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Review article

Neuroaesthetics of the psychedelic state

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ABSTRACT

Neuroaesthetics is a subdiscipline within cognitive neuroscience which describes the biological mechanisms of aesthetic experiences. These experiences encompass perceptions and evaluations of natural objects, artwork, and environments that are ubiquitous in daily life. Empirical research demonstrates that aesthetic experiences arise from an interplay of sensory, affective, and semantic processes. Neuroaesthetics is becoming an established scientific pursuit just as modern psychedelic research begins to develop. Psychedelics can profoundly alter perceptions and evaluations, positioning them as a valuable tool to advance research into the neural basis of aesthetic experience. As the central goal of this article, we identify several synergies between psychedelic and cognitive neuroscience to motivate research using psychedelics to advance neuroaesthetics. To achieve this, we explore psychedelic changes to aesthetic experiences in terms of their sensory, affective, and semantic effects, suggesting their value to understand the neural mechanisms in this process. Throughout the article, we leverage existing theoretical frameworks to best describe the unique ways psychedelics influence aesthetic experience. Finally, we offer a preliminary agenda by suggesting future research avenues and their implications.

1. Advancing neuroaesthetics through psychedelic research

Beauty has inspired thinkers and artists for centuries, forming the basis of aesthetic philosophy. While the study of aesthetics is ancient, the scientific exploration of how the brain perceives beauty, known as neuroaesthetics, began much later, emerging in the 1990s with advances in neuroimaging (Chatterjee and Vartanian, 2014; Nadal et al., 2014; Ramachandran and Hirstein, 1999; Skov and Vartanian, 2009; Zeki, 1999a, 1999b). Neuroaesthetics can be understood as a search for a universal set of rules that apply objective properties of art to brain activity underlying the experience of beauty (Conway and Rehding, 2013; C. Di Dio and Vittorio, 2009). The field explores the neural basis of aesthetic experiences which induce an emotional, cognitive, and perceptual state in the viewer. Incidentally, serotonergic psychedelics, such as psilocybin containing mushrooms, lysergic acid diethylamide (LSD), mescaline containing cactus, and N,N-dimethyltryptamine (DMT), belong to a class of psychoactive substances that can drastically alter emotion, cognition, and perception (F. S. Barrett et al., 2020a; F. S. Barrett et al., 2020b; Nichols, 2016).

Key features of an aesthetic experience established by previous philosophical research share parallels with reported subjective effects under psychedelics, guiding our review (Shusterman, 1997). First, aesthetic experience has a phenomenological dimension, such as a visual experience, that is subjectively perceived and which be altered and amplified by psychedelics. Second, aesthetic experience has an evaluative dimension, meaning it is inherently valuable and enjoyable, appreciated for its own sake, which is also characteristic of psychedelic experiences. Finally, aesthetic experience and psychedelics share a semantic dimension, being meaningful experiences rather than mere sensations.

Neuroaesthetic research strives to learn the neurological underpinnings of this philosophical groundwork, identifying aesthetic experience as an emergent state generated from activity between sensory-motor, emotion-valuation, and meaning-knowledge neural systems (Chatterjee and Vartanian, 2014). We refer to this aesthetic triad model throughout the paper; see Fig. 1. Compellingly, psychedelics act on many of the same neural systems, likely modulating aesthetic experience. In doing so, psychedelic states could inform neuroaesthetics by experimentally inducing changes to brain connectivity underlying aesthetic perceptions. By outlining research and theory on neuroaesthetics and the parallels with psychedelic states, we describe the potential of these substances to further understand the neural correlates

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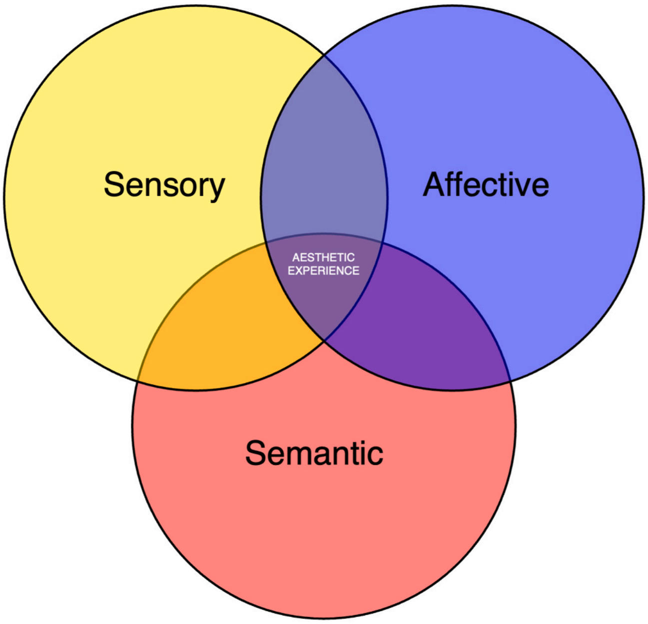

Fig. 1. The aesthetic triad model adapted from Chatterjee and Vartanian (2014) illustrates the three subsystems - sensory-motor, emotion-valuation, and meaning-knowledge - within the aesthetic triad model, each corresponding to distinct neural domains. The sensory-motor domain is responsible for processing sensory input and coordinating motor responses, contributing to the perception of form, color, and texture in aesthetic experiences. The emotion-valuation domain governs emotional reactions and value judgments, determining affective responses such as pleasure, awe, or discomfort. Finally, the meaning-knowledge domain integrates conceptual understanding and memory, enabling the interpretation of emotionally charged stimuli and the attribution of meaning. The additive quality of an aesthetic experience can be viewed as emergent through the integration of all three domains. We argue that psychedelic experience is also a state generated by the integration of each altered subsystem, enabling psychedelics to modulate aesthetic experience. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

of aesthetics and propose lines of research to develop psychedelic neuroaesthetic research.

1.1. Parallelism

A fundamental concept in neuroaesthetics, which informs our review of the ways psychedelics might amplify or modulate aesthetic sensory, cognitive, and emotional responses, is that of parallelism. Cognitive research on aesthetics emphasizes parallels between the properties of art and the organizational principles of the brain (Zeki, 1999a, 1999b). In other words, artists strive to visually represent objects in the same way our nervous system encodes and organizes the world. Parallelism in visual sensory representation refers to the independent outputs from each point in the primary visual cortex (V1) to different specialized areas of the prestriate cortex, allowing distinct aspects of visual information, like motion or color, to be processed simultaneously. Functional specialization, demonstrated by direct recordings from these areas, highlights how different visual regions handle specific features of perception (Zeki, 1990).

In line with this view, artists either consciously or unconsciously utilize techniques to create an aesthetically pleasing artwork consonant with the organizational principles of our nervous system (Ramachandran and Hirstein, 1999). Notably, the “peak shift” principle is an effect in which artists tend to exaggerate certain biologically relevant features, exemplified clearly (but not always literally) in caricature. While originally described in the context of reinforcement learning and visual generalization (Ghirlanda and Enquist, 2003), we invoke ‘peak shift’ here as an analogy, not a mechanistic account. That is, we use peak shift to describe amplification of salient stimulus features beyond normative perceptual bounds. To construct an aesthetically pleasing image, artists utilize the peak shift and other artistic principles including isolation of a single cue, perceptual grouping to delineate figure and ground, extraction of contrast, perceptual problem solving or "filling in the gaps", avoiding unique vantage points, symmetry, and use of symbolism and metaphor in art (Perrett et al., 1999). Caricature can also be created by capitalizing on dimensions other than form, like “color space” or “motion space” to best stimulate visual senses associated with their corresponding cortical modules, see Fig. 2. (Livingstone and Hubel, 1987; Ramachandran and Hirstein, 1999). In turn, sensory patterns of form, color, or motion are associated with emotional and semantic context (Fernandino et al., 2015; Guilbeault et al., 2020; Melcer and Isbister, 2016). A variety of evidence explored throughout this work suggests that psychedelic substances exert an effect on the processing mechanisms underwriting organizational principles of our nervous system described by parallelism, leading to an altered aesthetic experience.

2. Sensory dimension

Given the significant and somewhat obvious role of visual sensory information in aesthetics, it is prudent to first outline this dimension of aesthetic experience. From a neurophysiological perspective, the perceptual component of aesthetics is composed of elementary and complex visual processes (Marr, 1976). Elementary features of our visual sensorium describe basic attributes like color, line, motion, contrast, and orientation. These visual features are processed in lower-level visual areas of the cortex and are widely distributed (Grill-Spector and Malach, 2004). While, elementary visual processes are typically processed faster and in lower levels, complex visual

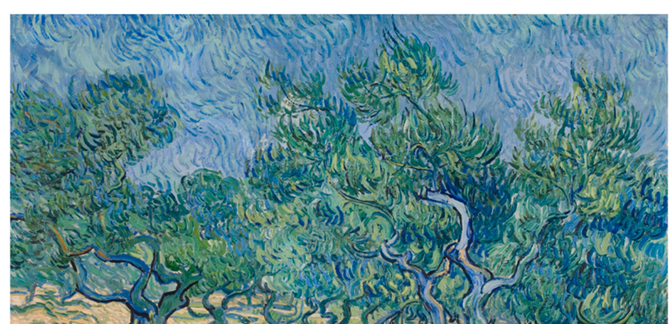

Fig. 2. In Van Gogh’s 1889 Olive Trees, we can observe a combination of aesthetic principles. The artist manipulates “peak shifts” in color, form, and motion space by exaggerating each. Isolation of a single cue is achieved through the line weight and contrast of the olive trees. Perceptual grouping is used through the direction and repetition of brush strokes. Van Gogh avoids any suspiciously unique vantage point in his composition. Finally, he manages to balance a critical level of detail with simplicity, creating an aesthetically pleasing painting. Psychedelics may similarly enhance visual elements by intensifying peak shifts, where color and form perception become exaggerated, not unlike the heightened contrasts and bold hues seen in Olive Trees. Altered sensory-motor processing under psychedelics may also amplify visual redundancy, creating a similar effect to the rhythmic brush strokes seen here. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

processes that integrate visual features are slower and take place in higher-level visual areas (Proverbio and Zani, 2002; Grill-Spector and Malach, 2004; Johnson and Olshausen, 2003). Complex visual features can represent people, animals, objects, or entire landscapes. Mapping the principles of aesthetics onto this structure, artistic laws such as peak shift, contrast, and symmetry exploit mainly elementary visual features. In contrast, isolation of a single cue, perceptual grouping, perceptual problem solving, and avoiding suspicious vantage points tend to exploit mechanisms more relevant to complex visual processing. Note that elementary visual features compose more complex visual features in a hierarchical fashion, paralleling the organization of the encoding cortical structure.

Psychedelics act on both types of visual processing and display corresponding alterations in aesthetic phenomenology (Kometer and Vollenweider, 2018). Psychedelics induce a spectrum of visual alteration ranging from pseudohallucination–which rely on and are alterations to phenomenal imagery from sensory input–to ideal hallucinations which are completely independent of the external sensorium and are virtually indistinguishable from environmental input (Horowitz, 1975). Thus, psychedelics are particularly relevant to exploring neuroaesthetic questions due to their roughly dose-dependent subjective effects, which in turn affect aesthetic experience (Hirschfeld and Schmidt, 2021; Holze et al., 2021; Klaiber et al., 2024). The following sections explore psychedelic induced effects on both types of visual processing.

2.1. Shifts in elementary visual features

At the lower end of the dose-intensity spectrum, elementary visual features are predominately altered (Hirschfeld and Schmidt, 2021). For example, perceptions of color saturation, brightness, and contrast are increased (Díaz, 2010; Dittrich, 1998; Klüver, 1966). Put differently, this evidence suggests psychedelics manipulate the peak shift principle in color space. Peak shift alterations to elementary visual percepts can also occur along the dimensions of form and motion space. For example, angles and edges exhibit rhythmic motion (Díaz, 2010), visual space is distorted through changes in the perception of depth and orientation (Fischer et al., 1970; Hill and Fischer, 1973) and symmetrical, recursive, geometric textures superimposed on the visual environment are observed at lower doses (Makin et al., 2023). An early analysis of psychedelic visual phenomena utilized mescaline to systematically characterize changes to perception. Despite some inter- and intra-individual differences, there were four recurring patterns, or "form-constants": lattices, cobwebs, tunnels, and spirals (Klüver, 1948; Klüver and Paul, 1928). This finding appears to suggest a parallel between common neural processes and subjective aesthetic experiences.

Corroborating this research, another single-blind study assessed the consistency of these motifs comparing multiple substances in a dark chamber, controlling the experimental conditions to replicate closed-eye, or ideal, visual experiences (Siegel and Jarvik, 1975). Psychedelic-induced visual effects consistently produced quicker movements of lattice and tunnel form-constants and were dominated by a warmer color palate compared to a cooler color palate produced by THC (Siegel and Jarvik, 1975). Phenomenological consistency across elementary visual features suggests a common change to aesthetic processes across individuals. Future work systematically quantifying motion or color distortions via psychedelics can enable measurement of these elementary mechanisms of aesthetic processing.

Ermentrout and Cowan (1979) provided a first mathematical theory of elementary form constants which was later expanded by describing a mathematical model of the primary visual cortex (V1) in the brain and provides a mathematical perspective from which we can begin to investigate elementary visual aesthetics (Bressloff et al., 2001, 2002). In this model, V1 is represented as a grid-like structure consisting of interconnected, symmetrical clusters called hypercolumns, each containing a set of interconnected hierarchically organized columns specialized in processing specific visual features. The authors posit that when a uniform resting state of V1 becomes unstable, various calculable patterns of neural activity emerge (Bressloff et al., 2002). These patterns, when transformed using a retino-cortical map, correspond to the typical form-constants, indirectly supporting the concept of aesthetic parallelism. In the future, this algorithmic approach could be applied alongside real-time neuroimaging techniques, allowing for precision mapping of neural dynamics during psychedelic states. By modeling the visual cortex's stability and predicting specific geometric patterns at varying doses, researchers could gain insight into how these altered perceptual phenomena unfold. Such advancements could lead to personalized models for predicting visual effects based on individual neural activity, substance, and dosage.

More contemporary mathematical approaches to elementary aesthetic components show that visual symmetry and fractal geometry are prominent in hallucinations induced by DMT. For example, the extrastriate cortex spontaneously generates aesthetically pleasing symmetrical representations in the absence of external stimuli (Makin et al., 2023). Through the lens of parallelism, the brain's natural wiring to detect reflectional symmetry may play a role in the overall appeal of aesthetics, with this feature being exaggerated by the effects of DMT. Phenomenological analysis also describes how DMT induces experiences of hyperbolic geometry, characterized by consistent negative curvature and complex, symmetrical, and recursive patterns; see Fig. 3 (Gómez-Emilsson, 2016). These studies together suggest that DMT heightens the brain's ability to generate and project visual geometrical structures, supporting the idea that psychedelics alter neuroaesthetic mechanisms responsive to symmetry and pattern. Computational approaches to visual phenomena may provide knowledge of how psychedelics can be used to shift elementary features and generate complex, abstract, aesthetically appealing geometries, even in the absence of external sensory input.

2.2. Shifts in complex visual features

At higher levels of subjective intensity, psychedelic visual alterations continue to modulate elementary features. However, they also begin to affect the processing of complex percepts, with visual effects shifting from bottom-up external stimuli to environment-independent, top-down

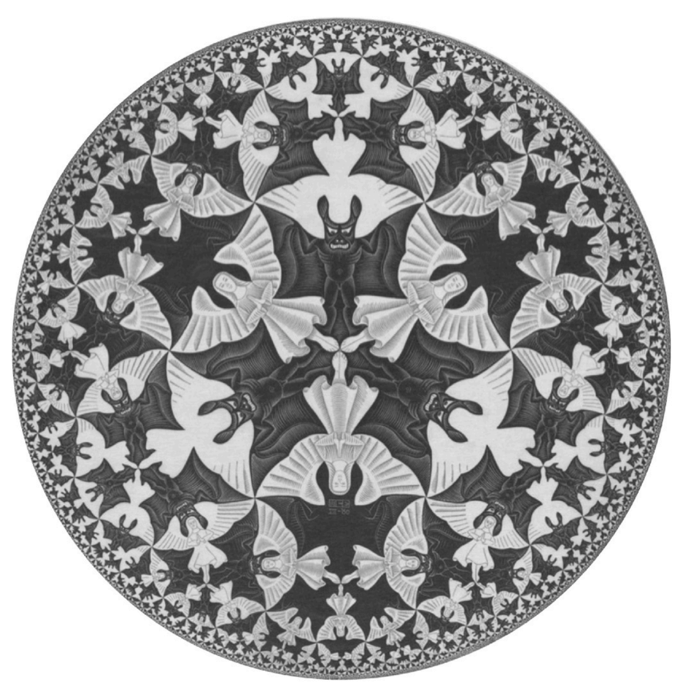

Fig. 3. Hyperbolic fractal geometry exemplified in the art of M.C. Escher's Circle Limit IV (Heaven and Hell), 1960.

imagery. As dose-dependent intensity increases, complex hallucinations can be seen even in bright light, virtually replacing the environmental sensorium (Shanon, 2002). Remarkably, clinical and phenomenological analysis utilizing DMT also reveals common and identifiable patterns in complex visual imagery (Gómez-Emilsson, 2016; Strassman, 2001; Strassman et al., 1994; Timmermann et al., 2018a,b). Intravenous DMT in the absence of external visual stimulation produces intensely vivid and complex visual experiences often described as hyperreal (Strassman et al., 1994). Hallucinations include kaleidoscopic patterns that build to hyper-detailed encounters with autonomous entities, and architectural spaces that seem alien and vast (Gómez-Emilsson, 2016; Strassman et al., 1994). Importantly, the experiences are frequently described as simultaneously familiar and novel, a common hallmark of aesthetic beauty (Song et al., 2021).

There is currently a general lack of scientific analysis of psychedelic induced complex aesthetic percepts. Contemporary phenomenological analyses have largely emerged from internet forums and blogs where users attempt to articulate and classify recurring subjective features. Although these analyses rely mainly on combined anecdotal evidence, they provide common and identifiable structures from which to categorize complex visual phenomenon. The spectrum of psychedelic intensity is usually divided into phenomenologically distinct stages or plateaus, with those placed at the highest end usually describing common complex visual features such as a “Magic Eye”, or autostereogram stage, a “Waiting Room” stage, and entire alien entities and beings such as elves or jesters (Gómez-Emilsson, 2016; Hyperspace Lexicon, 2023; Josie, 2024). At each stage, elementary visual geometry gradually accumulates in structured, fractal, moving, and highly detailed forms that seem to simultaneously embody a network of intrinsic semantic content (Díaz, 2010; Shanon, 2010, 2002; Josie, 2024).

Empirical work has begun to formalize and extend these initial reports. A large-scale qualitative analysis of DMT phenomenology identified recurring motifs such as intricate architectural spatial typologies (e.g. rooms, tunnels) frequently populated by autonomous entities with pedagogical or benevolent roles (Lawrence et al., 2022). Subsequent research expanded upon this work by documenting a chaotic initial onset of visual overload, followed by rapid resolution into synesthetic, symbolically saturated environments with shifting spatial frameworks (Michael et al., 2023). Further characterization of the immersive progression of these visuals identified consistent developmental sequences in which somatic effects preceded the emergence of complex 3D visual architecture, culminating in socially engaging ‘perceived presences’ (Sanders et al., 2025).

Across these studies, the visual content of the DMT experience exhibits a graded progression in complexity from simple geometric motifs to multidimensional multimodal constructs. Despite individual variation, high-frequency convergence on specific imagery (e.g. tunnels, tessellated architecture, archetypal figures) suggests the operation of shared structural and dynamic templates. These may reflect common attractor-like dynamics within perceptual hierarchies under entropic modulation (Carhart-Harris and Friston, 2019). Importantly, in all formal accounts, such visuals are not only strikingly vibrant but are often experienced as emotionally charged and inherently meaningful. This relationship will be examined further in the sections addressing affective and semantic domains.

2.3. Common neural mechanisms and theoretical approaches

To further emphasize shared ground between psychedelics and neuroaesthetic research, we will outline common neural mechanisms and situate them within established theoretical frameworks. This approach aims to provide clarity in understanding their overlap and broader implications.

Neural oscillations play a crucial role in integrating information across different cortical regions in time, including both higher- and lower-level visual areas (Bastos et al., 2015; Fries, 2015). In studies of aesthetic engagement, reduced alpha oscillations have been associated with the perception of emotionally or aesthetically moving stimuli (Sarasso et al., 2020; Strijbosch et al., 2022). Reduction in alpha power potentially lowers the threshold for sensory processing, allowing for uninhibited sensory input, enhancing the richness of perception. Similarly, gamma-band activity, often linked to aesthetic appreciation (Strijbosch et al., 2022), is associated with perceptual binding and local cortical processing, facilitating attention to fine sensory details.

These findings align closely with the neural effects of psychedelics. Under psychedelics, alpha power is significantly reduced, mirroring the decreased top-down control observed in aesthetic engagement (Kometer et al., 2013; Pallavicini et al., 2021). Reduction in alpha oscillations likely reflects increased neuronal firing and a lowered perceptual threshold, resulting in vivid and uninhibited bottom-up processing (Ergenoglu et al., 2004; Hanslmayr et al., 2007). Desynchronization of alpha oscillatory activity during psychedelic experiences is complemented by stable or increased gamma-band activity, particularly in response to visual stimuli (Acosta-Urquidi, 2015; Muthukumaraswamy et al., 2013). Apparent preservation of gamma activity suggests that even amidst global disruptions in brain dynamics, key mechanisms of elementary perceptual binding may remain intact.

Our sensory systems are fine-tuned to the statistical properties of natural environments, and humans generally find images with fractal-like spatial frequencies (following the power law $1/f^{\beta}$, where β approaches 2) more aesthetically pleasing (Menzel et al., 2015; Robles et al., 2021; Spehar et al., 2003, 2015). These patterns are not only prevalent in nature but also in art (Baker and Johnson, 2004; Redies, 2007). Fractal patterns are often associated with conscious experience of beauty and may engage low-level sensory areas (Calvo-Merino et al., 2008; Cupchik et al., 2009; Rasche et al., 2023; Vartanian and Goel, 2004). The slope (β) of the spatial frequency spectrum affects sensory processing efficiency, and visual discrimination is optimized when images adhere to more naturalistic β values (Párraga et al., 2000). This suggests that aesthetic preferences may, in part, arise from the brain’s evolved sensitivity to the fractal-like, non-deterministic properties of natural scenes.

In an EEG study administering DMT, researchers found significant reductions in power across all frequency bands below 30 Hz for the fractal component of visual processing, leading to a steepening of the power law (closer to $1/f^2$) (Timmermann et al., 2019). Intriguingly, there is a theoretical relationship between the spatial fractal dimension (D) and the power law exponent (β): $D = 1 + (\beta/2)$. This temporal alteration may parallel a change in how the brain processes fractal visual patterns, potentially heightening sensitivity to the complex, naturalistic features of the environment (see Fig. 4).

Taken together, these findings suggest that psychedelics, by altering neural oscillations and enhancing sensitivity to fractal dynamics, may shift perception to be more aligned with naturally occurring fractaline patterns. This aligns with the enhanced aesthetic perceptions frequently reported during psychedelic experiences, where sensory input appears richer (although, not always more beautiful). Such insights offer a potential bridge between mathematical and neurophysiological mechanisms to explain the heightened perceptual and aesthetic experiences during psychedelic states.

Additionally, neuroaesthetic principles align with Gestalt psychology, which emphasizes the human tendency to perceive whole forms rather than a collection of parts. Gestalt principles such as figure-ground organization, similarity, and closure are fundamental for understanding how we group elements in aesthetics and create cohesive visual experiences. Relatedly, psilocybin impacts the spatiotemporal dynamics of modal object completion, a process in which the brain perceives complete object boundaries and surfaces, even when sensory information is incomplete (Kometer et al., 2011). Under the influence of psilocybin, individuals demonstrate an enhanced capacity for reification—the brain’s ability to fill in gaps in visual information to form complete images. For instance, in a study using Kanizsa figures, participants under

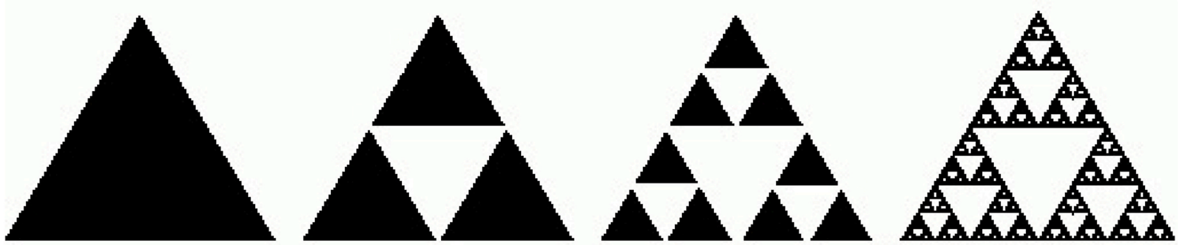

Fig. 4. A Sierpinski triangle is one example of a fractal pattern, characterized by self-similarity and complex, repeating structures. These patterns can be characterized by the power law $1/f^{\beta}$, where spatial frequencies create a visually appealing structure as β values approach 2. Such fractal power spectrum patterns are not only aesthetically pleasing but also characteristic of natural environments. In the context of fractal geometry and power laws, there is a theoretical relationship between the fractal dimension (D) and the power law exponent (β): $D = 1 + (\beta/2)$. This relationship illustrates that as the complexity of the fractal pattern increases (higher D), the power spectrum becomes steeper (higher β), aligning with our perception of natural and aesthetically pleasing patterns. The fractal dimension (D) of this pattern is approximately 1.6.

psilocybin exhibited increased reaction times and more robust perceptual completion compared to non-Kanizsa figures (see Fig. 5 (Kometer et al., 2011);). These findings suggest that psilocybin may enhance top-down mechanisms for generating complex visual features, making the generative aspects of perception more salient (Stoliker et al., 2024b).

These findings may initially appear at odds with evidence of increased bottom-up informational flow. Although psychedelics likely reduce the precision weighting of high-level priors, this does not equate to the elimination of top-down processing. Perceptual hierarchies may remain intact, with mid-level generative models actively compensating for and attenuating increased bottom-up signal flow (Stoliker et al., 2024b). Enhanced perception of illusory contours (e.g., Kanizsa figures) and hallucinations more generally may thus result from over-engagement of surviving predictive templates in response to heightened sensory uncertainty. This dynamic is consistent with the altered beliefs under psychedelics (ALBUS) model (Safron et al., 2025), which proposes that serotonergic signaling under psychedelics modulates hierarchical inference in a dose- and context-dependent manner. Rather than a contradiction, these findings reflect a nuanced dynamic between disinhibited input and unstable yet actively compensating predictive processes.

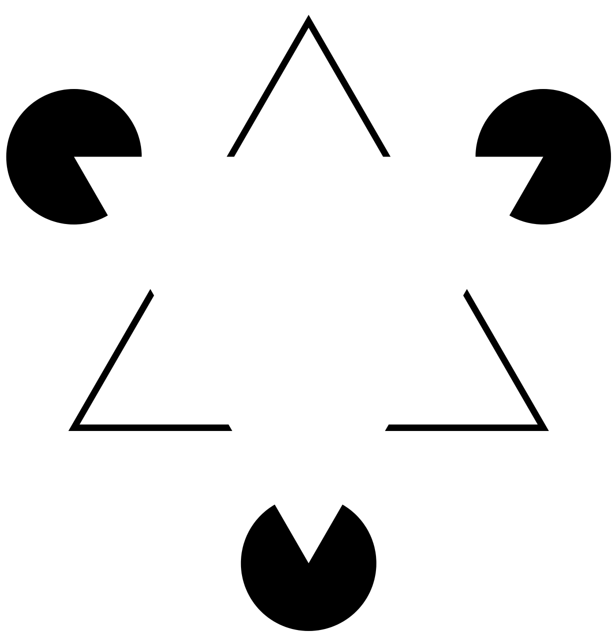

Fig. 5. A Kanizsa figure is a type of optical illusion where the brain perceives contours and shapes that aren't present in the image. A common example is this "Kanizsa triangle", which consists of three "pac-man" shaped figures arranged in a triangle formation. The way they are arranged gives the illusion of a bright triangle in the center, even though no lines define this triangle.

A heightened ability to perceive and complete visual forms under psychedelics can also be linked to divergent thinking, a cognitive process associated with creativity. Psilocybin's influence on reification and visual imagery suggests that individuals may experience more vivid and complex visualisations, potentially enhancing artistic flexibility and overall creativity, a phenomena observed under the influence of ayahuasca (Kuypers et al., 2016). By comparing performance in complex visualisation tasks under psychedelics in controlled trials, researchers could investigate potential increases in creative visual aesthetic output. This line of inquiry could shed light on how psychedelics influence both the perceptual processes involved in art appreciation and the creative processes in artistic production. Understanding these effects could pave the way for new approaches to enhancing visual creativity and artistic expression through psychedelics.

3. Affective dimension

Complementing the sensory aspect of the aesthetic experience is the affective domain. Certain cortical regions are directly involved in aesthetic emotion-valuation, including (but not limited to) the anterior insula (AI), medial prefrontal cortex (mPFC), and anterior cingulate cortex (ACC). These areas are key nodes in important neural networks such as the default mode network (DMN) and salience network (SN) (Barrett and Satpute, 2013; Wotruba et al., 2014). Under psychedelics, these regions undergo significant alterations; increased blood perfusion was found in each area under ayahuasca in a double-blind study (Riba et al., 2006; Stoliker et al., 2024a).

In a comprehensive voxel-based meta-analysis of neuroaesthetic processing, the right AI was consistently activated across sensory modalities during aesthetic appraisal (Brown et al., 2011). The right AI plays a key role in both affective experience and attentional processes, anchoring distinct networks that support emotional appraisal and attentional control (Touroutoglou et al., 2012). This dual function allows for the integration of interoceptive aspects of aesthetic experiences, and its altered connectivity under psychedelics could change how aesthetic stimuli are internally represented, attended to, and emotionally valued. Additionally, the bilateral insular cortex, encompassing the AI, has been implicated in self-awareness and related emotional processing (Craig, 2011; Phan et al., 2002). Under psychedelics, increased functional connectivity density in regions such as the insular cortex has been associated with reports of ego dissolution, suggesting a critical role for this region in mediating both the subjective and emotional dimensions of the psychedelic experience (Tagliazucchi et al., 2016). These findings highlight the insular cortex as a hub where self-referential and emotional processes converge, with its modulation potentially underpinning profound shifts in aesthetic evaluation during psychedelic states.

The mPFC also plays a central role in aesthetic evaluation, influencing how individuals perceive and judge the beauty of visual stimuli, including art (Cattaneo et al., 2020; Nakamura and Kawabata, 2015). Its activity is closely linked to affective responses and the integration of moral and aesthetic values (Ferrari et al., 2017; Luo et al., 2019). Interestingly, mPFC activity consistently decreases under psychedelics (Carhart-Harris et al., 2012; Olson et al., 2023; Palhano-Fontes et al., 2015), which may alter how aesthetic stimuli are experienced and evaluated, leading to novel emotional interpretations. Thus, the relationship between psychedelics and mPFC function may also provide insight into the neural mechanisms behind aesthetic evaluation.

Normally, the mPFC may act as a regulatory hub, filtering sensory and emotional input through pre-existing schemas, constraining the perception of beauty and emotional valence. When mPFC activity decreases under psychedelics, influence of canalized cognitive frameworks may be reduced by allowing for more spontaneous and novel emotional interpretations of aesthetic stimuli. Indeed, psychedelic states have been strongly associated with increased trait openness (Erritzoe et al., 2019; MacLean et al., 2011) which may produce greater openness to aesthetic stimuli. Put differenty, rather than enhancing aesthetic beauty per se, reduced mPFC activity may enable a state of experiential permeability and novelty reception more characteristic of exploratory aesthetic engagement.

The ACC, which is intimately involved in emotional processing, reward assessment, and social context integration (Allman et al., 2001; Bush et al., 2000; Martín-Loeches et al., 2014; Vartanian and Goel, 2004), may also be modulated by psychedelics. Preclinical evidence suggests psychedelics directly affect the ACC (Gresch et al., 2007). In humans, rostral ACC thickness predicted more emotionally intense psychedelic experiences in a double-blind psilocybin study (Lewis et al., 2020). Furthermore, psychedelics have been shown to desynchronise ACC functional connectivity with other brain regions, possibly contributing to emotional experiences (Carhart-Harris et al., 2012). Interestingly, ACC connectivity appears to increase post-acutely (Pasquini et al., 2020; Sampedro et al., 2017), suggesting a period of neural reorganization and heightened plasticity. Acute attenuation in the ACC may impair emotional valuation and the capacity to manage emotional distractions, both of which are critical for nuanced aesthetic evaluation. While this disruption may lead to less predictable, more capricious responses, post-acute enhanced connectivity could support long-term improvements in emotional and cognitive processing, contributing to more sophisticated aesthetic emotional regulation. In fact, aesthetic appreciation increased post-acutely in a small sample of ayahuasca users (Aday et al., 2024).

Subcortical regions also play a role in both psychedelic and aesthetic experiences (Ishizu and Zeki, 2013; Stoliker et al., 2022). Among these, the amygdala (AMG) is especially notable for its role in identifying emotional salience (Liberzon et al., 2002). The AMG directs top-down emotional attention in aesthetic judgments, particularly involving visual arrangements and color harmonies (D. C. Di Dio et al., 2007; Jacobs et al., 2012; Jacobs and Cornelissen, 2017). Notably, psilocybin was found to decrease AMG activity, correlating with increased positive emotions (Kraehenmann et al., 2015). Recent research strengthens this finding by showing that psilocybin reduces top-down effective connectivity from key resting-state networks (DMN and SN) to the AMG (Stoliker et al., 2024a). Reconfiguration of network dynamics was statistically linked to altered emotions under psilocybin. AMG signal attenuation may release normal constraints on emotional processing, allowing for more fluid and expansive emotional experiences. In fact, modulation of AMG activity was observed to persist for up to one month following a single high dose of psilocybin, as shown by sustained reductions in emotional reactivity and altered functional connectivity (Barrett et al., 2020a,b). In the context of aesthetic appreciation, this could alter emotional engagement with artistic stimuli.

In our terms, a reduction of AMG responses could produce an affective exaggeration analogous to a peak shift. Attenuation reduces emotional salience filtering, potentially allowing subthreshold stimuli to acquire affective weight. In other words, amygdala attenuation displaces emotional salience from canonical targets (e.g., threats) to novel or abstract representations, producing hyper-affective responses to non-prototypical stimuli. Additionally, functional decoupling from the mPFC may allow de-repression of associative affect, analagous to visual or conceptual entropy.

Other subcortical regions likely also contribute to the affective modulation of aesthetic experience under psychedelics. Instead, and given the involvement of numerous additional brain regions in affective processing, a conceptual approach may prove valuable. Schubert et al. (2016) proposed the Affect-Space Framework, an information-theoretic model that can organise the affective structure of both aesthetic and psychedelic experiences. The framework consists of three classifications: locus (internal or external representation), affect-valence (positive or negative), and hedonic tone (deep or shallow), which are represented across three dimensions (see Fig. 6). The authors argue that deep, internal-locus affect-valence is essential for aesthetic experience. From this perspective, psychedelics, under the right conditions, can reliably induce states of deep hedonic tone (Kaelen et al., 2015; Strassman et al., 1994), blurred representation locus (Smigielski et al., 2020), and intensified affect-valence (Pouyan et al., 2023; Roseman et al., 2019). In this sense, psychedelic states might again be conceptualized as peak-shifting the affect space, producing aesthetic states marked by more extreme valence, deeper hedonic tone, and expanded locus compared to typical aesthetic experiences.

4. Semantic dimension

Aesthetic experiences are inherently meaningful experiences. The

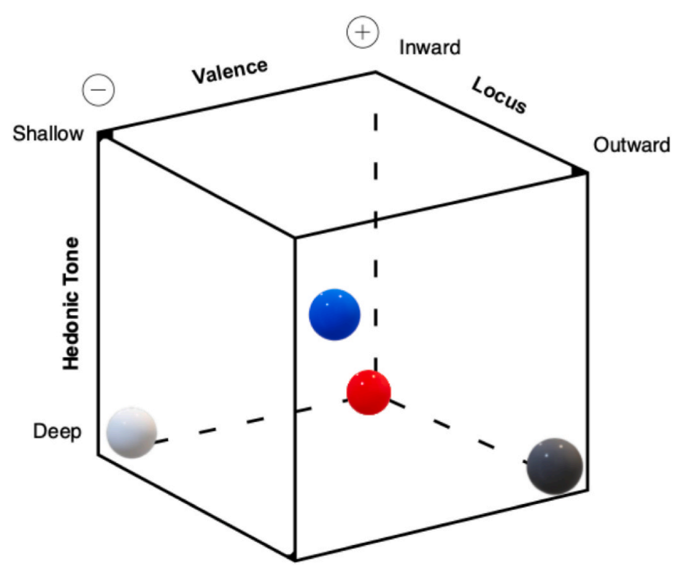

Fig. 6. A toy schematic of the Affect-Space framework (Schubert et al., 2016). The affect-space is represented here as a three-dimensional conceptual space with spheres representing individual conscious states. The blue sphere represents a normal conscious state hovering somewhere between each dimension, maintaining homeostasis and thus, avoiding the extremes. This experience would be relatively un-meaningful. The white sphere represents a state of deep hedonic tone, negative valence, and inward locus of representation. This experience might be extremely frustrating, disgusting, or irritating. The red sphere represents a state of deep hedonic tone, positive valence, and an inward locus of representation. This experience would produce awe, or transcendence. Finally, the black sphere represents a state of deep hedonic tone, positive valence, and an outward locus of representation. This experience could be described as beautiful, sublime, or amazing. Note this representation excludes the distinction between emotion- and affect-valence which the authors describe in more detail. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

semantic dimension of the aesthetic experience appears to involve top-down control that biases the activity in other neural systems (Chatterjee and Vartanian, 2014). This is exemplified clearly in framing effects. For instance, knowing that an image is a museum piece or understanding the title of an artwork can amplify our appreciation and emotional response (Szubielska et al., 2021). In this way, aesthetic pleasure is significantly influenced by the perceiver's processing dynamics, which are shaped by cultural and individual experiences (Jacobsen, 2009; Jacobsen and Beudt, 2017). Shared aesthetic tastes are more consistent across individuals for natural domains like faces and landscapes compared to artifacts of human culture such as architecture and artwork, suggesting that cultural and individual differences influence a certain degree of nested semantic content and thus aesthetic preferences (Vessel et al., 2018). This also supports the notion that aesthetic pleasure emerges from an optimization of familiarity and novelty (Berlyne, 1950, 1958; Song et al., 2021).

The semantic dimension of aesthetics integrates or contextualizes emotional and sensory domains, likely facilitated by a supramodal hub that blends sensory and affective information to generate conceptual models (Bara et al., 2022). Aesthetic experiences can be partially understood as a type of retrieval from stored representations, where meaning is constructed from the integration of sensory input with emotional and cultural contexts. This process of integration is central to aesthetic appreciation and may likewise be modulated by changes in network activity.

Temporal dynamics of the DMN have been studied in the context of aesthetics since self-referential processing is an essential feature of the semantic domain of aesthetic experience (Lee et al., 2020; Vessel et al., 2013). The network is characteristically active during states of "wakeful rest" when the mind is wandering and daydreaming, and it is believed to also be involved in rumination, introspection, and autobiographical memory (Buckner et al., 2008; Raichle and Snyder, 2007). The DMN not only activates during rest but also dynamically engages during aesthetic appreciation (Vessel et al., 2013, 2019). The DMN responds more to pleasing images and returns to baseline as viewers disengage (Belfi et al., 2019). Specifically, the DMN was shown to re-engage in the delayed phase of aesthetic appreciation, which occurs after the initial reaction to a stimulus and when participants begin to reflect more deeply on its beauty (Cela-Conde et al., 2013).

The DMN also enjoys substantial popularity within psychedelic literature. It has been theorized that psychedelic induced inhibitory activity within the DMN may be responsible for the perceived "dissolution of the self" (Carhart-Harris and Friston, 2010; R. L. Carhart-Harris et al., 2012; Timmermann et al., 2019; Timmermann et al., 2018a,b). Moreover, psychedelics might disrupt the brain's spaciotemporal organization by inducing a state of increased signaling complexity, which allows for the emergence of spontaneous patterns of neural activity and may underlie the subjective effects of psychedelics more broadly (Carhart-Harris and Friston, 2019; R. L. Carhart-Harris et al., 2014).

Both psychedelic induced and common aesthetic experiences modulate this neural network, implying shared involvement in deeper semantic systems. Although both processes converge on the same neural system, their effects may seem paradoxical at first glance. While prior work has implicated DMN activity in deeper aesthetic contemplation and meaning construction, acute reductions in DMN coherence under psychedelics do not necessarily impair aesthetic engagement. Rather than fragmenting aesthetic engagement, DMN suppression may transiently liberate experience from entrenched high-level narrative structures, enabling novel aesthetic insight that emerges across time. Recent work demonstrating that psychedelics align brain activity more closely with contextual stimuli (Stoliker et al., 2025) supports the view that DMN suppression may facilitate a more immersive and emotionally resonant mode of aesthetic engagement that differs qualitatively from typical evaluative reflection.

Over a dose-response course, DMN reintegration may facilitate reflective optimization and the attribution of meaning to sensory and affective signals. It is interesting to note that experiences of insight and abstracted beauty tend to occur during the later phase of the psychedelic experience when the DMN is reengaging, and top-down cognitive models are optimized (Carhart-Harris and Friston, 2019). We offer this dynamic temporal account to reconcile apparent contradictions between psychedelic-induced DMN suppression and the role of the DMN in aesthetic meaning-making. However, future research might use psychedelics as tools to directly test the relationship between the DMN and aesthetic appreciation.

Building on this idea, a wealth of evidence suggests psychedelics have meaning-enhancing properties (Hartogsohn, 2018). For example, psilocybin was found to alter self-stimuli encoding, reducing the distinction between self and other-related neural responses, which describes the subjective experience of unity and altered meanings associated with perceptions (Smigielski et al., 2020). For example, LSD significantly altered participants' perception of meaning, making previously meaningless stimuli seem meaningful (Preller et al., 2017). Further, psilocybin is often reported as having substantial personal meaning and spiritual significance (Griffiths et al., 2006), suggesting changes at deeper, subconsciously programmed levels of semantic hierarchical organization. Although conjectural, psychedelics may influence an individual's schemata through modulation of organizational spatiotemporal dynamics and networks such as the DMN and alpha rhythm (Carhart-Harris, 2018; Carhart-Harris et al., 2014). This effect would destabilize familiar notions of beauty, transforming their nested semantic context along with associated emotional interpretations in relation to the self-model—a topic worthy of future investigation.

Applying a generalized semantic framework (Bara et al., 2022), psychedelics could be seen as agents that profoundly peak shift the semantic dimension of aesthetic experiences. There is some evidence that a supramodal (integrative) hub is influenced under psychedelics. fMRI studies with psilocybin, reveal decreased activity and functional connectivity in key connector hubs such as the thalamus, claustrum and the anterior and posterior cingulate cortex (ACC/PCC)(Carhart-Harris et al., 2012; Doss et al., 2022). The claustrum, a region with dense 5-HT2A receptor expression, functions as an integrative hub that entrains cortical networks, and whose connectivity may be significantly altered under the influence of psychedelics (Crick and Koch, 2005; Doss et al., 2022). Psilocybin may also decrease the positive coupling between the mPFC and the PCC, supporting the hypothesis that psychedelics cause a state of unconstrained cognition by disrupting connectivity in key brain hubs (Carhart-Harris et al., 2013; Muthukumaraswamy et al., 2013). Finally, the anterior temporal lobe (ATL) integrates semantic information and facilitates multimodal sensory integration (Binder et al., 2009; Binder and Desai, 2011), however, to our knowledge there are no studies directly assessing psychedelic activity in this region. Future research could focus on exploring how psychedelics affect regional activity, effective connectivity, and subjective reports of semantic content during aesthetic experiences.

Psychedelic's effects on the semantic domain also involve profound changes in language production, comprehension, and cognitive processes. LSD increased the entropy and reduced the semantic coherence of language, mirroring some aspects of psychosis, characterized by more verbosity and a reduced lexicon, resulting in disorganized speech (Sanz et al., 2021). LSD also enhanced the spread of semantic activation, suggesting an increase in associative thinking and creativity (Family et al., 2016). Correspondingly, the subjective effects of psychedelics often produce detailed, metaphorical narratives that reveal changes in language organization and semantic content (Tagliazucchi, 2022). It has been suggested that LSD increases "primary process" thinking, which contributes to the loosening of cognitive associations and the production of novel, often non-linear, ideas (Kraehenmann et al., 2017). These alterations are linked to therapeutic effects, as the ability to recall and articulate previously inaccessible memories can be crucial in therapy (Carhart-Harris et al., 2016). Understanding how psychedelics alter semantics can help predict therapeutic outcomes and tailor treatments

(Yaden and Griffiths, 2021). Taken together, psychedelics may be used to profoundly impact semantic networks and concept production by increasing neural entropy and "peak-shifting" associative thinking. Investigating psychedelic effects on the semantic dimension is critical for understanding aesthetic experiences, their therapeutic mechanisms, and broader implications for cognitive neuroscience.

5. Summary and future directions

Throughout this paper, we explored the intersection of neuroaesthetics and psychedelic research, illustrating how psychedelic substances can serve as powerful tools for experimentally modulating sensory, affective, and semantic domains of the aesthetic triad, providing insights into the neural mechanisms that underlie these experiences. By synthesizing findings across dimensions, we propose a framework for understanding how psychedelics alter aesthetic processing and why these effects are significant for both neuroaesthetic theory and broader cognitive neuroscience.

The sensory-motor dimension of aesthetic experience is particularly sensitive to alterations under psychedelics, as evidenced by the intensification of elementary visual features like color saturation, contrast, and motion. These effects reflect changes in primary visual cortex dynamics, such as the emergence of form-constants and fractal patterns, which align with the brain's natural preference for the statistical regularities of natural environments. Psychedelic induced modulation of visual phenomena offers a unique way to investigate how the brain processes and organizes aesthetic sensory information, emphasizing the role of parallelism between neural activity and common artistic principles like symmetry.

The affective domain, mediated by regions like the AI, mPFC, ACC, and AMG, describes the emotional quality of both aesthetic and psychedelic experiences. Psychedelics modulate these regions by reducing top-down control and enhancing bottom-up emotional engagement, leading to shifts in how stimuli are valued and interpreted. The reconfiguration of affective networks supports more fluid and expansive emotional experiences, paralleling the spontaneous emotional resonance often associated with art. Observed increases in functional connectivity post-acutely suggest that psychedelics facilitate long-term emotional integration, offering new avenues for exploring the relationship between emotional regulation and aesthetic engagement.

Neural systems involved in the semantic domain integrate sensory and affective domains into coherent and meaningful experiences, often mediated by higher-order networks like the DMN. Psychedelics disrupt DMN activity, generating a state of unconstrained cognition that allows for novel associations and insights. These changes play on the role of context in aesthetic appreciation, due to the influence of prior knowledge and cultural framing on the perception of beauty. However, the impact of these semantic shifts is not uniform across individuals; trait-level differences in cognitive style, tolerance for ambiguity, and cultural background can shape whether altered semantic salience is experienced as enriching or disorienting (Studerus et al., 2012). Still, psychedelic states, characterized by enhanced meaning-making and abstract conceptualization, provide a fertile ground for exploring how diverse semantic systems generate and modulate aesthetic experiences.

A variety of common mechanisms were introduced, ranging from computational or abstract theoretical frameworks to specific neural substrates. In sum, psychedelic induced excitation may disrupt hierarchical predictive processing by desynchronizing spaciotemporal oscillations across distinct brain regions and networks. These affected areas, networks, and oscillations are normally engaged during the processing of aesthetic perceptions and judgments. Enhanced flow and salience of bottom-up information, coupled with continuous error-correction from top-down models, may give rise to characteristic hallucinations and their associated emotional and semantic attributes. Put differently, psychedelic induced visual phenomena merge increased novelty in the environment with an endogenous drive for familiarity, thereby intensifying key elements that stimulate aesthetic engagement.

Our analysis has shown that through action on the same neural systems, psychedelics can function as powerful amplifiers for aesthetic experience and thus serve as effective tools for perturbing the neural systems generating this emergent state. This does not imply that psychedelic experiences are inherently or uniformly beautiful; rather, they augment the generative processes underlying aesthetic experience, which may yield either heightened beauty or heightened aversion depending on context, set, and stimulus.

Returning to the central concept of parallelism, we propose that psychedelics induce an isomorphic peak shift effect across the domains of the aesthetic triad. In each domain, psychedelics appear to exaggerate salient features or expand feature space, resulting in intensified sensory, emotional, and conceptual engagement. The effect does not necessarily stem from learned reinforcement mechanisms as in classical peak shift, but rather from disrupted predictive hierarchies that amplify bottom-up inputs. Thus, the "peak shift" here functions as a metaphor for the emergence of amplified or caricatured pattern-level similarities within each domain, not implying identical neurocomputational processes. Abstractly, we suggest that psychedelics have potential to create an endogenous state akin to the experience of viewing a magnificent work of art, where environmental elements are optimally encoded to extract perceptual, emotional, and semantic information. However, instead of an actual piece of art, a heightened appreciation may be applied to otherwise ordinary objects within the user's environment such as plants, fabrics, or furniture. This effect is expressed in the ubiquitous beauty many psychedelic users report even for seemingly mundane objects. Aldous Huxley's vivid account of viewing flowers during a mescaline experience articulates the effect well: "I continued to look at the flowers, and in their living light I seemed to detect the qualitative equivalent of breathing- but of a breathing without returns to a starting point, with no recurrent ebbs but only a repeated flow from beauty to heightened beauty, from deeper to ever deeper meaning." (Aldous Huxley, 1954).

Building on this idea, in utilizing principles such as parallelism and the peak shift, art is able to serve as a refuge for unsatisfied ideals created by the brain's abstractive processes (Zeki, 2001). Plato's theory of forms suggests that the true essence of beauty exists in a metaphysical realm of perfect, immutable forms, which the physical world merely imitates (Mason, 2010). In psychological terms, these may be conceptualized as schema, prototype, or archetype (in the Jungian sense). In neurological terms, the Platonic Ideal may be thought of as the brain's stored abstracted (statistical) representation of the essential features of all the versions of an object type from which it has previously selected common features (Zeki, 1999b). The transmutation of percepts induced by psychedelics may allow individuals to perceive and appreciate these abstracted ideal forms more directly, especially in the context of stimulus-free or closed-eye environments where external influence is minimized, and top-down predictive models dominate the visual space (see also (McGovern et al., 2024). Psychedelics would thus deepen the aesthetic experience by connecting users more directly with the transcendent qualities of beauty as Plato envisioned. Although conjectural, this connection might help explain why psychedelics often lead to profound aesthetic revelations and a sense of encountering ultimate realities. This speculation is supported by the consistent recurrence of form constants, entity encounters, and associated emotions reported across individuals and cultures under psychedelics; patterns which may reflect the activation of latent cognitive templates. Recurring perceptual-emotional structures suggest that, even amid heightened neural entropy, certain abstract forms exhibit stability and salience. Empirically testing this philosophical claim may prove valuable in this regard.

In addition to theoretical or philosophical considerations, comprehensive empirical research using psychedelic substances can provide tangible insight into aesthetic experiences (see Table 1.). Utilizing and combining advanced methodologies such as neuroimaging, psychophysiological assessment, and systematic qualitative analysis will enable

Table 1
Potential research avenues in psychedelic neuroaesthetics.

Common Features	Potential Research Avenues
Peak Shift (exaggeration)	Investigate how exaggeration of features under psychedelics compares to artistic techniques.
Visual Motifs (form constants)	Study consistency of form constants across different psychedelic substances and dosages.
Symmetry	Explore neural correlates of symmetry perception under psychedelics.
Serotonin	Role of 5-HT2A agonism in aesthetic experience.
Oscillations (alpha, gamma)	Analyze changes in alpha and gamma oscillations during psychedelic experiences.
Fractal Dynamics (Spatial and Temporal)	Examine how psychedelics influence perception of fractal patterns and their temporal dynamics.
Regions (rAI, ACC, mOFC, mPFC, PCC, ATL, Claustrum, AMG, Thalamus)	Investigate activity and connectivity changes in these brain regions during psychedelic-induced aesthetic experiences.
Networks (DMN, SN)	Study the role of the DMN and SN in the dissolution of self and enhanced aesthetic experiences under psychedelics.
Complex System (emergent states and criticality)	Research the shift towards criticality and dynamic spaciotemporal trajectories in brain networks during psychedelic experiences.
Gestalt Psychology	Study how principles of Gestalt psychology are altered under psychedelics.
Generative Perception	Role of psychedelics for enhancing visual creativity.
Affect-Space	Role of psychedelics in modulating emotional reactions to aesthetic stimuli.
Semantics	Study how the aesthetic meaning of visual scenes is changed under psychedelics.
Natural Beauty Perception	Impact of psychedelics on the perception of natural beauty.
Natural Ugliness Perception	Impact of psychedelics on the perception of natural disgust or fear.
Dissolution of Self	The aesthetic experience in relation to the self under psychedelics.
Platonic Ideal or Archetype	Correlates of the Platonic Ideal or Archetype with and without psychedelics.
Artistic Style or Expression	Correlates of artistic style or expression modulated by psychedelics.

a more thorough examination of the neural underpinnings of psychedelic-induced aesthetic states. Collaboration across neuroscience, psychology, philosophy, and fine art may enrich the theoretical foundations and practical applications of psychedelic neuroaesthetics. This could involve studying the subjective experiences of artists and art viewers under the influence of psychedelics to gain insights into creative processes and aesthetic appreciation. By altering the meaning and emotional coloring behind sensations, psychedelics might enable artists and observers alike to break conventional aesthetic boundaries and explore more profound, transformative experiences through art. There may be serious implications for art therapy in this domain.

The humanities have approached aesthetics from various perspectives for centuries, demonstrating that a comprehensive understanding must integrate research from philosophy, art theory, psychology, and evolutionary aesthetics (Zaidel, 2010). While neuroaesthetics aims to study the neural underpinnings of aesthetic experiences, it addresses only one dimension of the field. Future collaborative research in these disciplines may also find success in incorporating psychedelics into their studies.

Aesthetic experience is a defining characteristic of art (Beardsley, 1983); however, a further limitation of this review lies in its specific focus on visual art. Given that the visual system and its associated emotion and meaning centers are well-studied in cognitive neuroscience, we chose to primarily use visual artwork as our reference point for aesthetics throughout this article. Although music and audition are also significant in neuroaesthetics, including them would have complicated our scope. While focusing on visual art is effective for our current purposes, these areas merit further exploration.

In closing, the diversified relationship between sensory, emotional, and semantic processing under the influence of psychedelics situates the study of altered conscious experience firmly within the field of neuroaesthetics. By investigating the aesthetic aspects of the psychedelic experience, researchers may continue to uncover novel insights into the neural mechanisms underlying aesthetic perception and evaluation. Research in this domain may contribute to a deeper understanding of the content and dynamic structure of human consciousness as it engages with artistic expression, concepts of beauty, and imaginative faculties. As neuroaesthetics and psychedelic research continue to evolve, collaboration between these fields offers a promising avenue for future exploration and discovery. We hope that future researchers consider directly advancing in this area of research.

CRediT authorship contribution statement

Jake Hooper: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Conceptualization. **Devon Stoliker:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Kyle Wolfe:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Kent Hutchison:** Writing – review & editing, Writing – original draft, Supervision, Resources, Funding acquisition.

Declaration of generative AI and AI-assisted technologies in the Writing process

During the preparation of this work the author(s) used OpenAI ChatGPT in order to selectively improve language and readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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No data was used for the research described in the article.

References

Acosta-Urquidi, J., 2015. QEEG studies of the acute effects of the visionary tryptamine DMT. The Journal of Natural and Social Philosophy 11 (Issue 2). www.cosmosandhistory.org115.

Aday, J.S., Bloesch, E.K., Davis, A.K., Domoff, S.E., Scherr, K., Woolley, J.D., Davoli, C.C., 2024. Increases in aesthetic experience following ayahuasca use: a prospective, naturalistic study. J. Humanist. Psychol. https://doi.org/10.1177/00221678241230609.

Aldous Huxley, 1954. The Doors of Perception.

Allman, J.M., Hakeem, A., Erwin, J.M., Nimchinsky, E., Hof, P., Hixon, F.P., 2001. The anterior cingulate cortex. Ann. N. Y. Acad. Sci. 935 (1), 107–117. https://doi.org/10.1111/J.1749-6632.2001.TB03476.X.

Baker, C.L., Johnson, A.P., 2004. First- and second-order information in natural images: a filter-based approach to image statistics. JOSA A 21 (6), 913–925. https://doi.org/10.1364/JOSAA.21.000913, 21(6), 913–925.

Bara, I., Binney, R.J., Ward, R., Ramsey, R., 2022. A generalised semantic cognition account of aesthetic experience. Neuropsychologia 173, 1–10. https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2022.108288.
Barrett, L.F., Satpute, A.B., 2013. Large-scale brain networks in affective and social neuroscience: towards an integrative functional architecture of the brain. Curr. Opin. Neurobiol. 23 (3), 361–372. https://doi.org/10.1016/j.conb.2012.12.012.
Barrett, F.S., Doss, M.K., Sepeda, N.D., Pekar, J.J., Griffiths, R.R., 2020a. Emotions and brain function are altered up to one month after a single high dose of psilocybin. Sci. Rep. 10 (1). https://doi.org/10.1038/s41598-020-59282-y.
Barrett, F.S., Krimmel, S.R., Griffiths, R., Seminowicz, D.A., Mathur, B.N., 2020b. Psilocybin acutely alters the functional connectivity of the claustrum with brain networks that support perception, memory, and attention. Neuroimage 218, 116980. https://doi.org/10.1016/J.NEUROIMAGE.2020.116980.
Bastos, A.M., Vezoli, J., Bosman, C.A., Schoffelen, J.M., Oostenveld, R., Dowdall, J.R., DeWeerd, P., Kennedy, H., Fries, P., 2015. Visual areas exert feedforward and feedback influences through distinct frequency channels. Neuron 85 (2), 390–401. https://doi.org/10.1016/J.NEURON.2014.12.018.
Beardsley, M.C., 1983. In: Curtler, H. (Ed.), *An Aesthetic Definition of Art* (W. is Art?.
Belfi, A.M., Vessel, E.A., Brielmann, A., Isik, A.I., Chatterjee, A., Leder, H., Pelli, D.G., Starr, G.G., 2019. Dynamics of aesthetic experience are reflected in the default-mode network. Neuroimage 188, 584–597. https://doi.org/10.1016/j.neuroimage.2018.12.017.
Berlyne, D.E., 1950. Novelty and curiosity as determinants of exploratory behaviour. Br. J. Psychol. 41 (1–2), 68–80. https://doi.org/10.1111/j.2044-8295.1950.tb00262.x. *General Section.*
Berlyne, D.E., 1958. The influence of complexity and novelty in visual figures on orienting responses. J. Exp. Psychol. 55 (3), 289–296. https://doi.org/10.1037/h0043555.
Binder, J.R., Desai, R.H., 2011. The neurobiology of semantic memory. Trends Cognit. Sci. 15 (11), 527–536. https://doi.org/10.1016/J.TICS.2011.10.001/ATTACHMENT/ADDDCAA3-D4D8-4FE1-88C4-A238D067CF1C/MMC1.PDF.
Binder, J.R., Desai, R.H., Graves, W.W., Conant, L.L., 2009. Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. Cerebr. Cortex 19 (12), 2767–2796. https://doi.org/10.1093/CERCOR/BHP055.
Bressloff, P.C., Cowan, J.D., Golubitsky, M., Thomas, P.J., Wiener, M.C., 2001. Geometric visual hallucinations, Euclidean symmetry and the functional architecture of striate cortex. Phil. Trans. Biol. Sci. 356 (1407), 299–330. https://doi.org/10.1098/rstb.2000.0769. Royal Society.
Bressloff, P.C., Cowan, J.D., Golubitsky, M., Thomas, P.J., Wiener, M.C., 2002. What geometric visual hallucinations tell Us about the visual cortex. Neural Comput. 14 (3), 473–491. https://doi.org/10.1162/089976602317250861.
Brown, S., Gao, X., Tisdelle, L., Eickhoff, S.B., Liotti, M., 2011. Naturalizing aesthetics: brain areas for aesthetic appraisal across sensory modalities. Neuroimage 58 (1), 250–258. https://doi.org/10.1016/J.NEUROIMAGE.2011.06.012.
Buckner, R.L., Andrews-Hanna, J.R., Schacter, D.L., 2008. The brain's default network. Ann. N. Y. Acad. Sci. 1124 (1), 1–38. https://doi.org/10.1196/ANNALS.1440.011.
Bush, G., Luu, P., Posner, M.I., 2000. Cognitive and emotional influences in anterior cingulate cortex. Trends Cognit. Sci. 4 (6), 215–222. https://doi.org/10.1016/S1364-6613(00)01483-2/ASSET/857758A5-449B-40BB-B454-586ED0F5CEE7/MAIN.ASSETS/GR5.SML.
Calvo-Merino, B., Jola, C., Glaser, D.E., Haggard, P., 2008. Towards a sensorimotor aesthetics of performing art. Conscious. Cognit. 17 (3), 911–922. https://doi.org/10.1016/j.concog.2007.11.003.
Carhart-Harris, R.L., 2018. The entropic brain - revisited. Neuropharmacology 142, 167–178. https://doi.org/10.1016/j.neuropharm.2018.03.010. Elsevier Ltd.
Carhart-Harris, R.L., Friston, K.J., 2010. The default-mode, ego-functions and free-energy: a neurobiological account of Freudian ideas. Brain 133 (4), 1265–1283. https://doi.org/10.1093/BRAIN/AWQ010.
Carhart-Harris, R.L., Friston, K.J., 2019. REBUS and the anarchic brain: toward a unified model of the brain action of psychedelics. Pharmacol. Rev. 71 (3), 316–344. https://doi.org/10.1124/pr.118.017160.
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. In: Proceedings of the National Academy of Sciences of the United States of America, vol 109, pp. 2138–2143. https://doi.org/10.1073/PNAS.1119598109/SUPPL_FILE/PNAS.201119598SI.PDF, 6.
Carhart-Harris, R.L., Leech, R., Erritzoe, D., Williams, T.M., Stone, J.M., Evans, J., Sharp, D.J., Feilding, A., Wise, R.G., Nutt, D.J., 2013. Functional connectivity measures after psilocybin inform a novel hypothesis of early psychosis. Schizophr. Bull. 39 (6), 1343–1351. https://doi.org/10.1093/schbul/sbs117.
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. Front. Hum. Neurosci. 8 (1 FEB). https://doi.org/10.3389/FNHUM.2014.00020.
Carhart-Harris, R.L., Bolstridge, M., Rucker, J., Day, C.M.J., Erritzoe, D., Kaelen, M., Bloomfield, M., Rickard, J.A., Forbes, B., Feilding, A., Taylor, D., Pilling, S., Curran, V.H., Nutt, D.J., 2016. Psilocybin with psychological support for treatment-resistant depression: an open-label feasibility study. Lancet Psychiatry 3 (7), 619–627. https://doi.org/10.1016/S2215-0366(16)30065-7.
Cattaneo, Z., Ferrari, C., Schiavi, S., Alekseichuk, I., Antal, A., Nadal, M., 2020. Medial prefrontal cortex involvement in aesthetic appreciation of paintings: a tDCS study. Cogn. Process. 21 (1), 65–76. https://doi.org/10.1007/S10339-019-00936-9/METRICS.
Cela-Conde, C.J., Garcfa-Prieto, J., Ramasco, J.J., Mirasso, C.R., Bajo, R., Munara, E., Flexasa, A., Del-Pozo, F., Maestu, F., 2013. Dynamics of brain networks in the aesthetic appreciation. In: Proceedings of the National Academy of Sciences of the United States of America, vol 110, pp. 10454–10461. https://doi.org/10.1073/PNAS.1302855110. Suppl 2(Suppl 2).
Chatterjee, A., Vartanian, O., 2014. Neuroaesthetics. Trends Cognit. Sci. 18 (7), 370–375. https://doi.org/10.1016/j.tics.2014.03.003.
Conway, B.R., Rehding, A., 2013. Neuroaesthetics and the trouble with beauty. PLoS Biol. 11 (3). https://doi.org/10.1371/journal.pbio.1001504.
(Bud) Craig, A.D., 2011. Significance of the insula for the evolution of human awareness of feelings from the body. Ann. N. Y. Acad. Sci. 1225 (1), 72–82. https://doi.org/10.1111/j.1749-6632.2011.05990.x.
Crick, F.C., Koch, C., 2005. What is the function of the claustrum? Phil. Trans. Biol. Sci. 360 (1458), 1271–1279. https://doi.org/10.1098/rstb.2005.1661.
Cupchik, G.C., Vartanian, O., Crawley, A., Mikulis, D.J., 2009. Viewing artworks: contributions of cognitive control and perceptual facilitation to aesthetic experience. Brain Cognit. 70 (1), 84–91. https://doi.org/10.1016/j.bandc.2009.01.003.
Díaz, J.L., 2010. Sacred plants and visionary consciousness. Phenomenol. Cognitive Sci. 9 (2), 159–170. https://doi.org/10.1007/s11097-010-9157-z.
Di Dio, C., Vittorio, G., 2009. Neuroaesthetics: a review. Curr. Opin. Neurobiol. 19 (6), 682–687. https://doi.org/10.1016/j.conb.2009.09.001. Elsevier Ltd.
Di Dio, D.C., Macaluso, E., Rizzolatti, G., 2007. The golden beauty: brain response to classical and Renaissance sculptures. PLoS One 2 (11), e1201. https://doi.org/10.1371/JOURNAL.PONE.0001201.
Dittrich, A., 1998. The standardized psychometric assessment of altered states of consciousness (ASCs) in humans. Pharmacopsychiatry 31 (Suppl. 2), 80–84. https://doi.org/10.1055/S-2007-979351. Suppl 2.
Doss, M.K., Madden, M.B., Gaddis, A., Nebel, M.B., Griffiths, R.R., Mathur, B.N., Barrett, F.S., 2022. Models of psychedelic drug action: modulation of cortical-subcortical circuits. Brain 145 (2), 441–456. https://doi.org/10.1093/brain/awab406. Oxford University Press.
Ergenoglu, T., Demiralp, T., Bayraktaroglu, Z., Ergen, M., Beydagi, H., Uresin, Y., 2004. Alpha rhythm of the EEG modulates visual detection performance in humans. Cogn. Brain Res. 20 (3), 376–383. https://doi.org/10.1016/J.COGBRAINRES.2004.03.009.
Ermentrout, G.B., Cowan, J.D., 1979. A mathematical theory of visual hallucination patterns. Biol. Cybern. 34 (3), 137–150. https://doi.org/10.1007/BF00336965.
Erritzoe, D., Smith, J., Fisher, P.M., Carhart-Harris, R., Frokjaer, V.G., Knudsen, G.M., 2019. Recreational use of psychedelics is associated with elevated personality trait openness: exploration of associations with brain serotonin markers. J. Psychopharmacol. 33 (9), 1068–1075. https://doi.org/10.1177/0269881119827891.
Family, N., Vinson, D., Vigliocco, G., Kaelen, M., Bolstridge, M., Nutt, D.J., Carhart-Harris, R.L., 2016. Semantic activation in LSD: evidence from picture naming. Language, Cognition and Neuroscience 31 (10), 1320–1327. https://doi.org/10.1080/23273798.2016.1217030.
Fernandino, L., Humphries, C.J., Seidenberg, M.S., Gross, W.L., Conant, L.L., Binder, J.R., 2015. Predicting brain activation patterns associated with individual lexical concepts based on five sensory-motor attributes. Neuropsychologia 76, 17–26. https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2015.04.009.
Ferrari, C., Nadal, M., Schiavi, S., Vecchi, T., Cela-Conde, C.J., Cattaneo, Z., 2017. The dorsomedial prefrontal cortex mediates the interaction between moral and aesthetic valuation: a TMS study on the beauty-is-good stereotype. Soc. Cognit. Affect Neurosci. 12 (5), 707–717. https://doi.org/10.1093/SCAN/NSX002.
Fischer, R., Hill, R., Thatcher, K., Scheib, J., 1970. Psilocybin-induced contraction of nearby visual space. Agents Actions 1 (4), 190–197. https://doi.org/10.1007/BF01965761/METRICS.
Fries, P., 2015. Rhythms for cognition: communication through coherence. Neuron 88 (1), 220–235. https://doi.org/10.1016/j.neuron.2015.09.034. Cell Press.
Ghirlanda, S., Enquist, M., 2003. A century of generalization. Anim. Behav. 66 (1), 15–36. https://doi.org/10.1006/anbe.2003.2174.
Gómez-Emilsson, A., 2016. The Hyperbolic Geometry of DMT Experiences: Symmetries, Sheets, and Saddled Scenes. Qualia Research Institute.
Gresch, P.J., Barrett, R.J., Sanders-Bush, E., Smith, R.L., 2007. 5-Hydroxytryptamine (Serotonin)2A receptors in rat anterior cingulate cortex mediate the discriminative stimulus properties of d-Lysergic acid diethylamide. J. Pharmacol. Exp. Therapeut. 320 (2), 662–669. https://doi.org/10.1124/JPET.106.112946.
Griffiths, R.R., Richards, W.A., McCann, U., Jesse, R., 2006. Psilocybin can occasion mystical-type experiences having substantial and sustained personal meaning and spiritual significance. Psychopharmacology 187 (3), 268–283. https://doi.org/10.1007/s00213-006-0457-5.
Grill-Spector, K., Malach, R., 2004. The human visual cortex. Annu. Rev. Neurosci. 27, 649–677. https://doi.org/10.1146/ANNUREV.NEURO.27.070203.144220/CITE/REFWORKS. Volume 27, 2004.
Guilbeault, D., Nadler, E.O., Chu, M., Lo Sardo, D.R., Kar, A.A., Desikan, B.S., 2020. Color associations in abstract semantic domains. Cognition 201. https://doi.org/10.1016/j.cognition.2020.104306.
Hanslmayr, S., Aslan, A., Staudigl, T., Klimesch, W., Herrmann, C.S., Bäuml, K.H., 2007. Prestimulus oscillations predict visual perception performance between and within subjects. Neuroimage 37 (4), 1465–1473. https://doi.org/10.1016/J.NEUROIMAGE.2007.07.011.
Hartogsohn, I., 2018. The meaning-enhancing properties of psychedelics and their mediator role in psychedelic therapy, spirituality, and creativity. Front. Neurosci. 12. https://doi.org/10.3389/fnins.2018.00129.
Hill, R.M., Fischer, R., 1973. Induction and extinction of psilocybin induced transformations of visual space. Pharmacopsychiatry 6 (4), 258–263. https://doi.org/10.1055/s-0028-1094389.

Hirschfeld, T., Schmidt, T.T., 2021. Dose–response relationships of psilocybin-induced subjective experiences in humans. J. Psychopharmacol. 35 (4), 384–397. https://doi.org/10.1177/0269881121992676.

Holze, F., Vizeli, P., Ley, L., Müller, F., Dolder, P., Stocker, M., Duthaler, U., Varghese, N., Eckert, A., Borgwardt, S., Liechti, M.E., 2021. Acute dose-dependent effects of lysergic acid diethylamide in a double-blind placebo-controlled study in healthy subjects. Neuropsychopharmacology 46 (3), 537–544. https://doi.org/10.1038/s41386-020-00883-6.

Horowitz, M.J., 1975. A cognitive model of hallucinations. Am. J. Psychiatr. 132 (8), 789–795. https://doi.org/10.1176/ajp.132.8.789.

Hyperspace Lexicon, 2023. DMT nexus. https://wiki.dmt-nexus.me/hyperspace_lexicon.

Ishizu, T., Zeki, S., 2013. The brain's specialized systems for aesthetic and perceptual judgment. Eur. J. Neurosci. 37 (9), 1413–1420. https://doi.org/10.1111/ejn.12135.

Jacobs, R.H.A.H., Cornelissen, F.W., 2017. An explanation for the role of the amygdala in aesthetic judgments. Front. Hum. Neurosci. 11. https://doi.org/10.3389/fnhum.2017.00080.

Jacobs, R.H.A.H., Renken, R., Cornelissen, F.W., 2012. Neural correlates of visual aesthetics - beauty as the coalescence of stimulus and internal state. PLoS One 7 (2). https://doi.org/10.1371/journal.pone.0031248.

Jacobsen, T., 2009. Beauty and the brain: culture, history and individual differences in aesthetic appreciation. J. Anat. 216 (2), 184–191. https://doi.org/10.1111/j.1469-7580.2009.01164.x.

Jacobsen, T., Beudt, S., 2017. Stability and variability in aesthetic experience: a review. Front. Psychol. 8 (FEB), 225045. https://doi.org/10.3389/FPSYG.2017.00143/BIBTEX.

Johnson, J.S., Olshausen, B.A., 2003. Timecourse of neural signatures of object recognition. J. Vis. 3 (7), 499–512. https://doi.org/10.1167/3.7.4.

Josie, Kins, 2024. Subjective Effect Index. PsychonautWiki. https://www.effectindex.com/.

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 (19), 3607–3614. https://doi.org/10.1007/s00213-015-4014-y.

Klaiber, A., Schmid, Y., Becker, A.M., Straumann, I., Erne, L., Jelusic, A., Thomann, J., Luethi, D., Liechti, M.E., 2024. Acute dose-dependent effects of mescaline in a double-blind placebo-controlled study in healthy subjects. Transl. Psychiatry 14 (1), 395. https://doi.org/10.1038/s41398-024-03116-2.

Klüver, H., 1948. Mechanisms of hallucinations. In: Studies in Personality. McGraw Hill Book Company, pp. 175–207.

Klüver, H., 1966. Mescal, and Mechanisms of Hallucinations, first ed. PHOENIX BOOKS.

Klüver, H., Paul, I., 1928. Mescal: the "Devine" Plant and its Psychological Effects.

Kometer, M., Vollenweider, F.X., 2018. Serotonergic hallucinogen-induced visual perceptual alterations. Behavioral Neurobiology of Psychedelic Drugs 36, 257–282. https://doi.org/10.1007/7854_2016_461/COVER. Springer Verlag.

Kometer, M., Cahn, B.R., Andel, D., Carter, O.L., Vollenweider, F.X., 2011. The 5-HT2A/1A agonist psilocybin disrupts modal object completion associated with visual hallucinations. Biol. Psychiatry 69 (5), 399–406. https://doi.org/10.1016/j.biopsych.2010.10.002.

Kometer, M., Schmidt, A., Jäncke, L., Vollenweider, F.X., 2013. Activation of serotonin 2A receptors underlies the psilocybin-induced effects on α oscillations, N170 visual-evoked potentials, and visual hallucinations. J. Neurosci. 33 (25), 10544. https://doi.org/10.1523/JNEUROSCI.3007-12.2013.

Kraehenmann, R., Preller, K.H., Scheidegger, M., Pokorny, T., Bosch, O.G., Seifritz, E., Vollenweider, F.X., 2015. Psilocybin-induced decrease in Amygdala reactivity correlates with enhanced positive mood in healthy volunteers. Biol. Psychiatry 78 (8), 572–581. https://doi.org/10.1016/J.BIOPSYCH.2014.04.010.

Kraehenmann, R., Pokorny, D., Aicher, H., Preller, K.H., Pokorny, T., Bosch, O.G., Seifritz, E., Vollenweider, F.X., 2017. LSD increases primary process thinking via serotonin 2A receptor activation. Front. Pharmacol. 8 (NOV). https://doi.org/10.3389/fphar.2017.00814.

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 (18), 3395–3403. https://doi.org/10.1007/s00213-016-4377-8.

Lawrence, D.W., Carhart-Harris, R., Griffiths, R., Timmermann, C., 2022. Phenomenology and content of the inhaled N, N-dimethyltryptamine (N, N-DMT) experience. Sci. Rep. 12 (1). https://doi.org/10.1038/s41598-022-11999-8.

Lee, H., Jacquot, A., Makowski, D., Arcangeli, M., Dokic, J., Piolino, P., Sperduti, M., 2020. Beauty is in the Eye of the Beholder: Evidence from a Common Mnemonic Advantage Between Aesthetics Judgement and self-reference. HAL. https://doi.org/10.31234/osf.io/rw39qï.

Lewis, C.R., Preller, K.H., Braden, B.B., Riecken, C., Vollenweider, F.X., 2020. Rostral anterior cingulate thickness predicts the emotional psilocybin experience. Biomedicines 8 (2), 34. https://doi.org/10.3390/BIOMEDICINES8020034, 2020, Vol. 8, Page 34.

Liberzon, I., Phan, K.L., Decker, L.R., Taylor, S.F., 2002. Extended Amygdala and emotional salience: a PET activation study of positive and negative affect. Neuropsychopharmacology 28 (4), 726–733. https://doi.org/10.1038/sj.npp.1300113, 2003 28:4.

Livingstone, M.S., Hubel, D.H., 1987. Psychophysical evidence for separate channels for the perception of form, color, movement, and depth. J. Neurosci. 7 (11), 3416. https://doi.org/10.1523/JNEUROSCI.07-11-03416.1987.

Luo, Q., Yu, M., Li, Y., Mo, L., 2019. The neural correlates of integrated aesthetics between moral and facial beauty. Sci. Rep. 9 (1), 1–10. https://doi.org/10.1038/s41598-019-38553-3, 2019 9:1.

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. J. Psychopharmacol. 25 (11), 1453–1461. https://doi.org/10.1177/0269881111420188.

Makin, A.D.J., Roccato, M., Karakashevska, E., Tyson-Carr, J., Odintsov, S.D., Luis, J., Guirao, G., Oikonomou, V.K., Graham, J.H., Keglevich, G., Makin, A.D.J., Roccato, M., Karakashevska, E., Tyson-Carr, J., Bertamini, M., 2023. Symmetry perception and psychedelic experience. Symmetry 15 (7), 1340. https://doi.org/10.3390/SYM15071340, 2023, Vol. 15, Page 1340.

Marr, D., 1976. Early processing of visual information. Philos. Trans. R. Soc. Lond. B Biol. Sci. 275 (942), 483–519. https://doi.org/10.1098/rstb.1976.0090.

Martín-Loeches, M., Hernández-Tamames, J.A., Martín, A., Urrutia, M., 2014. Beauty and ugliness in the bodies and faces of others: an fMRI study of person esthetic judgement. Neuroscience 277, 486–497. https://doi.org/10.1016/j.neuroscience.2014.07.040.

Mason, A.S., 2010. Plato's metaphysics: the "theory of Forms.". Plato 27–60. https://doi.org/10.1017/UPO9781844654352.004.

McGovern, H., Aquil, M., Atasoy, S., Carhart-Harris, R.L., 2024. Eigenmodes of the Deep Unconscious: the Neuropsychology of Jungian Archetypes and Psychedelic Experience.

Melcer, E., Isbister, K., 2016. Motion, emotion, and form: exploring affective dimensions of shape. In: Conference on Human Factors in Computing Systems - Proceedings, 07-12-May-2016, pp. 1430–1437. https://doi.org/10.1145/2851581.2892361.

Menzel, C., Hayn-Leichsenring, G.U., Langner, O., Wiese, H., Redies, C., 2015. Fourier power spectrum characteristics of face photographs: attractiveness perception depends on low-level image properties. PLoS One 10 (4). https://doi.org/10.1371/journal.pone.0122801.

Michael, P., Luke, D., Robinson, O., 2023. An encounter with the self: a thematic and content analysis of the DMT experience from a naturalistic field study. Front. Psychol. 14. https://doi.org/10.3389/fpsyg.2023.1083356.

Muthukumaraswamy, S.D., Carhart-Harris, R.L., Moran, R.J., Brookes, M.J., Williams, T. M., Errtizoe, D., Sessa, B., Papadopoulos, A., Bolstridge, M., Singh, K.D., Feilding, A., Friston, K.J., Nutt, D.J., 2013. Broadband cortical desynchronization underlies the human psychedelic state. J. Neurosci. 33 (38), 15171. https://doi.org/10.1523/JNEUROSCI.2063-13.2013.

Nadal, M., Gomila, A., Gàlvez-Pol, A., 2014. A History for Neuroaesthetics. Museum Tusculanum Press.

Nakamura, K., Kawabata, H., 2015. Transcranial direct current stimulation over the medial prefrontal cortex and left primary motor cortex (MPFC-lPMC) affects subjective beauty but not ugliness. Front. Hum. Neurosci. 9 (DEC), 164226. https://doi.org/10.3389/FNHUM.2015.00654/BIBTEX.

Nichols, D.E., 2016. Psychedelics. Pharmacol. Rev. 68 (2), 264. https://doi.org/10.1124/PR.115.011478.

Olson, R.J., Bartlett, L., Sonneborn, A., Bretton-Granatoor, Z., Firdous, A., Harris, A.Z., Abbas, A.I., 2023. The classic psychedelic DOI induces a persistent desynchronized state in medial prefrontal cortex. bioRxiv, 529963. https://doi.org/10.1101/2023.02.26.529963, 2023.02.26.

Palhano-Fontes, F., Andrade, K.C., Tofoli, L.F., Jose, A.C.S., Crippa, A.S., Hallak, J.E.C., Ribeiro, S., De Araujo, D.B., 2015. The psychedelic state induced by Ayahuasca modulates the activity and connectivity of the default mode network. PLoS One 10 (2). https://doi.org/10.1371/journal.pone.0118143.

Pallavicini, C., Cavanna, F., Zamberlan, F., de la Fuente, L.A., Ilksoy, Y., Perl, Y.S., Arias, M., Romero, C., Carhart-Harris, R., Timmermann, C., Tagliazucchi, E., 2021. Https://Doi.Org/10.1177/0269881120981384. Neural and Subjective Effects of Inhaled N,N-dimethyltryptamine in Natural Settings, vol. 35, pp. 406–420. https://doi.org/10.1177/0269881120981384, 4.

Párraga, C.A., Troscianko, T., Tolhurst, D.J., 2000. The human visual system is optimised for processing the spatial information in natural visual images. Curr. Biol. 10 (1), 35–38. https://doi.org/10.1016/S0960-9822(99)00262-6.

Pasquini, L., Palhano-Fontes, F., Araujo, D.B., 2020. Subacute effects of the psychedelic ayahuasca on the salience and default mode networks. J. Psychopharmacol. 34 (6), 623–635. https://doi.org/10.1177/0269881120909409/ASSET/IMAGES/LARGE/10.1177_0269881120909409-FIG4.JPEG.

Perrett, D.I., Burt, D.M., Penton-Voak, I.S., Lee, K.J., Rowland, D.A., Edwards, R., 1999. Symmetry and human facial attractiveness. Evol. Hum. Behav. 20.

Phan, K.L., Wager, T., Taylor, S.F., Liberzon, I., 2002. Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. Neuroimage 16 (2), 331–348. https://doi.org/10.1006/nimg.2002.1087.

Pouyan, N., Younesi Sisi, F., Kargar, A., Scheidegger, M., McIntyre, R.S., Morrow, J.D., 2023. The effects of Lysergic Acid Diethylamide (LSD) on the positive valence systems: a research domain criteria (RDoC)-Informed systematic review. CNS Drugs 37 (12), 1027–1063. https://doi.org/10.1007/s40263-023-01044-1. Adis.

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. Curr. Biol. 27 (3), 451–457. https://doi.org/10.1016/j.cub.2016.12.030.

Proverbio, A.M., Zani, A., 2002. Electrophysiological indexes of illusory contours perception in humans. Neuropsychologia 40 (5), 479–491. https://doi.org/10.1016/s0028-3932(01)00135-x.

Raichle, M.E., Snyder, A.Z., 2007. A default mode of brain function: a brief history of an evolving idea. Neuroimage 37 (4), 1083–1090. https://doi.org/10.1016/J.NEUROIMAGE.2007.02.041.

Ramachandran, V.S., Hirstein, W., 1999. The science of art A neurological theory of aesthetic experience. J. Conscious. Stud. 6 (7). www.imprint-academic.com/jcswww.imprint.co.uk/rama.

Rasche, S.E., Beyh, A., Paolini, M., Zeki, S., 2023. The neural determinants of abstract beauty. Eur. J. Neurosci. 57 (4), 633–645. https://doi.org/10.1111/ejn.15912.
Redies, C., 2007. A universal model of esthetic perception based on the sensory coding of natural stimuli. Spatial Vision 21 (1), 97–117. https://doi.org/10.1163/156856808782713780.
Riba, J., Romero, S., Grasa, E., Mena, E., Carrió, I., Barbanoj, M.J., 2006. Increased frontal and paralimbic activation following ayahuasca, the Pan-amazonian inebriant. Psychopharmacology 186 (1), 93–98. https://doi.org/10.1007/s00213-006-0358-7.
Robles, K.E., Roberts, M., Viengkham, C., Smith, J.H., Rowland, C., Moslehi, S., Stadlober, S., Lesjak, A., Lesjak, M., Taylor, R.P., Spehar, B., Sereno, M.E., 2021. Aesthetics and psychological effects of fractal based design. Front. Psychol. 12. https://doi.org/10.3389/fpsyg.2021.699962.
Roseman, L., Haijen, E., Idialu-Ikato, K., Kaelen, M., Watts, R., Carhart-Harris, R., 2019. Emotional Breakthrough and Psychedelics: Validation of the Emotional Breakthrough Inventory, vol. 33, pp. 1076–1087. https://doi.org/10.1177/0269881119855974. https://Ucdenver.Zoom.Us/j/92352544110, 9.
Safron, A., Juliani, A., Reggente, N., Klimaj, V., Johnson, M., 2025. On the varieties of conscious experiences: altered Beliefs under Psychedelics (ALBUS). Neuroscience of Consciousness 2025 (1). https://doi.org/10.1093/nc/niae038.
Sampedro, F., Revenga, M.D.L.F., Valle, M., Roberto, N., Domínguez-Clavé, E., Elices, M., Luna, L.E., Crippa, J.A.S., Hallak, J.E.C., Araujo, D.B.D., Friedlander, P., Barker, S.A., Álvarez, E., Soler, J., Pascual, J.C., Feilding, A., Riba, J., 2017. Assessing the psychedelic "After-Glow" in ayahuasca users: post-acute neurometabolic and functional connectivity changes are associated with enhanced mindfulness capacities. Int. J. Neuropsychopharmacol. 20 (9), 698–711. https://doi.org/10.1093/IJNP/PYX036.
Sanders, J.W., Millière, R., Demšar, E., Daily, Z.G., Carhart-Harris, R., Timmermann, C., 2025. Micro-Phenomenology of Immersion and Perceived Presences Under DMT.
Sanz, C., Pallavicini, C., Carrillo, F., Zamberlan, F., Sigman, M., Mota, N., Copelli, M., Ribeiro, S., Nutt, D., Carhart-Harris, R., Tagliazucchi, E., 2021. The entropic tongue: disorganization of natural language under LSD. Conscious. Cognit. 87, 103070. https://doi.org/10.1016/J.CONCOG.2020.103070.
Sarasso, P., Ronga, I., Kobau, P., Bosso, T., Artusio, I., Ricci, R., Neppi-Modona, M., 2020. Beauty in mind: aesthetic appreciation correlates with perceptual facilitation and attentional amplification. Neuropsychologia 136, 107282. https://doi.org/10.1016/J.NEUROPSYCHOLOGIA.2019.107282.
Schubert, E., North, A.C., Hargreaves, D.J., 2016. Aesthetic experience explained by the affect-space framework. Empirical Musicology Review 11 (3–4), 330–345. https://doi.org/10.18061/EMR.V11I3-4.5115.
Shanon, B., 2002. Ayahuasca visualizations a structural typology. J. Conscious. Stud. 9 (2), 3–30.
Shanon, B., 2010. The epistemics of ayahuasca visions. Phenomenol. Cognitive Sci. 9 (2), 263–280. https://doi.org/10.1007/s11097-010-9161-3.
Shusterman, R., 1997. The end of aesthetic experience. Source: J. Aesthet. Art Critic. 55 (Issue 1).
Siegel, R., Jarvik, M., 1975. Drug-induced hallucinations in animals and man. Hallucinations: Behavior, Experience, and Theor 81–161.
Skov, M., Vartanian, O., 2009. Neuroaesthetics. Baywood Publishing Co.
Smigielski, L., Kometer, M., Scheidegger, M., Stress, C., Preller, K.H., Koenig, T., Vollenweider, F.X., 2020. P300-mediated modulations in self–other processing under psychedelic psilocybin are related to connectedness and changed meaning: a window into the self–other overlap. Hum. Brain Mapp. 41 (17), 4982–4996. https://doi.org/10.1002/hbm.25174.
Song, J., Kwak, Y., Kim, C.Y., 2021. Familiarity and novelty in aesthetic preference: the effects of the properties of the artwork and the beholder. Front. Psychol. 12. https://doi.org/10.3389/fpsyg.2021.694927.
Spehar, B., Clifford, C.W.G., Newell, B.R., Taylor, R.P., 2003. Universal aesthetic of fractals. Comput. Graph. 27 (5), 813–820. https://doi.org/10.1016/S0097-8493(03)00154-7.
Spehar, B., Wong, S., van de Klundert, S., Lui, J., Clifford, C.W.G., Taylor, R.P., 2015. Beauty and the beholder: the role of visual sensitivity in visual preference. Front. Hum. Neurosci. 9 (September), 154390. https://doi.org/10.3389/FNHUM.2015.00514/BIBTEX.
Stoliker, D., Egan, G.F., Friston, K.J., Razi, A., 2022. Neural mechanisms and psychology of psychedelic ego dissolution. Pharmacol. Rev. 74 (4), 874–915. https://doi.org/10.1124/pharmrev.121.000508.
Stoliker, D., Novelli, L., Vollenweider, F.X., Egan, G.F., Preller, K.H., Razi, A., 2024a. Neural mechanisms of resting-state networks and the amygdala underlying the cognitive and emotional effects of psilocybin. Biol. Psychiatry. https://doi.org/10.1016/j.biopsych.2024.01.002.
Stoliker, D., Preller, K.H., Novelli, L., Anticevic, A., Egan, G.F., Vollenweider, F.X., Razi, A., 2024b. Neural mechanisms of psychedelic visual imagery. Mol. Psychiatr. https://doi.org/10.1038/s41380-024-02632-3.
Stoliker, D., Novelli, L., Khajehnejad, M., Biabani, M., Barta, T., Greaves, M.D., Williams, M., Chopra, S., Bazin, O., Simonsson, O., Chambers, R., Barrett, F., Deco, G., Seth, A., Preller, K.H., Carhart-Harris, R., Sundram, S., Egan, G.F., Razi, A., 2025. Psychedelics align brain activity with context. https://doi.org/10.1101/2025.03.09.642197.
Strassman, R., 2001. DMT: the Spirit Molecule. Park Street Press.
Strassman, R.J., Qualls, C.R., Uhlenhuth, E.H., Kellner, R., 1994. Dose-response study of N,N-Dimethyltryptamine in humans II. Subjective effects and preliminary results of a new rating scale. http://archpsyc.jamanetwork.com/.
Strijbosch, W., Vessel, E.A., Welke, D., Mitas, O., Gelissen, J., Bastiaansen, M., 2022. On the neuronal dynamics of aesthetic experience: evidence from electroencephalographic oscillatory dynamics. J. Cognit. Neurosci. 34 (3), 461–479. https://doi.org/10.1162/JOCN_A_01812.
Studerus, E., Gamma, A., Kometer, M., Vollenweider, F.X., 2012. Prediction of psilocybin response in healthy volunteers. PLoS One 7 (2). https://doi.org/10.1371/journal.pone.0030800.
Szubielska, M., Imbir, K., Szymańska, A., 2021. The influence of the physical context and knowledge of artworks on the aesthetic experience of interactive installations. Curr. Psychol. 40 (8), 3702–3715. https://doi.org/10.1007/S12144-019-00322-W/TABLES/3.
Tagliazucchi, E., 2022. Language as a window into the altered state of consciousness elicited by psychedelic drugs. Front. Pharmacol. 13, 812227. https://doi.org/10.3389/FPHAR.2022.812227/BIBTEX.
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. Curr. Biol. 26 (8), 1043–1050. https://doi.org/10.1016/j.cub.2016.02.010.
Timmermann, C., Roseman, L., Williams, L., Erritzoe, D., Martial, C., Cassol, H., Laureys, S., Nutt, D., Carhart-Harris, R., 2018a. DMT models the near-death experience. Front. Psychol. 9 (AUG). https://doi.org/10.3389/FPSYG.2018.01424/FULL.
Timmermann, C., Spriggs, M.J., Kaelen, M., Leech, R., Nutt, D.J., Moran, R.J., Carhart-Harris, R.L., Muthukumaraswamy, S.D., 2018b. LSD modulates effective connectivity and neural adaptation mechanisms in an auditory oddball paradigm. Neuropharmacology 142, 251–262. https://doi.org/10.1016/J.NEUROPHARM.2017.10.039.
Timmermann, C., Roseman, L., Schartner, M., Milliere, R., Williams, L.T.J., Erritzoe, D., Muthukumaraswamy, S., Ashton, M., Bendrioua, A., Kaur, O., Turton, S., Nour, M. M., Day, C.M., Leech, R., Nutt, D.J., Carhart-Harris, R.L., 2019. Neural correlates of the DMT experience assessed with multivariate EEG. Sci. Rep. 9 (1). https://doi.org/10.1038/S41598-019-51974-4.
Touroutoglou, A., Hollenbeck, M., Dickerson, B.C., Feldman Barrett, L., 2012. Dissociable large-scale networks anchored in the right anterior insula subserve affective experience and attention. Neuroimage 60 (4), 1947. https://doi.org/10.1016/J.NEUROIMAGE.2012.02.012.
Vartanian, O., Goel, V., 2004. Neuroanatomical correlates of aesthetic preference for paintings. Neuroreport 15 (5), 893–897. https://doi.org/10.1097/01.wnr.0000118723.38067.d6.
Vessel, E.A., Starr, G.G., Rubin, N., 2013. Art reaches within: aesthetic experience, the self and the default mode network. Front. Neurosci. 7 (7 DEC). https://doi.org/10.3389/FNINS.2013.00258.
Vessel, E.A., Maurer, N., Denker, A.H., Starr, G.G., 2018. Stronger shared taste for natural aesthetic domains than for artifacts of human culture. Cognition 179, 121–131. https://doi.org/10.1016/J.COGNITION.2018.06.009.
Vessel, E.A., Isik, A.I., Belfi, A.M., Stahl, J.L., Gabrielle Starr, G., 2019. The default-mode network represents aesthetic appeal that generalizes across visual domains. In: Proceedings of the National Academy of Sciences of the United States of America, vol 116, pp. 19155–19164. https://doi.org/10.1073/PNAS.1902650116, 38.
Wotruba, D., Michels, L., Buechler, R., Metzler, S., Theodoridou, A., Gerstenberg, M., Walitza, S., Kollias, S., Rössler, W., Heekeren, K., 2014. Aberrant coupling within and across the default mode, task-positive, and salience network in subjects at risk for psychosis. Schizophr. Bull. 40 (5), 1095–1104. https://doi.org/10.1093/schbul/sbt161.
Yaden, D.B., Griffiths, R.R., 2021. The subjective effects of psychedelics are necessary for their enduring therapeutic effects. ACS Pharmacol. Transl. Sci. 4 (2), 568–572. https://doi.org/10.1021/ACSPTSCI.0C00194/ASSET/IMAGES/LARGE/PT0C00194_0001.JPEG.
Zaidel, D.W., 2010. Art and brain: insights from neuropsychology, biology and evolution. J. Anat. 216 (2), 177. https://doi.org/10.1111/J.1469-7580.2009.01099.X.
Zeki, S., 1990. Parallelism and functional specialization in human visual cortex. Cold Spring Harbor Symp. Quant. Biol. 55 (0), 651–661. https://doi.org/10.1101/SQB.1990.055.01.062.
Zeki, S., 1999a. Art and the Brain.
Zeki, S., 1999b. Inner Vision: an Exploration of Art and the Brain. Oxford University Press, Oxford and New York.
Zeki, S., 2001. Artistic creativity and the brain. Science 293 (5527), 51–52. https://doi.org/10.1126/science.1062331.