DOI: 10.1111/nyas.15082

REVIEW

ANNALS OF THE NEW YORK ACADEMY OF SCIENCES

Psychedelia: The interplay of music and psychedelics

Katarina Jerotic[1,2,3] | Peter Vuust[3] | Morten L. Kringelbach[1,2,3]

[1]Centre for Eudaimonia and Human Flourishing, Linacre College, University of Oxford, Oxford, UK

[2]Department of Psychiatry, University of Oxford, Oxford, UK

[3]Center for Music in the Brain, Department of Clinical Medicine, Aarhus University & The Royal Academy of Music Aarhus/Aalborg, Aarhus, Denmark

Correspondence
Katarina Jerotic, Centre for Eudaimonia and Human Flourishing, Linacre College, University of Oxford, Oxford, UK.
Email: katarina.jerotic@psych.ox.ac.uk

Funding information
Pettit Foundation; Danish National Research Foundation, Grant/Award Number: DNRF117; Carlsbergfondet

Abstract

Music and psychedelics have been intertwined throughout the existence of *Homo sapiens*, from the early shamanic rituals of the Americas and Africa to the modern use of psychedelic-assisted therapy for a variety of mental health conditions. Across such settings, music has been highly prized for its ability to guide the psychedelic experience. Here, we examine the interplay between music and psychedelics, starting by describing their association with the brain's functional hierarchy that is relied upon for music perception and its psychedelic-induced manipulation, as well as an exploration of the limited research on their mechanistic neural overlap. We explore music's role in Western psychedelic therapy and the use of music in indigenous psychedelic rituals, with a specific focus on ayahuasca and the Santo Daime Church. Furthermore, we explore work relating to the evolution and onset of music and psychedelic use. Finally, we consider music's potential to lead to altered states of consciousness in the absence of psychedelics as well as the development of psychedelic music. Here, we provide an overview of several perspectives on the interaction between psychedelic use and music—a topic with growing interest given increasing excitement relating to the therapeutic efficacy of psychedelic interventions.

KEYWORDS
ayahuasca, DMT, LSD, music, psilocybin, psychedelic

INTRODUCTION

The full experience of music is uniquely human, omnipresent in societies globally, and plays important roles across cultures. It can be described as an organized collection of sounds (i.e., soundscape) that carries with it a sense of meaning and emotional valence.[1–3] There is now strong neuroimaging evidence that the constituent elements of music—melody, harmony, and rhythm—lead to continuously constructed predictions of what happens next in a musical piece, giving rise to perception, action, emotion, and over time, learning, formalized in the so-called predictive coding of music (PCM) model.[2]

Many ethnomusicologists will argue that music is difficult to define, especially when looking at its evolution throughout space and time. It is hard to draw a distinctive line between simple sound and music. Montagu defines music as "sound that conveys emotion;" however, he quickly goes on to explain that this is too simplistic a definition, as such a definition would include emotionally moving speeches or sonnets.[4] He notes that if we think of the potential beginning of music more broadly in terms of our ancestors' physical ability to produce music, then the examination of the cranium and jaw structure of fossil remains suggests singing ability to have originated as early as one million years ago.[4] Nevertheless, the physical capability does not necessarily entail the mental capacity for producing such vocalizations, and, therefore, it is most likely that the ability for music production through singing did not develop prior to the existence of *Homo sapiens* and their associated brain development some 300,000 years ago.[5] In the case of psychedelics, several authors have made the argument that the use of psychedelics is not only present throughout our evolutionary history but that it even affected our evolution.[6,7] An overview of the evolution of music and psychedelic use is given later on. Classic psychedelics are substances that stimulate the brain's serotonergic system, these include lysergic acid diethylamide (LSD), psilocybin, N,N-dimethyltryptamine (DMT), and mescaline.[8] Archeological evidence of human use of mescaline has been traced as far back as 8600 BC in modern-day Peru.[9] The use of music in accompaniment with psychedelics can be posited to be almost as old as our use of either of these elements on their own.

An altered state of consciousness can be defined as a "state of psychological functioning that is significantly different from that experienced in ordinary states of (waking) consciousness."[10] Music and altered states of consciousness have historically been intertwined, from religious ceremonies and rituals where practitioners are thought to get closer to God through the singing of hymns to the feeling of entering a trance or groove-like state when listening to your favorite music. Music has been thought to be of great importance when taking psychedelics (e.g., Refs. 11–14) both within traditional settings such as shamanic rituals where the combination of psychedelics and music is thought to work together to move members into the "spirit realm," and within more modern contexts such as raves—where masses "trip out" not only from the mind-altering substances they consume but also from the techno music they are surrounded by. Music has also been thought to be of great importance for positive outcomes following psychedelic therapy (e.g., Refs. 11, 12, 15, 16). Here, we explore the interplay of music and psychedelics, both from a mechanistic standpoint as well as more broadly from the perspective of music as an accompaniment to the consumption of psychedelics. We conclude by providing a brief examination of the potential for music to result in altered states of consciousness in the absence of pharmaceutical interventions.

We are in the midst of what many call a psychedelic research renaissance, a new rise in interest in the clinical potential of psychedelic substances in improving mental health.[17] Such substances taken within a therapeutic setting have been found to hold great potential for positive outcomes in depression, anxiety, and substance use disorders.[18–24] Commonly, in Western clinical research, these drugs are thought of as adjunct to therapy.[25] Drug therapies, such as psilocybin-assisted therapy, are for the first time since their classification as drugs of abuse being considered seriously as therapies for treatment-resistant conditions. In Australia, the Therapeutic Good Administration is allowing authorized psychiatrists to prescribe psilocybin for treatment-resistant depression.[26] Canada Health has added psilocybin-assisted therapy to their Special Access Program where practitioners can request access to the drug if there is a compelling case for its potential benefits as long as a patient's clinical history is provided.[27] The growing interest in the application of these therapies in clinical settings has been accompanied by a desire to understand the mechanisms through which psychedelics affect brain activity, as well as to ascertain the importance of the environment within which these substances are taken—with music being an environmental factor to which great importance has been attributed.[11,12,15,16]

RELIANCE ON AND CHANGES TO FUNCTIONAL HIERARCHY OF BRAIN DYNAMICS

Modern computational neuroscience relies on the framework of brain activity being organized in a functional hierarchy—a perspective critical to our understanding of both music perception and psychedelic action. Such a framework suggests a hierarchical processing system, with the bottom of the hierarchy composed of sensory regions, such as the primary auditory and visual cortices. The top of the hierarchy is composed of regions which are densely interconnected and responsible for both the integration of information from across the brain and the proceeding broadcasting of this information throughout the cortex.[28–30] This model of cognition can be explained through the predictive coding theory, which suggests that rather than passive reception of new information from the environment, the brain continually generates models of the world based on prior experience and context to predict new sensory input. Such models of the world are thought to be formed in regions higher up in the functional hierarchy, with information communicated through feedback connections to lower sensory areas.[31]

Early work described the process of incorporating new sensory information into cognition.[30] Basic features, such as color, motion, and shape, were described to be encoded from primary sensory areas and up through the hierarchy, while more complex information regarding the experience of people, places, and events is encoded and held in models at the top of the hierarchy (composed of what Mesulam termed trans-modal brain regions), which sends feedback to the bottom. This allows for continuous updating of both existing expectations and interpretations of incoming information within the system, which is often assumed to be Bayesian.[32,33] The important work by Margulies and colleagues depicted gradients of connectivity across the brain, with integrative regions, such as those constituting the Default Mode Network, being found on one end of the gradient, and primary sensory and motor regions on the other.[29] These gradients are equivalent to the first and second harmonics in the harmonics framework proposed by Atasoy and colleagues.[34,35] The Global Workspace (GW) theory was first proposed by Bernard Baars and stipulates that there are a small group of brain regions sitting at the top of this hierarchy through which information is integrated before being broadcast to the rest of the brain.[36] This led to the neuronal GW theory of Dehaene and Changeux describing the flow of information through this hierarchical system.[37] Most recently, scientists have been trying to understand which regions of the brain make up the GW, or in other words, which regions sit at the very top of the hierarchy.[28] The framework of functionally hierarchical information processing in the brain shows perception as a process of active inference, largely dependent on one's prior experiences and existing models of the world.[38]

MUSIC PERCEPTION IN THE BRAIN

For a long time, music listening was thought to be a passive process with information simply entering the brain through the auditory cortex. However, when examining rhythm—a fundamental component of music creation and perception—theorists make the distinction between rhythm, the perceived beat, and meter, the hierarchical prediction model of the music with regard to which we perceive rhythm.[39] Since the meter is a predictive mental model that is not necessarily present acoustically in what is presented to the brain, then the brain is cocreating the perception of rhythm. A clear example of this is polyrhythm such as 3 against 4, a rhythm which you can experience both as a waltz (3/4) and as a march (4/4), even though the acoustic input to the brain is exactly the same. This means that music perception is a mediation between bottom-up and top-down processing in the brain (i.e., between input and priors), and many of these are a product of statistical learning. Syncopation, polyrhythm, and groove all create tension between rhythm and meter, or rather between perception and expectation,[40] and importantly, all may result in music that is perceived as pleasurable.[1,41]

The current understanding of music listening more generally has been built on such frameworks, delineating music perception to be a process of active inference, wherein the listener is constantly making predictions about what they will hear next and using any errors in this prediction to improve future estimates.[2,42] The brain is constantly looking to minimize its prediction error by updating its model of the world and, therefore, expectations of what will be heard next. This theory aligns well with research showing that one's perception of music is modulated by one's prior experience and music preference.[11] In fact, the PCM model (Figure 1) formed by Vuust and colleagues is a development of the predictive processing theory, with the additional caveat of accounting for the influence of biological, cultural, and contextual factors that impact our perception of music.[2,42]

The Mismatch Negativity (MMN) paradigm is an auditory event-related potential. Research has shown that the MMN, in line with the predictive coding framework, relies heavily on the establishment of a model and responds only when that model is deviated from, providing further support for the PCM model.[39] The onset of the MMN relates to changes in a variety of sound features, such as intensity, timbre, and rhythm.[40,43] As music perception is based on pre-existing models of the world, it relies on the previously discussed hierarchical processing framework, whereby regions at the bottom of the hierarchy are responsible for novel input (the rhythm), and regions at the top of the hierarchy hold the individual's model of the music (the meter) which guides their predictions. It is important to note that the experience of listening to music is not limited to music perception, it includes the resulting action and emotional response to the music (both with regard to the listener and the performer).[2] The PCM model suggests that music perception, action, emotion, and learning are in fact all Bayesian processes within which the brain's key goal is minimizing prediction error.[2] For example, music-related emotion can be thought to modulate predictions, affecting our response to new music.[2] Therefore, a strong argument can be made for the integrative process of music perception, and response being dependent on the state of the brain's functional hierarchy—a hierarchy manipulated by psychedelic ingestion.

PSYCHEDELIC ACTION ON THE BRAIN

The hierarchical framework of brain function is thought to be impacted in altered states of consciousness, for example, when psychedelics are consumed. The Relaxed Beliefs Under Psychedelics (REBUS) model is a theory of psychedelic action on the brain's dynamic functional landscape that has gained a great deal of support in modern neuroimaging studies.[44–47] The model is inspired by two frameworks: the free-energy principle[38] and the entropic brain hypothesis.[48] The free-energy principle argues that the development and survival of living things relies on the need to minimize uncertainty and avoid chaos. This argument sits well with the hierarchical predictive coding theory of brain activity discussed above. The entropic brain hypothesis stipulates that, within a critical zone under the influence of psychedelics, there is a general increase in entropy in the brain, with greater and more diverse information flow across the brain. This increase in entropy of brain activity is then reflected in a richer conscious experience. Building upon this, the REBUS model (Figure 2) suggests that upon ingestion of a psychedelic, the individual experiences a flattening of the brain's functional hierarchy, in other words, the dynamic functional landscape within the mind is flattened, allowing for greater free-flow of information, a reduced effect of pre-existing models, and, therefore, an openness to new information coming into the system.[45] Another way to put this is that top-down processing is less prominent, giving more weight to bottom-up information under the influence of psychedelics. Such a change in the relationship between top-down and bottom-up information processing can impact music perception processes as understood through the PCM model described above. In fact, ingestion of LSD has been found to lead to significantly different cortical and subcortical responses to musical stimuli compared to placebo.[49]

Prior work has shown that the consumption of classic serotonergic psychedelics leads to significant decoupling among brain regions higher in the functional hierarchy, alongside simultaneous increases in communication between areas lower in the functional hierarchy.[50–52] Lord and colleagues used functional magnetic resonance imaging to show that ingestion of psilocybin led to increased global BOLD-phase coherence and movement toward a globally synchronized functional connectivity state alongside simultaneous disruption of a phase-locking pattern resembling the frontoparietal network[53,54]—a network previously associated with attention-based cognitive control through top-down mechanisms.[55–57] The harmonics framework allows for an understanding of brain activity as dynamic transitions across time from one frequency-specific brain state to another.[34,58] This framework has been applied to several psychedelic states, providing consistent findings.[59–61] Both psilocybin- and LSD-induced brain changes show a suppression of low-frequency harmonic energy, an increase in high-frequency harmonic energy, and an expansion of the connectome harmonic repertoire. These findings suggest a movement toward more complex dynamics while in these altered states. Additionally, recent work examining turbulence-based changes in hierarchical dynamics among individuals ingesting psilocybin or LSD resulted in further support for the REBUS model, showing an increase in turbulence and,

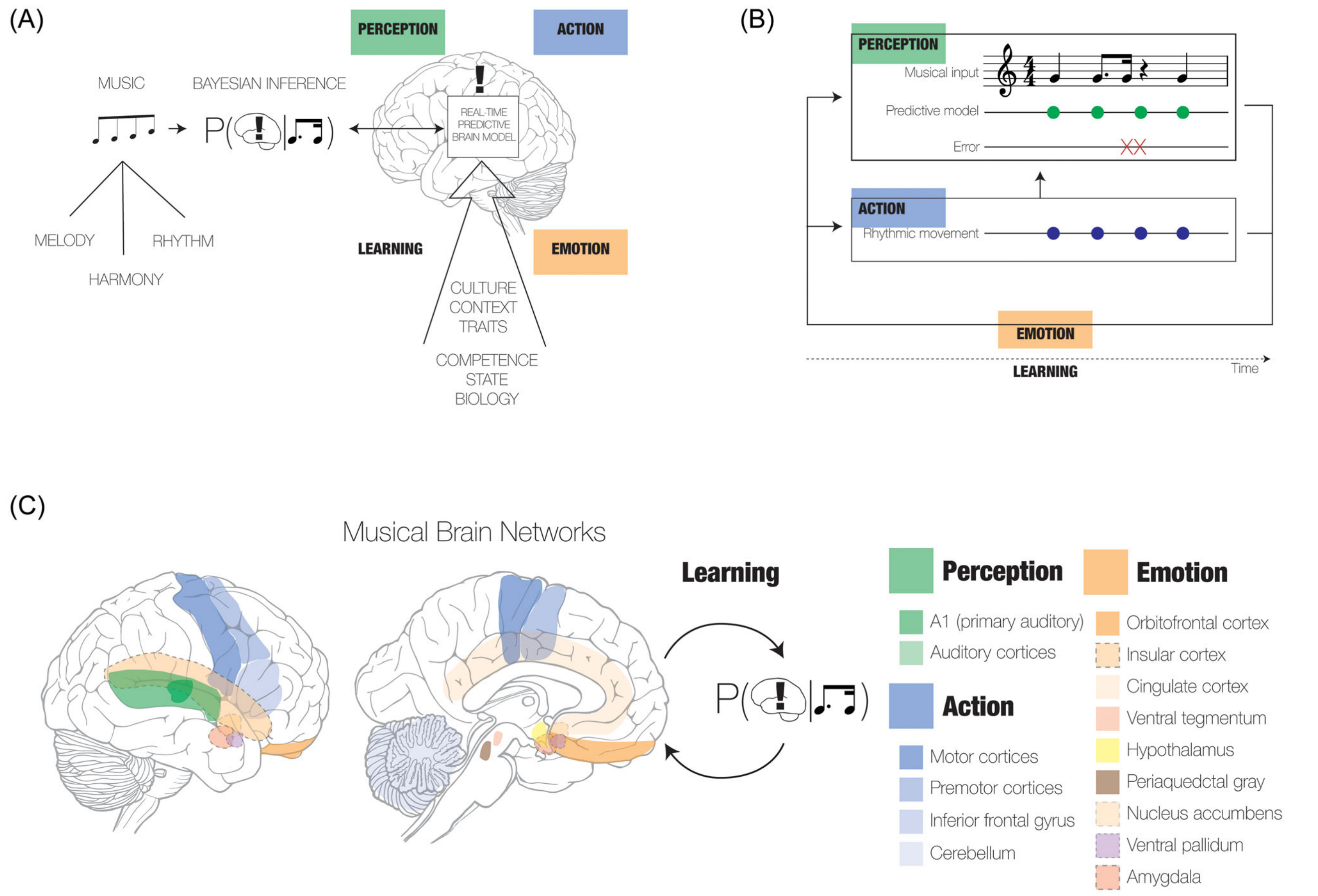

FIGURE 1 Predictive coding of music. (A) Music (composed of melody, harmony, and rhythm) perception is guided by predictions set by the brain's real-time predictive model through a process of Bayesian inference. The model depends on the listener's cultural background, the context within which the music is being heard, the individual traits of the listener, their competence, their brain state, as well as biological factors. (B) The musical excerpt shows a syncopated rhythm, which can be followed using a 4/4 meter. The syncopated note results in an error between the perceived rhythm and the predicted meter, urging the listener to act by reinforcing the meter through, for example, tapping. This process repeats every time the rhythm does, and long term, this allows for learning and music-evoked emotion. (C) Outline of the brain networks involved in music perception, action, and emotion processes. Learning is depicted as the ongoing update of predictive brain models through Bayesian inference.[2] P represents the ongoing update of musical predictions in the Bayesian inference.

therefore, a movement toward greater information transfer following psychedelic ingestion.[62]

COMMON BRAIN NETWORKS IN MUSIC AND PSYCHEDELICS

Given that music perception is thought to rely on hierarchical processing, which is argued to be affected under the influence of psychedelics, it is reasonable to think that the ingestion of psychedelics would affect one's perception of music stimuli. As far as we could tell, no work has been done looking at the interplay between psychedelics and music on a network level, and specifically linking it to changes in functional hierarchy. Further research needs to be conducted to more directly examine the effects of music listening during the psychedelic experience on functional brain activity, specifically on changes to the brain's functional hierarchy.[63–66] This section aims to outline existing work pointing to a mechanistic interplay or overlap between music and psychedelics in an effort to showcase the need for more research on this topic.

To assess the potential overlap between music experience (e.g., perception, action, appreciation, and provoked emotion) and psychedelic action on the brain, we focus on serotonin (5-HT). Classic psychedelics are widely known to act by affecting serotonin receptors in the brain. Several studies have shown that by blocking psychedelic 5-HT_{2A} agonism in healthy individuals by administering a 5-HT_{2A} receptor antagonist, the hallucinogenic effects of both psilocybin and LSD can be blocked.[67–70] Here, we outline work that has shown a connection between music and serotonin production. Exposure of rats to melodic music was found to lead to an increase in the release of 5-HT in the caudate-putamen as compared to controls.[71] Evers and Suhr[72] studied the effects of listening to pleasant versus unpleasant music on serotonin neurotransmitter production in healthy human controls using the platelet model for central neurotransmission. Results showed a significant positive correlation between the release of 5-HT and music unpleasantness ratings. A further study examining the effects of music

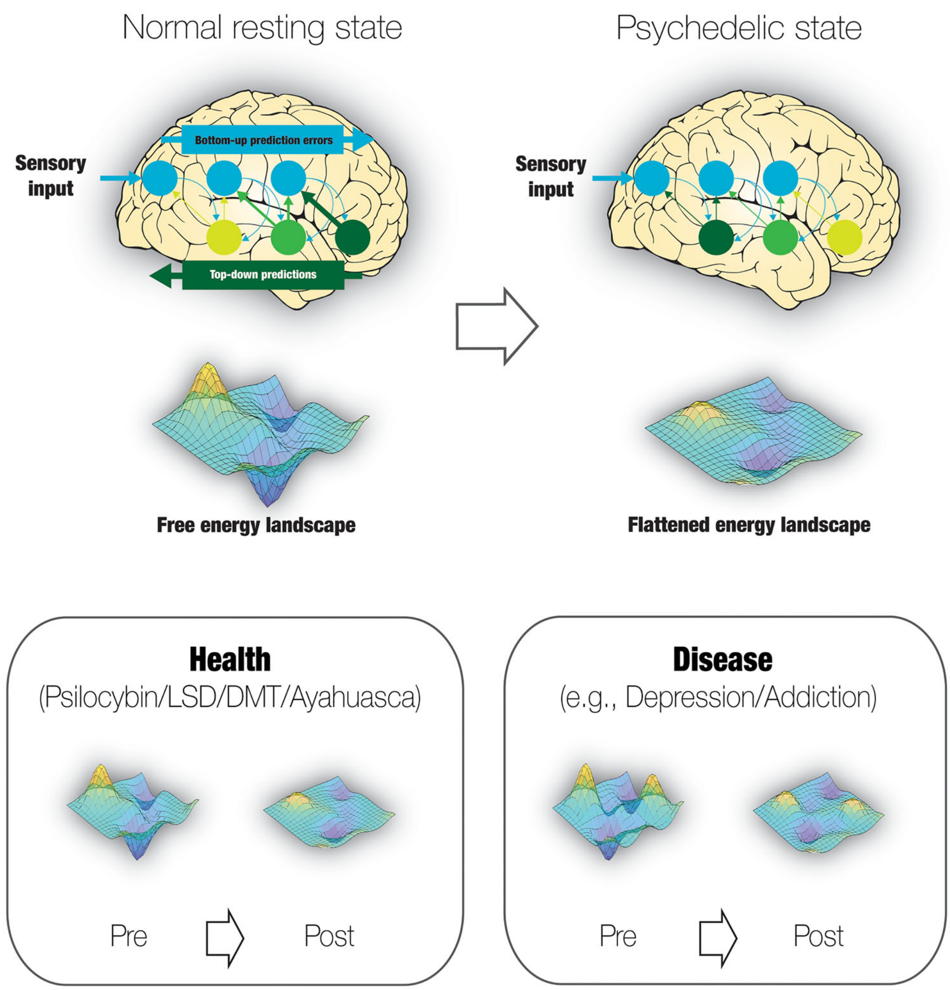

FIGURE 2 Flattening of brain's dynamic energy landscape following ingestion of psychedelics. Following the REBUS hypothesis,[45] the top section of the figure is designed to show that compared to a normal resting state, the psychedelic state is characterized by a flatter energy landscape and a lower influence of top-down predictions. The bottom two diagrams show the consequences of the REBUS hypothesis, namely, what this flattening of the energy landscape would look like in health and disease. The normal resting state in disease is characterized by a steeper energy landscape, which is then flattened under the influence of serotonergic psychedelics, allowing for lowered influence of existing models (depicted by the flattened peaks). Abbreviations: DMT, N,N-dimethyltryptamine; LSD, lysergic acid diethylamide.

therapy on depression in children and adolescents with attention-deficit/hyperactivity disorder found an increase in 5-HT secretion among those who had music therapy (accompanied by standard care) but not controls (who received standard care but not music therapy). Although this work seems to point to music and psychedelics affecting broadly overlapping systems in the brain, further research needs to be conducted to define the nature of a potential neuronal relationship between them as well as any potential for additive or compounding effects of music and psychedelics on each other mechanistically.

The important role of 5-HT_{2A} receptor agonism in psychedelics' mechanism of action is widely agreed upon.[67–70,73,74] Recent examination of brain regions involved in response to psilocybin-based therapy for depression showed brain regions associated with restoration of healthy brain function to overlap significantly with 5-HT_{2A} and 5-HT_{1A} receptor affinity maps.[75] Research has shown dense presentation of 5-HT_{2A} receptors in regions of the brain associated with music perception and music-evoked emotion.[76] In fact, 5-HT_{2A} receptor signaling under LSD led to a biased neural response to music stimuli when compared to placebo as well as when compared to pretreatment with a 5-HT_{2A} antagonist.[76] 5-HT_{2A} receptor signaling has previously been associated with increased cortical plasticity, thereby allowing for increased sensitivity to both endogenous and environmental influences, such as music.[77] Recent whole-brain modeling work suggests that dynamic mutual coupling of the neuronal and neurotransmitter systems is essential to our understanding of the dynamic connectome, especially in altered states of consciousness, such as under the influence of LSD or psilocybin.[78,79]

THE ROLE OF MUSIC IN MODERN PSYCHEDELIC THERAPY

Providing a supportive setting is of widely established importance for a psychedelic-based therapy session.[80] A primary aim when designing the space for such a session is to achieve a "living room-like setting"[80,81]; this includes having posters on the walls, rugs on the floor, a comfy sofa or recliner, and pleasant ambient lighting.[82] Patients usually wear eye masks and listen to music.[83] This focus on the surrounding space points to a well-established belief among scientists and clinicians alike that set and setting are fundamental to shaping the acute psychedelic experience as well as long-term outcomes following the psychedelic-based therapy session.[80,82] "Set" here refers to an individual's inner state at the time of consumption (i.e., their mood and expectations), while "setting" refers to the environment—both physical and social—that they find themselves in while under the influence of the drug.[84]

Music has widely been agreed upon to be a crucial part of the psychedelic setting, with well-chosen music being thought to encourage long-term positive mental health outcomes.[16,85] Music has been related to therapeutically useful emotions, mental imagery, and a sense of safety, among other benefits.[11] In the absence of psychedelics, music therapy—or the use of personalized music listening or music production interventions led by a trained music therapist—[86] has been widely shown to have positive clinical outcomes. Reviews of music therapy effectiveness in children, adolescents, and adults have shown strong positive outcomes. These include: positive effects on social functioning and speech production among children and adolescents with neurodevelopmental disorders[87]; lowering of anxiety, pain, and shortness of breath among patients with chronic or advanced illnesses[88]; improved quality of life among cancer patients[89]; reduction in depressive symptoms among older adults[90]; improvement in gait among patients with Parkinson's disease; global and social functioning among individuals with schizophrenia[91]; and improvements in verbal fluency and reductions in anxiety, depression, and apathy among patients with dementia[92]; and others.

Music is thought to both guide and deepen the psychedelic experience.[13,15,93,94] Music's role in shaping the psychedelic experience has been so ubiquitously agreed upon that structured guides have been developed to aid clinicians in their choice of musical stimuli. Bonny was instrumental in the development of structured playlists used to accompany psychedelic therapy prior to the banning of psychedelic therapy in the 1970s.[95,96] The guide was composed of hundreds of music recordings from a variety of genres, which had been used by therapists at the Maryland Psychiatric Research Center, Baltimore. Bonny found that by matching the intensity of the music to the intensity of the psychedelic experience, the therapist could provide additional nonverbal support for the patient.[8] Recently, there has been international consideration for music used in psychedelic therapy, as evidenced by the development of similar guides abroad, such as the Copenhagen Music Program.[8]

MUSIC IN RELATION TO MYSTICAL EXPERIENCE

A mystical experience has been characterized by *nonordinariness* and *profundity*.[97] Nonordinariness refers to the feeling of being unable to explain the experience within a naturalistic context. Profundity refers to the lack of triviality in these experiences, which usually concern factors such as the ultimate truth and, therefore, are considered "profound." At the most intense point of a psychedelic trip, subjects are at the highest likelihood of having a mystical experience, the occurrence of which is considered key for encouraging positive outcomes following psychedelic therapy.[98] The occurrence and strength of a mystical experience has been found to be a predictor of improved outcomes following psilocybin-mediated therapy for the treatment of treatment-resistant depression.[99,100] A systematic review of the importance of mystical experiences in predicting positive outcomes following psychedelic-based therapy showed positive correlations between having had a mystical experience and beneficial outcomes several weeks or months after the intervention.[101] The presence of a mystical experience during such a session has even been associated with persistent positive outcomes 12 months later.[102] Stace outlined six dimensions of mystical experience, including: sacredness, noetic quality, ineffability, paradoxicality, strong sense of positive mood, and transcendence of time and space, which were later used in the development of a standardized measure of mystical experience called the Mystical Experience Questionnaire (MEQ).[103,104] Formal assessments of mystical experience further include Hood's mysticism scale[105] and the Mystical Orientation Scale.[106,107]

Music listening under psychedelics is associated with an increased production of positive emotions such as transcendence—one of the six dimensions of mystical experiences.[108] Qualitative studies have helped further our understanding of the importance of music for encouraging mystical experience onset. Nineteen patients were interviewed in an effort to understand how music influenced their experience of taking psychedelics, and one of the major findings was that their experience of the music seemed to be associated with the onset of mystical experiences.[11] Ten clinicians with extensive experience of administering psilocybin within research and therapeutic settings outlined the elements of music they each believed to be key in encouraging such experiences, such as having "a feeling of continuous movement and forward motion that slowly builds over time" (p. 11).[93] Furthermore, the occurrence of a mystical experience under the influence of psilocybin, while listening to music, has been associated with long-term changes in personality—namely, openness—in a healthy population,[109] as well as with persistent improvements in depressive and anxiety-related symptoms in a patient population with life-threatening cancer.[110] Therefore, the existing evidence stands in support of the role of music in encouraging the onset of mystical experiences; however, further and more systematic research needs to be conducted to examine the role of music specifically in causing such effects.

MUSIC FOR EXPRESSION AND REGULATION OF EMOTION

Several studies have examined the effects of psychedelic ingestion on our emotional response to music. Research examining the effects of psychedelic ingestion on music-evoked emotion, for example, found that music could have both welcome (e.g., sense of guidance, calm, and safety) and unwelcome (e.g., feeling of being misguided) emotional outcomes.[11] The presence of LSD has been shown to lead to significant increases in positive emotions, such as wonder, transcendence, power, tenderness, nostalgia, peacefulness, and joy (as quantified using the Geneva Emotional Music Scale[111]) while listening to music.[108] However, the same was not observed for negative emotions, such as sadness and tension. Further research examined the effects of psilocybin-based therapy on music-evoked emotion in individuals with treatment-resistant depression.[112] Overall, there was a significant increase in perceived pleasure in response to music after treatment compared to before. Trajectories of changes were emotion-specific, with a significant increase in feelings of peacefulness in response to the music and a significant decrease in sadness. Among depressed patients, psilocybin-based therapy resulted in heightened neural responses to musical stimuli in brain regions associated with music-evoked emotion.[113] LSD has been found to increase people's perception of music meaningfulness for music that had been deemed both meaningful and meaningless prior to ingestion of the psychedelic.[68] This research showed altered activity in brain areas involved in meaningfulness processing following the drug's ingestion. It is important to note that the intensity of observed responses to music stimuli seems to be specific to classic psychedelics, as compared to dissociative anesthetic hallucinogens, such as dextromethorphan. High doses of psilocybin were found to result in significantly higher ratings of perception of music significance, and to a greater extent, music absorption.[114] Kaelen argued that music's ability to connect listeners with meaningful and therapeutic experiences may be enhanced due to the interaction with the psychedelic substance.[11,16] Furthermore, psychedelic ingestion in the presence of music seems to have a strong relationship with participants' preceding relationship to music and creativity more broadly. Following psilocybin therapy for smoking addiction, during which music was played, all 12 participants noted music as a central component of the psychedelic experience, with six reporting that particular pieces they had heard during the experience evoked overwhelming positive emotions even some 30 months later at the time of the follow-up interview.[94] Two participants mentioned commencing musical hobbies in the months following the intervention, even though music was not a focal part of the therapy.[94]

MUSIC FOR MODERATION OF VISUAL IMAGERY

Visual imagery can be thought of as changed perception in the visual field; this can range from simple changes in the brightness of colors or sharpness of edges, to the experience of full hallucinations of spaces where individuals are not really present.[115] Following the ingestion of psychedelics, such imagery has been noted to occur, with an increase in dose often leading to greater vividness and intensity.[115] Increases in dose have further been associated with hallucinations and a loss of awareness of the experience of reality.[115,116] Audio-visual synesthesia is the ability of music to shape the perception and dynamics of such visual imagery throughout the psychedelic experience.[115]

Shanon discussed his own experiences as well as the shared experiences of fellow practitioners taking ayahuasca (a psychedelic brew) within a ritual setting in the presence of music.[117] They noted the great importance afforded to music within such ceremonies in shaping the visions and their progression. Tempo and rhythm were thought to be particularly important, which determined the speed and movement of figures produced through visual imagery during the psychedelic experience. This observation is in line with the current understanding of music's ability to alter people's experience of space and time.[118] Music was even found to affect the content of the visions Shanon experienced, with hallucinated people and creatures being observed to play instruments or sing.

To examine the effects of psychedelic consumption and music listening on mental imagery and associated brain activity, Kaelen and colleagues conducted a neuroimaging study examining the effects of these factors on parahippocampal–visual cortex functional connectivity.[119] This region was chosen in part due to its prior association with visual imagery.[119,120] Information flow from the parahippocampal cortex to the visual cortex was positively affected by the presence of a combination of both music and LSD, leading to enhanced visual imagery.[119] This increase in functional connectivity was positively correlated with ratings of visual imagery. Further research examined the perceived benefits of music listening in psilocybin-mediated psychedelic therapy for treatment-resistant depression.[11] The music was said to evoke therapeutically useful mental imagery; however, in some cases, it had been said to have evoked unpleasant imagery as well.

DOES THE CHOICE OF MUSIC FOR PSYCHEDELICS MATTER?

Although music is widely acknowledged to be a major component of outcomes following the psychedelic session, not a lot of work has been done examining the effects of variation in music type (e.g., genre, mood, etc.), preference, and elements of music. Recent qualitative research found differences in mystical experience scores (as defined by the MEQ) dependent on the type of music played during the session.[121] Barrett and colleagues conducted a large survey examining what features are commonly recommended in music used for psychedelic therapies—as provided by therapists with vast experience in the administration of psychedelic-based interventions—and how therapists think these elements affect patient outcomes.[93] There seemed to be distinctions made based on which part of the trip the patient was experiencing, with phenomenological differences between responders' music recommendations for melodies played in the pre-peak and peak parts of the session. Qualitative and quantitative analyses of the provided musical recommendations showed that peak music had lower perceptual brightness than pre-peak music, for example. Such work focused on the characteristics of the musical pieces played and how they may vary throughout the session, with their effects examined across participants. However, no comparisons were made at the individual level. This may be too simple an approach, as patients' prior experiences of the music played during therapy have been found to predict experience quality.[85] Additionally, when asked for feedback on their psychedelic sessions, patients outlined the need for tailoring the musical playlist to the individual.[94] Music more generally seems to be critical in shaping not only the acute psychedelic experience during a therapy session but also the long-term outcomes following the session.[11] However, the choice and putative individualization of music and its timing throughout the session are important elements that must be explored in greater detail.

THE EVOLUTION OF MUSIC AND PSYCHEDELIC USE

Music has been argued to be universal throughout time and geography.[122] Although early debates argued for music either being a simple evolutionary mechanism or a cultural phenomenon, more recent discussions have come to find that a biocultural approach that combines these perspectives may be more conducive to a concrete understanding of the origins of music as a complex phenomenon.[123] In prior writings, Geissmann and later Hagen and Hammerstein show that coordinated vocalization and long-distance calls (loud, patterned sequences of notes) are not exclusive to *Homo sapiens* and are in fact found in 26 nonhuman primates.[124,125] Fossil evidence seems to suggest that *Homo sapiens*, specifically, have existed for approximately 300,000 years,[5,126] with our species being noted to make flute-like instruments some 43,000 years ago—pointing to an advanced form of music production being available at that time.[5,127] Extensive research has further been conducted examining why music is universal to humans. The two major theories relate to the positive effects of synchronization and mimesis on social bonding and the endogenous opioid system. Mimesis is characterized by actions, such as miming, imitating, gesturing, and repetitive rehearsal of skills.[128] Music, and associated activities such as dance, result in synchronization and mimesis, which have been argued to act as social bonding agents[129] by allowing for self–other merging, or the fading of the distinction between self and other members of the group.[130] Furthermore, musical behaviors, such as musicking, singing, and dancing, have been argued to lead to the release of endorphins,[130,131] providing a mechanistic explanation for the presence of music in our evolutionary history.

The use of psychedelics for ritual and religious purposes seems to stretch back thousands of years into human history. A recent review on the ancient roots of psychedelic medicine by George and colleagues[132] discussed the use of psychedelics across several cultures. Evidence includes the ingestion of psychoactive drink among ancient Greeks[9,132] and the ritual ingestion of mescaline, which seems to stretch back somewhere between 5000 and 40,000 years ago.[132,133] Furthermore, the review highlights the physical evidence of psychedelic use that dates back 1000 years through the discovery of a pouch uncovered in South West Bolivia containing residue of psilocybin, among other ingredients.[132,134] Such findings point to a long history of psychedelic use in human societies.

As music and psychedelics have existed throughout much of our history, the interaction of the two is likely to be just as old. Nevertheless, in the examination of the timeline of their interaction, we can focus on the history of shamanic ritual during which both music and psychedelics are employed. Shamanism is present across many cultures,[135] and shamans are often considered messengers between this world and what can broadly be termed "the spirit world," with variation across cultures as to what exactly this entails.[136] Shamanism is thought to have a central role in modern human ritual origins due to evidence of its historical presence across hunter-gatherer societies.[136] Music is a key part of shamanic rituals, with variations in specific elements of music such as rhythm through drumming or melody through vocalization. These elements are thought to lead to changes in the experience of the ritual.[117] The following sections refer to several examples of ancient ritual use of both music and psychedelics.

INDIGENOUS USE OF MUSIC IN PSYCHEDELIC RITUALS

Although Western research on psychedelics is largely associated with the psychedelic movement of the 1950s and 1960s, the use of music and psychedelics in tandem is a story which started much earlier. There has been a great deal of anthropological, musicological, and psychological research devoted to understanding the interaction between music and psychedelics in ancient cultures. For example, Beatriz Caiuby Labate performed anthropological research on the use of music and psychedelics in the rituals of Amazonian shamanic groups and syncretic churches of Brazil.[137,138] De Rios and Kratz theorized that through its tone and rhythm, music acts as a "jungle gym" of consciousness during rituals, providing pathways for the participants' movement through an altered state of consciousness while under psychedelics.[13] The theory was born through multiple decades of anthropological fieldwork across the Amazon. The psychological treatment and research conducted in the Centro Takiwasi in Peru has further been critical to our understanding of the phenomenological implications (e.g., the emotions experienced) of ayahuasca ingestion in the presence of songs originating from Amazonian shamanism.[139]

Native Americans historically, as well as now within the Native American Church, have used and continue to use peyote in their religious and healing rituals.[140] During said healing ceremonies, members consume peyote, stand in a circle around the person who is unwell, and sing ritual-relevant songs accompanied by drums.[141,142] Indigenous cultures of Mexico, such as the Mazatec Indians, commonly have shamans or guides who will lead the psilocybin ceremony through repetitive, musical incantations; a famous example of such a shaman is Maria Sabina.[143] Ceremonial use of psychedelics is also found in Gabon where the Bwiti tradition of ingesting the root of the Iboga shrub still carries on today and is commonly observed in initiation rituals.[144] Within such rituals, the music has been described as a "lifeline … that reaches from this life to the hereafter and serves as a means of locomotion in visionary space."[144] Across South America, ayahuasca is commonly used in Amazonian rituals, where it is accompanied by medicine songs called *icaros*. We will use ayahuasca as a case study of music use in psychedelic rituals as it not only allows for the exploration of how music was historically used in indigenous, rural settings, but also how such rituals have been carried over to urban areas, the modern context, and even onto the international stage.

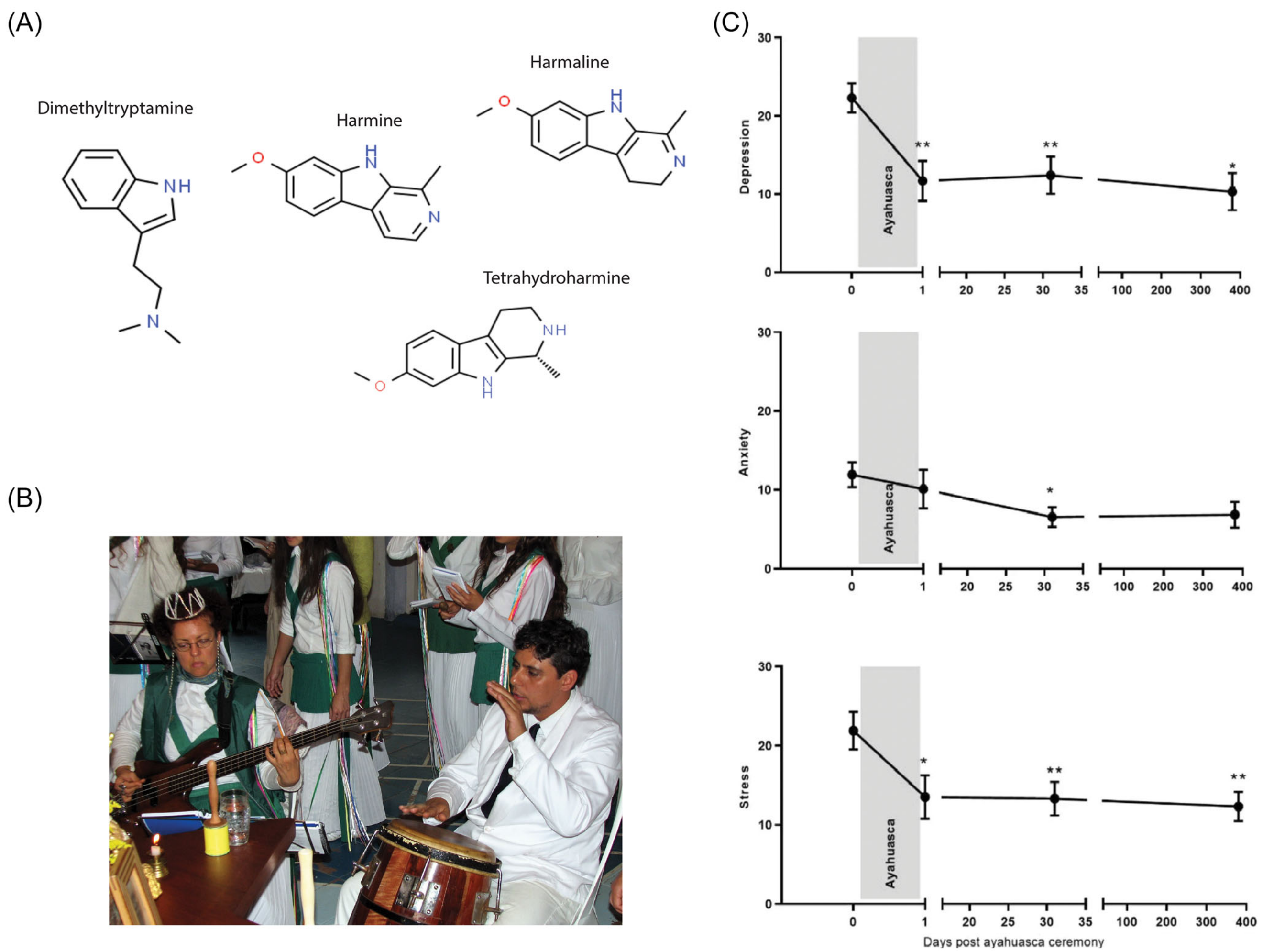

FIGURE 3 Ayahuasca composition, ritual, and outcomes. (A) The four major compounds most commonly found in the ayahuasca brew: harmine, harmaline, tetrahydroharmine, and DMT.[177–180] (B) The Santo Daime ayahuasca ritual during which members all wear white uniforms, consume ayahuasca, make music, sing, and dance[181] (CC BY-NC 2.0). (C) Results showing persistent lowered depression, anxiety, and stress scores in the days, weeks, and months following a single ayahuasca ingestion among clinically depressed patients.[155]

> The pervasive presence of music as an integral part of the drug experience constitutes one of the most powerful rituals associated with the social management of altered states of consciousness (de Rios, p. 98[14])

Ayahuasca use in ritual settings

Ayahuasca is a psychedelic brew made by brewing two plants: the *Banisteriopsis caapi* vine and commonly the *Psychotria viridis* shrub. *B. caapi* contains beta-carbolines (harmine, harmaline, and tetrahydroharmine) and *P. viridis* contains the active psychedelic component DMT (Figure 3A). Ayahuasca has been used in rituals of Amazonian indigenous groups for centuries for a variety of purposes, including diagnosis and healing of those who are unwell, resolution of social issues, and the gaining of insight.[145,146] Interviews with mestizo shamans in Peru highlight the importance of music in their use of ayahuasca, as the songs they sing are not only believed to have been gifted to the shamans by the spirit of the ayahuasca plant, but they are thought to have modulating effects on the psychedelic experience.[147] These songs, which have a very simple predictive structure, are thought to be able to change the strength of hallucinations, cure specific illnesses, and change the weather. The songs are of such importance to indigenous peoples of the region that the number of songs a shaman has is thought to be a clear representation of their knowledge or power.[147]

The consumption of the brew moved to more populous regions through the birth and growth of syncretic churches that incorporate the consumption of ayahuasca into regular ceremonies or *trabalhos* (works). The three largest of these groups are Santo Daime (the holy gift), Uniao do Vegetal (union of the plant), and Barquinha (little boat), all of which originate from Brazil. Two of these three groups, Santo Daime and Barquinha, hold music at high regard and value it not only as a way of verbally translating information regarding the religion, but also for its ability to allow a greater connection with God through its interaction with the brew. One-off as well as long-term, consistent ingestion of ayahuasca has been associated with a variety of positive mental health outcomes, including lower rates of anxiety,[148] depression,[149] and substance abuse,[150] as well as overall improved mental wellbeing, personal development, increased self-awareness, enhanced creativity, healing, divergent thinking, and improved personal problem-solving.[151–154] Such improvements are shown to persist; for example, a recent study showed ayahuasca analog ingestion to result in persistent improvements in depression, anxiety, and stress scores among clinically depressed patients even at a 1-year follow-up (Figure 3C).[155] Furthermore, a placebo-controlled study of ayahuasca ingestion suggested both drug effects and nonpharmacological factors (of which music was one) to be important in the observed mental health improvements.[156] In fact, ayahuasca ceremonies are commonly accompanied by *icaros*. A recent examination of the importance of *icaros* in the experience of ayahuasca ceremonies at the Addiction Rehabilitation Centro Takiwasi in Peru showed that patients reported experiencing the medicine songs as "therapeutically significant."[139] The *icaros* were described as having a modulating effect on both patients' emotions and the altered states of consciousness they experienced under the influence of ayahuasca.[139]

The case of Santo Daime

The Santo Daime is the oldest of these syncretic churches and incorporates within its beliefs and practices elements of Catholicism, European spirituality, Afro-Brazilian rituals and beliefs, as well as shamanic rituals of Amazonian indigenous peoples. Music plays a fundamental and guiding role in the ayahuasca rituals of the Santo Daime (Figure 3B), to the extent that the church is often referred to by its members as a "musical doctrine." The church has two major branches: the Centro de Iluminacao Crista Luz Universal (CICLU) and the Igreja do Culto Ecletico da Fuente Luz Universal Patrono Sebastiao Mota de Melo (ICEFLU).[84] The latter has spread greatly both within Brazil and abroad and is, therefore, the group referred to when the term "Santo Daime" is used. Santo Daime ceremonies are usually accompanied by hymns, which all participants are encouraged to sing along to. It is the belief of the Santo Daime that these hymns are not made by members, but rather "received" from the spirit realm that they often seek to communicate with during their ceremonies.[137] Although the lyrics of these hymns may have been adapted and modified with time and travel across countries and languages, the structure of the music itself has remained largely unchanged, consisting of songs following one of three rhythms: the march, the waltz, and the mazurka.[84,137] This suggests an importance of the music's extra-verbal qualities, especially as some practitioners have noted being able to remember a hymn just from its melody or rhythm in the absence of remembering the words themselves.[137] Among the Santo Daime, the ayahuasca brew retains critical importance in relation to the music, with many suggesting that it is only in the presence of the ayahuasca that the true meaning of the songs becomes clear.[137]

MUSIC FOR PSYCHEDELICS OR PSYCHEDELIC MUSIC?

> Music provides structure to rituals, creates narrative, activates deep emotions, produces religious ecstasy, and permits spiritual transcendence; it invokes collective memory and tears down and rebuilds notions of time and space, creating the experience of a self-evident, intangible truth (Labate et al., pp. 102–103[137])

Although much of the work discussed thus far has focused on music being an effective accompaniment to the psychedelic experience, it is important to consider the capacity for music to lead to altered states of consciousness in the absence of psychedelic drug ingestion. Following the classification of psychedelics as Schedule 1 substances and the prohibition of their research and use in therapy, Helen Bonny developed the Bonny Method of Guided Imagery and Music (BMGIM).[95,96] The method includes 30–45 min of a carefully selected music program during which imagery is induced and the patients share the experienced mental imagery with their therapist.[16,157] The therapist is thought to use the music to guide the experience and to provide reassurance to the patient or deepen the experience.[15] McKinney and Honig describe the BMGIM as "a music-centered approach to exploring consciousness for personal growth and transformation" (p. 1).[157] Their review of the clinical outcomes following BMGIM in both healthy and clinical populations showed improvements in anxiety and depression outcomes for several groups who had been given six or more BMGIM sessions. Many of the noted positive improvements were shown to persist at follow-up. BMGIM has been used for the treatment of a variety of conditions, including mood disturbances, trauma, and addiction, and its positive effects have been noted in cancer care as well as more general personal growth such as spiritual development and creativity enhancement.[157]

The idea of using music alone to reach altered states of consciousness is not a novel premise. Listening to music has been found to lead to altered states, such as groove, flow, and trance.[12] There are several reported instances across a variety of cultures of members being able to reach altered states of consciousness within their usual ritual setting in the absence of psychedelic substances. Members of the Santo Daime have compared their *icaros* to mantras, wherein the music in the absence of ayahuasca led to a type of acoustic trance.[137,158] Ancient Greeks were thought to use a variety of instruments to evoke and guide trance states, including double clarinets, pan flutes, and multi-stringed lyres.[159] The use of drums, rattles, and bells for the induction or manipulation of imagery is commonly observed in shamanic rituals across cultures.[160] Warao shamans of the Northern coasts of South America use music as a tool for the induction of trance states.[160,161] The Tumbuka healers (*nchimi*) of Malawi use drums to enter trance-dancing states through which they access divine information regarding ailments of members of the group and how best to treat them.[162]

Rouget[159] argued that the primary function of music in such ceremonial settings was to induce, accompany, or lead a trance state. Several authors have discussed the connection between rhythmic drumming and the invocation of trance.[159,163–165] In fact, Neher[166,167] postulated that trance states could be invoked by drumming at frequencies of 3–8 Hz (beats per second) and 8–13 Hz in accordance with electroencephalogram theta and alpha wave activity, respectively. This is thought to have led to later work relating music and altered state of consciousness to the concept of entrainment—the coupling of a body's internal rhythms to external stimuli.[168] Nevertheless, this line of thinking has been argued to be too simplistic as it does not take into account the importance of setting, personal beliefs, attitudes, and culture in the onset of these trance states.[159,168,169] For example, the onset of a specific form of trance state, termed possession trance, has been found to be correlated with the complexity of the society within which it is occurring.[160,170] Work to date on the induction of trance states through music is largely anecdotal or observational in nature. Neuroscientific research studies would have to be conducted to disentangle the relationship between music and alterations in brain activity leading to an altered state of consciousness. Furthermore, the relative impact of music compared to factors such as group setting, expectation, and faith is yet to be delineated systematically.

While the renaissance of interest in psychedelics in the 1950s and 1960s led to exciting growth in scientific and clinical research in the field, an equally exciting effect of this interest was experienced in the arts. The late 1960s experienced the birth and growth of "psychedelic sound" characterized by "elaborate studio effects, incorporation of eastern elements, and boundary dissolving effects …, [the use of] wah-wah pedal, tremolo vibrato, and reverb" (p. 584).[171] Excitingly, these new sounds were welcomed by some of the greatest musicians and bands of the era, including the Beatles, Jimi Hendrix, Pink Floyd, and many more.[171] The wider culture of arts, including music, influenced by 1960s psychedelic culture is broadly termed "psychedelia."[172]

The development of this new wave of psychedelic music, and the wave of psychedelic research and therapy being explored have remained largely distinct from one another. Recently, musicians and companies have sought to bring these two streams together. Jon Hopkins, the English electronic-music creator, released the album "Music for Psychedelic Therapy" in 2021.[173] Rather than simply being inspired by the psychedelic experience, the songs on this album were specifically designed to act as an accompaniment to psychedelic therapy. Furthermore, the United Kingdom-based company Wavepaths was founded by Dr. Mendel Kaelen with the aim of providing a musical experience that is meaningful to the extent of potentially leading to improved wellbeing.[174] *Dreamachine* was an audiovisual immersive experience developed by researchers in collaboration with artists (e.g., the music was created by Jon Hopkins).[175] It toured around the United Kingdom throughout 2022 as part of the UNBOXED tour. The idea behind the experience was inspired by Brion Gysin's 1959 invention of the dreamachine—a device that encouraged visual illusions through flickering light.[176] Unlike Wavepaths, the modern dreamachine, much like its predecessor, was developed for general enjoyment rather than a specific aim of improved wellbeing.[175] Nevertheless, the project was also made in the hopes of gaining an understanding of individual perceptual differences in response to this stimulating environment of flickering light and accompanying music. Although the experience is no longer accessible, the data analysis is ongoing.

CONCLUSION

We have shown how music and psychedelics have been intertwined across time and space. The two have been used in tandem both within modern clinical settings and within ancient rituals. This is exemplified by the use of ayahuasca in the Santo Daime, a modern religion rooted in ancient beliefs whose regular ceremonies are characterized by the ingestion of ayahuasca and participation in ritual-relevant singing and dancing. We outlined key ideas regarding the evolution of music and psychedelics, positioning them not simply as outcomes of our brain development but rather as integral features of our social bonding. Furthermore, we explored the potential of music to elicit altered states of consciousness in the absence of psychedelics and the creation and development of psychedelic music. Overall, our discussion showcases strong evidence for an ongoing association between music and psychedelics, whereby not only is the ingestion of psychedelics thought to impact our perception of music, but also the presence of music is thought to guide the psychedelic experience and its outcomes.

Music and psychedelics, respectively, utilize and manipulate the same underlying functional hierarchy, and both seem to affect serotonin pathways in the brain. These overlaps may hint toward neurocomputational and neurological explanations for their consistent interaction across societies. Through the examination of a diverse array of evidence, as presented, it has become clear that any one of these perspectives alone would be insufficient for reaching a complete understanding of this interaction. Therefore, future research needs to focus on examining how music and psychedelics interact and affect one another within an interdisciplinary outlook, incorporating a variety of perspectives, including the neurological, neurocomputational, cognitive, phenomenological, social, and cultural.

AUTHOR CONTRIBUTIONS

K.J. conducted the research and wrote the initial draft under the supervision and guidance of M.L.K. P.V. provided advice concerning content and structure during the drafting process. All authors edited the final version of the review and approved the final manuscript.

ACKNOWLEDGMENTS

M.L.K. and K.J. are supported by the Centre for Eudaimonia and Human Flourishing (funded by the Pettit and Carlsberg Foundations) and the Center for Music in the Brain (funded by the Danish National Research Foundation, DNRF117). P.V. is supported by the Center for Music in the Brain (funded by the Danish National Research Foundation, DNRF117).

COMPETING INTERESTS

The authors declare that they have no competing interests.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/nyas.15082

REFERENCES

1. Koelsch, S. (2014). Brain correlates of music-evoked emotions. *Nature Reviews Neuroscience*, *15*, 170–180. https://doi.org/10.1038/nrn3666
2. Vuust, P., Heggli, O. A., Friston, K. J., & Kringelbach, M. L. (2022). Music in the brain. *Nature Reviews Neuroscience*, *23*, 287–305. https://doi.org/10.1038/s41583-022-00578-5
3. Zatorre, R. J., Chen, J. L., & Penhune, V. B. (2007). When the brain plays music: Auditory–motor interactions in music perception and production. *Nature Reviews Neuroscience*, *8*, 547–558. https://doi.org/10.1038/nrn2152
4. Montagu, J. (2017). How music and instruments began: A brief overview of the origin and entire development of music, from its earliest stages. *Frontiers in Sociology*, *2*, 8.
5. Harvey, A. R. (2018). Music and the meeting of human minds. *Frontiers in Psychology*, *9*, 762. https://doi.org/10.3389/fpsyg.2018.00762
6. Winkelman, M. J. (2021). The evolved psychology of psychedelic set and setting: Inferences regarding the roles of shamanism and entheogenic ecopsychology. *Frontiers in Pharmacology*, *12*, 619890. https://doi.org/10.3389/fphar.2021.619890
7. Rodríguez Arce, J. M., & Winkelman, M. J. (2021). Psychedelics, sociality, and human evolution. *Frontiers in Psychology*, *12*, 729425.
8. Messell, C., Summer, L., Bonde, L. O., Beck, B. D., & Stenbæk, D. S. (2022). Music programming for psilocybin-assisted therapy: Guided imagery and music-informed perspectives. *Frontiers in Psychology*, *13*, 873455.
9. Samorini, G. (2019). The oldest archeological data evidencing the relationship of homo sapiens with psychoactive plants: A worldwide overview. *Journal of Psychedelic Studies*, *3*, 63–80. https://doi.org/10.1556/2054.2019.008
10. APA Dictionary of Psychology. https://dictionary.apa.org/
11. Kaelen, M., Giribaldi, B., Raine, J., Evans, L., Timmerman, C., Rodriguez, N., Roseman, L., Feilding, A., Nutt, D., & Carhart-Harris, R. (2018). The hidden therapist: Evidence for a central role of music in psychedelic therapy. *Psychopharmacology*, *235*, 505–519. https://doi.org/10.1007/s00213-017-4820-5
12. Barrett, F. S., Preller, K. H., & Kaelen, M. (2018). Psychedelics and music: Neuroscience and therapeutic implications. *International Review of Psychiatry*, *30*, 350–362. https://doi.org/10.1080/09540261.2018.1484342
13. de Rios, M. D., & Katz, F. (1975). Some relationships between music and hallucinogenic ritual: The "Jungle Gym" in consciousness. *Ethos*, *3*, 64–76.
14. Dobkin de Rios, M. (2005). The role of music in healing with hallucinogens: Tribal and western studies. In: J. Fachner, & D. Aldridge (Eds.), *Music and altered states: Consciousness, transcendence, therapy and addictions* (pp. 97–100). Jessica Kingsley Publishers.
15. Bonny, H. L., & Pahnke, W. N. (1972). The use of music in psychedelic (LSD) psychotherapy. *Journal of Music Therapy*, *9*, 64–87. https://doi.org/10.1093/jmt/9.2.64
16. O'callaghan, C., Hubik, D. J., Dwyer, J., Williams, M., & Ross, M. (2020). Experience of music used with psychedelic therapy: A rapid review and implications. *Journal of Music Therapy*, *57*, 282–314. https://doi.org/10.1093/jmt/thaa006
17. Sessa, B. (2018). The 21st century psychedelic renaissance: Heroic steps forward on the back of an elephant. *Psychopharmacology*, *235*, 551–560. https://doi.org/10.1007/s00213-017-4713-7
18. Calleja-Conde, J., Morales-García, J. A., Echeverry-Alzate, V., Bühler, K. M., Giné, E., & López-Moreno, J. A. (2022). Classic psychedelics and alcohol use disorders: A systematic review of human and animal studies. *Addiction Biology*, *27*, e13229. https://doi.org/10.1111/adb.13229
19. Galvão-Coelho, N. L., Marx, W., Gonzalez, M., Sinclair, J., De Manincor, M., Perkins, D., & Sarris, J. (2021). Classic serotonergic psychedelics for mood and depressive symptoms: A meta-analysis of mood disorder patients and healthy participants. *Psychopharmacology*, *238*, 341–354. https://doi.org/10.1007/s00213-020-05719-1
20. Johnson, M. W. (2022). Classic psychedelics in addiction treatment: The case for psilocybin in tobacco smoking cessation. In: F. S. Barrett, & K. H. Preller (Eds.), *Disruptive psychopharmacology* (pp. 213–227). Springer International Publishing. https://doi.org/10.1007/7854_2022_327
21. Johnson, M. W., Garcia-Romeu, A., Johnson, P. S., & Griffiths, R. R. (2017). An online survey of tobacco smoking cessation associated with naturalistic psychedelic use. *Journal of Psychopharmacology*, *31*, 841–850. https://doi.org/10.1177/0269881116684335
22. Magaraggia, I., Kuiperes, Z., & Schreiber, R. (2021). Improving cognitive functioning in major depressive disorder with psychedelics: A dimensional approach. *Neurobiology of Learning and Memory*, *183*, 107467. https://doi.org/10.1016/j.nlm.2021.107467
23. Muttoni, S., Ardissino, M., & John, C. (2019). Classical psychedelics for the treatment of depression and anxiety: A systematic review. *Journal of Affective Disorders*, *258*, 11–24. https://doi.org/10.1016/j.jad.2019.07.076
24. Schimmers, N., Breeksema, J. J., Smith-Apeldoorn, S. Y., Veraart, J., Van Den Brink, W., & Schoevers, R. A. (2022). Psychedelics for the treatment of depression, anxiety, and existential distress in patients with a terminal illness: A systematic review. *Psychopharmacology*, *239*, 15–33. https://doi.org/10.1007/s00213-021-06027-y
25. Andersen, K. A. A., Carhart-Harris, R., Nutt, D. J., & Erritzoe, D. (2021). Therapeutic effects of classic serotonergic psychedelics: A systematic review of modern-era clinical studies. *Acta Psychiatrica Scandinavica*, *143*, 101–118. https://doi.org/10.1111/acps.13249
26. Therapeutic Goods Administration. (2023). Therapeutic Goods Administration (TGA). https://www.tga.gov.au/news/news/update-mdma-and-psilocybin-access-and-safeguards-1-july-2023
27. Health Canada. (2023). Government of Canada. https://www.canada.ca/en/health-canada/services/drugs-health-products/drug-products/announcements/requests-special-access-program-psychedelic-assisted-psychotherapy.html
28. Deco, G., Vidaurre, D., & Kringelbach, M. L. (2021). Revisiting the global workspace orchestrating the hierarchical organization of the human brain. *Nature Human Behaviour*, *5*, 497–511. https://doi.org/10.1038/s41562-020-01003-6
29. Margulies, D. S., Ghosh, S. S., Goulas, A., Falkiewicz, M., Huntenburg, J. M., Langs, G., Bezgin, G., Eickhoff, S. B., Castellanos, F. X., Petrides, M., Jefferies, E., & Smallwood, J. (2016). Situating the default-mode network along a principal gradient of macroscale cortical organization. *Proceedings of the National Academy of Sciences*, *113*, 12574–12579. https://doi.org/10.1073/pnas.1608282113
30. Mesulam, M. (1998). From sensation to cognition. *Brain*, *121*, 1013–1052. https://doi.org/10.1093/brain/121.6.1013
31. Friston, K., & Kiebel, S. (2009). Predictive coding under the free-energy principle. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*, 1211–1221. https://doi.org/10.1098/rstb.2008.0300
32. Geisler, W. S., & Diehl, R. L. (2003). A Bayesian approach to the evolution of perceptual and cognitive systems. *Cognitive Science*, *27*, 379–402. https://doi.org/10.1207/s15516709cog2703_3
33. Knill, D. C., & Pouget, A. (2004). The Bayesian brain: The role of uncertainty in neural coding and computation. *Trends in Neuroscience*, *27*, 712–719. https://doi.org/10.1016/j.tins.2004.10.007
34. Atasoy, S., Donnelly, I., & Pearson, J. (2016). Human brain networks function in connectome-specific harmonic waves. *Nature Communications*, *7*, 10340. https://doi.org/10.1038/ncomms10340

35. Glomb, K., Kringelbach, M. L., Deco, G., Hagmann, P., Pearson, J., & Atasoy, S. (2021). Functional harmonics reveal multi-dimensional basis functions underlying cortical organization. *Cell Reports*, *36*, 109554. https://doi.org/10.1016/j.celrep.2021.109554
36. Baars, B. J. (1997). In the theatre of consciousness. Global workspace theory, a rigorous scientific theory of consciousness. *Journal of Consciousness Studies*, *4*, 292–309.
37. Dehaene, S., Kerszberg, M., & Changeux, J.-P. (1998). A neuronal model of a global workspace in effortful cognitive tasks. *Proceedings of the National Academy of Sciences*, *95*, 14529–14534. https://doi.org/10.1073/pnas.95.24.14529
38. Friston, K. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience*, *11*, 127–138. https://doi.org/10.1038/nrn2787
39. Vuust, P., & Witek, M. A. G. (2014). Rhythmic complexity and predictive coding: A novel approach to modeling rhythm and meter perception in music. *Frontiers in Psychology*, *5*, 1111.
40. Vuust, P., Gebauer, L. K., & Witek, M. A. G. (2014). Neural underpinnings of music: The polyrhythmic brain. In: H. Merchant, & V. de Lafuente (Eds.), *Neurobiology of interval timing* (pp. 339–356). Springer. https://doi.org/10.1007/978-1-4939-1782-2_18
41. Koelsch, S. (2015). Music-evoked emotions: Principles, brain correlates, and implications for therapy. *Annals of the New York Academy of Sciences*, *1337*, 193–201. https://doi.org/10.1111/nyas.12684
42. Vuust, P., & Frith, C. D. (2008). Anticipation is the key to understanding music and the effects of music on emotion. *Behavioral and Brain Sciences*, *31*, 599–600. https://doi.org/10.1017/S0140525x08005542
43. Näätänen, R., Tervaniemi, M., Sussman, E., Paavilainen, P., & Winkler, I. (2001). 'Primitive intelligence' in the auditory cortex. *Trends in Neuroscience*, *24*, 283–288. https://doi.org/10.1016/S0166-2236(00)01790-2
44. Alamia, A., Timmermann, C., Nutt, D. J., Vanrullen, R., & Carhart-Harris, R. L. (2020). DMT alters cortical travelling waves. *eLife*, *9*, e59784. https://doi.org/10.7554/eLife.59784
45. Carhart-Harris, R. L., & Friston, K. J. (2019). REBUS and the anarchic brain: Toward a unified model of the brain action of psychedelics. *Pharmacological Reviews*, *71*, 316–344. https://doi.org/10.1124/pr.118.017160
46. Girn, M., Roseman, L., Bernhardt, B., Smallwood, J., Carhart-Harris, R., & Nathan Spreng, R. (2022). Serotonergic psychedelic drugs LSD and psilocybin reduce the hierarchical differentiation of unimodal and transmodal cortex. *Neuroimage*, *256*, 119220. https://doi.org/10.1016/j.neuroimage.2022.119220
47. Zeifman, R. J., Spriggs, M. J., Kettner, H., Lyons, T., Rosas, F., Mediano, P., Erritzoe, D., & Carhart-Harris, R. (2022). From Relaxed Beliefs Under Psychedelics (REBUS) to Revised Beliefs After Psychedelics (REBAS): Preliminary development of the RElaxed Beliefs Questionnaire (REB-Q). https://doi.org/10.31234/osf.io/w8j6t
48. Carhart-Harris, R. L., Leech, R., Hellyer, P. J., Shanahan, M., Feilding, A., Tagliazucchi, E., Chialvo, D. R., & Nutt, D. (2014). The entropic brain: A theory of conscious states informed by neuroimaging research with psychedelic drugs. *Frontiers in Human Neuroscience*, *8*, 20.
49. Kaelen, M., Lorenz, R., Barrett, F., Roseman, L., Orban, C., Santos-Ribeiro, A., Wall, M. B., Feilding, A., Nutt, D., Muthukumaraswamy, S., Carhart-Harris, R., & Leech, R. (2017). Effects of LSD on music-evoked brain activity. https://doi.org/10.1101/153031 bioRxiv
50. Carhart-Harris, R. L., Erritzoe, D., Williams, T., Stone, J. M., Reed, L. J., Colasanti, A., Tyacke, R. J., Leech, R., Malizia, A. L., Murphy, K., Hobden, P., Evans, J., Feilding, A., Wise, R. G., & Nutt, D. J. (2012). Neural correlates of the psychedelic state as determined by fMRI studies with psilocybin. *Proceedings of the National Academy of Sciences*, *109*, 2138–2143. https://doi.org/10.1073/pnas.1119598109
51. Carhart-Harris, R. L., Muthukumaraswamy, S., Roseman, L., Kaelen, M., Droog, W., Murphy, K., Tagliazucchi, E., Schenberg, E. E., Nest, T., Orban, C., Leech, R., Williams, L. T., Williams, T. M., Bolstridge, M., Sessa, B., Mcgonigle, J., Sereno, M. I., Nichols, D., Hellyer, P. J., … Nutt, D. J. (2016). Neural correlates of the LSD experience revealed by multimodal neuroimaging. *Proceedings of the National Academy of Sciences*, *113*, 4853–4858. https://doi.org/10.1073/pnas.1518377113
52. Tagliazucchi, E., Roseman, L., Kaelen, M., Orban, C., Muthukumaraswamy, S. D., Murphy, K., Laufs, H., Leech, R., Mcgonigle, J., Crossley, N., Bullmore, E., Williams, T., Bolstridge, M., Feilding, A., Nutt, D. J., & Carhart-Harris, R. (2016). Increased global functional connectivity correlates with LSD-induced ego dissolution. *Current Biology*, *26*, 1043–1050. https://doi.org/10.1016/j.cub.2016.02.010
53. Lord, L.-D., Expert, P., Atasoy, S., Roseman, L., Rapuano, K., Lambiotte, R., Nutt, D. J., Deco, G., Carhart-Harris, R. L., Kringelbach, M. L., & Cabral, J. (2018). Altered trajectories in the dynamical repertoire of functional network states under psilocybin. https://doi.org/10.1101/376491 bioRxiv
54. Lord, L.-D., Expert, P., Atasoy, S., Roseman, L., Rapuano, K., Lambiotte, R., Nutt, D. J., Deco, G., Carhart-Harris, R. L., Kringelbach, M. L., & Cabral, J. (2019). Dynamical exploration of the repertoire of brain networks at rest is modulated by psilocybin. *Neuroimage*, *199*, 127–142. https://doi.org/10.1016/j.neuroimage.2019.05.060
55. Cole, M. W., & Schneider, W. (2007). The cognitive control network: Integrated cortical regions with dissociable functions. *Neuroimage*, *37*, 343–360. https://doi.org/10.1016/j.neuroimage.2007.03.071
56. Dosenbach, N. U. F., Fair, D. A., Cohen, A. L., Schlaggar, B. L., & Petersen, S. E. (2008). A dual-networks architecture of top-down control. *Trends in Cognitive Sciences*, *12*, 99–105. https://doi.org/10.1016/j.tics.2008.01.001
57. Xin, F., & Lei, X. (2015). Competition between frontoparietal control and default networks supports social working memory and empathy. *Social Cognitive and Affective Neuroscience*, *10*, 1144–1152. https://doi.org/10.1093/scan/nsu160
58. Atasoy, S., Deco, G., Kringelbach, M. L., & Pearson, J. (2018). Harmonic brain modes: A unifying framework for linking space and time in brain dynamics. *Neuroscientist*, *24*, 277–293. https://doi.org/10.1177/1073858417728032
59. Atasoy, S., Roseman, L., Kaelen, M., Kringelbach, M. L., Deco, G., & Carhart-Harris, R. L. (2017). Connectome-harmonic decomposition of human brain activity reveals dynamical repertoire re-organization under LSD. *Scientific Reports*, *7*, 17661. https://doi.org/10.1038/s41598-017-17546-0
60. Atasoy, S., Deco, G., & Kringelbach, M. L. (2019). Playing at the edge of criticality: Expanded whole-brain repertoire of connectome-harmonics. In: N. Tomen, J. M. Herrmann, & U. Ernst (Eds.), *The functional role of critical dynamics in neural systems* (pp. 27–45). Springer International Publishing. https://doi.org/10.1007/978-3-030-20965-0_2
61. Atasoy, S., Vohryzek, J., Deco, G., Carhart-Harris, R. L., & Kringelbach, M. L. (2018). Common neural signatures of psychedelics: Frequency-specific energy changes and repertoire expansion revealed using connectome-harmonic decomposition. *Progress in Brain Research*, *242*, 97–120. https://doi.org/10.1016/bs.pbr.2018.08.009
62. Cruzat, J., Perl, Y. S., Escrichs, A., Vohryzek, J., Timmermann, C., Roseman, L., Luppi, A. I., Ibañez, A., Nutt, D., Carhart-Harris, R., Tagliazucchi, E., Deco, G., & Kringelbach, M. L. (2022). Effects of classic psychedelic drugs on turbulent signatures in brain dynamics. *Network Neuroscience*, *6*, 1104–1124. https://doi.org/10.1162/netn_a_00250
63. Deco, G., Sanz Perl, Y., Bocaccio, H., Tagliazucchi, E., & Kringelbach, M. L. (2022). The INSIDEOUT framework provides precise signatures of the balance of intrinsic and extrinsic dynamics in brain states. *Communications Biology*, *5*(1), 572. https://doi.org/10.1038/s42003-022-03505-7

64. Deco, G., Perl, Y. S., Sitt, J. D., Tagliazucchi, E., & Kringelbach, M. L. (2021). Deep learning the arrow of time in brain activity: Characterising brain–environment behavioural interactions in health and disease. 2021.07.02.450899. https://doi.org/10.1101/2021.07.02.450899 bioRxiv
65. Deco, G., & Kringelbach, M. L. (2020). Turbulent-like dynamics in the human brain. *Cell Reports*, *33*, 108471. https://doi.org/10.1016/j.celrep.2020.108471
66. Kringelbach, M. L., Perl, Y. S., Tagliazucchi, E., & Deco, G. (2023). Toward naturalistic neuroscience: Mechanisms underlying the flattening of brain hierarchy in movie-watching compared to rest and task. *Science Advances*, *9*, eade6049. https://doi.org/10.1126/sciadv.ade6049
67. Schmid, Y., Enzler, F., Gasser, P., Grouzmann, E., Preller, K. H., Vollenweider, F. X., Brenneisen, R., Müller, F., Borgwardt, S., & Liechti, M. E. (2015). Acute effects of lysergic acid diethylamide in healthy subjects. *Biological Psychiatry*, *78*, 544–553. https://doi.org/10.1016/j.biopsych.2014.11.015
68. Preller, K. H., Herdener, M., Pokorny, T., Planzer, A., Kraehenmann, R., Stämpfli, P., Liechti, M. E., Seifritz, E., & Vollenweider, F. X. (2017). The fabric of meaning and subjective effects in LSD-induced states depend on serotonin 2A receptor activation. *Current Biology*, *27*, 451–457. https://doi.org/10.1016/j.cub.2016.12.030
69. Vollenweider, F. X., Vollenweider-Scherpenhuyzen, M. F. I., Bäbler, A., Vogel, H., & Hell, D. (1998). Psilocybin induces schizophrenia-like psychosis in humans via a serotonin-2 agonist action. *Neuroreport*, *9*, 3897.
70. López-Giménez, J. F., & González-Maeso, & J. (2018). Hallucinogens and serotonin 5-HT2A receptor-mediated signaling pathways. *Current Topics in Behavioral Neurosciences*, *36*, 45–73. https://doi.org/10.1007/7854_2017_478
71. Moraes, M. M., Rabelo, P. C. R., Pinto, V. A., Pires, W., Wanner, S. P., Szawka, R. E., & Soares, D. D. (2018). Auditory stimulation by exposure to melodic music increases dopamine and serotonin activities in rat forebrain areas linked to reward and motor control. *Neuroscience Letters*, *673*, 73–78. https://doi.org/10.1016/j.neulet.2018.02.058
72. Evers, S., & Suhr, B. (2000). Changes of the neurotransmitter serotonin but not of hormones during short time music perception. *European Archives of Psychiatry and Clinical Neuroscience*, *250*, 144–147. https://doi.org/10.1007/s004060070031
73. Glennon, R. A., Titeler, M., & Mckenney, J. D. (1984). Evidence for 5-HT2 involvement in the mechanism of action of hallucinogenic agents. *Life Sciences*, *35*, 2505–2511. https://doi.org/10.1016/0024-3205(84)90436-3
74. Preller, K. H., Pokorny, T., Hock, A., Kraehenmann, R., Stämpfli, P., Seifritz, E., Scheidegger, M., & Vollenweider, F. X. (2016). Effects of serotonin 2A/1A receptor stimulation on social exclusion processing. *Proceedings of the National Academy of Sciences*, *113*, 5119–5124. https://doi.org/10.1073/pnas.1524187113
75. Vohryzek, J., Cabral, J., Lord, L.-D., Fernandes, H., Roseman, L., Nutt, D., Carhart-Harris, R., Deco, G., & Kringelbach, M. (2022). Brain dynamics predictive of response to psilocybin for treatment-resistant depression. https://doi.org/10.1101/2022.06.30.497950 bioRxiv
76. Barrett, F. S., Preller, K. H., Herdener, M., Janata, P., & Vollenweider, F. X. (2018). Serotonin 2A receptor signaling underlies LSD-induced alteration of the neural response to dynamic changes in music. *Cerebral Cortex*, *28*, 3939–3950. https://doi.org/10.1093/cercor/bhx257
77. Carhart-Harris, R., & Nutt, D. J. (2017). Serotonin and brain function: A tale of two receptors. *Journal of Psychopharmacology*, *31*, 1091–1120. https://doi.org/10.1177/0269881117725915
78. Deco, G., Cruzat, J., Cabral, J., Knudsen, G. M., Carhart-Harris, R. L., Whybrow, P. C., Logothetis, N. K., & Kringelbach, M. L. (2018). Whole-brain multimodal neuroimaging model using serotonin receptor maps explains non-linear functional effects of LSD. *Current Biology*, *28*, 3065–3074.e6. https://doi.org/10.1016/j.cub.2018.07.083
79. Kringelbach, M. L., Cruzat, J., Cabral, J., Knudsen, G. M., Carhart-Harris, R., Whybrow, P. C., Logothetis, N. K., & Deco, G. (2020). Dynamic coupling of whole-brain neuronal and neurotransmitter systems. *Proceedings of the National Academy of Sciences*, *117*, 9566–9576. https://doi.org/10.1073/pnas.1921475117
80. Johnson, M. W., Richards, W. A., & Griffiths, R. R. (2008). Human hallucinogen research: Guidelines for safety. *Journal of Psychopharmacology*, *22*, 603–620. https://doi.org/10.1177/0269881108093587
81. Noorani, T. (2021). Containment matters: Set and setting in contemporary psychedelic psychiatry. *Philosophy, Psychiatry, & Psychology*, *28*, 201–216. https://doi.org/10.1353/ppp.2021.0032
82. Golden, T. L., Magsamen, S., Sandu, C. C., Lin, S., Roebuck, G. M., Shi, K. M., & Barrett, F. S. (2022). Effects of setting on psychedelic experiences, therapies, and outcomes: A rapid scoping review of the literature. *Current Topics in Behavioral Neurosciences*, *56*, 35–70. https://doi.org/10.1007/7854_2021_298
83. Garcia-Romeu, A., & Richards, W. A. (2018). Current perspectives on psychedelic therapy: Use of serotonergic hallucinogens in clinical interventions. *International Review of Psychiatry*, *30*, 291–316. https://doi.org/10.1080/09540261.2018.1486289
84. Hartogsohn, I. (2021). Set and setting in the Santo Daime. *Frontiers in Pharmacology*, *12*, 651037.
85. Kaelen, M. (2017). The psychological and human brain effects of music in combination with psychedelic drugs. https://doi.org/10.25560/55900<./bib>
86. De Witte, M., Pinho, A. D. S., Stams, G.-J., Moonen, X., Bos, A. E. R., & Van Hooren, S. (2022). Music therapy for stress reduction: A systematic review and meta-analysis. *Health Psychology Review*, *16*, 134–159. https://doi.org/10.1080/17437199.2020.1846580
87. Mayer-Benarous, H., Benarous, X., Vonthron, F., & Cohen, D. (2021). Music therapy for children with autistic spectrum disorder and/or other neurodevelopmental disorders: A systematic review. *Frontiers in Psychiatry*, *12*, 643234.
88. Gallagher, L. M., Lagman, R., Walsh, D., Davis, M. P., & Legrand, S. B. (2006). The clinical effects of music therapy in palliative medicine. *Supportive Care in Cancer*, *14*, 859–866. https://doi.org/10.1007/s00520-005-0013-6
89. Gramaglia, C., Gambaro, E., Vecchi, C., Licandro, D., Raina, G., Pisani, C., Burgio, V., Farruggio, S., Rolla, R., Deantonio, L., Grossini, E., Krengli, M., & Zeppegno, P. (2019). Outcomes of music therapy interventions in cancer patients—A review of the literature. *Critical Reviews in Oncology/Hematology*, *138*, 241–254. https://doi.org/10.1016/j.critrevonc.2019.04.004
90. Zhao, K., Bai, Z. G., Bo, A., & Chi, I. (2016). A systematic review and meta-analysis of music therapy for the older adults with depression. *International Journal of Geriatric Psychiatry*, *31*, 1188–1198. https://doi.org/10.1002/gps.4494
91. Kamioka, H., Mutoh, Y., Tsutani, K., Yamada, M., Park, H., Okuizumi, H., Tsuruoka, K., Honda, T., Okada, S., Park, S.-J., Kityuguchi, J., Abe, T., Handa, S., & Oshio, T. (2014). Effectiveness of music therapy: A summary of systematic reviews based on randomized controlled trials of music interventions. *Patient Preference and Adherence*, *8*, 727–754. https://doi.org/10.2147/PPA.S61340
92. Lam, H. L., Li, W. T. V., Laher, I., & Wong, R. Y. (2020). Effects of music therapy on patients with dementia—A systematic review. *Geriatrics*, *5*, 62. https://doi.org/10.3390/geriatrics5040062
93. Barrett, F. S., Robbins, H., Smooke, D., Brown, J. L., & Griffiths, R. R. (2017). Qualitative and quantitative features of music reported to support peak mystical experiences during psychedelic therapy sessions. *Frontiers in Psychology*, *8*, 1238. https://doi.org/10.3389/fpsyg.2017.01238
94. Noorani, T., Garcia-Romeu, A., Swift, T. C., Griffiths, R. R., & Johnson, M. W. (2018). Psychedelic therapy for smoking cessation: Qualitative

analysis of participant accounts. *Journal of Psychopharmacology*, *32*, 756–769. https://doi.org/10.1177/0269881118780612
95. Bonde, L. O. (2002). Guided imagery and music—and beyond?: A book essay. *Nordic Journal of Music Therapy*, *11*, 167–171. https://doi.org/10.1080/08098130209478058
96. Bonny, H. L. (2002). *Music and consciousness: the evolution of guided imagery and music* (L. Summer, Ed.). Barcelona Publishers.
97. Brainard, F. S. (1996). Defining "mystical experience". *Journal of the American Academy of Religion*, *LXIV*, 359–394.
98. Mcculloch, D. E.-W., Grzywacz, M. Z., Madsen, M. K., Jensen, P. S., Ozenne, B., Armand, S., Knudsen, G. M., Fisher, P. M., & Stenbæk, D. S. (2022). Psilocybin-induced mystical-type experiences are related to persisting positive effects: A quantitative and qualitative report. *Frontiers in Pharmacology*, *13*, 841648. https://doi.org/10.3389/fphar.2022.841648
99. Carhart-Harris, R. L., Bolstridge, M., Day, C. M. J., Rucker, J., Watts, R., Erritzoe, D. E., Kaelen, M., Giribaldi, B., Bloomfield, M., Pilling, S., Rickard, J. A., Forbes, B., Feilding, A., Taylor, D., Curran, H. V., & Nutt, D. J. (2018). Psilocybin with psychological support for treatment-resistant depression: Six-month follow-up. *Psychopharmacology*, *235*, 399–408. https://doi.org/10.1007/s00213-017-4771-x
100. Roseman, L., Nutt, D. J., & Carhart-Harris, R. L. (2018). Quality of acute psychedelic experience predicts therapeutic efficacy of psilocybin for treatment-resistant depression. *Frontiers in Pharmacology*, *8*, 974.
101. Ko, K., Knight, G., Rucker, J. J., & Cleare, A. J. (2022). Psychedelics, mystical experience, and therapeutic efficacy: A systematic review. *Frontiers in Psychiatry*, *13*, 917199. https://doi.org/10.3389/fpsyt.2022.917199
102. Schmid, Y., & Liechti, M. E. (2018). Long-lasting subjective effects of LSD in normal subjects. *Psychopharmacology*, *235*, 535–545. https://doi.org/10.1007/s00213-017-4733-3
103. Pahnke, W. N., & Richards, W. A. (1966). Implications of LSD and experimental mysticism. *Journal of Religion and Health*, *5*, 175–208. https://doi.org/10.1007/BF01532646
104. Stace, W. T. (1960). Mysticism and philosophy. *Philosophy*, *37*, 179–182.
105. Hood, R. W. (1975). The construction and preliminary validation of a measure of reported mystical experience. *Journal for the Scientific Study of Religion*, *14*, 29–41. https://doi.org/10.2307/1384454
106. Francis, L. J., & Louden, S. H. (2000). The Francis-Louden Mystical Orientation Scale (MOS): A study among Roman Catholic priests. In J. M. Greer & D. O. Moberg (Eds.),*Research in the social scientific study of religion* (pp. 99–116). Brill. https://doi.org/10.1163/9789004493278_008
107. Hood, Jr. R. W., & Francis, L. J. (2013). Mystical experience: Conceptualizations, measurement, and correlates. In: *APA handbook of psychology, religion, and spirituality (Vol 1): Context, theory, and research*. American Psychological Association. https://doi.org/10.1037/14045-021
108. Kaelen, M., Barrett, F. S., Roseman, L., Lorenz, R., Family, N., Bolstridge, M., Curran, H. V., Feilding, A., Nutt, D. J., & Carhart-Harris, R. L. (2015). LSD enhances the emotional response to music. *Psychopharmacology*, *232*, 3607–3614. https://doi.org/10.1007/s00213-015-4014-y
109. Maclean, K. A., Johnson, M. W., & Griffiths, R. R. (2011). Mystical experiences occasioned by the hallucinogen psilocybin lead to increases in the personality domain of openness. *Journal of Psychopharmacology*, *25*, 1453–1461. https://doi.org/10.1177/0269881111420188
110. Griffiths, R. R., Johnson, M. W., Carducci, M. A., Umbricht, A., Richards, W. A., Richards, B. D., Cosimano, M. P., & Klinedinst, M. A. (2016). Psilocybin produces substantial and sustained decreases in depression and anxiety in patients with life-threatening cancer: A randomized double-blind trial. *Journal of Psychopharmacology*, *30*, 1181–1197. https://doi.org/10.1177/0269881116675513
111. Zentner, M., Grandjean, D., & Scherer, K. R. (2008). Emotions evoked by the sound of music: Characterization, classification, and measurement. *Emotion*, *8*, 494–521. https://doi.org/10.1037/1528-3542.8.4.494
112. Shukuroglou, M., Roseman, L., Wall, M., Nutt, D., Kaelen, M., & Carhart-Harris, R. (2023). Changes in music-evoked emotion and ventral striatal functional connectivity after psilocybin therapy for depression. *Journal of Psychopharmacology*, *37*, 70–79. https://doi.org/10.1177/02698811221125354
113. Wall, M. B., Lam, C., & Ertl, N., Kaelen, M., Roseman, L., Nutt, D. J., & Carhart-Harris, R. L. (2022). Increased low-frequency brain responses to music after psilocybin therapy for depression. https://doi.org/10.1101/2022.02.13.480302 bioRxiv
114. Carbonaro, T. M., Johnson, M. W., Hurwitz, E., & Griffiths, R. R. (2018). Double-blind comparison of the two hallucinogens psilocybin and dextromethorphan: Similarities and differences in subjective experiences. *Psychopharmacology*, *235*, 521–534. https://doi.org/10.1007/s00213-017-4769-4
115. Kometer, M., & Vollenweider, F. X. (2018). Serotonergic hallucinogen-induced visual perceptual alterations. In: A. L. Halberstadt, F. X. Vollenweider, & D. E. Nichols (Eds.), *Behavioral neurobiology of psychedelic drugs* (pp. 257–282). Springer. https://doi.org/10.1007/7854_2016_461
116. Shanon, B. (2002). Ayahuasca visualizations: A structural typology. *Journal of Consciousness Studies*, *9*, 3–30.
117. Shanon, B. (2011). Music and ayahuasca. In D. Clarke & E. Clarke (Eds.), *Music and consciousness: Philosophical, psychological, and cultural perspectives* (pp. 281-294). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199553792.003.0077
118. Schäfer, T., Fachner, J., & Smukalla, M. (2013). Changes in the representation of space and time while listening to music. *Frontiers in Psychology*, *4*, 508.
119. Kaelen, M., Roseman, L., Kahan, J., Santos-Ribeiro, A., Orban, C., Lorenz, R., Barrett, F. S., Bolstridge, M., Williams, T., Williams, L., Wall, M. B., Feilding, A., Muthukumaraswamy, S., Nutt, D. J., & Carhart-Harris, R. (2016). LSD modulates music-induced imagery via changes in parahippocampal connectivity. *European Neuropsychopharmacology*, *26*, 1099–1109. https://doi.org/10.1016/j.euroneuro.2016.03.018
120. Epstein, R. A. (2008). Parahippocampal and retrosplenial contributions to human spatial navigation. *Trends in Cognitive Sciences*, *12*, 388–396. https://doi.org/10.1016/j.tics.2008.07.004
121. Strickland, J. C., Garcia-Romeu, A., & Johnson, M. W. (2021). Set and setting: A randomized study of different musical genres in supporting psychedelic therapy. *ACS Pharmacology & Translational Science*, *4*, 472–478. https://doi.org/10.1021/acsptsci.0c00187
122. Miller, E., Miller, L., Turner, R. P., & Evans, J. R. (2017). The use of music for neuromodulation. In: J. R. Evans, & R. P. Turner (Eds.), *Rhythmic stimulation procedures in neuromodulation* (pp. 159–192). Academic Press. https://doi.org/10.1016/B978-0-12-803726-3.00006-7
123. van der Schyff, D., & Schiavio, & A. (2017). Evolutionary musicology meets embodied cognition: Biocultural coevolution and the enactive origins of human musicality. *Frontiers in Neuroscience*, *11*, 519.
124. Hagen, E. H., & Hammerstein, P. (2009). Did Neanderthals and other early humans sing? Seeking the biological roots of music in the territorial advertisements of primates, lions, hyenas, and wolves. *Musicae Scientiae*, *13*, 291–320. https://doi.org/10.1177/1029864909013002131
125. Geissmann, T. (2000). Gibbon song and human music from an evolutionary perspective. In: N. L. Wallin, B. Merker, & S. Brown (Eds.), *The origins of music* (pp. 103–123). Cambridge, MA.
126. Hublin, J.-J., Ben-Ncer, A., Bailey, S. E., Freidline, S. E., Neubauer, S., Skinner, M. M., Bergmann, I., Le Cabec, A., Benazzi, S., Harvati, K., & Gunz, P. (2017). New fossils from Jebel Irhoud, Morocco and the pan-African origin of *Homo sapiens*. *Nature*, *546*, 289.

127. Higham, T., Basell, L., Jacobi, R., Wood, R., Ramsey, C. B., & Conard, N. J. (2012). Testing models for the beginnings of the Aurignacian and the advent of figurative art and music: The radiocarbon chronology of Geißenklösterle. *Journal of Human Evolution*, *62*, 664–676. https://doi.org/10.1016/j.jhevol.2012.03.003
128. Donald, M. (2006). Art and cognitive evolution. In M. Turner (Ed.), *The artful mind: Cognitive science and the riddle of human creativity* (pp. 3–20). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195306361.003.0001
129. Tarr, B., Launay, J., & Dunbar, R. I. M. (2016). Silent disco: Dancing in synchrony leads to elevated pain thresholds and social closeness. *Evolution and Human Behavior*, *37*, 343–349. https://doi.org/10.1016/j.evolhumbehav.2016.02.004
130. Tarr, B., Launay, J., & Dunbar, R. I. M. (2014). Music and social bonding: "self-other" merging and neurohormonal mechanisms. *Frontiers in Psychology*, *5*, 1096.
131. Launay, J., Tarr, B., & Dunbar, R. I. M. (2016). Synchrony as an adaptive mechanism for large-scale human social bonding. *ethologist*, *122*, 779–789. https://doi.org/10.1111/eth.12528
132. George, D. R., Hanson, R., Wilkinson, D., & Garcia-Romeu, A. (2022). Ancient roots of today's emerging renaissance in psychedelic medicine. *Culture, Medicine and Psychiatry*, *46*, 890–903. https://doi.org/10.1007/s11013-021-09749-y
133. Prue, B. (2013). Indigenous supports for recovery from alcoholism and drug abuse: The Native American Church. *Journal of Ethnic and Cultural Diversity in Social Work*, *22*, 271–287. https://doi.org/10.1080/15313204.2013.843138
134. Miller, M. J., Albarracin-Jordan, J., Moore, C., & Capriles, J. M. (2019). Chemical evidence for the use of multiple psychotropic plants in a 1,000-year-old ritual bundle from South America. *Proceedings of the National Academy of Sciences*, *116*, 11207–11212. https://doi.org/10.1073/pnas.1902174116
135. Winkelman, M. J. (2021). Anthropology, shamanism, and hallucinogens. In: C. S. Grob, & J. Grigsby (Eds.), *Handbook of medical hallucinogens* (pp. 46–67). Guilford Publications.
136. Peoples, H. C., Duda, P., & Marlowe, F. W. (2016). Hunter—gatherers and the origins of religion. *Human Nature*, *27*, 261–282. https://doi.org/10.1007/s12110-016-9260-0
137. Labate, B. C., de Assis, G. L., & Cavnar, C. (2017). A religious battle: Musical dimensions of the Santo Daime diaspora. In: *The world ayahuasca diaspora*. Routledge.
138. Labate, B. C., Cavnar, C., & Gearin, A. K. (2016). *The world ayahuasca diaspora: Reinventions and controversies*. Taylor & Francis.
139. Graham, O. J., Saucedo, G. R., & Politi, M. (2023). Experiences of listening to Icaros during ayahuasca ceremonies at Centro Takiwasi: An interpretive phenomenological analysis. *Anthropology of Consciousness*, *34*, 35–67. https://doi.org/10.1111/anoc.12170
140. Labate, B. C., Cavnar, C., & Dawson, A. (2016). Peyote: Past, present, and future. In B. C. Labate & C. Cavnar (Eds.), *Peyote: History, tradition, politics and conservation* (pp. xii–xv). Praeger.
141. Peyote in Native American Traditions. (2011). Indigenous religious traditions. https://sites.coloradocollege.edu/indigenoustraditions/6-independent-projects/peyote-in-native-american-traditions/
142. Whybrow, P. C. (1962). Peyotl. *University College Hospital Magazine*, *XLV*, 112–116.
143. Sabina, M. (2003). *María Sabina: Selections*. University of California Press.
144. Maas, U., & Strubelt, S. (2003). Music in the Iboga initiation ceremony in Gabon: Polyrhythms supporting a pharmacotherapy. https://issuu.com/presidentwfmt/docs/mtt_4_1_-4_3__2003/252
145. Frecska, E., Bokor, P., & Winkelman, M. (2016). The therapeutic potentials of ayahuasca: Possible effects against various diseases of civilization. *Frontiers in Pharmacology*, *7*, 35. https://doi.org/10.3389/fphar.2016.00035
146. Naranjo, P. (1986). *Ayahuasca in Ecuadorian archeology*.
147. Luna, L. E. (1984). The concept of plants as teachers among four mestizo shamans of Iquitos, northeastern Peru. *Journal of Ethnopharmacology*, *11*, 135–156. https://doi.org/10.1016/0378-8741(84)90036-9
148. Dos Santos, R. G., Osório, F. D. e L., Rocha, J. M., Rossi, G. N., Bouso, J. C., Rodrigues, L. S., De Oliveira Silveira, G., Yonamine, M., & Hallak, J. E. C (2021). Ayahuasca improves self-perception of speech performance in subjects with social anxiety disorder: A pilot, proof-of-concept, randomized, placebo-controlled trial. *Journal of Clinical Psychopharmacology*, *41*, 540. https://doi.org/10.1097/JCP.0000000000001428
149. Sanches, R. F., De Lima Osório, F., Dos Santos, R. G., Macedo, L. R. H., Maia-De-Oliveira, J. P., Wichert-Ana, L., De Araujo, D. B., Riba, J., Crippa, J. A. S., & Hallak, J. E. C. (2016). Antidepressant effects of a single dose of ayahuasca in patients with recurrent depression: A SPECT study. *Journal of Clinical Psychopharmacology*, *36*, 77. https://doi.org/10.1097/JCP.0000000000000436
150. Barbosa, P. C. R., Tófoli, L. F., Bogenschutz, M. P., Hoy, R., Berro, L. F., Marinho, E. A. V., Areco, K. N., & Winkelman, M. J. (2018). Assessment of alcohol and tobacco use disorders among religious users of ayahuasca. *Frontiers in Psychiatry*, *9*, 136.
151. Hamill, J., Hallak, J., & Dursun, S. M., & Baker, G. (2019). Ayahuasca: Psychological and physiologic effects, pharmacology and potential uses in addiction and mental illness. *Current Neuropharmacology*, *17*, 108–128. https://doi.org/10.2174/1570159x16666180125095902
152. Kiraga, M. K., Mason, N. L., Uthaug, M. V., van Oorsouw, K. I. M., Toennes, S. W., Ramaekers, J. G., & Kuypers, K. P. C. (2021). Persisting effects of ayahuasca on empathy, creative thinking, decentering, personality, and well-being. *Frontiers in Pharmacology*, *12*, 721537.
153. Kuypers, K. P. C., Riba, J., De La Fuente Revenga, M., Barker, S., Theunissen, E. L., & Ramaekers, J. G. (2016). Ayahuasca enhances creative divergent thinking while decreasing conventional convergent thinking. *Psychopharmacology*, *233*, 3395–3403. https://doi.org/10.1007/s00213-016-4377-8
154. Uthaug, M. V., Van Oorsouw, K., Kuypers, K. P. C., Van Boxtel, M., Broers, N. J., Mason, N. L., Toennes, S. W., Riba, J., & Ramaekers, J. G. (2018). Sub-acute and long-term effects of ayahuasca on affect and cognitive thinking style and their association with ego dissolution. *Psychopharmacology*, *235*, 2979–2989. https://doi.org/10.1007/s00213-018-4988-3
155. Van Oorsouw, K., Toennes, S. W., & Ramaekers, J. G. (2022). Therapeutic effect of an ayahuasca analogue in clinically depressed patients: A longitudinal observational study. *Psychopharmacology*, *239*, 1839–1852. https://doi.org/10.1007/s00213-021-06046-9
156. Uthaug, M. V., Mason, N. L., Toennes, S. W., Reckweg, J. T., De Sousa Fernandes Perna, E. B., Kuypers, K. P. C., Van Oorsouw, K., Riba, J., & Ramaekers, J. G. (2021). A placebo-controlled study of the effects of ayahuasca, set and setting on mental health of participants in ayahuasca group retreats. *Psychopharmacology*, *238*, 1899–1910. https://doi.org/10.1007/s00213-021-05817-8
157. Mckinney, C. H., & Honig, T. J. (2017). Health outcomes of a series of Bonny Method of Guided Imagery and Music sessions: A systematic review. *Journal of Music Therapy*, *54*(1), 1–34. https://doi.org/10.1093/jmt/thw016
158. Saraiva, C. (2013). Pretos velhos across the Atlantic: Afro-Brazilian religions in Portugal. In L. G. Beaman & P. Beyer (Eds.), *The diaspora of Brazilian religions* (pp. 197–222). Brill. https://doi.org/10.1163/9789004246034_009
159. Rouget, G. (1985). *Music and trance: A theory of the relations between music and possession*. University of Chicago Press.
160. Price-Williams, D., & Hughes, D. J. (1994). Shamanism and altered states of consciousness. *Anthropology of Consciousness*, *5*(2), 1–15. https://doi.org/10.1525/ac.1994.5.2.1

161. Olsen, D. A. (1975). Music-induced altered states of consciousness among Warao shamans. *Journal of Latin American Lore*, *1*, 19–33.
162. Friedson, S. M. (2016). Dancing the disease: Music and trance in Tumbuka healing. In P. Gouk (Ed.), *Musical healing in cultural contexts* (pp. 67–84). Routledge.
163. Wier, D. R. (1996). *Trance: From magic to technology*. Trans Media.
164. Vitebsky, P. (1995). *The shaman*. Little, Brown.
165. Becker-Blease, K. A. (2004). Dissociative states through new age and electronic trance music. *Journal of Trauma & Dissociation*, *5*, 89–100. https://doi.org/10.1300/J229v05n02_05
166. Neher, A. (1961). Auditory driving observed with scalp electrodes in normal subjects. *Electroencephalography and Clinical Neurophysiology*, *13*, 449–451. https://doi.org/10.1016/0013-4694(61)90014-1
167. Neher, A. (1962). A physiological explanation of unusual behavior in ceremonies involving drums. *Human Biology*, *34*, 151–160.
168. Fachner, J., & Fachner, C. (2011). Time is the key: Music and altered states of consciousness. In E. Cardena & M. Winkelman, *Altering consciousness: A multidisciplinary perspective* (1st ed., pp. 355–376). Preager.
169. Fachner, J. (2007). Researching music and altered states in therapy and culture. *Music Therapy Today*, *8*, 306–323.
170. Bourguignon, E. (1973). *Religion, altered states of consciousness and social change*. Ohio State University Press.
171. Hartogsohn, I. (2022). Modalities of the psychedelic experience: Microclimates of set and setting in hallucinogen research and culture. *Transcultural Psychiatry*, *59*, 579–591. https://doi.org/10.1177/13634615221100385
172. Psychedelia. (2007). *Oxford English Dictionory*.
173. Haver Currin, G. (2021). Jon Hopkins's psychedelics journey to a new way of creating music. *N. Y. Times*.
174. Siebert, A. (2021). Forbes. https://www.forbes.com/sites/amandasiebert/2021/10/28/wavepaths-the-neuroscientist-founded-company-producing-music-for-and-as-psychedelic-therapy/
175. Ranscombe, P. (2023). Stepping inside a dreamachine. *Lancet Neurology*, *22*, 302. https://doi.org/10.1016/S1474-4422(23)00088-1
176. Dreamachine. (2022). About Dreamachine. https://dreamachine.world/about/
177. ChemSpider. CSID:4444445. http://www.chemspider.com/Chemical-Structure.4444445.html Accessed July 16, 2023
178. ChemSpider. CSID:10211258. http://www.chemspider.com/Chemical-Structure.10211258.html Accessed July 16, 2023
179. ChemSpider. CSID:390643. http://www.chemspider.com/Chemical-Structure.390643.html Accessed July 16, 2023
180. ChemSpider. CSID:5864. http://www.chemspider.com/Chemical-Structure.5864.html Accessed July 16, 2023
181. Gold, L. (2008). IMG_7365. https://www.flickr.com/photos/visionshare/2343931044/in/album-72157604154800939/

How to cite this article: Jerotic, K., Vuust, P., & Kringelbach, M. L. (2024). Psychedelia: The interplay of music and psychedelics. *Ann NY Acad Sci.*, *1531*, 12–28. https://doi.org/10.1111/nyas.15082