and physiological responses in an extreme collective ritual. PLoS ONE, 9(2), e88355
Fischer R, Bortolini T, Karl JA, Zilberberg M, Robinson K, Rabelo A, Gemal L, Wegerhoff D, Nguyễn T, Irving B (2020a) & others. Rapid Review and Meta-Meta-Analysis of Self-Guided Interventions to Address Anxiety, Depression, and Stress During COVID-19 Social Distancing. Frontiers in Psychology 11(563876)
Fischer R, Bortolini T, Karl J, Zilberberg M, Robinson K, Rabelo A, Gemal L, Wegerhoff D, Nguyễn T, Irving B, Chrystal M, Mattos P (2020b) Rapid review and Meta-Meta-Analysis of Self-Guided interventions to address anxiety, depression, and stress during COVID-19 social distancing. Front Psychol 11. https://doi.org/10.3389/fpsyg.2020.563876
Fischer R, Bailey Y, Shankar M, Safaeinili N, Karl J, Daly A, Johnson FN, Winter T, Arahanga-Doyle H, Fox R (2024) & others. Cultural challenges for adapting behavioral intervention frameworks: A critical examination from a cultural psychology perspective. *Clinical Psychology Review*, 102425
Flynn MA, Veilleux E, Stana A (2022) A post from the Woods: social media, well-being and our connection to the natural world. Computers Hum Behav Rep 5:100171. https://doi.org/10.1016/j.chbr.2022.100171
Franken R, Bekhuis H, Tolsma J (2023) Kudos make you run! How runners influence each other on the online social network Strava. Social Networks 72:151–164. https://doi.org/10.1016/j.socnet.2022.10.001
Fredrickson BL, Cohn MA, Coffey KA, Pek J, Finkel SM (2008) Open hearts build lives: positive emotions, induced through loving-kindness meditation, build consequential personal resources. J Personal Soc Psychol 95(5). https://doi.org/10.1037/a0013262
Frommel J, Mandryk RL (2022) Daily quests or daily pests?? The benefits and pitfalls of engagement rewards in games. Proc ACM Hum -Comput Interact 6(CHI PLAY):2261–22623. https://doi.org/10.1145/3549489
Frumkin H, Bratman GN, Breslow SJ, Cochran B, Kahn PH Jr, Lawler JJ, Levin PS, Tandon PS, Varanasi U, Wolf KL, Wood SA (2017) Nature contact and human health: A research agenda. Environ Health Perspect 125(7):075001. https://doi.org/10.1289/EHP1663
Gilbert JA, Blaser MJ, Caporaso JG, Jansson JK, Lynch SV, Knight R (2018) Current Understanding of the human Microbiome. Nat Med 24(4):392–400. https://doi.org/10.1038/nm.4517
Graeber D, Wengrow D (2021) The dawn of everything: A new history of humanity. First American edition. Farrar, Straus and Giroux
Green J (2024) TikTok and the changing landscape of therapeutic digital spaces of care. Digit Geogr Soc 6:100077. https://doi.org/10.1016/j.diggeo.2023.100077
Gumo S (2017) Praying for rain: Indigenous systems of rainmaking in Kenya. Ecum Rev 69(3). https://doi.org/10.1111/erev.12301
Habicht ME, Varotto E, Galassi FM (2022) The Swiss Canton of Thurgau– not the Kingdom of Bavaria—Was the first state to introduce compulsory vaccination against smallpox. Public Health 205:e16. https://doi.org/10.1016/j.puhe.2022.01.028
Haidt J (2024) The anxious generation: how the great rewiring of childhood is causing an epidemic of mental illness. Allen Lane, an imprint of Penguin Books
Håland EJ (2005) Rituals of Magical Rain-Making in Modern and Ancient Greece: A Comparative Approach. *Cosmos: The Journal of the Traditional Cosmology, 17/2: 197–251*. https://www.academia.edu/1391932/Rituals_of_Magical_Rain_Making_in_Modern_and_Ancient_Greece_A_Comparative_Approach
Hanski I, Von Hertzen L, Fyhrquist N, Koskinen K, Torppa K, Laatikainen T, Karisola P, Auvinen P, Paulin L, Mäkelä MJ, Vartiainen E, Kosunen TU, Alenius H, Haahtela T (2012) Environmental biodiversity, human microbiota, and allergy are interrelated. Proc Natl Acad Sci 109(21):8334–8339. https://doi.org/10.1073/pnas.1205624109
Harrison S (2004) Emotional climates: ritual, seasonality and affective disorders. J Roy Anthropol Inst 10(3):583–602. https://doi.org/10.1111/j.1467-9655.2004.00203.x
Hartig T, Böök A, Garvill J, Olsson T, Gärling T (1996) Environmental influences on psychological restoration. Scand J Psychol 37(4):378–393. https://doi.org/10.1111/j.1467-9450.1996.tb00670.x
Hawkes K, O'Connell JF, Blurton Jones NG (2001a) Hadza meat sharing. Evol Hum Behav 22(2). https://doi.org/10.1016/S1090-5138(00)00066-0
Hawkes K, O'Connell JF, Blurton Jones NG (2001b) Hunting and nuclear families: some lessons from the Hadza about Men's work. Curr Anthropol 42(5). https://doi.org/10.1086/322559
Hayashima K (1962) A Climatological and religious explanation of the conception of suññata in early Buddhism. J Indian Buddh Stud (Indogaku Bukkyogaku Kenkyu) 10(2) Article 2. https://doi.org/10.4259/ibk.10.765
Heine S, Prebish CS (eds) (2003) Buddhism in the Modern World: Adaptations of an Ancient Tradition, 1st edn. Oxford University Press
Hill E (2011) Animals as agents: hunting ritual and relational ontologies in prehistoric Alaska and Chukotka. Camb Archaeol J 21(3):407–426. https://doi.org/10.1017/S0959774311000448
Hill RA, Dunbar RIM (2003) Social network size in humans. Hum Nat (Hawthorne N Y) 14(1):53–72. https://doi.org/10.1007/s12110-003-1016-y
Hobson NM, Schroeder J, Risen JL, Xygalatas D, Inzlicht M (2018) The psychology of rituals: an integrative review and Process-Based framework. Personality Social Psychol Rev 22(3). https://doi.org/10.1177/1088868317734944
Hohm I, Wormley AS, Schaller M, Varnum MEW (2024) Homo temporus: seasonal cycles as a fundamental source of variation in human psychology. Perspect Psychol Sci 19(1):151–172. https://doi.org/10.1177/17456916231178695
Hoogland M, Ploeger A (2022) Two different mismatches: integrating the developmental and the Evolutionary-Mismatch hypothesis. Perspect Psychol Sci 17456916221078318. https://doi.org/10.1177/17456916221078318
Hsiao C-H, Tang K-Y (2021) Who captures whom– Pokémon or tourists? A perspective of the Stimulus-Organism-Response model. Int J Inf Manag 61:102312. https://doi.org/10.1016/j.ijinfomgt.2021.102312

Hutton R (1996) The stations of the sun: A history of the ritual year in Britain, (reissued). Oxford University Press

ʻĀina of Kaʻōnohi, Deluze AK, Enos K, Mossman K, Gunasekera I, Espiritu D, Jay C, Jackson P, Connelly S, Han MH, Giardina CP, McMillen H, Meyer MA (2023) Urban ʻĀina: an Indigenous, biocultural pathway to transforming urban spaces. Sustainability 15(13) Article 13. https://doi.org/10.3390/su15139937

Irving B, Kavanagh C, Fischer R, Yuki M (2024) Dance for the dead: the role of top-down beliefs for social cohesion and anxiety management in naturally occurring collective rituals. PLoS ONE, 19(3), e0291655

Irwin BC, Scorniaenchi J, Kerr NL, Eisenmann JC, Feltz DL (2012) Aerobic exercise is promoted when individual performance affects the group: A test of the Kohler motivation gain effect. Ann Behav Med 44(2):151–159. https://doi.org/10.1007/s12160-012-9367-4

Jolly KL (2006) Prayers from the field: practical protection and demonic defense in Anglo-Saxon England. Traditio 61:95–147. https://doi.org/10.1017/S0362152900002865

Kapitány R, Kavanagh C, Whitehouse H (2020) Ritual morphospace revisited: the form, function and factor structure of ritual practice. Philosophical Trans Royal Soc B: Biol Sci 375(1805):20190436. https://doi.org/10.1098/rstb.2019.0436

Karasik MB (2024) Digital Girl culture: postfeminist sensibilities of social media Girl trends. J Student Res 13(1), Article 1. https://www.jsr.jofsr.org/index.php/path/article/view/2429

Karl JA, Fischer R (2018) Rituals, repetitiveness and cognitive load: A competitive test of ritual benefits for stress. Hum Nat 29(4):418–441

Karl JA, Fischer R (2022) The relationship between negative affect, state mindfulness, and the role of personality. Mindfulness 13(11):2729–2737. https://doi.org/10.1007/s12671-022-01989-2

Karl JA, Johnson FN, Bucci L, Fischer R (2021) In search of mindfulness: A review and reconsideration of cultural dynamics from a cognitive perspective. J Royal Soc New Z 52(2):168–191. https://doi.org/10.1080/03036758.2021.1915804

Kerr NL, Messé LA, Seok D-H, Sambolec EJ, Lount RB, Park ES (2007) Psychological mechanisms underlying the Köhler motivation gain. Pers Soc Psychol Bull 33(6):828–841. https://doi.org/10.1177/0146167207301020

Keshavarzi S, Saunders C, Karimi M (2023) Persistent Anti-Littering activism in a Non-Western context: the case of the nature cleaners movement in Iran. Soc Nat Resour 36(10):1181–1199. https://doi.org/10.1080/08941920.2023.2201809

Knupfer H, Neureiter A, Jörg M (2023) From social media diet to public riot? Engagement with greenfluencers and young social media users' environmental activism. Comput Hum Behav 139:107527. https://doi.org/10.1016/j.chb.2022.107527

Korpela KM, Ratcliffe E (2021) Which is primary: preference or perceived instoration? J Environ Psychol 75:101617. https://doi.org/10.1016/j.jenvp.2021.101617

Krichen M, Abdalzaher MS, Elwekeil M, Fouda MM (2024) Managing natural disasters: an analysis of technological advancements, opportunities, and challenges. Internet Things Cyber-Physical Syst 4:99–109. https://doi.org/10.1016/j.iotcps.2023.09.002

Laing J, Frost W (eds) (2014) Rituals and traditional events in the modern world. Routledge. https://doi.org/10.4324/9781315886879

Laland KN (2017) Darwin's unfinished symphony: how culture made the human Mind. Princeton University Press

Laland KN, Brown GR (2011) Sense and nonsense: Evolutionary perspectives on human behaviour, 2nd edn. Oxford University Press

Lang M (2024) Formalized rituals May have preceded the emergence of religions. Relig Brain Behav 14(1):78–81. https://doi.org/10.1080/2153599X.2023.2168737

Lang M, Kundt R (2023) The evolution of human ritual behavior as a cooperative signaling platform. Relig Brain Behav 1–23. https://doi.org/10.1080/2153599X.2023.2197977

Lang M, Krátký J, Shaver JH, Jerotijević D, Xygalatas D (2015) Effects of anxiety on spontaneous ritualized behavior. Curr Biol 25(14):1892–1897. https://doi.org/10.1016/j.cub.2015.05.049

Lang M, Krátký J, Xygalatas D (2020) The role of ritual behaviour in anxiety reduction: an investigation of Marathi religious practices in Mauritius. Philosophical Trans Royal Soc B: Biol Sci 375(1805):20190431. https://doi.org/10.1098/rstb.2019.0431

Lee JY (1973) The seasonal rituals of Korean shamanism. History Religions 12(3):271–287. https://doi.org/10.1086/462680

Lemstra M, Bird Y, Nwankwo C, Rogers M, Moraros J (2016) Weight-loss intervention adherence and factors promoting adherence: A meta-analysis. Patient Prefer Adherence 10:1547–1559. https://doi.org/10.2147/PPA.S103649

Li NP, Van Vugt M, Colarelli SM (2018) The evolutionary mismatch hypothesis: implications for psychological science. Curr Dir Psychol Sci 27(1):38–44. https://doi.org/10.1177/0963721417731378

Li W, Meng X, Zhang K-J, Yang Z, Feng Z, Tong K, Tian J (2023) Meditation using a mobile app improves surgery trainee performance: A Simulation-Based randomized controlled trial. Arthroscopy: J Arthroscopic Relat Surg 39(5):1262–1270. https://doi.org/10.1016/j.arthro.2022.09.008

Linden E (2007) The winds of change: climate, weather, and the destruction of civilizations. Simon & Schuster. (Reprint edition)

Lõhmus M, Balbus J (2015) Making green infrastructure healthier infrastructure. Infect Ecol Epidemiol 5. https://doi.org/10.3402/iee.v5.30082

MacKie EW (2009) The prehistoric solar calendar: an Out-of-fashion Idea revisited with new evidence. Time Mind 2(1):9–46. https://doi.org/10.2752/175169709X374263

Malinowski B (1992) Magic, science and religion and other essays. Waveland Pr Inc

Mbaya H, Mbaya TJ (2024) Chewa rainmaking beliefs and the Dutch reformed missionaries in central Malawi, 1889–1905. Afr Hist Rev 0(0):1–18. https://doi.org/10.1080/17532523.2024.2339594

McDonald D, Hyde E, Debelius JW, Morton JT, Gonzalez A, Ackermann G, Aksenov AA, Behsaz B, Brennan C, Chen Y, DeRight Goldasich L, Dorrestein PC, Dunn RR, Fahimipour AK, Gaffney J, Gilbert JA, Gogul G, Green JL, Hugenholtz P, Knight R (2018) American Gut: an open platform for citizen science Microbiome research. mSystems 3(3). https://doi.org/10.1128/msystems.00031–18

Mendoza RG, Hansen L (eds) (2024) Ritual Human Sacrifice in Mesoamerica: Recent Findings and New Perspectives, 1st edn. Springer International Publishing. https://doi.org/10.1007/978-3-031-36600-0

Modaff D (2014) Leadership trails: lessons from the Lakota sun dance. J Values-Based Leadersh 7(1).

Mogan R, Fischer R, Bulbulia J (2017) To be in synchrony or not? A meta-analysis of synchrony's effects on behavior, perception, cognition and affect. J Exp Soc Psychol 72:13–20. https://doi.org/10.1016/j.jesp.2017.03.009

Mogan R, Bulbulia J, Fischer R (2018) Behavioral synchrony and shared intentionality affect components of creativity differently. Front Psychol 9:2790

Morris I (2013) The measure of civilization: how social development decides the fate of nations. Princeton Univ. Press

Ms S, T, F., A, T., J H (2020) Environmental justice, Indigenous knowledge systems, and native Hawaiians and other Pacific Islanders. Hum Biol 92(1). https://doi.org/10.13110/humanbiology.92.1.06

Muthukrishna M, Henrich J, Slingerland E (2021) Psychology as a historical science. Ann Rev Psychol 72(72, 2021):717–749. https://doi.org/10.1146/annurev-psych-082820-111436

Nguyen L, Walters J (2024) Benefits of nature exposure on cognitive functioning in children and adolescents: A systematic review and meta-analysis. J Environ Psychol 96:102336. https://doi.org/10.1016/j.jenvp.2024.102336

O'Day EB, Butler RM, Morrison AS, Goldin PR, Gross JJ, Heimberg RG (2021) Reductions in social anxiety during treatment predict lower levels of loneliness during follow-up among individuals with social anxiety disorder. J Anxiety Disord 78:102362. https://doi.org/10.1016/j.janxdis.2021.102362

Odling-Smee FJ, Laland KN, Feldman MW (2003) Niche construction: the neglected process in evolution. Princeton University Press

Ombati M (2021) Climate Rituals: Cultural Response for Climate Change Adaptations in Africa. In Ú. Oswald Spring & H. G. Brauch (Eds.), *Decolonising Conflicts, Security, Peace, Gender, Environment and Development in the Anthropocene* (pp. 385–410). Springer International Publishing. https://doi.org/10.1007/978-3-030-62316-6_11

Orlando L, Allaby R, Skoglund P, Sarkissian D, Stockhammer C, Ávila-Arcos PW, Fu MC, Krause Q, Willerslev J, Stone E, A. C., Warinner C (2021) Ancient DNA analysis. Nat Reviews Methods Primers 1(1):1–26. https://doi.org/10.1038/s43586-020-00011-0

Pacheco A (2019) New Mexico death rituals: A history. History

Pennebaker JW (2018) Expressive writing in psychological science. Perspect Psychol Sci 13(2):226–229. https://doi.org/10.1177/1745691617707315

Pennebaker JW, Evans JF (2014) Expressive writing: words that heal. Idyll Arbor, Inc.

Pezzi M, Corsano P, Santoro G, Gori A, Gámez-Guadix M, Musetti A (2024) Solitary experience and problematic social media use among young adults: A systematic review with recommendations for future research. Clin Neuropsychiatry 21(4):284–298. https://doi.org/10.36131/cnfioritieditore20240405

Plana F, Pérez J, Abeliuk A (2023) Modularity of food-sharing networks minimises the risk for individual and group starvation in hunter-gatherer societies. PLoS ONE 18(5). https://doi.org/10.1371/journal.pone.0272733

Pliny, Healy JF (1991) Natural history, a selection. Penguin Books

Poudel JM (2020) The rhythms of life in the Himalaya: seasonality and sociality among the Gurung people of the Nhāson Valley. Int J Anthropol Ethnology 4(1):10. https://doi.org/10.1186/s41257-020-00036-z

Prince M (2004) Does active learning work?? A review of the research. J Eng Educ 93(3):223–231. https://doi.org/10.1002/j.2168-9830.2004.tb00809.x

Rackow P, Scholz U, Hornung R (2015) Received social support and exercising: an intervention study to test the enabling hypothesis. Br J Health Psychol 20(4):763–776. https://doi.org/10.1111/bjhp.12139

Reddish P, Fischer R, Bulbulia J (2013) Let's dance together: synchrony, shared intentionality and Cooperation. PLoS ONE, 8(8), e71182

Rees JS, Castellano S, Andrés AM (2020) The genomics of human local adaptation. Trends Genet 36(6):415–428. https://doi.org/10.1016/j.tig.2020.03.006

Richerson PJ, Boyd R (2010) Not by genes alone: how culture transformed human evolution. University of Chicago Press

Rojas-Rueda D, Nieuwenhuijsen MJ, Gascon M, Perez-Leon D, Mudu P (2019) Green spaces and mortality: A systematic review and meta-analysis of cohort studies. Lancet Planet Health 3(11):e469–e477. https://doi.org/10.1016/S2542-5196(19)30215-3

Rook GA (2013) Regulation of the immune system by biodiversity from the natural environment: An ecosystem service essential to health. Proceedings of the National Academy of Sciences 110(46):18360–18367. https://doi.org/10.1073/pnas.1313731110

Rook GAW, Lowry CA, Raison CL (2013) Microbial 'old friends', immunoregulation and stress resilience. Evol Med Public Health 2013(1):46–64. https://doi.org/10.1093/emph/eot004

Rook GAW, Lowry CA, Raison CL (2015) Hygiene and other early childhood influences on the subsequent function of the immune system. Brain Res 1617:47–62. https://doi.org/10.1016/j.brainres.2014.04.004

Rosendahl J, Alldredge CT, Burlingame GM, Strauss B (2021) Recent developments in group psychotherapy research. Am J Psychother 74(2):52–59. https://doi.org/10.1176/appi.psychotherapy.20200031

Rossano MJ (2012) The essential role of ritual in the transmission and reinforcement of social norms. Psychol Bull 138(3):529–549. https://doi.org/10.1037/a0027038

Ruokolainen L, Hertzen L, Fyhrquist N, Laatikainen T, Lehtomäki J, Auvinen P, Karvonen AM, Hyvärinen A, Tillmann V, Niemelä O, Knip M, Haahtela T, Pekkanen J, Hanski I (2015) Green areas around homes reduce atopic sensitization in children. Allergy 70(2):195–202. https://doi.org/10.1111/all.12545

Sarkisova K (2023) A Deeper Dive Into Girl Dinner. https://karinaenglish101.wordpress.com/wp-content/uploads/2023/12/ma4-rough-draft.pdf

Sasson T, Vernon J (2015) Practising the British way of famine: technologies of relief, 1770–1985. Eur Rev History: Revue Européenne D'histoire 22(6):860–872. https://doi.org/10.1080/13507486.2015.1048193

Scott JC (2017) Against the grain: A deep history of the earliest States. Yale University Press

Shaffer LJ (2018) Rain rituals as a barometer of vulnerability in an uncertain climate. J Ecol Anthropol 19(1):1–17. https://doi.org/10.5038/2162-4593.19.1.1228

Shephard RJ, Aoyagi Y (2009) Seasonal variations in physical activity and implications for human health. Eur J Appl Physiol 107(3):251–271. https://doi.org/10.1007/s00421-009-1127-1

Shrode F (2012) Mobile apps for nature field guides. Ref Reviews 26(7):4–6. https://doi.org/10.1108/09504121211270771

Smith BD (1998) The emergence of agriculture, Paperback edn. Scientific American Library

Soga JH (1931) The AmaXhosa: life and customs. Lovedale

Sosis R, Bressler ER (2003) Cooperation and commune longevity: A test of the costly signaling theory of religion. Cross-Cultural Research: J Comp Social Sci 37(2):211–239. https://doi.org/10.1177/1069397103037002003

Soutar C, Wand APF (2022) Understanding the spectrum of anxiety responses to climate change: A systematic review of the qualitative literature. Int J Environ Res Public Health 19(2). https://doi.org/10.3390/ijerph19020990

Spijkerman MPJ, Pots WTM, Bohlmeijer ET (2016) Effectiveness of online mindfulness-based interventions in improving mental health: A review and meta-analysis of randomised controlled trials. Clin Psychol Rev 45:102–114. https://doi.org/10.1016/j.cpr.2016.03.009

Stay Wild| The Wildlife Trusts. (n.d.). Retrieved November 14, (2024) from https://www.wildlifetrusts.org/stay-wild

Sun J, Schwartz HA, Son Y, Kern ML, Vazire S (2020) The Language of well-being: tracking fluctuations in emotion experience through everyday speech. J Personal Soc Psychol 118(2):364–387. https://doi.org/10.1037/pspp0000244

Talhelm T, Dong X (2024) People quasi-randomly assigned to farm rice are more collectivistic than people assigned to farm wheat. Nat Commun 15(1):1782. https://doi.org/10.1038/s41467-024-44770-w

Talhelm T, Zhang X, Oishi S, Shimin C, Duan D, Lan X, Kitayama S (2014) Large-Scale psychological differences within China explained by rice versus wheat agriculture. Science 344(6184):603–608. https://doi.org/10.1126/science.1246850

Tam KYY, Inzlicht M (2024) People are increasingly bored in our digital age. Commun Psychol 2(1):1–9. https://doi.org/10.1038/s44271-024-00155-9
Thompson JC, Wright DK, Ivory SJ, Choi J-H, Nightingale S, Mackay A, Schilt F, Otárola-Castillo E, Mercader J, Forman SL, Pietsch T, Cohen AS, Arrowsmith JR, Welling M, Davis J, Schiery B, Kaliba P, Malijani O, Blome MW, Gomani-Chindebvu E (2021) Early human impacts and ecosystem reorganization in southern-central Africa. Sci Adv 7(19):eabf9776. https://doi.org/10.1126/sciadv.abf9776
Togawa T (1999) Considering the long-term survival of the human race. Technol Soc 21(3). https://doi.org/10.1016/S0160-791X(99)00012-3
Twenge JM (2020) Increases in depression, Self-Harm, and suicide among U.S. Adolescents after 2012 and links to technology use: possible mechanisms. Psychiatric Res Clin Pract 2(1):19–25. https://doi.org/10.1176/appi.prcp.20190015
Twenge JM, Campbell WK (2018) Associations between screen time and lower psychological well-being among children and adolescents: evidence from a population-based study. Prev Med Rep 12:271–283. https://doi.org/10.1016/j.pmedr.2018.10.003
Vaiglova P, Halstead P, Pappa M, Triantaphyllou S, Valamoti SM, Evans J, Fraser R, Karkanas P, Kay A, Lee-Thorp J, Bogaard A (2018) Of cattle and feasts: Multi-isotope investigation of animal husbandry and communal feasting at neolithic Makriyalos, Northern Greece. PLoS ONE 13(6) Article 6. https://doi.org/10.1371/journal.pone.0194474
Van de Vliert E (2020) The global ecology of differentiation between Us and them. Nat Hum Behav 4(3). https://doi.org/10.1038/s41562-019-0783-3
Van de Vliert E, Welzel C, Shcherbak A, Fischer R, Alexander AC (2018) Got milk?? How freedoms evolved from dairying climates. J Cross-Cult Psychol 49(7):1048–1065
Van Holt T, Townsend WR, Cronkleton P (2010) Assessing local knowledge of game abundance and persistence of hunting livelihoods in the Bolivian Amazon using consensus analysis. Hum Ecol 38(6) Article 6. https://doi.org/10.1007/s10745-010-9354-y
Verduyn P, Ybarra O, Résibois M, Jonides J, Kross E (2017) Do social network sites enhance or undermine subjective Well-Being? A critical review. Social Issues Policy Rev 11(1):274–302. https://doi.org/10.1111/sipr.12033
Von Mutius E, Vercelli D (2010) Farm living: effects on childhood asthma and allergy. Nat Rev Immunol 10(12):861–868. https://doi.org/10.1038/nri2871
Watts J, Sheehan O, Atkinson QD, Bulbulia J, Gray RD (2016) Ritual human sacrifice promoted and sustained the evolution of stratified societies. Nature 532(7598):228–231. https://doi.org/10.1038/nature17159
Wengrow D, Graeber D (2015) Farewell to the 'childhood of man': ritual, seasonality, and the origins of inequality. J Roy Anthropol Inst 21(3):597–619. https://doi.org/10.1111/1467-9655.12247
White MP, Elliott LR, Gascon M, Roberts B, Fleming LE (2020) Blue space, health and well-being: A narrative overview and synthesis of potential benefits. Environ Res 191:110169. https://doi.org/10.1016/j.envres.2020.110169
Wiessner PW (2014) Embers of society: Firelight talk among the Ju/'hoansi Bushmen. Proceedings of the National Academy of Sciences 111(39):14027–14035. https://doi.org/10.1073/pnas.1404212111
Worden N (2011) The Making of Modern South Africa: Conquest, Apartheid, Democracy, 5th edn. Wiley-Blackwell
Xiaojing Z (2009) Come ye not without song, offering, prayer: ecological ethics in Hawai'ian songs. Interdisciplinary Stud Literature Environ 16(1):3–22
Xu L, Choi S, Zhao Y, Li M, Rogers BP, Anderson A, Gore JC, Gao Y, Ding Z (2023) Seasonal variations of functional connectivity of human brains. Sci Rep 13(1):16898. https://doi.org/10.1038/s41598-023-43152-4
Xygalatas D, Mitkidis P, Fischer R, Reddish P, Skewes J, Geertz AW, Roepstorff A, Bulbulia J (2013) Extreme rituals promote prosociality. Psychol Sci 24(8):1602–1605
Xygalatas D, Lang M, Maňo P, Krátký J, Fischer R (2024) Emotional contagion in a collective ritual. Am J Hum Biology: Official J Hum Biology Council e24111. https://doi.org/10.1002/ajhb.24111
Yang Y, Zhu S, Gan Y, Dang J (2021) To Be Authentic, to Be Eco: Exploring the Link Between Authenticity and Pro-environmental Behavior. Frontiers in Psychology 12. https://doi.org/10.3389/fpsyg.2021.755860
Yang Y, Sedikides C, Wang Y, Cai H (2024) Nature nurtures authenticity: mechanisms and consequences. J Personal Soc Psychol 126(1):79–104. https://doi.org/10.1037/pspi0000432
Zainuddin MF (2023) When tradition Meets modernity: the adaptation of Bajau community in Malaysia amidst Sociocultural transformation. J Contemp Rituals Traditions 1(1). https://doi.org/10.15575/jcrt.220
Zanella M, Vitriolo A, Andirko A, Martins PT, Sturm S, O'Rourke T, Laugsch M, Malerba N, Skaros A, Trattaro S, Germain P-L, Mihailovic M, Merla G, Rada-Iglesias A, Boeckx C, Testa G (2019) Dosage analysis of the 7q11.23 Williams region identifies BAZ1B as a major human gene patterning the modern human face and underlying self-domestication. Sci Adv 5(12):eaaw7908. https://doi.org/10.1126/sciadv.aaw7908
Zeller E, Timmermann A, Yun K-S, Raia P, Stein K, Ruan J (2023) Human adaptation to diverse biomes over the past 3 million years. Science 380(6645):604–608. https://doi.org/10.1126/science.abq1288
Zhao X, Thomas I, Salem A, Alassal SE, Liu Y, Sun Q, Chen J, Ma F, Finlayson B, Chen Z (2020) Holocene climate change and its influence on early agriculture in the nile delta, Egypt. Palaeogeogr Palaeoclimatol Palaeoecol 547:109702. https://doi.org/10.1016/j.palaeo.2020.109702