The Enigma of Mind

A Theory of Evolution and Conscious Experience

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8 The Enigma of Mind: A Theory of Evolution and Conscious Experience

ALBERT Y.-M. LIN AND J. DEREK LOMAS[1]

Introduction

In July 2011, while surveying the buried remains of a cluster of fourteenth-century ceremonial structures in the remote mountains of Northern Mongolia – in the heart of a region known as the Ich Korig (the 'Forbidden Zone'), and at the base of a mountain believed to be the historic Burkhan Khaldun, or 'God Mountain' – my team and I encountered a group of seven Mongolian shamans who had come on pilgrimage to commune with that very location. We had travelled for three days by horseback and heavy four-wheel-drive trucks through the rugged wilderness. Amidst rains and mudslides, we forded swollen rivers to get to the mountain. Foreigners have been restricted from this specific location for over 800 years by decree of Genghis Khan himself, and even though we were operating with special permissions from the Ministry of Culture, that night I was summoned to meet the head shaman in a moment of reckoning.

> Field notes July 18th, 2011, 12:50 am – I will struggle to find the words to describe what I just experienced and although I will surely fail to do it justice, I must try. My heart beat loudly in my throat as the hammer fell upon the drum, its rhythm pounded through the air, like waves through the thick fog. As the sunlight hit the amber tone the mist began to rise from the knoll above our camp. The shaman had summoned me, Ishdorj had guided me to sit next to him, and to recite the respected words that sounded like 'amaraa sanbano uhau'. I was terrified I would not say them

[1] Note to the reader: as this chapter deals directly with conscious experience, we take the unconventional approach of weaving between first-person accounts and a collaborative scholarly discussion. The first-person accounts are told from Albert Lin's perspective.

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> correctly. The beat moved faster, then faster still until it almost seemed like a constant burst of energy.
>
> Then the shaman, cloaked with a black facial mask of thick cloth covering his eyes, rose to his feet and spun in circles, slamming his hammer into the drum in an explosion of sound, his long cords of cloth (blue, black, white, maroon) spun in the air around him. And then, suddenly, silence. He dropped to the ground in a sitting position and leaned forward while jerking his head back and forth like a crow. His voice grunted low, in spurts of three. As if he were clearing his throat, but also as if he were agreeing with some internal message. 'Unch, unch, unch.'

Throughout my life I have had the great privilege of travelling the world and, upon reflection, I realise that I have encountered aspects of shamanism in many distant cultures. For instance, deep within the Pacific Ocean on the island of Pohnpei – home to the capital of Micronesia – we obtained permission to enter and apply aerial LIDAR to survey the enigmatic archaeological site of Nan Madol through our participation in a tribal ceremony with the Nahnmwarki (High Chief) of the Madol En Inal clan. Like most ceremonies in this oceanic culture, it began with the sacred and mind-altering sakau[2] drink 'to commune with the spirits'. This tradition of ritual altered states is so embedded into the cultural story of the Pacific that not only are sakau pounding stones found within the heart of the ancient megalithic city of Nan Madol (an artificial island complex built *c.* 1180 AD[3]), but the tradition is also within the modern flag of Pohnpei – which carries the sakau cup at its centre. One can easily imagine the importance of rituals of the mind in building an oceanic society brave enough to stand at the shore and harness the collective courage to set sail towards an unknown horizon. To this day, the same bell-like sound – of rock pounding against the sacred sakau stone – rings through mangroves on islands across the Pacific almost daily, summoning all within earshot to begin the sacred ceremony.

[2] Kava (*piper methysticum*).

[3] M. D. McCoy, H. A. Alderson, R. Hemi, H. Cheng, and R. L. Edwards, 'Earliest direct evidence of monument building at the archaeological site of Nan Madol (Pohnpei, Micronesia) identified using ^{230}Th/U coral dating and geochemical sourcing of megalithic architectural stone', *Quaternary Research*, 86(3) (2016), 295–302.

Looking further back into our shared human story, while travelling through Norway's most northern tip, I was stunned by the magnificent Neolithic rock art at Alta. In a remarkable portrait of the emergence of modern culture, thousands of images from as early as 4200 BC are carved into the coastal bedrock of the Alta fjord. In the midnight sun, when long shadows are cast over the subtle contours, I saw ancient representations of human ingenuity, such as deep-sea fishing, and representations of our collective spiritual roots. The site's UNESCO World Heritage designation describes the 'exceptionally high number of human figures and compelling portrayals of prehistoric social life, dancing, processions, and rituals'. They seem to show 'communication between the world of the living and the worlds of the spirits [giving] insight into the cosmology of prehistoric hunters and gatherers'.[4]

All human cultures have developed technologies to shape and explore our conscious experience: ritual, ceremony, art, music, and concoctions of intoxication. These technologies of consciousness have been woven into our societies, leaving temples and monuments in their wake. Why? How have these consciousness-altering tools affected human evolution?

From Anthropology to Personal Experience

In the most unexpected way, my interest in the anthropological enigma of consciousness intersected with my own personal evolution. Five years after standing on Mongolia's most sacred mountain, I found myself lying in the dirt: blood pouring out of my leg, I had been crushed by the weight of an overturned vehicle. Rushed to the hospital, I unwittingly embarked upon a journey into the enigma of the mind.

The following month I endured the intense mental and physical pain of an attempt at limb salvage. The repeated surgeries each brought rounds of excruciating wound care, hours in a hyperbaric oxygen chamber, and an intimacy with the overall experience of pain that I had not known possible. Ultimately it didn't work, and a final surgery removed the material aspects of a limb that had been a part of my mental body map for over 36 years. But the imprint of the pain in my mind endured.

[4] whc.unesco.org/en/list/352/.

I cannot recall if it was just moments or days after the amputation, but gradually I began to notice a tingly sensation in my right foot – the one that was no longer there. The phenomenon of phantom pain soon followed. Burning, darting, pangs of pain, the sensation of every tendon, ligament, and bone in my ankle and foot being repeatedly broken and lit on fire in waves of electric shock coursing through the air where my foot once was. This pain was real, yet it occurred in a part of my body that I rationally knew did not exist.

Serendipity's hand revealed that I happened to work at the same university campus as Dr V. S. Ramachandran, the man who literally wrote the book on the phantom limb phenomenon.[5] In our first meeting, he asked: "Do we really know where the body ends and the mind begins?" A long-time distinguished professor at UC San Diego, 'Rama' had developed the use of 'mirror box therapy'. Placing a borderless mirror between my legs, he could 'trick' my mind into seeing an illusion of a functioning right leg in the reflection of the left. This experience permits new (and less painful) memories to be created; memories to displace my neural attachments to pain and trauma. The mirror box therapy was uncanny: I could see my right toes wiggling again, a mirror image always moving in synchrony with my left. It was comical but comforting; somehow the visual experience in my mind gave me physical relief. Yet, almost as soon as the mirror was removed, the pain would return. The stubbornness of my mind (the 'ego' through which I perceive the world) would not hold on to the new narrative I was attempting to tell my brain.

Now incapacitated by the weight of the mysterious 'phantom pain', I needed to find a solution. Suspecting that a lack of neuroplasticity could be the culprit, I began exploring cognitive technologies that I had encountered throughout the world: Kundalini Yoga, chanting, meditation, sensory deprivation float tanks, among others. Finally, deep in the sand dunes of Death Valley, I discovered that a single large dose of psilocybin or 'magic mushrooms' – in conjunction with Ramachandran's mirror therapy – finally resolved my phantom limb pain in an enduring way. Somehow, the ego-crushing power of the hallucinogenic experience enabled my brain to

[5] V. S. Ramachandran and S. Blakeslee, *Phantoms in the Brain: Probing the Mysteries of the Human Mind* (New York, NY: William Morrow & Co., 1998).

loosen up and accept the re-framed reality that the mirrors presented. This case has now been published and a formal clinical trial of psilocybin in phantom pain therapy is under way at UC San Diego, at the newly formed Psychedelics and Health Research Initiative.[6]

In phantom limb pain, the mind is clearly capable of crafting realities that extend beyond what we can rationally understand. No amount of verbal explanation could convince my brain to let go of the pain it felt was real. But then a few grams of entheogenic mushrooms facilitated an experience so overwhelming that I lost my sense of self. In that moment of communion with a vast cosmos, I was able to let go of the bounds of prior truths and re-imagine a more harmonised state of existence. It was similar to what Mihaly Csikszentmihalyi described as a 'flow state'.[7] Had I been more skilled, perhaps I could have achieved a comparable experience through meditation or another practice. So much evidence now shows that psychedelics can increase neural plasticity that some scientists have named these drugs 'psychoplastogens'. But psilocybin doesn't just seem to create a biochemical effect – it isn't aspirin. The *experience* itself seems necessary for the benefit of plasticity.[8]

Ramachandran once suggested that our species could more appropriately be named *Homo plasticus* because 'lifelong plasticity' is the 'central player in the evolution of human uniqueness'.[9] In my case, *psilocybin* augmented my plasticity, but I suspect that many non-drug-induced states of consciousness could also produce neural plasticity.[10] Perhaps

[6] V. S. Ramachandran, C. Chunharas, Z. Marcus, T. Furnish, and A. Lin, 'Relief from intractable phantom pain by combining psilocybin and mirror visual-feedback (MVF)', *Neurocase*, 24(2) (2018), 105–110.

[7] 'Flow is the way people describe their state of mind when consciousness is harmoniously ordered', M. Csikszentmihalyi and J. Nakamura, 'Flow, altered states of consciousness, and human evolution', *Journal of Consciousness Studies*, 25 (11–12) (2018), 102–114.

[8] C. Ly, A. C. Greb, L. P. Cameron, J. M. Wong, E. V. Barragan et al., 'Psychedelics promote structural and functional neural plasticity', *Cell Reports*, 23(11) (2018), 3170–3182; N. R. P. W. Hutten, N. L. Mason, P. C. Dolder, E. L. Theunissen, F. Holze et al., 'Low doses of LSD acutely increase BDNF blood plasma levels in healthy volunteers', *ACS Pharmacology & Translational Science*, 4(2) (2021), 461–466.

[9] V. S. Ramachandran, *The Tell-Tale Brain: A Neuroscientist's Quest for What Makes Us Human* (New York, NY: W. W. Norton & Co., 2011).

[10] In 2019, Robert Turner, director at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, published a new theory

even the shamanic experience I encountered in the 'Forbidden Zone' was accompanied by a similar kind of neural transformation?

Human Experience, Evolution, and Design

I now wish to introduce my co-author, Dr James Derek Lomas, a professor at Delft University of Technology. As a cognitive scientist, designer, and philosopher, he explores human experience from within the field of human-centred design. Over the last decade, Dr Lomas has been my closest friend and intellectual partner. The journey I described above was largely accompanied by our conversations surrounding consciousness and its many augmentations. Throughout our adventures together we have explored the intersection of human experience, technology, and philosophy. The present chapter shares the culmination of our discussions about the role of conscious experience in evolution – and for this, we will now transition from a first-person narrative into a joint discussion.

Darwinism in the Mind

'It is a great honor to have been invited to give the first Darwin Lecture at Darwin College, in Cambridge, which of all universities is most closely connected with Charles Darwin and the Darwin family.'

So began the philosopher Karl Popper in the inaugural Darwin Lecture, 'Natural Selection and the Emergence of Mind'.[11] In his accompanying book chapter, Popper proposed a new idea: that the evolutionary forces of natural selection were actually operating within the conscious mind. He called this 'the greatest marvel of our universe'. As an example,

regarding the role of neural plasticity in ritual experiences. He suggested that dramatic rituals could help catalyse equally dramatic consolidation in neural pathways, particularly when involving rhythmic entrainment. See R. Turner, 'Finding likeness: Neural plasticity and ritual experience', *Anthropology Today*, 35 (3) (2019), 3–6.

[11] Karl Popper is well known for his advocacy of falsifiability in the sciences – that hypotheses must be able to be proven false – but he also said that 'the theory of natural selection could be untestable (as is a tautology) and yet of great scientific interest'. Popper additionally said, 'the doctrine of natural selection is a most successful metaphysical research program'. See K. Popper, 'Natural selection and the emergence of mind', *Dialectica*, 32 (1978), 339–355.

Popper described how Albert Einstein generated an 'immense number of hypotheses' and then rejected the vast majority, in a process of evolutionary natural selection. As another example of evolution through natural selection, Popper described his own experience of writing: both writing many words and crossing many out. He then evoked the image of an artist, painting out spots of colour before reflecting whether to keep the strokes or paint over them again. For Popper, this was the everyday nature of evolutionary forces manifesting in the mind – the experience of evolution. He proposed that evolutionary forces occur within three 'mutually interacting' worlds: the physical world, the world of experience, and the world of artefacts.

We now wish to further consider Popper's notion of evolutionary forces in human experience and extend the idea to more extreme and ancient human circumstances. We are inspired by Popper's call for 'intellectual daring in the search for truth' while remembering his caution to avoid making claims about ultimate questions, riddles of existence, or humanity's task in this world. We humbly seek to understand how conscious experience might relate to evolutionary theory and are motivated by the very same question that motivates all thinking on the topic of evolution: how did we arrive at the world we see today?

Summary: A Theory of Evolutionary Forces in the Mind

The elegant sculpting power of natural selection is not limited to genetic systems.[12] Instead, evolutionary fitness forces are expected to emerge within any system that has three key properties: variation, replication, and selection. To understand the operation of evolution in the mind, we will review three properties of experience that seem to satisfy these three requirements of evolutionary theory. There may be many properties of experience that can support variation, replication, and selection, but we focus on the following: (1) variation via imagination, (2) replication via sympathy, and (3) selection via harmonisation.

[12] R. Bonduriansky and T. Day, 'Nongenetic inheritance and its evolutionary implications', *Annual Review of Ecology and Systematics*, 40 (2009), 103–125.

We begin with the topic of human imagination as an important source for diversity and variety in the human mind. After reviewing key archeological milestones in the development of the creative imagination, we reflect on the curious cultural ubiquity of shamanistic practices and consider the basic drive for altering consciousness. We suggest that altered states of consciousness may facilitate neural plasticity and produce increased variation in the imagination. If so, then the uneven geographical distribution of psychoactive plants may have influenced the diversity of human culture, both in the recent past and deep into prehistory.[13]

After imagination, we suggest that the human capacity for sympathy plays an important role in the replication of conscious experiences between people. Specifically, we consider the theory that *sympathetic resonance* serves as a prelinguistic mechanism for the replication of conscious experience from one person to the next.[14] The capacity to replicate feelings through sympathetic resonance may have emerged even prior to deliberate human imitation. Ramachandran's theory regarding the role of 'mirror neurons' in cultural evolution is one description of how neural resonance might create the capacity to share mental states and experiences across people and time. With evidence from recent multi-person brain-imaging 'hyperscanning' studies, we link the profoundly rhythmic nature of the human brain to the reproduction of experiences between people – through resonance. Finally, we give examples of cultural forms that may have evolved to maximise human resonance and sympathy, such as Mayan bloodletting ceremonies.

Having introduced sources for the variation and replication of experience, we then consider processes that might govern Darwinian selection forces in the mind, namely within the competition for attention. In what might be described as an integration of Platonism with evolutionary theory, we focus on *harmonisation* as a selection pressure and fitness function in the mind.[15] Both Darwin and Alfred Russel Wallace gave descriptions of this 'harmony' in natural selection. We show how this classical concept plays a role in the

[13] For current distribution maps of peyote cactus (*Lophophora williamsii*), fly agaric mushroom (*Amanita muscaria*) and mushrooms of the genus Psilocybe, see © Open Street Map and GBIF contributors www.gbif.org/.

[14] J. D. Lomas, A. Lin, S. Dikker, D. Forster, M. L. Lupetti et al., 'Resonance as a design strategy for AI and social robots', *Frontiers in Neurorobotics*, 16 (2022), article 850489.

[15] J. D. Lomas and H. Xue, 'Harmony in design: A synthesis of literature from classical philosophy, the sciences, economics, and design', *She Ji: The Journal of Design, Economics, and Innovation*, 8(1) (2022), 5–64.

mind, both as a metaphor and as a mechanism. We then summarise the powerful role that harmony has played in empirical science, past and present.

In the end, we hope to have brought new detail to Popper's fascinating link between evolution and conscious experience. Are these ideas practical? We conclude by considering how new technologies and cultural practices might build upon these principles to support a more positive and resilient human future. To illustrate this very possibility, Dr Albert Lin shares a final first-person account of his journey to a secret mystical temple within the heart of the jungles of the Yucatán peninsula.

The Mind and Evolution

Despite living thousands of miles apart, Charles Darwin (1809–1882) and Alfred Russel Wallace (1823–1913) each independently discovered the principles of evolution. Darwin wrote 'I never saw a more striking coincidence.'[16] Both Darwin and Wallace also considered the role of the human mind in evolution, with Wallace suggesting that 'it may well be that evolution is a fundamental law of the universe of mind as well as that of matter'.[17] It is this enigma that we investigate: the nature of evolutionary forces operating *within* the realm of the conscious mind – and how evolution in the mind manifests itself in the remarkable diversity of human cultures.

Imagination, Variation, and Human Evolution

Darwin and Wallace agreed that once humans developed certain mental abilities, evolution would no longer affect the body so strongly, but that evolution would continue *within the mind*. Indeed, while *Homo sapiens* emerged between 350,000 and 260,000 years ago,[18] the earliest known representational cave painting, found in Indonesia, dates to 43,000 BC.[19]

[16] C. Darwin, A. R. Wallace, G. Sarton, C. Lyell, and J. D. Hooker, 'Discovery of the theory of natural selection', *Isis*, 14(1) (1930), 133–154.

[17] A. R. Wallace, 'The harmony of spiritualism and science', *Light* (25 July 1885).

[18] C. M. Schlebusch, H. Malmström, T. Günther, P. Sjödin, A. Coutinho et al., 'Southern African ancient genomes estimate modern human divergence to 350,000 to 260,000 years ago', *Science*, 358(6363) (2017), 652–655.

[19] This painting was discovered not far from where Wallace first experienced the incredible insight of evolution through natural selection. See A. Brumm, A. A. Oktaviana, B. Burhan, B. Hakim, R. Lebe et al., 'Oldest cave art found in Sulawesi', *Science Advances*, 7(3) (2021), article eabd4648.

The first known European representational art dates to 35,000 BC and the earliest discovered in Africa dates to about 30,000 BC.[20] Thus, while the human body evolved in Africa and dispersed across the world, it seems that evolution in the mind took place in locations all around the world. What evolved, in each case, seems to be a profound awakening in the human capacity for imagination.

The archeological record can indicate key threshold events in the evolution of the imagination.[21] For instance, the Löwenmensch or Lion-Man sculpture (*c.* 35,000 BC) (as depicted earlier in this volume in Figure 1.1) clearly shows evidence of mentally synthesising human and animal parts in the imagination and carving them into reality. The emergence of 'synthetic imagination' seems to have given humans the capacity to mentally model different objects and consider their combination through trial and error in the mind alone. This novel capacity for synthetic imagination relies on the ability to literally synchronise different object-encoding neural circuits together – a process known as prefrontal synthesis.

Once humans could play around with combinations of objects in their mind, rather than through physical manipulation, cultural evolution may have accelerated dramatically. Complex artefacts like boats (enabling the peopling of Australasia), traps (for killing the soon-to-be-extinct megafauna), or other game-changing tools and techniques could now be imagined. These factors alone would create an enormous evolutionary advantage. But the emergence of the Synthetic Imagination also seemed to enable activities with much less obvious benefit for Palaeolithic humans, like rituals, ceremonial burial, music, and art.

Near the discovery of the Löwenmensch, researchers uncovered the highly sexualised Venus of Hohle Fels (Figure 8.1) and the earliest known bone flutes (Figure 8.2), found just 70 centimetres apart.[22] This

[20] R. Ego, *Visionary Animal: Rock Art from Southern Africa*, trans. D. Dusinberre (Johannesburg: Wits University Press, 2019).

[21] A. Vyshedskiy, 'Neuroscience of imagination and implications for human evolution', *Current Neurobiology*, 10(2) (2019), 89–109.

[22] N. J. Conard, 'A female figurine from the basal Aurignacian of Hohle Fels Cave in southwestern Germany', *Nature*, 459(7244) (2009), 248–252; N. J. Conard, M. Malina, and S. C. Münzel, 'New flutes document the earliest musical tradition in southwestern Germany', *Nature*, 460(7256) (2009), 737–740.

FIGURE 8.1 The Venus of Hohle Fels. Photo: Hilde Jensen. Copyright: Universität Tübingen.

set of artefacts shows the emergence of a capability to shape the material environment for the purpose of *evoking experiences* in other people.[23] These magnificent artifacts do not serve a practical purpose as a spear or a flint would, but instead describe an awakening of the artist in our human nature, an aspect of the mind that is driven by our uniquely existential consciousness.

[23] The much older use of ochre may also be evidence of this. See T. Hodgskiss, 'Ochre use in the middle stone age', in *Oxford Research Encyclopedia of Anthropology* (Oxford: Oxford University Press, 2020), online.

FIGURE 8.2 The Flute of Hohle Fels. Photo: Hilde Jensen. Copyright: Universität Tübingen.

Does the birth of the artist in humanity coincide with the evolution of spirituality in human culture? Or is the art simply the evidence of a far more ancient set of spiritual practices? This brings us to shamanism, an ancient and mysterious phenomenon associated with the performative induction of spiritual experiences in the mind.

Shamanism, Altered States and Diversity in the Human Imagination

The term 'shaman' comes from the Siberian Tungus people.[24] But it is used to describe phenomena that are present in practically all cultures around the world, ancient and modern,[25] where altered states of consciousness are used to conduct divinatory work, prayer, healing, or other soul journeys, manipulations, or transformations. Shamanism is notoriously difficult to define with precision, but it involves the widespread tendency for specialised individuals to engage in what distinguished archaeologist Johan Reinhard described as a 'non-ordinary psychic state'.[26]

In animal evolution, the presence of a common phenotype or characteristic suggests either a common ancestor or convergent evolution. Similarities between disconnected shamanic traditions may therefore point to a common lineage or to convergent evolution due to common biological factors. For example, accelerating drumming, reaching 4 Hz or 240 beats per minute, is prevalent in shamanistic tradition globally and may have evolved due to interactions with natural theta frequencies of brain response.[27] Global similarities in shamanistic practice may be a result of ancient origins as well as the convergence of cognitive technologies after generations of trial and error, refinement and integration.

Apart from shamanism, pathways to altered states of consciousness are found throughout cultures globally. Across a sample of 488 world societies, over 90 per cent exhibited some form of institutionalised altered states of consciousness.[28] In Islamic Sufism, for example, Whirling Dervishes

[24] S. M. Shirokogoroff, *Psychomental Complex of the Tungus* (London: Routledge and Kegan Paul, 1935).

[25] M. Eliade, *Shamanism: Archaic Techniques of Ecstasy* (New York, NY: Pantheon Books, 1964); D. Stern, 'Masters of ecstasy', *National Geographic*, 222(6) (2012), 110–131.

[26] J. Reinhard, 'Shamanism and spirit possession – the definition problem', in J. T. Hitchcock and R. L. Jones (eds.), *Spirit Possession in the Nepal Himalayas* (Warminster: Aris and Phillips, 1976), pp. 12–20; M. Singh, 'The cultural evolution of shamanism', *Behavioral and Brain Sciences*, 41 (2018), 1–83.

[27] M. J. Hove, J. Stelzer, T. Nierhaus, S. D. Thiel, C. Gundlach et al., 'Brain network reconfiguration and perceptual decoupling during an absorptive state of consciousness', *Cerebral Cortex*, 26(7) (2016), 3116–3124.

[28] E. Bourguignon, 'World distribution and patterns of possession states', in R. Prince (ed.), *Trance and Possession States* (Montreal: R. M. Bucke Memorial Society, 1968), pp. 3–34.

attempt to dissolve one's ego by entering a trance state via the ritual of spinning continuously amidst chants and song. Hindu Sadhus devote themselves to meditation, a life of ritual and a renunciation of worldly things to achieve a certain state of mental experience. Gospel choirs entrance churchgoers to prepare them for prayer, preaching, and liturgy.

Cultures have developed many techniques for inducing trance-like altered states, including drumming, chanting, dancing, meditation, sexual practices, sacred objects, architecture, immersion in nature, pain, fasting, music, extreme sports, sleep deprivation, and the use of psychoactive substances, to name but a few. Yet, with the exception of sexual trance (which is rarely institutionalised),[29] few of these methods seem to offer much evolutionary benefit to the individual participants. The pursuit of altered states might even seem maladaptive, particularly for Neolithic peoples living in a dangerous environment. Yet, the tendency exists nearly universally across cultures. What benefits do altered states bring to people, now or deep in the past?

In an fMRI study, researchers observed that shamanic trance states were associated with a suppression of perceptual stimuli. The authors propose that shamanic trance enables a decoupling of cognition from the constraints of the external world. Through dissociation, fundamental aspects of reality might be grasped in different ways. This decoupling may be important for exploring the diverse and ineffable experiences deep in one's own imagination. Visionary shamanic techniques may have offered the benefit of enabling practitioners to see new realities in their imagination that others could not.[30]

Altered States as a Source of Variation in the Mind

For natural selection to operate in the realm of the mind, it needs a source of variation. Variation in conscious experience can be produced in many ways, including creative play and dreams. We propose that some altered states of consciousness are a culturally important mechanism for

[29] A. Safron, 'What is orgasm? A model of sexual trance and climax via rhythmic entrainment', *Socioaffective Neuroscience & Psychology*, 6(1) (2016), 1–17.

[30] R. Noll, 'Mental imagery cultivation as a cultural phenomenon: The role of visions in shamanism', *Current Anthropology*, 26(4) (1985), 443–461.

promoting the generation of diversity and variation in mental experiences. For evidence, we look to the clinical research and neuroimaging emerging from the current renaissance in psychedelic research in medicine. In laboratory studies, psychedelics have been shown to promote divergent thinking[31] and associative processing[32] – and the vividness and richness of the imagination is a key self-reported characteristic of psychedelic experiences. Researchers describe the subjective effects of psilocybin or magic mushrooms as 'broadly unconstrained perception and cognition, hyper-associative cognition and, at higher doses, a breakdown in the perception of time, space and selfhood'.[33]

Heavy drumbeats, ritual, or psychotropic experiences can disrupt the 'default mode' of our logical and verbal mind.[34] Once a person's dominant brain narrative releases control, there emerges an opportunity for bottom-up elements to constitute a more diverse range of thinking. This is the realm of intuition and free play in the imagination. Disrupting inhibitory control can create an experience that more broadly explores the space of cognitive combinations, leading to the discovery of new ways of seeing the world.

This appears to be reflected on a neurological level. A recent placebo-controlled fMRI study showed the significant causal impact of psilocybin on connections between previously unconnected regions of the brain (Figure 8.3).[35] The authors note 'the emergence of strong, topologically long-range functional connections that are not present in a normal state'. They conclude that the brain imaging shows 'a less constrained and more

[31] N. L. Mason, E. Mischler, M. V. Uthaug, and K. P. C. Kuypers, 'Sub-acute effects of psilocybin on empathy, creative thinking, and subjective well-being', *Journal of Psychoactive Drugs*, 51(2) (2019), 123–134.

[32] M. Spitzer, M. Thimm, L. Hermle, P. Holzmann, K. A. Kovar et al., 'Increased activation of indirect semantic associations under psilocybin', *Biological Psychiatry*, 39(12) (1996), 1055–1057.

[33] L.-D. Lord, P. Expert, S. Atasoy, L. Roseman, K. Rapuano et al., 'Dynamical exploration of the repertoire of brain networks at rest is modulated by psilocybin', *Neuroimage*, 199 (2019), 127–142.

[34] I. McGilchrist, *The Master and His Emissary: The Divided Brain and the Making of the Western World* (New Haven, CT: Yale University Press, 2019).

[35] G. Petri, P. Expert, F. Turkheimer, R. Carhart-Harris, D. Nutt et al., 'Homological scaffolds of brain functional networks', *Journal of the Royal Society Interface*, 11(101) (2014), article 20140873.

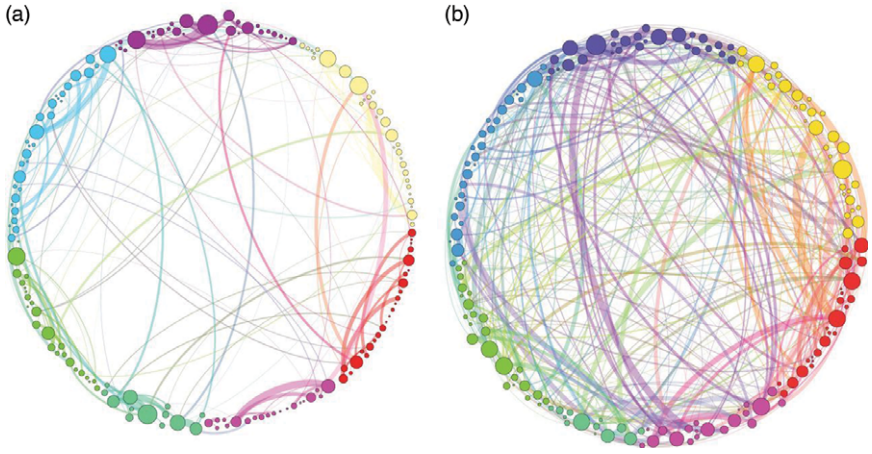

FIGURE 8.3 Simplified visualisation of homological scaffolds representing a comparison of communication between brain networks in people given a non-psychedelic placebo compound (a) or psilocybin (b). Source: G. Petri et al., 'Homological scaffolds of brain functional networks', *Journal of the Royal Society Interface*, 11 (2014), article 20140873, Fig. 6, doi:10.1098/rsif.2014.0873. Licence: CC-BY.

intercommunicative mode of brain function, which is consistent with descriptions of the nature of consciousness in the psychedelic state'.

One recent theory regarding psychedelic action in the brain focuses on the relaxation of existing belief structures. A remarkable fMRI study by Carhart-Harris et al. showed a deactivation of what is referred to as the 'default mode network' (DMN) – a group of brain regions associated with introspection and self-referencing – during the hallucinogenic state produced by psilocybin.[36] The DMN is a normal daily part of brain activity; as we mature with experience, the pathways of information exchange in the brain become more rigid or constrained in their patterns. These patterns in the DMN shape the way in which we perceive the world, quite literally forming the default mode of our self-narrative, or 'ego'. The authors suggest 'the subjective effects of psychedelic drugs are caused by

[36] R. L. Carhart-Harris, D. Erritzoe, T. Williams, J. M. Stone, L. J. Reed et al., 'Neural correlates of the psychedelic state as determined by fMRI studies with psilocybin', *Proceedings of the National Academy of Sciences*, 109(6) (2012), 2138–2143.

decreased activity and connectivity in the brain's key connector hubs, enabling a state of unconstrained cognition'.

In part by reducing inhibitory frontal control, deactivating the DMN, and momentarily turning off our 'ego', a psychedelic experience can allow the imagination to operate more loosely, taking into account a broader variety of bottom-up information streams and producing a greater diversity of mental variation. To describe this effect, Robin Carhart-Harris and Karl Friston[37] introduced the REBUS model, which claims that psychedelics cause an increase in bottom-up information flow and an increase in overall brain signal diversity.[38] The result is that the brain's 'free energy landscape' is made more accessible. Psychedelics are compared to annealing in metallurgy, where heating a system allows it to 'attain a state of heightened plasticity, in which the discovery of new energy minima . . . is accelerated'. The authors further suggest that increased plasticity during psychedelic states enables the emergence of new belief structures that 'resonate more harmoniously with previously hidden or silenced information'.

Ethnobotany and the Geography of Imagination

This next section considers the following question: how might the availability of psychedelic plants and fungi have affected early societies and cultural evolution?

One source of human cultural diversity is geographical diversity. For instance, the local temperature of the environment can influence clothing, shelters, and food. Geographical variations also seem to create an imprint in the imagination: people tend to *experience* different things in a lush rainforest, in a sparse highland steppe, or in a windswept fjord. Another way in which geography may affect the imagination is through variation in the availability of psychoactive plants. Harvard ethnobotanist

[37] Friston is famous for devising a now dominant model of predictive coding in the brain known as 'free energy minimisation' which is mathematically equivalent to Smolensky's 'harmony maximisation' function in artificial neural networks. See K. J. Friston and K. E. Stephan, 'Free-energy and the brain', *Synthese*, 159(3) (2007), 417–458.

[38] R. L. Carhart-Harris and K. J. Friston, 'REBUS and the anarchic brain: Toward a unified model of the brain action of psychedelics', *Pharmacological Reviews*, 71(3) (2019), 316–344.

Dr Richard Schultes ('father of ethnobotany') and Dr Albert Hofmann (the first to synthesise LSD and psilocybin) paint a clear picture of the incredibly broad cultural use of these plants throughout the ages:

> The use of hallucinogenic or consciousness-expanding plants has been a part of human experience for many millennia,[39] yet modern Western societies have only recently become aware of the significance that these plants have had in shaping the history of primitive and even of advanced cultures.[40]

The deliberate use of mind-altering plants can be found across the animal kingdom.[41] The cultural use of 'psychoplastogens' probably antedates the emergence of *Homo sapiens* (and may have catalysed it, as has been suggested in the 'Stoned Ape' theory of human evolution).[42] However, ready access to psychoactive plants is highly dependent on ecological conditions. Mind-altering plants such as peyote, San Pedro cactus, ayahuasca, or anadenanthera,[43] for instance, could only have been found in the Americas. By some fluke, the Americas are home to over 200 species of hallucinogenic plants; there are just one-tenth as many psychoactive species across all of Eurasia and Africa. The reason for this imbalance of botanical diversity is an outstanding scientific enigma.[44]

How might the accessibility of psychoactive plants have affected the evolution of the various cultures? The different chemicals found in different plants produce significantly different experiences. Psilocybin mushrooms, *Amanita muscaria*, San Pedro cacti, ayahuasca, datura, kava, or cannabis – they all produce a very different set of mental effects. What might this mean for cultural evolution? If the collective imagination of a

[39] Alternatively, this timeline may extend back millions of years, applying the notion that human ancestors may have regularly eaten dung-loving (coprophilic) mushrooms while following the tracks of megafauna, as proposed in T. McKenna, *Food of the Gods: The Search for the Original Tree of Knowledge: A Radical History of Plants, Drugs and Human Evolution* (London: Random House, 1999).

[40] R. E. Schultes, A. Hoffman, and C. Ratsch, *Plants of the Gods: Their Sacred, Healing and Hallucinogenic Powers* (Rochester, VT: Healing Arts Press, 2012).

[41] G. Samorini, *Animals and Psychedelics: The Natural World and the Instinct to Alter Consciousness* (New York, NY: Simon & Schuster, 2002).

[42] McKenna, *Food of the Gods*.

[43] C. M. Torres, 'Archaeological evidence for the antiquity of psychoactive plant use in the Central Andes', *Annali dei Musei Civici Rovereto*, 11 (1995), 291–326.

[44] W. La Barre, 'Old and new world narcotics: A statistical question and an ethnological reply', *Economic Botany*, 24(1) (1970), 73–80.

population is influenced by the types of altered states they can access, then perhaps the local accessibility of certain plants may help explain certain patterns of cultural evolution. For instance, various rock art motifs may have included representations of 'entoptic visuals' – that is, visual patterns from certain altered states may have been carved directly onto the rock.[45] David Lewis-Williams and Thomas Dowson illustrate a comparison between Neolithic art patterns and the neurophysiological visual phenomena sometimes called 'form constants' or 'phosphenes' described by volunteers in a laboratory setting (Figure 8.4). Rock art represents a material record of early human imagination; it is provocative to consider that the history of altered states of mind is reflected in that record (Figure 8.5).[46]

The mere geographical availability of entheogens does not guarantee their cultural adoption. For instance, while several species of psilocybin mushrooms have been widespread in Europe for millennia, scholars agree that there is no definitive textual evidence for the intentional use of psilocybin-containing mushrooms prior to the twentieth century.[47] Only the iconic red and white speckled *Amantia muscaria* mushrooms have any documented ethnographic history (and these mushrooms do not contain the psychedelic chemical psilocybin). Yet, surely 50,000 years of hungry human explorers would have accidentally revealed the powerful effects of consuming psilocybin mushrooms. Thus, we face an enigma: if psilocybin mushrooms were widely available in Europe, why is there so little remaining evidence of their usage prior to the historical 'discovery' of rituals incorporating magic mushrooms in Mexico in 1957?

[45] J. D. Lewis-Williams and T. A. Dowson, 'On vision and power in the Neolithic: Evidence from the decorated monuments', *Cultural Anthropology*, 34(1) (1993), 55–65.

[46] Alta, Norway, has been designated a UNESCO World Heritage site for its 'compelling portrayals of prehistoric social life, dancing, processions, and rituals'. While many of the (over 6,000) etchings at the site depict human or animal figures, there is also a selection of unexplainable forms, providing support to the theory that some of the art reflects mental or 'entopic' visualisations.

[47] G. Guzmán, J. W. Allen, and J. Gartz, 'A worldwide geographical distribution of the neurotropic fungi, an analysis and discussion', *Annali dei Musei Civici Rovereto*, 14 (1998), 189–280; C. Ruck, 'The mushroom stones: Dionysus, Orpheus and the wolves of war', in D. Spasova (ed.), *Megalithic Culture in Ancient Thrace* (Blagoevgrad: Rilski University Press, 2015), pp. 1–7; G. Samorini, 'Mushroom effigies in world archaeology: From rock art to mushroom-stones', in D. Spasova (ed.), *Proceedings of the Conference 'The Stone Mushrooms of Thrace'* (Alexandroupoli: Greek Open University, 2012), pp. 16–42.

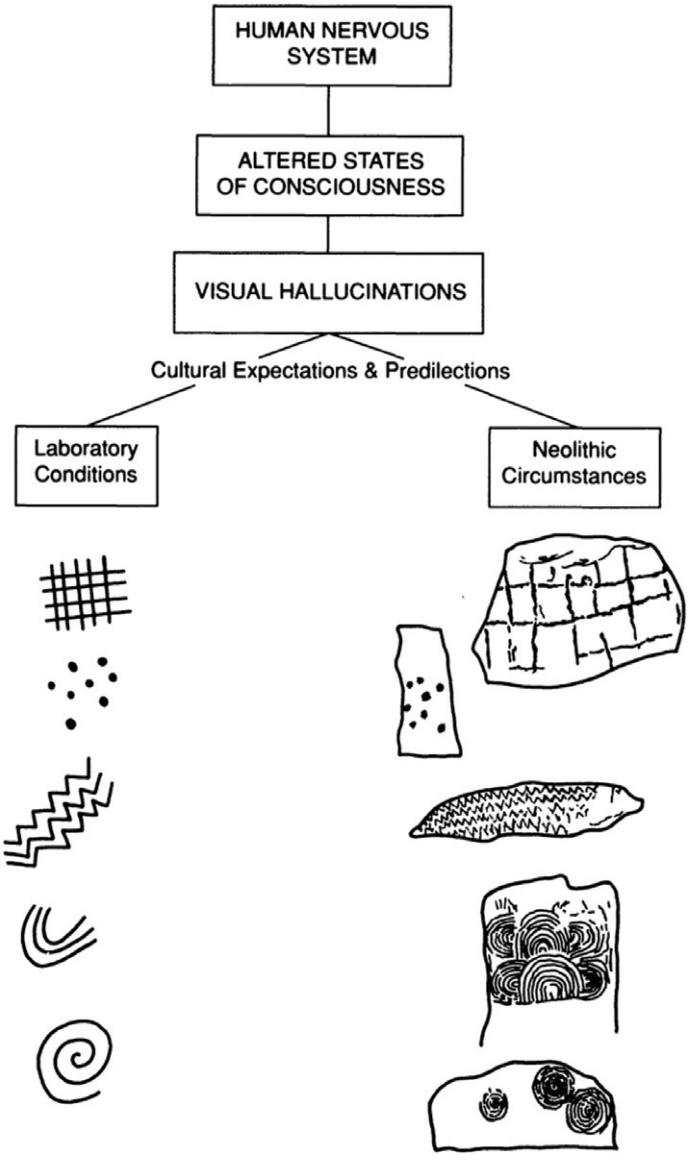

FIGURE 8.4 Model illustrating suggested parallels between neurophysiological visual 'form constants' and Neolithic rock art motifs. Source: J. D. Lewis-Williams and T. A. Dowson, 'On vision and power in the Neolithic: Evidence from the decorated monuments', *Cultural Anthropology*, 34(1) (1993), 55–65 (at 56, Fig. 1, after Siegel 1977 and Shee Twohig 1981). Republished with permission of University of Chicago Press – Journals, permission conveyed through Copyright Clearance Center, Inc.

FIGURE 8.5 Rock art from roughly 4000 BC observed at Alta, Norway. Photo: Albert Lin.

During our investigations on this unusual matter, we have come across one striking and provocative counter-example which suggests the possibility of representations of the entheogenic use of mushrooms in ancient Europe. With due caution, we note that there are well over 100 prehistoric carvings on Stonehenge that, at least to a naive modern eye, appear 'mushroom-shaped' (Figure 8.6).[48] However, since the carvings were first discovered on Stonehenge in 1953, scholars have agreed that the carvings represent bronze axeheads, each with its blade facing the sky. Even today, this hypothesis remains the most likely. Experts have dated many of the Stonehenge carvings to 1500–1300 BC because this was the only time period in the archaeological record when these unusual 'crescent-shaped' bronze axeheads were used in Britain.

This approach to dating leaves some room for doubt, however. If the development of new technologies for dating rock art were to reveal a

[48] M. Abbott and H. Anderson-Whymark, *Stonehenge Laser Scan: Archaeological Analysis Report* (Portsmouth: English Heritage, 2012). Although described as 'axeheads', the carvings are far more diverse in form than the comparatively conservative shapes of bronze age axeheads from southern Britain. See S. Needham, *The Classification of Chalcolithic and Early Bronze Age Copper and Bronze Axe-Heads from Southern Britain* (Oxford: Archaeopress, 2018).

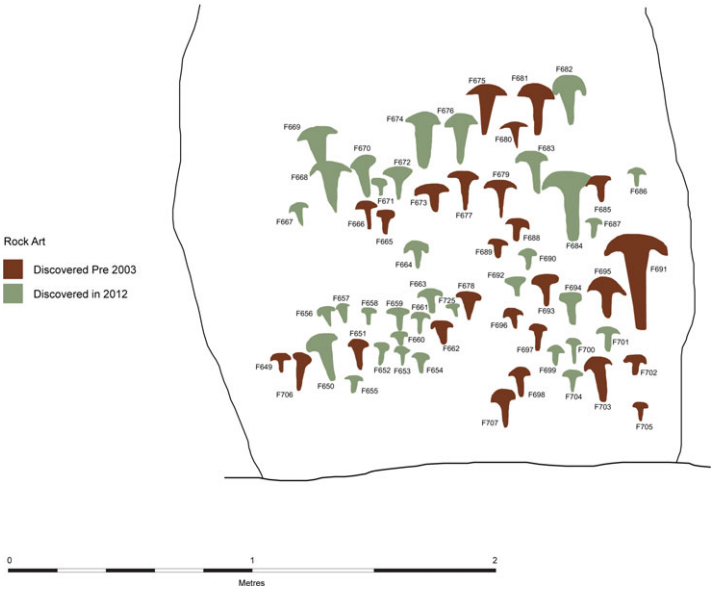

FIGURE 8.6 Prehistoric carvings on Stonehenge (exterior E face of Stone 4). Source: M. Abbott and H. Anderson-Whymark, *Stonehenge Laser Scan: Archaeological Analysis Report* (Portsmouth: English Heritage, 2012), 29, Fig. 12. © Historic England.

substantially different date for these carvings (e.g., a date in late antiquity), this might weaken the axehead hypothesis. Therefore, an alternative hypothesis may at least be worthy of further investigation: that some carvings on Stonehenge could represent the ancient use of entheogenic mushrooms. Putting aside the debate over what exactly these enigmatic carvings actually represent, we can state with little doubt that the modern 'discovery' of psilocybin mushrooms catalysed a powerful transformation of human culture.[49] Given their geographical availability, it seems highly unlikely that this was the very first time that 'magic mushrooms' had this transformative cultural effect.

Why might psychoactive substances have been used in the distant past and then lost again? Consider *Cannabis sativa*, which is the most commonly used entheogen. Cannabis has a well-documented history in ritual experience, beginning with a rich textual description of Scythian

[49] R. G. Wasson, 'Seeking the magic mushroom', *Life Magazine*, 42(19) (1957), 100–120.

https://doi.org/10.1017/9781009232517.009 Published online by Cambridge University Press

ceremonial cannabis smoke-tents in 430 BC.[50] In 2019, archaeologists found hard evidence for the smoking of cannabis in the mountains of eastern China, dating to 500 BC. There, researchers found braziers with high Δ^9-tetrahydrocannabinol (THC) cannabis in tombs that showed evidence of 'funerary rites that included flames, rhythmic music, and hallucinogen smoke, all intended to guide people into an altered state of mind'.[51] Nevertheless, there are large gaps in the history of cannabis. Despite its having reached Europe by 6000 BC,[52] the psychoactive effects of cannabis seem to have been ignored by the civilisations of Egypt, Greece, Rome, and, of course, later Christian cultures in Europe.

A recent find indicates that the spiritual use of cannabis was known by some. In 2020, a team of archaeologists found direct evidence for the spiritual use of cannabis in the ancient Judahite religion. These researchers discovered the psychoactive chemical (THC), found only in cannabis, within burned residues on a temple altar in the ancient kingdom of Judah, dating to *c.* 700 BC.[53] For context, the first Jewish temple in Jerusalem was built approximately 950 BC, but it was not until after 650 BC that the Jerusalem temple was made the exclusive temple.

This is not the only evidence for cannabis use in ancient Mosaic religious practices. A passage in Exodus indicates the use of קנה בשם (*qaneh bosem*) in the formula for the production of the sacred anointing oil for priests.[54] For thousands of years, *qaneh bosem* has been translated as 'sweet cane' (or calamus), yet it is just as likely to be a Hebrew transliteration of a foreign word just like another ingredient in the holy oil, קנמון *qinamon*, or

[50] J. M. McPartland and W. Hegman, 'Cannabis utilization and diffusion patterns in prehistoric Europe: A critical analysis of archaeological evidence', *Vegetation History and Archaeobotany*, 27(4) (2018), 627–634.

[51] M. Ren, Z. Tang, X. Wu, R. Spengler, H. Jiang et al., 'The origins of cannabis smoking: Chemical residue evidence from the first millennium BCE in the Pamirs', *Science Advances*, 5(6) (2019), article eaaw1391.

[52] The Yamnaya Culture, a proto-Indoeuropean culture, may have introduced the practice of smoking cannabis by 3500 BC. See T. Long, M. Wagner, D. Demske, C. Leipe, and P. E. Tarasov, 'Cannabis in Eurasia: Origin of human use and Bronze Age trans-continental connections', *Vegetation History and Archaeobotany*, 26(2) (2017), 245–258.

[53] E. Arie, B. Rosen, and D. Namdar, 'Cannabis and frankincense at the Judahite Shrine of Arad', *Tel Aviv*, 47(1) (2020), 5–28.

[54] 'Take the following fine spices: 500 shekels of liquid myrrh, half as much (that is, 250 shekels) of fragrant cinnamon, 250 shekels of fragrant calamus [קנה בשם *qaneh bosem*], 500 shekels of cassia – all according to the sanctuary shekel – and a hin of olive oil. Make these into a sacred anointing oil, a fragrant blend, the work of a perfumer. It will be the sacred anointing oil.' NIV, Exodus 30:23–25.

cinnamon.[55] Just as the Hebrew *qinamon* can be linked to the Greek *kinnamonon*, it seems the Hebrew *qaneh bosem* can be linked to the Greek *kánnabis*. This idea was originally proposed by Polish anthropologist Sara Benetowa in 1936, yet it fell into obscurity. One obvious reason for this obscurity is the intense cultural taboo around cannabis: 1936 was the same year as the release of the anti-cannabis propaganda film *Reefer Madness*.[56] There can be little doubt that, in the modern era, cultural taboos have actively suppressed knowledge regarding entheogens. This suppression also seems to have occurred in the ancient past, as well. An example of such a taboo can even be seen in Exodus, which demands a punishment of exile to any common person making use of a similar formula:

> Say to the Israelites, 'This is to be my sacred anointing oil for the generations to come. Do not pour it on anyone else's body and do not make any other oil using the same formula. It is sacred, and you are to consider it sacred. Whoever makes perfume like it and puts it on anyone other than a priest must be cut off from their people.'[57]

Why is it so common for cultures to institute taboos on the use of entheogenic plants and mushrooms? On the one hand, it may be that psychoactive plants and fungi are dangerous – cultures that suppress them may be healthier. Yet, ancient Greece and Roman sources regularly discussed more toxic psychoactive plants, like henbane or datura.[58] So, alternatively, the taboos might be motivated by the transformative nature of entheogenic experiences, insofar as they pose a disruptive threat to dominant cultural power structures. Power structures, particularly those dealing with magic and spirituality, may have been more likely to sustain their power if they forbade the common use of entheogenic plants. That is, if only the high priests could access entheogenic experiences, lesser priests and common people were less likely to be having different ideas. Yet, it is still a mystery why entheogens were virtually unknown during most of

[55] J. Benner, 'The facts about kaneh bosem' (Ancient Hebrew Research Center, 2020), www.ancient-hebrew.org/studies-words/facts-about-kaneh-bosem.htm.
[56] M. Booth, *Cannabis: A History* (London: Macmillan, 2015).
[57] NIV, Exodus 30:31–33.
[58] K. Fatur, '"Hexing herbs" in ethnobotanical perspective: A historical review of the uses of anticholinergic Solanaceae plants in Europe', *Economic Botany*, 74(2) (2020), 140–158.

European history and so virulently opposed during the 'Drug War' of the last 50 years. Now that the taboos are lifting on entheogen use,[59] it is possible to scientifically study the effects of these powerful sources of neuroplasticity and variation in the imagination and ask the following question: how will they affect the future evolution of the conscious mind?

Sympathy and the Replication of Conscious Experience

Now we turn to the second evolutionary mechanism in conscious experience: sympathy. Variations in experience, like variations in the genetic code, are a crucial driver of evolution. But how can these variations in conscious experience be reproduced between people?[60] A great deal of thinking has considered the outsize role of language and imitation in replicating experiences and human culture. We propose that sympathy is an even more primitive mechanism for spreading experiences between people. Sympathy, or fellow feeling, seemingly facilitates the reproduction of conscious feelings and affective states of mind. Sympathetic resonance between people allows the mental experiences of one person to be shared with another.[61]

In 1976, Richard Dawkins introduced 'memes' – as the counterpart to genes – as the 'units of imitation' that might explain cultural evolution.[62] Darwin himself had originally proposed that imitation played a major role in man's rapid cultural evolution:

> If some one man in a tribe, more sagacious than the others, invented a new snare or weapon, or other means of attack or defence, the plainest self-interest, without the assistance of much reasoning power, would prompt the other members to imitate him; and all would thus profit.[63]

[59] For one of many examples, the Entheogenic Plant and Fungus Policy Act of 2020 has decriminalised natural psychedelics including magic mushrooms, ayahuasca, and mescaline in the jurisdiction of Washington, DC.

[60] Individual memory is too vast a subject to discuss here. Yet, in Donald Hebb's *The Organization of Behavior: A Neuropsychological Theory* (New York, NY: Wiley, 1947) the 'mnemonic trace' is described as 'a lasting pattern of reverberatory activity'.

[61] A comprehensive review of resonance in physics, human experience, and design is provided by the authors in Lomas et al., 'Resonance as a design strategy'.

[62] R. Dawkins, *The Selfish Gene*, 40th anniversary edn (Oxford: Oxford University Press, 2016).

[63] C. Darwin, *The Descent of Man, and Selection in Relation to Sex*, 2 vols. (New York, NY: Appleton, 1871).

While imitation is valuable for accumulating and spreading cultural knowledge, it is a cognitive capacity that is largely unique to humans. Some groups of chimpanzees can transmit simple skills from parent to child – for instance, cracking nuts with a stone and anvil – but their process of social imitation is extremely slow. Scientists have found that it takes *multiple years* for young chimpanzees to learn nut cracking skills.[64]

If imitation is largely unique to humans, what came before? Darwin suspected that a social nature needed to evolve before imitation. In another sweet concordance with Wallace,[65] Darwin claimed (in *The Descent of Man*) that a key factor of sociality was *sympathy*:

> In order that ... the apelike progenitors of man should become social, they must have acquired the same instinctive feelings ... they would have felt uneasy when separated from their comrades, for whom they would have felt some degree of love ... all this implies some degree of sympathy.

Both Darwin and Wallace viewed sympathy as a primitive and essential factor in human social evolution. Thus, we claim that, even before the development of language or imitation (imitation is specifically necessary for 'memetic' cultural evolution),[66] sympathy provided a mechanism for reproducing conscious feelings. To understand how, the term *sympathy* needs some historical framing, especially since its modern meaning has shifted to mean something more like 'pity'.

Darwin was familiar with the Scottish economist Adam Smith, who, in his first book, investigated the role of sympathy in human society.[67] Smith

[64] Further, recent work disputes that social 'copying' is, in fact, the mechanism for the transmission. See E. Bandini, J. Grossmann, M. Funk, A. Albiach-Serrano, and C. Tennie, 'Naïve orangutans (*Pongo abelii and Pongo pygmaeus*) individually acquire nut-cracking using hammer tools', *American Journal of Primatology*, 83(9) (2021), article e23304.

[65] 'When the social and sympathetic feelings came into active operation, and the intellectual and moral faculties became fairly developed, man would cease to be influenced by "natural selection" in his physical form ... [but] his mind would become subject to those very influences from which his body had escaped', A. R. Wallace, 'The origin of human races and the antiquity of man deduced from the theory of "natural selection"', *Journal of the Anthropological Society of London*, 2 (1864), clviii–clxxxvii.

[66] S. Blackmore, 'Imitation and the definition of a meme', *Journal of Memetics – Evolutionary Models of Information Transmission*, 2(11) (1998), 159–170.

[67] A. Smith, *The Theory of Moral Sentiments* (London: Printed for A. Miller and A. Kincaid and J. Bell in Edinburgh, 1759).

explains how sympathy causes the automatic exchange of feelings, such that people feel good when other people feel good and feel bad when other people feel bad. Smith claimed that this sympathetic capacity gives people a natural incentive for moral action: that is, it feels good to make others feel good.

Today, the sympathy of Darwin or Wallace might be described with the term 'empathy'. Yet, empathy is a rather new word, introduced in 1909 as a translation of the German *Einfühlung* – a term used by Theodor Lipps and other psychologists to describe the *psychische Resonanz* that occurred during aesthetic experiences.[68] In a modern context, empathy is sometimes described as 'an effortful process by which we try to comprehend another's experience' whereas sympathy is 'a direct perceptual awareness of another person's experience akin to the phenomenon of sympathetic resonance'.[69] Thus, we aim to understand human sympathy through the physical concept of sympathetic resonance.

Resonance, Mirror Neurons, and Rhythmic Entrainment

The idea of sympathetic resonance is one of the most powerful and generalisable ideas in the physical sciences. It occurs when 'a system – a physical oscillator – is subjected to a periodic driving force by an external agency'.[70] Even in ancient times, people may have noticed how beating a drum can make another drum rattle or hum, even at a distance. The Greek Stoic philosophers taught that the universe was in sympathetic resonance with itself.[71] Today, modern cosmological models use sympathetic resonance to explain the origin of the universe during the inflationary stage of the 'Big Bang'.[72]

[68] S. Lanzoni, 'Sympathy in mind (1876–1900)', *Journal of the History of Ideas*, 70(2) (2009), 265–287.

[69] J. Decety and T. Chaminade, 'Neural correlates of feeling sympathy', *Neuropsychologia*, 41(2) (2003), 127–138.

[70] A. P. French, *Vibrations and Waves* (New York, NY: MIT Press, 1966).

[71] '[Chrysippus] first holds that the whole is unified by *pneuma*, which pervades it completely, and by which the universe is held together and stabilised and is sympathetic with itself', Alexander of Aphrodisias, *On Mixture*, 216.14–16; 'Meditate often on the interconnectedness and mutual interdependence of all things in the universe. For in a sense, all things are mutually woven together and therefore have an affinity for each other – for one thing follows after another according to their tension of movement, their sympathetic stirrings, and the unity of all substance', Marcus Aurelius, *Meditations*, 6.38.

[72] The winners of the 2002 Dirac Prize for physics claim that, during cosmic inflation, an oscillating 'inflaton' field resonated with all the other fields in the

While sympathetic resonance is a firmly scientific concept, it also played a central role in the history of magic.[73] And, perhaps because resonance seemed so magical, it took hundreds of years for scientists to accept the concept of resonance as more than a metaphor, namely as a common principle operating across all physical media, in acoustic systems, electromagnetic systems, gravitational systems, etc.[74] It is also common, however, to invoke the concept of 'resonance' to explain properties and values within human social systems, e.g., describing an artwork that 'resonates' with a viewer or a politician that 'resonates' with his or her followers.[75] Popular business books even provide guidance on how to give speeches or presentations to *resonate* with an audience.[76] Is this sort of human resonance a metaphor, or is it a mechanism? Consider the view of neurologist Oliver Sacks:

> People sing together and dance together in every culture, and one can imagine them having done so around the first fires, a hundred thousand years ago ... In such a situation, there seems to be an actual binding of nervous systems accomplished by rhythm.[77]

Some human resonances surely occur in the brain due to the oscillatory nature of neurons and neural circuitry. The brain contains vast hierarchies of rhythmic, reverberatory electrical oscillations; with all these oscillators, the brain inevitably resonates with itself and with stimuli in the environment. One simple and strong resonance effect, measurable via EEG, occurs when perceiving rhythmic pulses of light.[78] Oddly, some

standard model, producing particles. The Big Bang, in effect, created everything in the universe through this resonance. See L. Kofman, A. Linde, and A. A. Starobinsky, 'Towards the theory of reheating after inflation', *Physical Review D*, 56(6) (1997), article 3258. Special thanks to Patrick Cooper for drawing this to our attention.

[73] 'How do magic spells work? By sympathy, and by the natural concord of things that are alike and opposition of things that are different', Plotinus (b. 204 AD), *The Enneads*, IV. 4. 40.

[74] M. Buchanan, 'Going into resonance', *Nature Physics*, 15 (2019), article 203.

[75] H. Rosa, *Resonance: A Sociology of Our Relationship to the World* (Cambridge, MA: Polity Press, 2019).

[76] N. Duarte, *Resonate: Present Visual Stories That Transform Audiences* (Hoboken, NJ: Wiley, 2013).

[77] O. Sacks, *Musicophilia: Tales of Music and the Brain* (New York, NY: Knopf, 2007).

[78] C. S. Herrmann, 'Human EEG responses to 1–100 Hz flicker: Resonance phenomena in visual cortex and their potential correlation to cognitive phenomena', *Experimental Brain Research*, 137(3–4) (2001), 346–353.

of the most powerful neural resonances are correlated with the induction of hallucinations with geometrical patterns similar to those seen during psychedelic altered states.[79]

A more complex form of human resonance is known as 'motor resonance'. This phenomenon describes resonances between individuals, and it occurs when observations of human actions produce matching activity in the observer's brain and behaviour. For instance, an observer who watches someone pick up an egg will have, in their brain, a similar set of neural firing patterns as when they pick up an egg themselves. Observation of another person's actions triggers associated intentions, goals, or affective states; these resonant associations allow individuals to gain inference on the person they are observing. Astonishingly, scientists have measured this motor resonance – it occurs not just when observing actions directly but also when simply listening to stories describing actions or when reading stories about actions.[80]

We propose that the mechanism of sympathetic resonance enables the sharing of *feelings* (or at least some approximation of the feelings) between people during interpersonal interactions or through their interactions with artefacts. The proposed neural-cognitive basis for this sympathetic resonance is the so-called 'mirror neuron system'.[81] In a now famous essay, Ramachandran claimed that advances in the mirror neuron system seemed to be the key mechanism underpinning humanity's 'great leap forward' in evolutionary success:

> Anytime you watch someone else doing something (or even starting to do something), the corresponding mirror neuron might fire in your brain, thereby allowing you to 'read' and understand another's intentions, and thus to develop a sophisticated 'theory of other minds'.[82]

[79] B. C. Ter Meulen, D. Tavy, and B. C. Jacobs, 'From stroboscope to dream machine: A history of flicker-induced hallucinations', *European Neurology*, 62(5) (2009), 316–320; T. P. Cowan, 'Devils in the ink: William Burroughs, Brion Gysin, and geometry as a method for accessing intermediary beings', *Aries*, 19(2) (2019), 167–211.

[80] R. A. Zwaan, L. J. Taylor, and M. De Boer, 'Motor resonance as a function of narrative time: Further tests of the linguistic focus hypothesis', *Brain and Language*, 112(3) (2010), 143–149.

[81] G. Rizzolatti, L. Fadiga, L. Fogassi, and V. Gallese, 'Resonance behaviors and mirror neurons', *Archives italiennes de biologie*, 137(2) (1999), 85–100.

[82] V. S. Ramachandran, 'Mirror neurons and imitation learning as the driving force behind "the great leap forward" in human evolution', *Edge.Org* (2000), 1–7.

Long before language permitted the exchange of complex ideas, human sympathetic resonance seems to have enabled the exchange of conscious mental states. These experiences weren't shared with complete fidelity, of course, but the phenomenon might be comparable to how music provides a meaningfully similar reproduction of rich affective experiences between people. The ability to *feel* the music or to *feel* what another person is feeling is, of course, highly dependent on prior cultural experience. But, subject to cultural attunement, the rhythms of music do seem to 'induce affective states' through resonances with the naturally oscillatory brain:[83]

> The brain does not . . . 'compute' keys of melodic sequences, and it does not 'infer' meters of rhythmic input. Rather, it resonates to music [due to] oscillation of neural populations, rhythmic bursting, and neural synchrony.[84]

In a group of people, the sympathetic exchange of intersubjective emotional states is sometimes referred to as 'the vibe'. Because people have the ability to feel what other people in a group are feeling, the direct exchange of experience can lead to the emergence of prototypical group entrainment states that may evolve depending on their contribution to important cultural activities. For instance, certain group states could support vigour and enthusiasm during war or support calm focus for cognitive activities like complex tool manufacturing. This sympathetic resonance can also help explain what Émile Durkheim called 'collective consciousness' or 'collective effervescence' during tribal ceremonies:

> Once the individuals are gathered together, a sort of electricity is generated from their closeness and quickly launches them to an extraordinary height of exaltation . . . Thus the men of the clan and the things which are classified in it form by their union a solid system, all of whose parts are united and vibrate sympathetically.[85]

[83] W. J. Trost, C. Labbé, and D. Grandjean, 'Rhythmic entrainment as a musical affect induction mechanism', *Neuropsychologia*, 96 (2017), 96–110.
[84] E. W. Large, 'Neurodynamics of music', in M. R. Jones, R. R. Fay, and A. N. Popper (eds.), *Music Perception* (New York, NY: Springer, 2010), pp. 201–231.
[85] É. Durkheim, *The Elementary Forms of the Religious Life*, trans. J. Swain (London: George Allen & Unwin, 1912).

Rhythmic entrainment is a form of resonance activity that describes the spontaneous synchrony that occurs when two or more closely tuned oscillators interact with each other. Entrainment was discovered by the Dutch scientist Christiaan Huygens in 1665, after observing the emergent synchrony of the pendula of two clocks placed on a common beam. The capacity for rhythmic entrainment in music, dance, and other rituals may have played a significant role in human cultural evolution. In modern studies, entrainment has been found to improve cooperation in teams,[86] enhance social bonding, and increase prosocial behaviour.[87]

Although rhythmic entrainment naturally emerges in oscillatory systems throughout nature, 'holding a musical beat' is a uniquely human characteristic.[88] Although there are isolated instances in animals (like the YouTube star Snowball, a dancing parakeet),[89] these exceptions prove the rule.[90] Non-human animals are, for some reason, deeply resistant to the natural phenomena of sympathetic resonance or rhythmic entrainment.

Yet, animals *should* have the capacity for rhythmic entrainment – simply because much of everyday neural functioning relies upon entrainment. For instance, the rhythmic beating of the heart is driven by its rhythmic entrainment to central pattern generators in the spinal cord.[91] This example precisely shows why it can be dangerous for animals to allow entrainment to external rhythms – it is one thing for the heart of an animal to be entrained by the spinal cord, but it would be deadly if its heart could be entrained by a clever predator. Did animals evolve defence

[86] S. S. Wiltermuth and C. Heath, 'Synchrony and cooperation', *Psychological Science*, 20(1) (2009), 1–5.

[87] T. C. Rabinowitch and A. N. Meltzoff, 'Synchronized movement experience enhances peer cooperation in preschool children', *Journal of Experimental Child Psychology*, 160 (2017), 21–32.

[88] S. A. Kotz, A. Ravignani, and W. T. Fitch, 'The evolution of rhythm processing', *Trends in Cognitive Sciences*, 22 (2018), 896–910.

[89] A. D. Patel, J. R. Iverson, M. R. Bregman, and I. Schulz, 'Experimental evidence for synchronization to a musical beat in a nonhuman animal', *Current Biology*, 19 (10) (2009), 827–830.

[90] A. D. Patel, 'The evolutionary biology of musical rhythm: Was Darwin wrong?', *PLoS Biology*, 12(3) (2014), article e1001821.

[91] R. L. Calabrese, F. Nadim, and Ø. H. Olsen, 'Heartbeat control in the medicinal leech: A model system for understanding the origin, coordination, and modulation of rhythmic motor patterns', *Journal of Neurobiology*, 27(3) (1995), 390–402.

mechanisms to protect against external entrainment?[92] If so, perhaps humans evolved biological or cultural capacities to 'let down the guard' and open up to certain kinds of rhythmic entrainment with other people. Notably, some psychoactive plants and alcohol seem to enhance the perception of music, dance, and interpersonal sympathy; in ages past, perhaps they helped catalyse new depths of human resonance and rhythmic entrainment?

Our understanding of human resonance is rapidly advancing in response to various advances in biosensing. Hyperscanning is a brain imaging technique used to measure correlated brain activity between multiple people as they interact.[93] Scientists have found, for instance, that there is greater neural synchrony between the brains of two conversing friends than between the brains of two conversing strangers.[94] Neuroscientist Suzanne Dikker et al. discovered that brain synchrony is associated with the performance of students in classrooms and collaborators on teams.[95] Technologist Ramesh Rao applied hyperscanning to the heart beats of multiple people performing the highly repetitive movements in Kundalini meditation; his findings showed a fascinating pattern of emergent interpersonal coherence.[96] In the ritual context of fire walking, researchers have found evidence for physiological resonance (synchronisation in heart rate) between participants and related observers.[97] Thus, new scientific techniques are revealing how different

[92] For instance, the cuttlefish uses flickering skin patterns to mesmerise prey. See M. J. How, M. D. Norman, J. Finn, W.-S. Chung, and N. J. Marshall, 'Dynamic skin patterns in cephalopods', *Frontiers in Physiology*, 8 (2017), article 393.

[93] A. Czeszumski, S. Eustergerling, A. Lang, D. Menrath, M. Gerstenberger et al., 'Hyperscanning: A valid method to study neural inter-brain underpinnings of social interaction', *Frontiers in Human Neuroscience*, 14 (2020), article 39.

[94] S. Kinreich, A. Djalovski, L. Kraus, Y. Louzoun, and R. Feldman, 'Brain-to-brain synchrony during naturalistic social interactions', *Scientific Reports*, 7(1) (2017), 1–12.

[95] S. Dikker, L. Wan, I. Davidesco, L. Kaggen, M. Oostrik et al., 'Brain-to-brain synchrony tracks real-world dynamic group interactions in the classroom', *Current Biology*, 27(9) (2017), 1375–1380; D. A. Reinero, S. Dikker, and J. J. Van Bavel, 'Inter-brain synchrony in teams predicts collective performance', *Social Cognitive and Affective Neuroscience*, 16(1–2) (2021), 43–57.

[96] G. Quer, J. Daftari, and R. R. Rao, 'Heart rate wavelet coherence analysis to investigate group entrainment', *Pervasive Mobile Computing*, 28 (2016), 21–34.

[97] D. Xygalatas, 'The biosocial basis of collective effervescence: An experimental anthropological study of a fire-walking ritual', *Fieldwork in Religion*, 9(1) (2015), 53–67.

ritual practices can support synchrony, rhythmic entrainment, and physiological resonance. Because the synchrony of neural firing helps create conscious experiences in individuals, biological synchrony between people perhaps indicates the shared and extended nature of consciousness.[98] Many rituals seem to enable humans to share a collective consciousness.

The evolution of rhythmic rituals may have had a profound effect on social cohesion. War drums are used in many cultures to bind together groups of warriors and give them a shared mental state. However, not all rituals need to be rhythm-centred to induce the sympathetic replication of mental states. For instance, the extensive archaeological record of Mayan culture – and advances in epigraphy – have painted a picture of a cultural fabric held together through a framework of spirituality accessed via altered states of consciousness by all levels of society.[99] As interpreted by David Stuart, the acclaimed Mayanist credited with deciphering the Maya Codex, altered states were accessed through exhaustive repetitive dance, public incense burning, extreme fasting, entheogens, and, most prominently, the auto-sacrificial letting of blood by rulers (Figure 8.7).[100]

Bloodletting was resonant but it was not rhythmic. The high king was believed to be the 'vessel' of 'ku'h' – a force understood as the divine energy flowing within all things. Standing atop pyramids in front of their gathered subjects, kings spilled their blood in ritualised acts symbolising the transferal of the ku'h within them to the people, thus establishing their societal power. These were bloody ceremonies of pain, as the ruler would pierce their own tongue or penis with a holy instrument, such as an engraved stingray spine. Through the human capacity for sympathy, ritual spectacles like this would have produced extremely powerful shared experiences. Perhaps ritual experiences that resonate more will replicate more.

[98] A. L. Valencia and T. Froese, 'What binds us? Inter-brain neural synchronization and its implications for theories of human consciousness', *Neuroscience of Consciousness*, 2020(1) (2020), article niaa010.

[99] D. Stuart, 'Ideology and classic Maya kingship', in V. L. Scarborough (ed.), *A Catalyst for Ideas: Anthropological Archaeology and the Legacy of Douglas Schwartz* (Santa Fe, NM: School of American Research Press, 2005), pp. 257–286; S. Houston and D. Stuart, 'Of gods, glyphs and kings: Divinity and rulership among the classic Maya', *Antiquity*, 70(268) (1996), 289–312.

[100] S. Houston, 'Into the minds of ancients: Advances in Maya glyph studies', *Journal of World Prehistory*, 14(2) (2000), 121–201.

FIGURE 8.7 Mayan bloodletting ceremony, as depicted in Lintel 24 from Structure 23 at Yaxchilan (Am1923, Maud.4, The Yaxchilan Lintels, The British Museum). © The Trustees of the British Museum.

Resonance, in the context of this discussion, is a mechanism for *experience transmission* between people. In culture, as was exhibited by the Maya, the role of resonant experiences between minds may be integral to maintaining the coherence of societal structure. Yet it is challenging to translate an internal experience into a transmittable external action, a reality reflected in the Mayan glyph *tzak* meaning 'conjure (in the context of vision)', which shows a fish held in a left hand.[101] As Stuart points out, a slippery fish in hand may be a metaphor for the illusive nature of our

[101] Stuart, 'Ideology and classic Maya kingship'.

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liminal and ineffable dance with the divine. Yet, the attempt to face the challenge of sharing internal experience is present in the rich variety of public ceremonies found throughout human culture.

Harmony as a Selection Pressure in Human Evolution

In this chapter, we have proposed *imagination* as a mechanism of mental variation and *sympathy* as a mechanism of mental reproduction. We now consider the classical concept of *harmony* as a selection mechanism within conscious experience. To begin, we address the following question: what is conscious experience? The neuroscientist Stanislaw Deheane put forward one of the most popular theories of consciousness, known as the 'Global Neuronal Workspace'.[102] Given that a person can only have one conscious experience at a time, Dehaene claims that consciousness consists of the mental elements that have temporarily won the ongoing competition for access to this unified space (that is, the global neuronal workspace). Thus, conscious experience is that which is integrated into the global neural workspace – and this competition for dominance in awareness serves as an evolutionary pressure.

Beyond the competition of individual mental elements, we suggest that the mind *harmonises* competing mental impulses into a single conscious experience. How might the classical concept of harmony help explain complex selection pressures in the mind? We hypothesise that harmonisation drives mental selection forces because coherence or periodic synchrony between mental elements is stabler and lower in free energy.[103] In the following section, we will show how harmonisation might be able to explain how the mind can integrate the diverse experiences of an individual

[102] S. Dehaene, H. Lau, and S. Kouider, 'What is consciousness, and could machines have it?', *Science*, 358(6362) (2017), 486–492.

[103] A similar discussion can be found in Safron's consideration of self-organising harmonic modes: A. Safron, 'An Integrated World Modeling Theory (IWMT) of consciousness: Combining integrated information and global neuronal workspace theories with the free energy principle and active inference framework; towards solving the Hard problem and characterizing agentic causation', *Frontiers in Artificial Intelligence*, 3 (2020), article 30.

or collective consciousness. The humanistic concept of harmony can be found in both Eastern and Western classical philosophy, psychology, neuroscience, and physics, but we will begin with evolutionary theory.

Wallace, the younger co-discoverer of Darwinian evolution, presented 'harmony' as an overarching selection force in the evolution of life: 'health, strength, and long life are the results of a harmony between the individual and the universe that surrounds it'. For Wallace, a plant or animal is in harmony with its environment when it is well-matched to it. When the environment changes, a species can fall out of harmony. Natural selection can return an animal species to harmony with a changing universe, 'like the governor of a steam engine',[104] but only through slow change over many generations. In contrast, Wallace notes that 'man is kept in harmony by his mind'.[105]

In *The Descent of Man*, Darwin quotes Wallace, saying that 'man is enabled through his mental faculties to keep with an unchanged body in harmony with the changing universe'.[106] The concept of harmony here is clear enough: organisms that better harmonise with their environment will flourish. In the classical meaning,[107] harmony is defined as the joining together of diverse elements into a well-*fitted* whole: so, 'survival of the fittest' could also reasonably be termed 'survival of the harmonised'.

Harmony is an important concept in many cultures, including in indigenous spiritual systems in the Americas and in Africa. Historically, the concept emerged as a dominant philosophical theme almost simultaneously

[104] Wallace provides an early view on cybernetics or control theory: 'The action of this principle is exactly like that of the centrifugal governor of the steam engine, which checks and corrects any irregularities almost before they become evident; and in like manner no unbalanced deficiency in the animal kingdom can ever reach any conspicuous magnitude, because it would make itself felt at the very first step, by rendering existence difficult and extinction almost sure soon to follow', Alfred Russel Wallace, 'On the tendency of varieties to depart indefinitely from the original type' (Ternate, February 1858), ed. Charles H. Smith, http://people.wku.edu/charles.smith/wallace/S043.htm.

[105] Wallace, 'The origin of human races', 160 and 184.

[106] Darwin, *The Descent of Man*, Part 1, ch. 5, p. 158.

[107] This history is represented with astonishing clarity – and a direct call to revolution – in HRH the Prince of Wales, T. Juniper, and I. Skelly, *Harmony: A New Way of Looking at Our World* (London: Harper Collins, 2010). Also see Lomas and Xue, 'Harmony in Design', 5–64.

around 550 BC in ancient China[108] and in ancient Greece,[109] a coincidence perhaps comparable to the simultaneous discovery of Darwinism. While the concept of 'harmony' might strike some as unscientific, it actually played a key role in the development of the Western sciences.

The first known empirical philosophers in the Western tradition were the Greek Pythagoreans (*c.* 500 BC), who were known for their mathematical theory of harmony.[110] While previous thinkers had proposed that the world was fundamentally made of elements like air, water, fire, or aether, the Pythagoreans believed that the cosmos was made of *mathematical structure*. As a result, they believed that natural harmonies in mathematics should manifest themselves within the physical cosmos. This viewpoint is still provocative today, in part because it seems to integrate an immaterial or even spiritual perspective with scientific inquiry and mathematics.

Notably, the Pythagoreans tested their mathematical model of harmony in what appears to be the first documented scientific experiment. The historian Leonid Zhmud explains that 'Hippasus [*c.* 530–450 BC] conducted an experiment with bronze discs, confirming the numerical expressions of the principal concords discovered by Pythagoras, 2:1 for the octave, 3:2 for the fifth, and 4:3 for the fourth.'[111] The Pythagoreans empirically demonstrated that a bronze chime twice the thickness (ratio of 1:2) of another made a musical octave while a chime 150 per cent thicker (ratio of 2:3) played a musical fifth, and so on. These simple combinations of pure numbers were also found in the ratios used to tune stringed instruments. For instance, a guitar string pressed at half the length will play an octave higher, at a ratio of 2:1. These early

[108] In sixth-century BC China, Confucians and Daoists believed that harmony described the joining of diversity into wholeness. It wasn't the elimination of differences or 'sameness', it was a coherent integration of variety, like a soup with many contrasting ingredients, coming together as a whole. See C. Li, 'The philosophy of harmony in classical Confucianism', *Philosophy Compass*, 3(3) (2008), 423–435.

[109] Philolaus (470–385 BC), born 100 years after Pythagoras (*c.* 570–495 BC), was the first Pythagorean known to write about harmony: 'Harmony is generally the result of contraries: for it is the unity of multiplicity, and the agreement of discordances' (Nicomachus, *Arith. Intr.*, 2. 509, DK 10).

[110] The terms 'philosophy' and 'cosmos' are attributed to Pythagoras. See C. Riedweg, *Pythagoras: His Life, Teaching, and Influence* (Ithaca, NY: Cornell University Press, 2008).

[111] L. Zhmud, 'Aristoxenus and the Pythagoreans', in C. Huffman (ed.), *Aristoxenus of Tarentum: Discussion* (New Brunswick, NJ: Transaction, 2012), pp. 223–249.

experiments provided empirical evidence to support the Pythagorean hypothesis, that transcendent mathematical relationships govern the material universe and are manifested as literal harmonies in the physical cosmos as well as in the mind.[112]

Evidence from contemporary neuroscience suggests that the Pythagorean hypothesis may be worthy of some further consideration. For instance, the brain is not just rhythmic, it is also profoundly harmonic. Electrical brainwaves are structured by doublings of frequency – in music, these doublings are known as octaves. Just as an octave above middle A (440 Hz) is 880 Hz, each brainwave band is roughly double in frequency: gamma brainwaves are roughly double the frequency of beta waves, which are roughly double the frequency of alpha waves, and so on. These doublings support periodic synchrony; for instance, the peaks of one frequency's wave can 'kiss' the peaks of another frequency's wave every other cycle. In this manner, harmonic ratios support periodic synchrony and coupling between neural circuits. Because irrational ratios can *prevent* synchrony, famous irrational ratios like the golden mean have been proposed as mechanisms useful for preventing interference between different neural functions.[113] For example, functions at 'high theta' won't interfere with functions at 'low theta' if the high and low frequencies are separated by a ratio of the golden mean.

The harmonic structure of the brain can be described as a nested hierarchy of frequency couplings. By analogy, consider how the rapid play of a violin can fit within the slower frequencies of the musical pulse indicated by a conductor's baton: in the same way, rapid, localised ~40 Hz gamma cycles can fit (or nest) into the brain-wide metrical structure of ~4 Hz theta oscillations. Thus, local and global frequencies can be coupled together through a nested hierarchy of periodic phase synchrony.[114]

[112] J. Godwin, *The Harmony of the Spheres: A Sourcebook of the Pythagorean Tradition in Music* (Rochester, NY: Inner Traditions International, 1993); A. Balbi, *The Music of the Big Bang: The Cosmic Microwave Background and the New Cosmology* (Berlin and London: Springer Science & Business Media, 2008).

[113] B. Pletzer, H. Kerschbaum, and W. Klimesch, 'When frequencies never synchronize: The golden mean and the resting EEG', *Brain Research*, 1335 (2010), 91–102.

[114] P. Uhlhaas, G. Pipa, B. Lima, L. Melloni, S. Neuenschwander et al., 'Neural synchrony in cortical networks: History, concept and current status', *Frontiers in Integrative Neuroscience*, 3 (2009), article 17.

When different neural circuits fire in synchrony, they are perceived together in consciousness;[115] long-range synchronisation is understood as the binding force for the perception of smaller 'nested' elements. For instance, neural synchrony in the imagination blends and synthesises different concepts into new concepts.[116] Oscillatory chunks of language are merged together through rhythmic nested synchrony – phonemes nested in syllables nested in words nested in phrases and so on.[117]

It is this dynamic, hierarchical *harmony* – the symphony of the brain – that seems to generate the integrated unified nature of conscious experience.[118] As neuroscientists seek a 'common currency'[119] to explain the link between immaterial mental experiences and physical brain activities, the concept of harmony is a strong candidate for this common currency. Scientists have even discovered that electrical oscillations in the brain can produce so-called 'harmonic modes':[120] electrical patterns resembling the beautiful patterns of sand that can emerge on a vibrating Chladni plate. Science is only beginning to unravel how the brain's massive hierarchy of neural oscillation fits together in a rhythmic, metrical structure. While much remains to be discovered, mathematical principles of harmony really do seem to be manifested in the brain. Pythagoreans can be proud.

But even if principles of harmony operate in the brain and mind, what makes harmony a selection pressure? A guitar string offers a simple illustration. When a guitar string is plucked, a massive range of initial frequencies are generated, but only the *fit* will survive;[121] that is, only the

[115] A. K. Engel and W. Singer, 'Temporal binding and the neural correlates of sensory awareness', *Trends in Cognitive Sciences*, 5(1) (2001), 16–25.
[116] A. Vyshedskiy and R. Dunn, 'Mental synthesis involves the synchronization of independent neuronal ensembles', *Research Ideas and Outcomes*, 1 (2015), article e7642.
[117] G. Buzsáki, *The Brain from Inside Out* (New York, NY: Oxford University Press, 2019), ch. 6.
[118] F. Varela, J.-P. Lachaux, E. Rodriguez, and J. Martinerie, 'The brainweb: Phase synchronization and large-scale integration', *Nature Reviews Neuroscience*, 2(4) (2001), 229–239.
[119] G. Northoff, S. Wainio-Theberge, and K. Evers, 'Is temporo-spatial dynamics the "common currency" of brain and mind? In quest of "Spatiotemporal Neuroscience"', *Physics of Life Reviews*, 33 (2019), 34–54.
[120] S. Atasoy, I. Donnelly, and J. Pearson, 'Human brain networks function in connectome-specific harmonic waves', *Nature Communications*, 7(1) (2016), 1–10.
[121] D. A. Jaffe and J. O. Smith, 'Extensions of the Karplus–Strong plucked-string algorithm', *Computer Music Journal*, 7(2) (1983), 56–69.

vibrations with wavelengths literally *fitting* the length of the string will be amplified. All other frequencies will be damped. These frequencies are the string's fundamental frequency and its harmonics. Thus, a 'survival of the harmonised' process operates; from among a multitude of frequencies, harmony selects only those that fit the length of the string. Notably, it is this selection process that gives rise to the overall sound of a guitar. By direct analogy, rhythmic elements in the brain that do not fit or harmonise with dominant neural rhythms will be unable to enter conscious awareness.[122] In this way, we hypothesise that harmony serves as a 'fitness function' for the brain: neural circuits are tuned through selection forces to maximise harmony.

We have been speaking of harmony in the brain, but what about harmony in human experience? In everyday mental experiences, harmony offers a powerful and intuitive description of several deep and vital human motivations. For instance, harmony is deeply linked to 'happiness' as an encompassing driver of human experience. When researchers gathered open-ended definitions of happiness from nearly 3,000 adults (from Argentina, Brazil, Croatia, Hungary, India, Italy, Mexico, New Zealand, Norway, Portugal, South Africa, and the United States), they found that 'inner harmony' was the most common everyday 'lay-person' definition of happiness.[123] A harmonious state of mind is indeed a pleasant one – yet we also need tension and unpleasant 'cognitive dissonance' to motivate actions that return us to states of greater harmony.[124] After all, the best music relies on dissonance and the best stories rely on narrative tension; harmony appears to be greater when there are discords to harmonise or challenges to overcome.

There may be more extreme states of mental harmony, as well. Mihaly Csikszentmihalyi describes the trance-like peak experience of top performers, the so-called flow states, using the concept of harmony: 'Flow is

[122] P. Fries, 'Rhythms for cognition: Communication through coherence', *Neuron*, 88 (1) (2015), 220–235; R. F. Helfrich, A. Breska, and R. T. Knight, 'Neural entrainment and network resonance in support of top-down guided attention', *Current Opinion in Psychology*, 29 (2019), 82–89.

[123] A. Delle Fave, I. Brdar, M. P. Wissing, U. Araujo, A. Castro Solano et al., 'Lay definitions of happiness across nations: The primacy of inner harmony and relational connectedness', *Frontiers in Psychology*, 7 (2016), 30.

[124] B. Weiner, *Human Motivation* (London: Psychology Press, 2013), p. 305.

the way people describe their state of mind when consciousness is harmoniously ordered.'[125] Flow states don't occur when one is distracted or when one's attention is split; they occur only when a performer interacts *whole-mindedly* with the demands of their environment. When there is a dynamic match between a person's skill and the demands of the task, this can result in a state of harmony or 'flow'. An example could be conjured in the image of a skilled musician entranced in an effortless union of mind and sound, where thought is not needed to determine placement of fingers upon a fretboard – rather, the music seems to emerge from a direct link between the mind and the instrument.

Extending the analogy of the musician, a group flow or harmony in improvisational music ('jamming') depends upon a harmonious balance of listening, feeling, and generation by each individual musician. When a group harmony is achieved, the intersection of diverse individual musical ideas is profoundly unified. New ideas may need to resonate in order to reproduce, but it is through selection-by-harmony that they can evolve to fit within the context of a larger social system.

Harmony does not only occur in the brain or within individual experiences, it also manifests itself as the social harmony that binds people together in community. Individual actions that fit the expectations of a larger social group are less likely to be dampened and extinguished. Some behaviours harmonise with the rhythms of other people, and some don't. People seek interpersonal harmony with each other because it feels good – and because alignment into friendships and larger social groups generally supports individual health and reproductive success. The attunement of people within social groups appears to be necessary for joint attention,[126] coordinated action, and shared intention. Harmony, as a selection pressure in the evolution of the social mind, may have enabled more collaborative behaviours and larger social groups. Groups of humans that don't harmonise will have more conflict and fragment over time, whereas

[125] M. Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (New York, NY: Harper & Row, 1990).

[126] M. Tomasello, M. Carpenter, J. Call, T. Beyne, and H. Moll, 'Understanding and sharing intentions: The origins of cultural cognition', *Behavioral and Brain Sciences*, 28(5) (2005), 675–691.

groups that harmonise well may grow ever larger. Over time, then, harmonious groups may come to dominate the less harmonious.

One critique of harmony is that it isn't a scientific concept. Yet, during the European Enlightenment, the notion of harmony and scientific humanism were closely aligned. Alexander von Humboldt, the world explorer and inspiration to Darwin, named his masterpiece of science *Kosmos* as a reference to the Pythagorean philosophy. Similarly, both Copernicus and Newton credited Pythagoreans for their greatest insights.[127] Other scientists, like Galileo, Kepler, Descartes, Spinoza, and Hooke (among many others) scientifically investigated harmony. In the first years of the early Royal Society, for instance, there were dozens of experiments conducted on the science of harmony.[128]

For a variety of esoteric reasons,[129] the concept of harmony has largely fallen out of consideration in the sciences. Even Karl Popper was critical of it.[130] Richard Dawkins referred to the idea of ecological harmony between species as 'dotty mysticism'.[131] Perhaps. But, if this classical concept motivates people to seek inner harmony, to design a more harmonious global society,[132] and to pursue a more lasting harmony with nature, perhaps it should be understood better through authentic scientific inquiry:

> Nature itself is a harmonic system ... if we ignore the principles that sustain that harmony, nature's essential balance and equilibrium become quite literally disordered.[133]

[127] J. E. McGuire and P. M. Rattansi, 'Newton and the "Pipes of Pan"', *Notes and Records of the Royal Society of London*, 21(2) (1966), 108–143.
[128] P. Gouk, *Music, Science and Natural Magic in Seventeenth-Century England* (New Haven, CT: Yale University Press, 1999).
[129] W. J. Hanegraaff, *Esotericism and the Academy: Rejected Knowledge in Western Culture* (Cambridge: Cambridge University Press, 2012).
[130] But perhaps due to a misunderstanding, as discussed in C. Li and D. Düring, 'Harmony: Origin of totalitarianism or patron of pluralism', *Journal of East–West Thought*, 10(2) (2020), 1–9.
[131] R. Dawkins and Y. Wong, *The Ancestor's Tale: A Pilgrimage to the Dawn of Life* (London: Hachette, 2016).
[132] D. Mahiet, 'Rethinking harmony in international relations', *Journal of International Political Theory*, 17(3) (2021), 257–275.
[133] HRH the Prince of Wales, Juniper and Skelly, *Harmony*.

Synopsis

Do evolutionary forces operate within the human mind? In this chapter, we have examined factors in conscious experience that support variation, reproduction, and selection: the key ingredients for natural selection. We propose that *imagination* provides a key source of *variety* in human experience. We propose that *sympathy* serves as a powerful mechanism for the *replication* of conscious experiences. Finally, we propose that principles of *harmony* govern the *selection* of mental experiences, both within individuals and within collective consciousness.

Looking across the world today, we see the results of a mere ~70,000 years of cultural adaptation from the moment our modern human ancestors left Africa to populate the lands beyond. A band of possibly fewer than 1,000 individuals crossed the Red Sea strait and began the lasting migration wave that would disperse humanity over mountains, across oceans, and onto every corner of habitable land that this planet has to offer. In the generations that followed, many conditions led to a diverse set of human experiences that influenced a seemingly endless variety of experiments in culture. Empires rose and fell, societies formed and dissolved, and ideas were born and transformed through it all. What we are left with is an archaeological library of human imagination.

As a species, we will always need to create new ways of thinking in order to adapt to our continuously changing realities. Now, in a time where globalisation and the information revolution have dissolved geographical boundaries of knowledge exchange, there may be a rational and appropriate need to reflect on our longstanding relationship with the boundaries of the mind, to expand our imagination of the universe and to seek a more harmonious future for ourselves within it.

Further scientific discovery can reveal how resonance and harmony shape our universe and how they relate to each other and to other basic concepts like entropy and the flow of free energy. Understanding these forces will surely inform the continued evolution of humanity. We are humbled by the complexity of the emergence of new realities within the mind – the birth of new ideas remains a mystery. The enigma of our imagination may be as elusive as the origin of life; by exploring this enigma, we seek the spirit of human inspiration. From the shaman's drum

in Mongolia to the sakau stones in Micronesia, we have as a species been driven to evolve as explorers of the mind. By continuing to redefine the boundaries of our conscious experience, we can forge and formulate reality itself.

Epilogue: The Continuing Frontier

In the field of biomimetics, lessons from nature are used to inform engineering. How might we build upon the evolution of cultural rituals and cognitive technologies to inform the design of new and transformative experiences today?

A. Lin personal account – In late March of 2019, during the spring equinox, I was invited to a private installation deep within the Yucatán jungles of Mexico. It was designed by the landscape artist James Turrell and built by conservationists/explorers Roberto Hernández and Claudia Madrazo Hernández with a philosophical grounding in Maya cosmology. It was described to me as a technology to facilitate connection to the cosmos and the binding forces in nature. The installation consisted of a massive stone pyramid built over an underground *cenote* (a naturally formed limestone cavern deep enough to access groundwater). The interior of the pyramid framed a series of internal spaces, each designed to challenge and 'unlock the mind'.

Embedded at the centre of the base layer was a voluminous space that, due to the lack of corners, gave the illusion of having no end. From no specific source, a perfectly ubiquitous light shifted in colour almost imperceptibly. My hosts referred to this as 'The Ganzfeld' (Figure 8.8). They instructed me to sit quietly and stare into the seemingly endless abyss – an entrancing, amorphous canvas of formless space with nothing in it but us. Then, we took a small series of stairs (Figure 8.9) to a half-spherical space referred to as 'The Metasphere'. We lay on our backs on top of a circular platform and stared into the dimly glowing dome above. Suddenly, the sea of diffuse light began to oscillate and flicker from alternating hidden sources. As I stared into the pulsing featureless space, I saw morphing multicolour images emerge like a dance of constructive and destructive interference patterns in my mind. I heard an audio signal at a similar alternating frequency – it pulsed and

FIGURE 8.8 'Ganz field' inside the pyramid in the Yucatán jungles of Mexico (designed by James Turrell; built by Roberto Hernández and Claudia Madrazo Hernández). Photo: Albert Lin.

hummed and seemed to entangle itself in my mental images. I was told that the frequencies were attuned to disrupt the normal rhythmic operation of my brain.

When we reached the third level, we saw a dark and cavernous room holding the 'skyspace' – a starkly cut elliptical view of the sky that was framed sharply on all sides by pulsing diffuse lights filling the interior of the space (Figure 8.10). A final minimal staircase rose to the opening, giving way to a reflection pool situated on top of the pyramid (Figure 8.11). From the top of the steps, we emerged from the interior to witness the endless jungle horizon. Even the colours and sounds of the jungle seemed significantly brighter upon emerging from the pyramid. We sat just below the skyspace as the sky tone shifted with the setting sun. The boundaries of both colour and depth played unexplainable games with my perception.

FIGURE 8.9 Channel through the heart of the pyramid into the cenote. Photo: Albert Lin.

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FIGURE 8.10 The 'Skyspace' inside the pyramid (the grey oval is open sky). Photo: Albert Lin.

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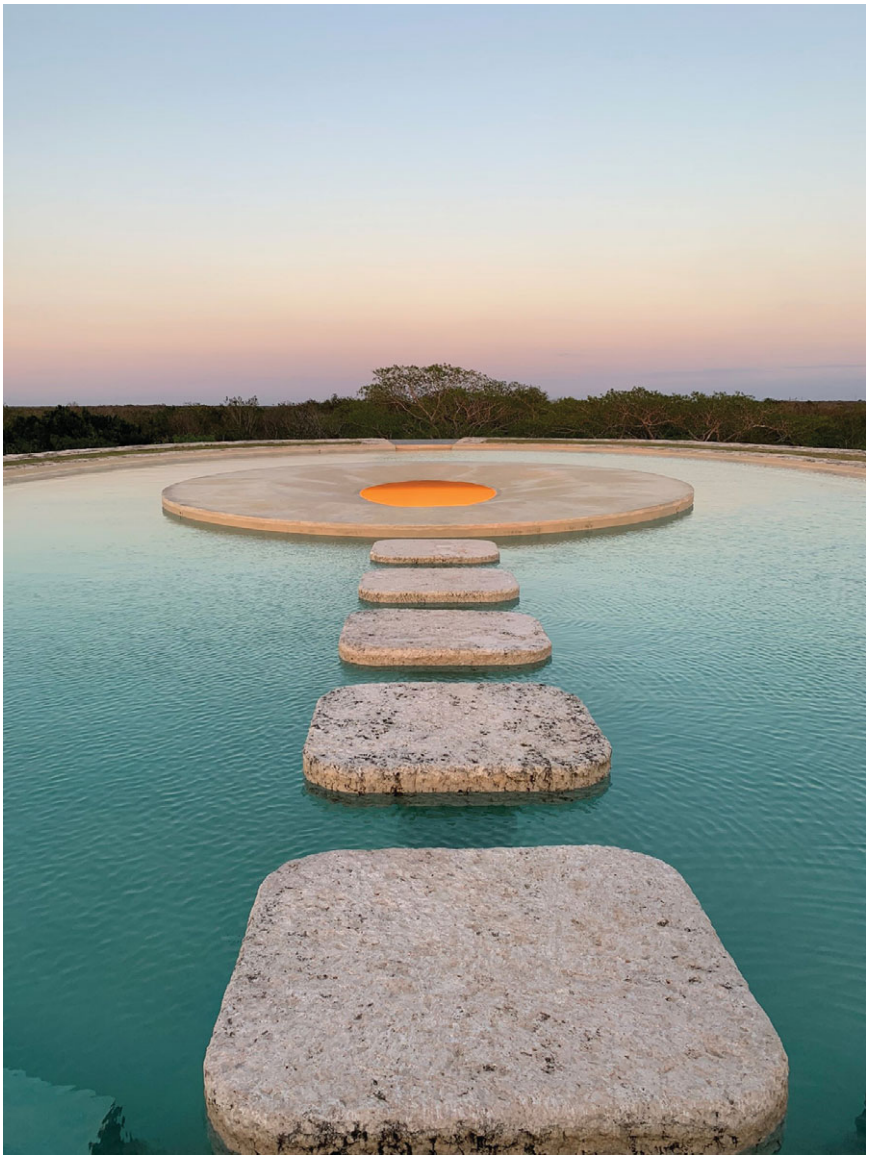

FIGURE 8.11 Reflection pool on the top level of the pyramid. Photo: Albert Lin.

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FIGURE 8.12 Light hitting the cenote surface within the pyramid. Photo: Albert Lin.

A single long channel led from the top of the pyramid down several hundred feet to the dark blue waters of the natural *cenote* below (Figure 8.12). I will never forget those few minutes during the spring equinox when a stunning beam of sunlight travelled through the incense-filled heart of the pyramid and exploded into the rippling, clear waters.

Over the course of three days, my experience there was punctuated only by the rhythms of ceremony, the simple ritual of eating small meals and our ongoing discussion of the cosmos and our relationship to it. Without any entheogenic substances, this otherworldly and existential experience – generated through architecture, immersive light, and conversation – was enveloping to the point of mystical ego-death.

This experience shows how the design of new cognitive technologies might tap into the more existential aspects of the human mind. The frontiers of this very human quest will surely be advanced by many

explorers of art, technology, science, and philosophy. With a greater understanding of imagination, sympathetic resonance, and harmony, how might we envision new designs that could enlighten our experience and aid our evolution as a more resilient and harmonious species?

The Earth has never been more connected together at a global scale. Yet the world can feel, at times, profoundly disconnected. We have seemingly infinite access to information and experience – all the great works of science, literature, music, film, and more – yet it is rare to participate in the physical, embodied group ritual experiences that have generally held societies together in the past. Dancing together is powerful but, in 2021, it is deeply provocative. As humans – if we have the capacity – do we also have the *responsibility* to imagine new ceremonies, rituals, or technologies that could help bind together our future societies? We leave this discussion wondering what resonant experiences might enable humans to better harmonise with each other and with the ever-changing natural world. Most of all, we continue to wonder, where will our collective imagination take us next?

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