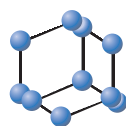


## REVIEW ARTICLE

BENTHAM  
SCIENCE

# Dreams and Psychedelics: Neurophenomenological Comparison and Therapeutic Implications



Rainer Kraehenmann\*

*Neuropsychopharmacology and Brain Imaging, Department of Psychiatry, Psychotherapy and Psychosomatics, Psychiatric Hospital, Faculty of Medicine, University of Zurich, Zurich, Switzerland*

**Abstract: Background:** A resurgence of neurobiological and clinical research is currently under-way into the therapeutic potential of serotonergic or ‘classical’ psychedelics, such as the prototypical psychedelic drug lysergic acid diethylamide (LSD), psilocybin (4-phosphoryloxy-N,N-dimethyltryptamine), and ayahuasca – a betacarboline- and dimethyltryptamine (DMT)-containing Amazonian beverage. The aim of this review is to introduce readers to the similarities and dissimilarities between psychedelic states and night dreams, and to draw conclusions related to therapeutic applications of psychedelics in psychiatry.

**Methods:** Research literature related to psychedelics and dreaming is reviewed, and these two states of consciousness are systematically compared. Relevant conclusions with regard to psychedelic-assisted therapy will be provided.

**Results:** Common features between psychedelic states and night dreams include perception, mental imagery, emotion activation, fear memory extinction, and sense of self and body. Differences between these two states are related to differential perceptual input from the environment, clarity of consciousness and meta-cognitive abilities. Therefore, psychedelic states are closest to lucid dreaming which is characterized by a mixed state of dreaming and waking consciousness.

**Conclusion:** The broad overlap between dreaming and psychedelic states supports the notion that psychedelics acutely induce dreamlike subjective experiences which may have long-term beneficial effects on psychosocial functioning and well-being. Future clinical studies should examine how therapeutic outcome is related to the acute dreamlike effects of psychedelics.

**Keywords:** Dreams, psychedelics, subjective experience, perception, mental imagery, emotion activation, fear memory extinction, sense of self and body.

## 1. INTRODUCTION

The tendency of dreams and psychedelic drugs to induce visionary experiences inspired scientific and cultural development for thousands of years [1-6]. Given that both rapid eye movement sleep (REMS) and psychedelics induce profound effects on perception, mental imagery, emotion activation, fear memory extinction, and sense of self and body [7, 8], and given that both dreams and psychedelics share phenomenological and neurophysiological features [9, 10], it has been hypothesized that dreams may be understood as prototypical hallucinatory experiences [11] and that, on the other hand, psychedelic states may be understood as “experimental

dreams” [12]. The latter notion is supported by previous studies showing that serotonin is crucially involved in the regulation of sleep-wake cycles [13, 14] and that the serotonergic psychedelic lysergic acid diethylamide (LSD) may facilitate REMS in humans [15-17]. A close relationship between hallucinatory experiences and REMS is also supported by evidence that in narcolepsy, a REMS disorder, complex visual hallucinations are best treated by serotonergic antidepressants [18]. Given that both dreams and psychedelics acutely induce characteristic changes in subjective experience, one may hypothesize that therapeutic effects of psychedelics in psychiatric patients may be mediated by the dreamlike experiences of the patients during psychedelic treatment. Therefore, in this short review, dreams and psychedelic states will first be reviewed separately, followed by a direct comparison in terms of similarities and differences. Finally, therapeutic implications and conclusions will be drawn based on available evidence.

\*Address correspondence to this author at the Neuropsychopharmacology and Brain Imaging, Department of Psychiatry, Psychotherapy and Psychosomatics, Psychiatric Hospital, Faculty of Medicine, University of Zurich, Zurich, Switzerland; Tel: +41 (0)44 384 2609; E-mail: [r.kraehenmann@bli.uzh.ch](mailto:r.kraehenmann@bli.uzh.ch)

## 2. DREAMS

### 2.1. Perception and Mental Imagery

Dreams can be extremely vivid, sensorimotor hallucinatory experiences which predominantly involve the visual domain, follow a narrative structure, and occur during sleep, when the brain is disconnected from the environment [19]. Whether dreaming is more closely related to bottom-up perception or top-down imagery is still a matter of debate [20], especially given that both visual mental imagery and perception share similar cortical representations [21]. According to Hobson's activation-synthesis model [22], dreams are produced by chaotic bottom-up activation of sensory cortex in the brainstem (*e.g.*, PGO waves<sup>1</sup>) during REMS, activation of the visual cortex, and secondary interpretation and synthesizing by mnemonic and higher-order frontal areas. Despite the initial lack of structured information, the activation-synthesis model views the secondary elaboration of spontaneous brainstem signals as a constructive process – a synthesis where images from the memory systems are called up to instill some meaning into random signals. In contrast, the neurocognitive model explains dreaming as the top-down product of higher-level mental imagery [23]. According to this model, dreaming is understood as “the purest form of imagination” [19] which is an involuntary but organized mental act that originates in abstract knowledge and figurative thinking and which is then signaled back to perceptive areas to generate “embodied simulations” [24] of the real world. It has been postulated [25, 26] that virtual realities are simulated by the dreaming brain to prepare people for integrative functions during wakefulness, including learning and higher-order consciousness. The neurocognitive model of dreaming is supported by evidence indicating that brain areas supporting sensory processing are activated during mental imagery in the absence of perceptual inputs [27, 28] and from lesion studies showing that lesions in the temporoparieto-occipital junction affect both dreaming and mental imagery during wakefulness [29, 30].

### 2.2. Emotion Activation and Fear Memory Extinction

Apart from profound visual effects, the most distinctive feature of dreams is the activation of emotions. However, emotions are not randomly activated in dreams – instead, there is evidence [31–33] that dreams often appear to be biased towards negative emotions, particularly anxiety, fear, and aggression – although this has not been consistently confirmed [11]. Importantly, there is substantial evidence [31, 34] indicating that dreams serve an adaptive function because they support the regulation of emotions, especially fear. Given that in dreams, the dream self is re-exposed to fear-conditioned stimuli in a realistic but safe simulation of the world [35], and given that repeated exposure to a fear-conditioned stimulus (CS; *e.g.*, a tone) without the reinforcement of the unconditioned stimulus (US; *e.g.*, a foot shock) leads to the gradual decrease in the expression of the

fear-conditioned response (CR; *e.g.*, freezing), fear extinction may be a crucial mechanism underlying the fear regulation function of dreaming. This notion is supported by neurophysiological evidence [36, 37] that during human REMS, significant increase in regional brain activity has been found in the limbic emotion processing network, including amygdala, hippocampus, and anterior cingulate cortex (ACC) – brain regions which support memory consolidation processes, in particular emotional memories and fear memory [38]. Given that fear extinction is not simple erasing of an acquired fear memory, but rather the formation of new extinction memories *via* associative learning of CS in new, non-fearful contexts [39], facilitation of fear memory extinction by dreaming has been related to the following cognitive processes [34]: 1) deconstruction of coherent episodic fear memories into isolated memory units which are largely dissociated from their episodic (real-world) context, 2) recombination of isolated memory units into a constant and phenomenologically coherent flow of dream imagery, leading to novel context representations that reinforce the development of new extinction memories, and 3) emotion expression to ensure maximal allocation of attentional and neural resources. Emotion expression is further enhanced by the “reality mimesis” characteristic of dream phenomenology, *i.e.*, the fact that dreams feel real and that dream imagery is experienced as waking perception [39]. Despite the mechanism of fear extinction, which does not alter the original memory *per se* but rather creates a new memory in a safe context, dreaming might also directly rewrite fear memories *via* memory reconsolidation [40–43]. Schiller *et al.* [42], for example showed that in humans, old fear memories can be permanently updated with non-fearful information if this new information is provided during the reconsolidation window, *i.e.*, immediately following fear memory retrieval. Most interestingly, it was shown that specific fear memories can be selectively attenuated during wake [43] or during sleep [40] if reactivation of the old fear memory is combined with pharmacological compounds which temporarily disrupt amygdala functioning.

### 2.3. Cognition

From the perspective of the waking state, dreams often appear chaotic and difficult to comprehend because of cognitive bizarreness, *i.e.*, incongruities, indeterminacy or discontinuities in the dream narrative [26]. Cognitive bizarreness has been closely related to the neural “signature” of REMS with random brainstem activation and secondary activation in higher-order areas (AIM model) [26, 44–46]. In addition, the dorsolateral prefrontal cortex (DLPFC) and parietal cortex [31] are consistently deactivated during REMS. The DLPFC is involved in goal-directed and context-dependent stimulus selection [47]. Therefore, deactivation of the DLPFC during REMS might partially explain the lack of volitional capabilities and the uncritical acceptance of many bizarre elements in the dream [31]. In addition, it has been shown that during REMS, cortical activity in the high frequency gamma range is absent [48]. Given that gamma frequency activity is related to neural integration among different cortical regions, which is critical for cognitive functions, this lack of gamma frequency activity during REMS may

<sup>1</sup>Ponto-geniculo-occipital waves (PGO) spike waves are phasic field potentials and occur immediately before and during REMS; PGO waves are generated in the pontine brainstem, and then propagate *via* the lateral geniculate nucleus residing in the thalamus, finally ending up in the primary visual cortex of the occipital lobe.

underlie cognitive bizarreness during REMS dreaming [19, 26].

However, there is accumulating evidence indicating that cognitive bizarreness is just “the other side of the coin” of a more fluid and flexible cognitive processing during REMS compared to non-REMS (NREMS) and waking state [49]. In this vein, dreaming has been conceptualized as off-line, unconscious thought-in-progress in which associative mechanisms and visual imagery are less tightly constrained by prefrontal cortical control mechanisms, and hence are less strictly confined by logical reasoning but predominantly driven by underlying emotions [50-53]. Compared to waking mentation, therefore, dreaming has the cognitive advantage of facilitating creative insight – the forming of associative elements into new image-based combinations which lead to greater understanding and which are useful to solve a problem [54]. This notion is further supported by some data which support the idea that dreaming cognition can be superior to wake cognition in tasks which require cognitive flexibility [55], formation of new associations [56, 57], or insight into hidden abstract rules [58].

#### 2.4. Sense of Self and Body

Dreaming always induces alterations in the sense of self and body. Self-centered perspective is usually strong and vivid in dreams: the dreamer is inside the scene, taking part in the dream events from a first-person perspective, or looking at the events as external observer. However, the dreamer is usually unaware that the content coming from the imaginative activity is only the product of his imaginative activity. In fact, the dreamer interprets the phenomena as coming from external reality. This “single-mindedness” [59] is typical for REMS dreams and reflects a lack of meta-cognition, *i.e.* lack of insight into the fact that one is currently dreaming and the capacity to reflect and to make conscious decisions during dreams [60]. Loss of self and body boundaries is frequently occurring in dreams, and ranges from wake-like representation of the body to complete absence of body boundaries [61]. Weak body boundaries are often occurring in REMS dreams (“mini-me”), whereas strong body boundaries are often occurring in lucid dreams [61]. At a neurophysiological level, deactivation of certain brain regions during REMS may underlie the experience of a minimal body self: the parietal lobe and the precuneus have been related to memory-guided imagery and visuospatial processing [62]. The deactivation of these regions during REMS may impair the formation of body representations [63, 64].

A major exception to REMS dream-induced loss of self and body boundaries is lucid dreaming, a rare state of sleep where subjects regain reflective capabilities, becoming aware that they are currently dreaming, and having full access to their memory [65]. Here, an interesting aspect is the occurrence of a “divided self”: one part watches and the other part dreams. Furthermore, the watching self can influence dream continuation and command changes in dream content [66]. Previous electrophysiological (EEG) and functional magnetic resonance imaging (fMRI) studies showed that lucid dreaming is related to increased phase synchrony and increased gamma frequency activity at around 40 Hz in fronto-temporal brain regions [67-69]. A recent transcranial mag-

netic brain stimulation (TMS) study by Voss *et al.* [70] proved that fronto-temporal current stimulation in the lower gamma band at around 25 and 40 Hz during REMS induced lucid dreaming. Given that 40 Hz power has been correlated with waking consciousness, this indicates that lucid dreaming is a “hybrid state” of both wakefulness and REMS [69]. Interestingly, it has been found that the precuneus, a brain region related to perspective taking, agency, and visual awareness, showed the strongest increase in activation during lucid compared to non-lucid REMS, consistent with the exceptional brightness, visual clarity, and intensity of colors of lucid dream sceneries [68]. Taken together, there is consistent evidence that lucid dreaming is related to increased activation in prefrontal, temporal, and parietal cortical regions, and increased cortical activity in the gamma frequency range – both of which are absent in REMS dreaming and which need to be restored in order to become lucid [26].

In the waking state, nondual awareness<sup>2</sup> refers to an empty mind with no phenomenological content, where there is no affect and cognition, and where any sense of physical boundaries and separateness between self and other is dissolved [72]. At a neurophysiological level, nondual awareness has been related to decreased anti-correlation between activity in extrinsic and intrinsic networks of the brain, which are mediating attention to the external environment and internal states, respectively [73]. Nondual awareness, or “dream witnessing” [74] may also occur during dreaming and even during deep sleep, but not as an inherent property of sleep, but rather as a consequence of longstanding meditative practice and habituation which is transferred from the waking state into the sleep and dreaming state.

### 3. PSYCHEDELICS

#### 3.1. Perception and Mental Imagery

Classical psychedelics<sup>3</sup> are a unique class of psychoactive drugs whose most distinguishing feature is the “capacity reliably to induce states of altered perception, thought, and feeling that are not experienced otherwise except in dreams or at times of religious exaltation” [75]. Psychedelic-induced states are characterized by enhanced perceptual sensitivity to external and internal stimuli [76]. At a neurophysiological level, it has been shown [77, 78] that psychedelics disrupt information processing in inhibitory cortico-striato-thalamocortical (CSTC) feedback loops that have been implicated in sensory gating of internal and external information to the cortex. This psychedelic-induced disinhibition leads to an inability to filter, inhibit, and screen out exteroceptive and interoceptive stimuli, which in turn leads to bot-

<sup>2</sup>The expressions “samadhi” (Sanskrit), “satori” (Japanese), “dzogchen” (Tibetan), “emptiness”, “nothingness”, “beingness”, “suchness”, “mental silence”, “void”, “formless”, “oneness”, “pure consciousness”, “cosmic consciousness”, “unity”, “absolute unitary being”, “the gap”, and “witnessing” are used as synonyms [71].

<sup>3</sup>The psychoactive effects of classical, or serotonergic psychedelics are commonly mediated *via* activation of central serotonin 2A (5HT<sub>2A</sub>) receptors [7]; classical psychedelics include the indoleamines such as dimethyltryptamine (DMT), psilocybin (4-phosphoryloxy-DMT), and lysergic acid diethylamide (LSD); and the phenylalkylamines such as mescaline and 2,5-dimethoxy-4-iodoamphetamine (DOI) [8].

tom-up sensory overload of higher-level cortical regions and the formation of hallucinations [76]. There is also evidence [79, 80] that psychedelics lead to visual hallucinations *via* serotonergic receptor activation in visual cortical regions, leading to a processing mode in which stimulus-driven cortical excitation is disrupted by stimulus-independent (“spontaneous”) neuronal excitation through modulation of alpha oscillations. Furthermore, de Araujo *et al.* [81] recently investigated the neuronal mechanisms underlying psychedelic-induced visual mental imagery using functional magnetic resonance imaging (fMRI). They first asked subjects to passively view images of people, animals, or trees (perception condition). Then, they asked participants to close their eyes and voluntarily generate a picture they had just seen before (mental imagery condition). The authors found that ayahuasca significantly increased activation in the mental imagery condition within an extended mental imagery network, including early visual areas (BA 17, 18, 19), parahippocampal gyrus, middle temporal cortex, and frontal cortex (BA10). Most importantly, they showed that for ayahuasca, activation in primary visual cortex during mental imagery was comparable to the activation during perception, indicating that ayahuasca enhances the intensity of voluntary imagery to the same level of a perceived image, lending a status of reality to inner experiences. They also showed that ayahuasca-induced changes in primary visual cortex (BA17) were preceding and leading the activation patterns in higher-level areas, indicating that ayahuasca-induced imagery is initiated in BA17, but then complemented by activity of higher-level cortical areas involved with episodic memory retrieval and the processing of contextual associations, such as BA30 and BA37, which might feed memory-related content back to primary visual areas. A recent fMRI-study by Carhart-Harris *et al.* [79] using LSD supports the notion that psychedelic-induced hallucinations are closely related to activity in primary visual cortex.

However, contrary to the notion that psychedelic-induced visual hallucinations are caused by bottom-up driven neuronal activity, there is substantial evidence that psychedelics induce visual hallucinations primarily *via* neuronal activation of prefrontal cortical or temporal areas as well as top-down spreading of activation to parietal and primary visual regions – a mechanism that is also underlying visual mental imagery [82–84]: 1. classic psychedelics produce their effects primarily *via* activation of postsynaptic cortical serotonin 2A (5-HT<sub>2A</sub>) receptors on pyramidal neurons in layer V of the prefrontal cortex (PFC), leading to glutamate-dependent downstream activity changes [85]; 2. visual hallucinations may be caused by neuronal stimulation of PFC [86] or temporal lobe [37, 87], and spreading activation to primary visual cortex; and 3. psychedelic hallucinations are related to increased functional connectivity between PFC and primary visual cortex [79], indicating that psychedelic hallucinations substantially depend on PFC regions, and not solely on primary visual regions. A third explanatory model for psychedelic hallucinations would be a mixed bottom-up/top-down model, where visual noise is fed into higher-level areas, which then interpret and make sense of the noise [88]. Basically, this is similar with a projective test, such as the Rorschach [89], but instead of using external ambiguous stimuli, this mechanism interprets internally-generated visual noise.

This notion is supported by evidence that a substantial proportion of psychedelic hallucinations are bottom-up driven, elementary hallucinations, *i.e.*, simple geometric forms, colors, and wave-like or contracting visual distortions (Klüver’s form constants) related to activation in primary visual cortex; and by behavioral studies on the other hand which indicate that psychedelic imagery is strongly influenced by higher-level regions in the brain, given that psychedelic imagery is highly structured, thematically elaborated, and strongly determined by personality aspects [90, 91]. In future neuroimaging studies investigating the neural mechanisms underlying psychedelic-induced hallucinations, top-down versus bottom-up connectivity changes should be specifically analyzed, for example by using dynamic causal modelling approaches or by concurrent electrical cortical stimulation.

### 3.2. Emotion Activation and Fear Memory Extinction

Consistent evidence indicates that psychedelics intensify and broaden emotional experiencing, both in terms of emotional memories and affective state [92]. These emotional changes often determine course and content of psychedelic percepts and imagery [93]. Although elevated mood states and pleasant feelings are most frequent [94–96], anxiety reactions may occur, especially at higher doses when normal cognitive frames of reference are diminished (“dread of ego dissolution”) [95]. There is consistent evidence [97–102] that psychedelics modulate neural processes related to anxiety and threat, especially in brain regions which are relevant for conditioned fear memory, such as amygdala, hippocampus, and ACC. Moreover, there is accumulating evidence from animal studies [103–105] indicating that psychedelics may facilitate extinction of conditioned fear memory by enhancing BDNF-dependent neuroplasticity. Importantly, it has been found that psychedelics also enhance associative learning and memory consolidation [103, 106]. Therefore, psychedelic-induced retrieval of emotional memories, especially contextual information related to fear and anxiety (CS, conditioned stimulus, *e.g.*, a traumatic memory), might facilitate fear extinction *via* effects on memory modulation and re-consolidation if there is no reinforcement by the unconditioned stimulus (US, *e.g.* aggressor). Therefore, it is conceivable that psychedelics might facilitate conditioned fear extinction if the conditioned fear memory is retrieved (*e.g.*, *via* exposure to relevant stimuli), and if the psychedelic-experience during and after this fear exposure is modified and re-consolidated by positive, self-protective information within a trustful interpersonal context.

### 3.3. Cognition

Psychedelics dose-dependently impair vigilance and induce cognitive dysfunctions, including reduced attentional performance, increased distractibility, and reduced spatial working memory [107–112]. Despite these cognitive deficits, evidence from animal and human studies indicates that psychedelics may enhance cognition, including associative reasoning [113, 114], thinking in metaphors and symbols [115], and creative problem solving [116, 117]. At a neurophysiological level, it has been found that psychedelic-induced decreases of DLPFC oscillatory activity [118], as well as changes in functional connectivity between regions in frontal

cortex [119], might explain the psychedelics-induced changes in cognitive style, including reduced reality testing and increased lateral thinking [120]. A recent psychopharmacological study by Kraehenmann *et al.* [121] tested the hypothesis that LSD produces dreamlike waking imagery. The authors used a guided mental imagery task and quantified cognitive bizarreness of guided mental imagery reports as a standardized formal measure of dream mentation. It was found that LSD, compared with placebo, significantly increased cognitive bizarreness. The LSD-induced increase in cognitive bizarreness was positively correlated with the LSD-induced loss of self-boundaries and cognitive control.

### 3.4. Sense of Self and Body

Psychedelics induce a broad range of alterations in the sense of self, including loss of self and body boundaries, self-control, and volition which are similar to depersonalization, a psychotic-like psychosomatic syndrome [121, 122]. Alterations in body feelings are closely related to self-changes, and are very frequent in psychedelic states. They range from numbness and paresthesia in body parts to feelings of separation from the body, feelings of the unreality of the body or its parts, and body distortions or variations in size, including feelings of denial or estrangement: “*in one subject the depersonalization proceeded to a degree where*

*his body was projected as an influencing machine which made him see pictures (hallucinations) and controlled his thoughts, feelings, and actions*” [123]. Psychedelic-induced changes in the sense of self and body are frequently paired with changes in perception and imagery [93, 122]. Savage describes this for some of his patients during LSD treatment: “*the boundary between his perceptions and his inner feelings is lost, and the distortions which he sees in the faces of other people can sometimes be traced back to the projection of his own self-image. One patient saw other patients as small, flat, yellow, wherein he reveals his feelings about himself. Another saw the nurse as a kind faced and concerned, wherein he projected his need for her concern*” [123].

The psychedelic-induced shift from a self-centered perspective to a selflessness-perspective often facilitates a state of nondual awareness, or unity of consciousness, where the individual, or narrative self is shifted towards the pre-reflective experience of the self (minimal self). This may generate a transpersonal self-perspective, including feelings of connectedness with people and environment, positive affective state, and reduced helplessness or anxiety when confronted with challenging memories or fantasies [100, 124, 125]. This state of self has also been described as self-transcendence, where past experiences and present conflicts

**Table 1. Neurophenomenological comparison between dreaming and psychedelic states.**

| Category                                        | Dreaming                                     | Psychedelic State              |
|-------------------------------------------------|----------------------------------------------|--------------------------------|
| Vigilance <sup>a</sup>                          | ↓ sleep                                      | ↓ drowsiness                   |
| Perception <sup>b</sup>                         | ↓ disconnection from environment             | ↑ eyes open                    |
| Mental imagery <sup>c</sup>                     | ∅ simple <sup>h</sup><br>↑ complex           | ↑ eyes closed<br>↑ eyes closed |
| Emotion activation                              | ↑                                            | ↑                              |
| Conditioned fear memory extinction <sup>d</sup> | ↑<br>↓ recurring night-mares                 | ↑<br>↓ horror trips            |
| Cognition                                       | ↑ bizarreness<br>↑ creativity                | ↑ bizarreness<br>↑ creativity  |
| Self and body boundaries <sup>e</sup>           | ↓ REMS <sup>i</sup> dreams<br>↑ lucid dreams | ↓                              |
| Clear consciousness <sup>f</sup>                | ∅ REMS dreams<br>↑ lucid dreams              | ↑                              |
| Unity of consciousness <sup>g</sup>             | ∅ REMS dreams<br>↑ lucid dreams              | ↑                              |

<sup>a</sup>Arousal level on the sleep-wake spectrum.

<sup>b</sup>Sensory (*e.g.* visual) experience caused by sensory (*e.g.*, visual) stimulation.

<sup>c</sup>Sensory (*e.g.* visual) experience in the absence of sensory (*e.g.*, visual) stimulation.

<sup>d</sup>Decline in conditioned fear response following nonreinforced exposure to a feared conditioned stimulus.

<sup>e</sup>Boundary between self-representation and object-representation.

<sup>f</sup>Meta-awareness of current state of consciousness.

<sup>g</sup>Nondual awareness following complete loss of self boundaries.

<sup>h</sup>Exception: hypnagogic imagery in the transitional state from wakefulness to sleep; and hypnopompic imagery in the state leading out of sleep.

<sup>i</sup>Rapid eye movement sleep, or paradoxical sleep.

↑, increase; ↓, decrease; ∅, minimal or no change.

are seen with lucid awareness and without distortion coming from biological or social conditioning [126].

## 4. DISCUSSION

### 4.1. Similarities and Differences Between Dreams and Psychedelic States

The comparison of dreams with psychedelic states shows that both consciousness states share some similarities (Table 1). First, they are characterized by vivid imaginary experiences which predominantly involve the visual domain. Although the underlying neurobiological mechanisms are yet unclear, there is evidence that visual experiences in these states share some features of bottom-up perception and top-down mental imagery. Second, both states activate emotional memories and affects, mostly in the direction of elevated mood states, and frequently paired with retrieval of fear memory. Imaginary exposure to fear-conditioned memory may be a crucial function in both states. Third, cognition in dreams and psychedelic states may both decrease logical and increase associative reasoning, similar with creative thinking [121, 127-130]. This may be related to deactivations in prefrontal control regions such as DLPFC. And fourth, changes in the sense of self occur in both states [121, 131], leading to depersonalization, loss of self and body boundaries, and nondual awareness. The similarities between psychedelic states and dreaming are summarized by Grinspoon and Bakalar [132]: *“There are good reasons for applying the term ‘oneirogenic,’ producing dreams, to psychedelic drugs. In its imagery, emotional tone, and vagaries of thought and self-awareness, the drug trip, especially with eyes closed, resembles no other state so much as a dream”*.

There are also some differences between these two states (Table 1). First, elementary percepts such as geometric forms and abstract movements - which frequently occur in psychedelic states - only rarely occur in normal REMS dreams, but do occur in lucid dreams [133]. This is supported by recent evidence indicating that psychedelics strongly activate primary visual regions, correlating with psychedelic imagery [79, 81]. Second, although both states enhance mental imagery, there are at least gradual differences between psychedelic states where external stimuli from the body and the outside world are still influencing conscious experience (especially during eyes-open conditions), and dreams, where consciousness is decoupled from the environment, generating intrinsic simulations of the world and the body-self [19]. And third, typical REMS dreams are “single-minded” [59] and lack meta-cognition, whereas lucid dreams and psychedelic states are characterized by “clear consciousness” [121], which means a very nuanced, emotional and intellectual clarity of mind, as well as remembrance and reflection of current and past circumstances and relationships [12].

Taken together, although both dreams and psychedelic states share a common phenomenological and neurobiological basis, there are also some differences between them, which are mainly due to greater perceptual influences from the external environment, clarity of consciousness and meta-cognitive abilities in psychedelic states compared to REMS.

Lucid dreams, however, show a comparable degree of perceptual clarity and meta-cognitive capacity. Therefore, both psychedelic states and lucid dreams may be conceptualized as hybrid states of consciousness [69, 121], sharing features of both dreaming and waking consciousness.

### 4.2. Therapeutic Implications

Given that psychedelic states share many characteristics with lucid dreaming, it is highly probable that positive effects of dreaming on psychosocial functioning and well-being may also apply for psychedelics. Most importantly, there is accumulating evidence that our self is not sleeping during dreams, but on the contrary that dreams intensify self-relevant processes by virtue of their ability to induce self-relevant, virtual reality “play-grounds” [134]. Importantly, dreams are, per definition, subjective experiences, and there are strong indications [19, 66, 121, 134, 135] that subjective experiences in dreams and psychedelic states are not just “epiphenomena” of neuronal wiring, but are key to promote self-knowledge and ensuing therapeutic change.

The notion that psychedelic-induced self-relevant experiences are relevant to the therapeutic effects of psychedelics is explained by Soskin [136]: *“LSD appeared to be of primary value in enabling the patient to transcend the network of learned social judgments that had previously constituted his sense of selfhood. In so doing, he established contact with his real self, defined by Horney as ‘that central inner force, common to all human beings and yet unique in each, which is the deep source of growth’. Too often, we assume that what is repressed consists of negative or antisocial tendencies. Yet the more important insights developed by the patient involved corrections of the distortions in his self-image, affirmation of his basic self-worth, and awareness of his previously unrecognized resources for growth and fulfilment”*.

Finally, some precaution and safety aspects [137] should be taken into account when applying psychedelics to both healthy subjects and patients, given that psychedelics are potent modulators of consciousness states, and given that previous history (e.g., Timothy Leary) [138] has shown that the self-enhancing effects of psychedelics might also have adverse long-term effects if not provided within a supervised professional setting. An intriguing early approach to enhance safety and therapeutic efficacy had been the combination of psychedelics with imaginative psychotherapy by Hanscarl Leuner [93] and others [139-141]. The rationale behind this approach was that psychedelics are not pharmacotherapeutic “medications” per se, but rather tools to enhance psychotherapeutic processes *via* introspective experiences. This therapeutic approach was termed “psycholytic therapy”, indicating that psychedelics facilitate access to self-relevant processes by reducing cognitive control (“defense mechanisms”, in psychodynamic terms) and enhancing mental imagery. Interestingly, it has been shown that some imagery-based psychotherapeutic interventions, such as guided affective imagery (GAI) may also induce dreamlike states, even in the absence of the imagery-enhancing effects of psychedelics [142].

## CONCLUSION

The broad overlap between dreaming and psychedelic states supports the notion that psychedelics acutely induce dreamlike subjective experiences which may have long-term beneficial effects on psychosocial functioning and well-being [121]. The potential therapeutic effect of psychedelics is supported by recent clinical studies of psilocybin [143-145], LSD [146], and ayahuasca [147] treatment in depression and anxiety. Future clinical studies should examine how therapeutic outcome is related to the acute dreamlike effects of psychedelics. It is plausible to assume that the lucid dreaming mindset may enhance core processes of psychotherapy such as self-understanding and psychological insight, and may therefore facilitate psychological change – a prerequisite of symptom reduction and behavioural adaptation.

## CONSENT FOR PUBLICATION

Not applicable.

## CONFLICT OF INTEREST

The author declares that the work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## ACKNOWLEDGEMENTS

This work was presented at the First Global Psychedelic Forum “Beyond Psychedelics” in Prague, Czech Republic, 30.09.-02.10.2016 (<http://beyondpsychedelics.cz>).

## REFERENCES

- Miller, A.I. *Imagery in scientific thought*; MIT Press: Cambridge, Massachusetts, **1986**.
- Noll, R.; Achterberg, J.; Bourguignon, E.; George, L.; Harner, M.; Honko, L.; Hultkrantz, Å.; Krippner, S.; Kiefer, C.W.; Preston, R.J.; Siikala, A.-L.; Vázquez, I.S.; Lex, B.W.; Winkelman, M. Mental imagery cultivation as a cultural phenomenon: the role of visions in shamanism. *Curr. Anthropol.*, **1985**, *26*, 443-461. [<http://dx.doi.org/10.1086/203305>]
- Metzner, R. Hallucinogenic drugs and plants in psychotherapy and shamanism. *J. Psychoactive Drugs*, **1998**, *30*(4), 333-341. [<http://dx.doi.org/10.1080/02791072.1998.10399709>] [PMID: 9924839]
- Shepard, G.H., Jr. Psychoactive plants and ethnopsychiatric medicines of the Matsigenka. *J. Psychoactive Drugs*, **1998**, *30*(4), 321-332. [<http://dx.doi.org/10.1080/02791072.1998.10399708>] [PMID: 9924838]
- Luna, L.E. The healing practices of a Peruvian shaman. *J. Ethnopharmacol.*, **1984**, *11*(2), 123-133. [[http://dx.doi.org/10.1016/0378-8741\(84\)90035-7](http://dx.doi.org/10.1016/0378-8741(84)90035-7)] [PMID: 6387284]
- Luna, L.E. The concept of plants as teachers among four mestizo shamans of Iquitos, northeastern Peru. *J. Ethnopharmacol.*, **1984**, *11*(2), 135-156. [[http://dx.doi.org/10.1016/0378-8741\(84\)90036-9](http://dx.doi.org/10.1016/0378-8741(84)90036-9)] [PMID: 6492831]
- Nichols, D.E. Psychedelics. *Pharmacol. Rev.*, **2016**, *68*(2), 264-355. [<http://dx.doi.org/10.1124/pr.115.011478>] [PMID: 26841800]
- Halberstadt, A.L. Recent advances in the neuropsychopharmacology of serotonergic hallucinogens. *Behav. Brain Res.*, **2015**, *277*, 99-120. [<http://dx.doi.org/10.1016/j.bbr.2014.07.016>] [PMID: 25036425]
- Fischman, L.G. Dreams, hallucinogenic drug states, and schizophrenia: a psychological and biological comparison. *Schizophr. Bull.*, **1983**, *9*(1), 73-94. [<http://dx.doi.org/10.1093/schbul/9.1.73>] [PMID: 6133348]
- Jacobs, B. Dreams and hallucinations: a common neurochemical mechanism mediating their phenomenological similarities. *Neurosci. Biobehav. Rev.*, **1978**, *2*, 59-69. [[http://dx.doi.org/10.1016/0149-7634\(78\)90007-6](http://dx.doi.org/10.1016/0149-7634(78)90007-6)]
- Fosse, R.; Stickgold, R.; Hobson, J.A. Brain-mind states: reciprocal variation in thoughts and hallucinations. *Psychol. Sci.*, **2001**, *12*(1), 30-36. [<http://dx.doi.org/10.1111/1467-9280.00306>] [PMID: 11294225]
- Friedrichs, H.; Passie, T. *Die Psychologie des Meskalinrausches*, VWB: Berlin.
- Pace-Schott, E.F. Serotonin and dreaming. In: *Serotonin and sleep: molecular, functional and clinical aspects*; Monti, J.M.; Pandi-Perumal, S.R.; Jacobs, B.L.; Nutt, D.J., Eds.; Birkhäuser Verlag: Basel, **2008**; pp. 307-324. [[http://dx.doi.org/10.1007/978-3-7643-8561-3\\_12](http://dx.doi.org/10.1007/978-3-7643-8561-3_12)]
- McGinty, D.J.; Harper, R.M. Dorsal raphe neurons: depression of firing during sleep in cats. *Brain Res.*, **1976**, *101*(3), 569-575. [[http://dx.doi.org/10.1016/0006-8993\(76\)90480-7](http://dx.doi.org/10.1016/0006-8993(76)90480-7)] [PMID: 1244990]
- Torda, C. Contribution to serotonin theory of dreaming (LSD infusion). *N. Y. State J. Med.*, **1968**, *68*(9), 1135-1138. [PMID: 5239970]
- Muzio, J.N.; Roffwarg, H.P.; Kaufman, E. Alterations in the nocturnal sleep cycle resulting from LSD. *Electroencephalogr. Clin. Neurophysiol.*, **1966**, *21*(4), 313-324. [[http://dx.doi.org/10.1016/0013-4694\(66\)90037-X](http://dx.doi.org/10.1016/0013-4694(66)90037-X)] [PMID: 4162426]
- Green, W.J. The effect of LSD on the sleep-dream cycle. An exploratory study. *J. Nerv. Ment. Dis.*, **1965**, *140*(6), 417-426. [<http://dx.doi.org/10.1097/00005053-196506000-00004>] [PMID: 5827242]
- Manford, M.; Andermann, F. Complex visual hallucinations. Clinical and neurobiological insights. *Brain*, **1998**, *121*(Pt 10), 1819-1840. [<http://dx.doi.org/10.1093/brain/121.10.1819>] [PMID: 9798740]
- Nir, Y.; Tononi, G. Dreaming and the brain: from phenomenology to neurophysiology. *Trends Cogn. Sci. (Regul. Ed.)*, **2010**, *14*(2), 88-100. [<http://dx.doi.org/10.1016/j.tics.2009.12.001>] [PMID: 20079677]
- Foulkes, D.; Domhoff, G.W. Bottom-up or top-down in dream neuroscience? A top-down critique of two bottom-up studies. *Conscious. Cogn.*, **2014**, *27*, 168-171. [<http://dx.doi.org/10.1016/j.concog.2014.05.002>] [PMID: 24905546]
- Cichy, R.M.; Heinze, J.; Haynes, J.D. Imagery and perception share cortical representations of content and location. *Cereb. Cortex*, **2012**, *22*(2), 372-380. [<http://dx.doi.org/10.1093/cercor/bhr106>] [PMID: 21666128]
- Hobson, J.A.; Pace-Schott, E.F. The cognitive neuroscience of sleep: neuronal systems, consciousness and learning. *Nat. Rev. Neurosci.*, **2002**, *3*(9), 679-693. [<http://dx.doi.org/10.1038/nrn915>] [PMID: 12209117]
- Domhoff, G. A new neurocognitive theory of dreams. *Dreaming*, **2001**, *11*, 13-33. [<http://dx.doi.org/10.1023/A:1009464416649>]
- Domhoff, G.W.; Fox, K.C. Dreaming and the default network: A review, synthesis, and counterintuitive research proposal. *Conscious. Cogn.*, **2015**, *33*, 342-353. [<http://dx.doi.org/10.1016/j.concog.2015.01.019>] [PMID: 25723600]
- Fox, K.C.; Nijboer, S.; Solomonova, E.; Domhoff, G.W.; Christoff, K. Dreaming as mind wandering: evidence from functional neuroimaging and first-person content reports. *Front. Hum. Neurosci.*, **2013**, *7*, 412. [<http://dx.doi.org/10.3389/fnhum.2013.00412>] [PMID: 23908622]
- Hobson, J.A. REM sleep and dreaming: towards a theory of protoconsciousness. *Nat. Rev. Neurosci.*, **2009**, *10*(11), 803-813. [PMID: 19794431]
- Berger, C.C.; Ehrsson, H.H. The fusion of mental imagery and sensation in the temporal association cortex. *J. Neurosci.*, **2014**, *34*(41), 13684-13692. [<http://dx.doi.org/10.1523/JNEUROSCI.0943-14.2014>] [PMID: 25297095]
- Horikawa, T.; Tamaki, M.; Miyawaki, Y.; Kamitani, Y. Neural decoding of visual imagery during sleep. *Science*, **2013**, *340*(6132), 639-642. [<http://dx.doi.org/10.1126/science.1234330>] [PMID: 23558170]
- Solms, M. Dreaming and REM sleep are controlled by different brain mechanisms. *Behav. Brain Sci.*, **2000**, *23*(6), 843-850. [<http://dx.doi.org/10.1017/S0140525X00003988>] [PMID: 11515144]
- Kerr, N.H.; Foulkes, D. Right hemispheric mediation of dream visualization: a case study. *Cortex*, **1981**, *17*(4), 603-609. [[http://dx.doi.org/10.1016/S0010-9452\(81\)80066-4](http://dx.doi.org/10.1016/S0010-9452(81)80066-4)] [PMID: 7344824]
- Desseilles, M.; Dang-Vu, T.T.; Sterpenich, V.; Schwartz, S. Cognitive and emotional processes during dreaming: a neuroimaging

- view. *Conscious. Cogn.*, **2011**, 20(4), 998-1008. [http://dx.doi.org/10.1016/j.concog.2010.10.005] [PMID: 21075010]
- [32] Smith, M.R.; Antrobus, J.S.; Gordon, E.; Tucker, M.A.; Hirota, Y.; Wamsley, E.J.; Ross, L.; Doan, T.; Chaklader, A.; Emery, R.N. Motivation and affect in REM sleep and the mentation reporting process. *Conscious. Cogn.*, **2004**, 13(3), 501-511. [http://dx.doi.org/10.1016/j.concog.2004.03.002] [PMID: 15336244]
- [33] Revonsuo, A. The reinterpretation of dreams: an evolutionary hypothesis of the function of dreaming. *Behav. Brain Sci.*, **2000**, 23(6), 877-901. [http://dx.doi.org/10.1017/S0140525X00004015] [PMID: 11515147]
- [34] Nielsen, T.; Levin, R. Nightmares: a new neurocognitive model. *Sleep Med. Rev.*, **2007**, 11(4), 295-310. [http://dx.doi.org/10.1016/j.smrv.2007.03.004] [PMID: 17498981]
- [35] Valli, K.; Revonsuo, A. The threat simulation theory in light of recent empirical evidence: a review. *Am. J. Psychol.*, **2009**, 122(1), 17-38. [PMID: 19353929]
- [36] Braun, A.R.; Balkin, T.J.; Wesenten, N.J.; Carson, R.E.; Varga, M.; Baldwin, P.; Selbie, S.; Belenky, G.; Herscovitch, P. Regional cerebral blood flow throughout the sleep-wake cycle. An H2(15)O PET study. *Brain*, **1997**, 120(Pt 7), 1173-1197. [http://dx.doi.org/10.1093/brain/120.7.1173] [PMID: 9236630]
- [37] Mégevand, P.; Groppe, D.M.; Goldfinger, M.S.; Hwang, S.T.; Kingsley, P.B.; Davidesco, I.; Mehta, A.D. Seeing scenes: topographic visual hallucinations evoked by direct electrical stimulation of the parahippocampal place area. *J. Neurosci.*, **2014**, 34(16), 5399-5405. [http://dx.doi.org/10.1523/JNEUROSCI.5202-13.2014] [PMID: 24741031]
- [38] Hartley, C.A.; Phelps, E.A. Changing fear: the neurocircuitry of emotion regulation. *Neuropsychopharmacology*, **2010**, 35(1), 136-146. [http://dx.doi.org/10.1038/npp.2009.121] [PMID: 19710632]
- [39] Levin, R.; Nielsen, T. Nightmares, bad dreams, and emotion dysregulation. *Curr. Dir. Psychol. Sci.*, **2009**, 18, 84-88. [http://dx.doi.org/10.1111/j.1467-8721.2009.01614.x]
- [40] Rolls, A.; Makam, M.; Kroeger, D.; Colas, D.; de Lecea, L.; Heller, H.C. Sleep to forget: interference of fear memories during sleep. *Mol. Psychiatry*, **2013**, 18(11), 1166-1170. [http://dx.doi.org/10.1038/mp.2013.121] [PMID: 24081009]
- [41] Monfils, M.-H.; Cowansage, K.K.; Klann, E.; LeDoux, J.E. Extinction-reconsolidation boundaries: key to persistent attenuation of fear memories. *Science*, **2009**, 324(5929), 951-955. [http://dx.doi.org/10.1126/science.1167975] [PMID: 19342552]
- [42] Schiller, D.; Monfils, M.H.; Raio, C.M.; Johnson, D.C.; LeDoux, J.E.; Phelps, E.A. Preventing the return of fear in humans using reconsolidation update mechanisms. *Nature*, **2010**, 463(7277), 49-53. [http://dx.doi.org/10.1038/nature08637] [PMID: 20010606]
- [43] Nader, K.; Schafe, G.E.; LeDoux, J.E. Fear memories require protein synthesis in the amygdala for reconsolidation after retrieval. *Nature*, **2000**, 406(6797), 722-726. [http://dx.doi.org/10.1038/35021052] [PMID: 10963596]
- [44] Scarone, S.; Manzone, M.L.; Gambini, O.; Kantzas, I.; Limosani, I.; D'Agostino, A.; Hobson, J.A. The dream as a model for psychosis: an experimental approach using bizarreness as a cognitive marker. *Schizophr. Bull.*, **2008**, 34(3), 515-522. [http://dx.doi.org/10.1093/schbul/sbm116] [PMID: 17942480]
- [45] Williams, J.; Merritt, J.; Rittenhouse, C.; Hobson, J.A. Bizarreness in dreams and fantasies. *Conscious. Cogn.*, **1992**, 1, 172-185. [http://dx.doi.org/10.1016/1053-8100(92)90059-J]
- [46] Mamelak, A.N.; Hobson, J.A. Dream bizarreness as the cognitive correlate of altered neuronal behavior in REM sleep. *J. Cogn. Neurosci.*, **1989**, 1(3), 201-222. [http://dx.doi.org/10.1162/jocn.1989.1.3.201] [PMID: 23968505]
- [47] Rudorf, S.; Hare, T.A. Interactions between dorsolateral and ventromedial prefrontal cortex underlie context-dependent stimulus valuation in goal-directed choice. *J. Neurosci.*, **2014**, 34(48), 15988-15996. [http://dx.doi.org/10.1523/JNEUROSCI.3192-14.2014] [PMID: 25429140]
- [48] Castro, S.; Falconi, A.; Chase, M.H.; Tortorolo, P. Coherent neocortical 40-Hz oscillations are not present during REM sleep. *Eur. J. Neurosci.*, **2013**, 37(8), 1330-1339. [http://dx.doi.org/10.1111/ejn.12143] [PMID: 23406153]
- [49] Walker, M.P.; Stickgold, R. Overnight alchemy: sleep-dependent memory evolution. *Nat. Rev. Neurosci.*, **2010**, 11(3), 218. [http://dx.doi.org/10.1038/nrn2762-c1] [PMID: 20168316]
- [50] Llewellyn, S. Dream to predict? REM dreaming as prospective coding. *Front. Psychol.*, **2016**, 6, 1961. [http://dx.doi.org/10.3389/fpsyg.2015.01961] [PMID: 26779078]
- [51] Ritter, S.M.; van Baaren, R.B.; Dijksterhuis, A. Creativity: the role of unconscious processes in idea generation and idea selection. *Think. Skills Creativity*, **2011**.
- [52] Stickgold, R.; Hobson, J.A.; Fosse, R.; Fosse, M. Sleep, learning, and dreams: off-line memory reprocessing. *Science*, **2001**, 294(5544), 1052-1057. [http://dx.doi.org/10.1126/science.1063530] [PMID: 11691983]
- [53] Rittenhouse, C.D.; Stickgold, R.; Hobson, J.A. Constraint on the transformation of characters, objects, and settings in dream reports. *Conscious. Cogn.*, **1994**, 3, 100-113. [http://dx.doi.org/10.1006/ccog.1994.1007]
- [54] Mednick, S.A. The associative basis of the creative process. *Psychol. Rev.*, **1962**, 69, 220-232. [http://dx.doi.org/10.1037/h0048850] [PMID: 14472013]
- [55] Walker, M.P.; Liston, C.; Hobson, J.A.; Stickgold, R. Cognitive flexibility across the sleep-wake cycle: REM-sleep enhancement of anagram problem solving. *Brain Res. Cogn. Brain Res.*, **2002**, 14(3), 317-324. [http://dx.doi.org/10.1016/S0926-6410(02)00134-9] [PMID: 12421655]
- [56] Cai, D.J.; Mednick, S.A.; Harrison, E.M.; Kanady, J.C.; Mednick, S.C. REM, not incubation, improves creativity by priming associative networks. *Proc. Natl. Acad. Sci. USA*, **2009**, 106(25), 10130-10134. [http://dx.doi.org/10.1073/pnas.0900271106] [PMID: 19506253]
- [57] Stickgold, R.; Scott, L.; Rittenhouse, C.; Hobson, J.A. Sleep-induced changes in associative memory. *J. Cogn. Neurosci.*, **1999**, 11(2), 182-193. [http://dx.doi.org/10.1162/089892999563319] [PMID: 10198133]
- [58] Wagner, U.; Gais, S.; Haider, H.; Verleger, R.; Born, J. Sleep inspires insight. *Nature*, **2004**, 427(6972), 352-355. [http://dx.doi.org/10.1038/nature02223] [PMID: 14737168]
- [59] Rechtschaffen, A. The single-mindedness and isolation of dreams. *Sleep*, **1978**, 1(1), 97-109. [http://dx.doi.org/10.1093/sleep/1.1.97] [PMID: 227026]
- [60] Cicogna, P.C.; Bosinelli, M. Consciousness during dreams. *Conscious. Cogn.*, **2001**, 10(1), 26-41. [http://dx.doi.org/10.1006/ccog.2000.0471] [PMID: 11273624]
- [61] Windt, J. The immersive spatiotemporal hallucination model of dreaming. *Phenomenol. Cogn. Sci.*, **2010**, 9, 295-316. [http://dx.doi.org/10.1007/s11097-010-9163-1]
- [62] Lundstrom, B.N.; Petersson, K.M.; Andersson, J.; Johansson, M.; Fransson, P.; Ingvar, M. Isolating the retrieval of imagined pictures during episodic memory: activation of the left precuneus and left prefrontal cortex. *Neuroimage*, **2003**, 20(4), 1934-1943. [http://dx.doi.org/10.1016/j.neuroimage.2003.07.017] [PMID: 14683699]
- [63] Koppehele-Gossel, J.; Klimke, A.; Schermelleh-Engel, K.; Voss, U. A template model of embodiment while dreaming: Proposal of a mini-me. *Conscious. Cogn.*, **2016**, 46, 148-162. [http://dx.doi.org/10.1016/j.concog.2016.09.021] [PMID: 27718407]
- [64] Voss, U.; Schermelleh-Engel, K.; Windt, J.; Frenzel, C.; Hobson, A. Measuring consciousness in dreams: the lucidity and consciousness in dreams scale. *Conscious. Cogn.*, **2013**, 22(1), 8-21. [http://dx.doi.org/10.1016/j.concog.2012.11.001] [PMID: 23220345]
- [65] Filevich, E.; Dresler, M.; Brick, T.R.; Kühn, S. Metacognitive mechanisms underlying lucid dreaming. *J. Neurosci.*, **2015**, 35(3), 1082-1088. [http://dx.doi.org/10.1523/JNEUROSCI.3342-14.2015] [PMID: 25609624]
- [66] Hobson, J.A.; Hong, C.C.; Friston, K.J. Virtual reality and consciousness inference in dreaming. *Front. Psychol.*, **2014**, 5, 1133. [http://dx.doi.org/10.3389/fpsyg.2014.01133] [PMID: 25346710]
- [67] Dresler, M.; Eibl, L.; Fischer, C.F.; Wehrle, R.; Spoormaker, V.I.; Steiger, A.; Czisch, M.; Pawlowski, M. Volitional components of consciousness vary across wakefulness, dreaming and lucid dreaming. *Front. Psychol.*, **2014**, 4, 987. [http://dx.doi.org/10.3389/fpsyg.2013.00987] [PMID: 24427149]
- [68] Dresler, M.; Wehrle, R.; Spoormaker, V.I.; Koch, S.P.; Holsboer, F.; Steiger, A.; Obrig, H.; Sämann, P.G.; Czisch, M. Neural correlates of dream lucidity obtained from contrasting lucid versus non-lucid REM sleep: a combined EEG/fMRI case study. *Sleep*, **2012**, 35(7), 1017-1020. [http://dx.doi.org/10.5665/sleep.1974] [PMID: 22754049]
- [69] Voss, U.; Holzmann, R.; Tuin, I.; Hobson, J.A. Lucid dreaming: a state of consciousness with features of both waking and non-lucid

- dreaming. *Sleep*, **2009**, 32(9), 1191-1200. [http://dx.doi.org/10.1093/sleep/32.9.1191] [PMID: 19750924]
- [70] Voss, U.; Holzmann, R.; Hobson, A.; Paulus, W.; Koppehele-Gossel, J.; Klimke, A.; Nitsche, M.A. Induction of self awareness in dreams through frontal low current stimulation of gamma activity. *Nat. Neurosci.*, **2014**, 17(6), 810-812. [http://dx.doi.org/10.1038/nn.3719] [PMID: 24816141]
- [71] Nash, J.D.; Newberg, A. Toward a unifying taxonomy and definition for meditation. *Front. Psychol.*, **2013**, 4, 806. [http://dx.doi.org/10.3389/fpsyg.2013.00806] [PMID: 24312060]
- [72] Berman, A.E.; Stevens, L. EEG manifestations of nondual experiences in meditators. *Conscious. Cogn.*, **2015**, 31, 1-11. [http://dx.doi.org/10.1016/j.concog.2014.10.002] [PMID: 25460236]
- [73] Josipovic, Z.; Dinstein, I.; Weber, J.; Heeger, D.J. Influence of meditation on anti-correlated networks in the brain. *Front. Hum. Neurosci.*, **2012**, 5, 183. [http://dx.doi.org/10.3389/fnhum.2011.00183] [PMID: 22287947]
- [74] Mason, L.I.; Orme-Johnson, D. Transcendental consciousness wakes up in dreaming and deep sleep. *Int. J. Dream Res.*, **2010**, 3, 28-32.
- [75] Goodman, L.S. *Goodman and Gilman's the pharmacological basis of therapeutics*; McGraw-Hill: New York, **1996**.
- [76] Vollenweider, F.X.; Geyer, M.A. A systems model of altered consciousness: integrating natural and drug-induced psychoses. *Brain Res. Bull.*, **2001**, 56(5), 495-507. [http://dx.doi.org/10.1016/S0361-9230(01)00646-3] [PMID: 11750795]
- [77] Schmid, Y.; Enzler, F.; Gasser, P.; Grouzmann, E.; Preller, K.H.; Vollenweider, F.X.; Brenneisen, R.; Müller, F.; Borgwardt, S.; Liechti, M.E. Acute effects of lysergic acid diethylamide in healthy subjects. *Biol. Psychiatry*, **2015**, 78(8), 544-553. [http://dx.doi.org/10.1016/j.biopsych.2014.11.015] [PMID: 25575620]
- [78] Quednow, B.B.; Komater, M.; Geyer, M.A.; Vollenweider, F.X. Psilocybin-induced deficits in automatic and controlled inhibition are attenuated by ketanserin in healthy human volunteers. *Neuropsychopharmacology*, **2012**, 37(3), 630-640. [http://dx.doi.org/10.1038/npp.2011.228] [PMID: 21956447]
- [79] Carhart-Harris, R.L.; Muthukumaraswamy, S.; Roseman, L.; Kaelen, M.; Droog, W.; Murphy, K.; Tagliazucchi, E.; Schenberg, E.E.; Nest, T.; Orban, C.; Leech, R.; Williams, L.T.; Williams, T.M.; Bolstridge, M.; Sessa, B.; McGonigle, J.; Sereno, M.I.; Nichols, D.; Hellyer, P.J.; Hobden, P.; Evans, J.; Singh, K.D.; Wise, R.G.; Curran, H.V.; Feilding, A.; Nutt, D.J. Neural correlates of the LSD experience revealed by multimodal neuroimaging. *Proc. Natl. Acad. Sci. USA*, **2016**, 113(17), 4853-4858. [http://dx.doi.org/10.1073/pnas.1518377113] [PMID: 27071089]
- [80] Komater, M.; Schmidt, A.; Jäncke, L.; Vollenweider, F.X. Activation of serotonin 2A receptors underlies the psilocybin-induced effects on  $\alpha$  oscillations, N170 visual-evoked potentials, and visual hallucinations. *J. Neurosci.*, **2013**, 33(25), 10544-10551. [http://dx.doi.org/10.1523/JNEUROSCI.3007-12.2013] [PMID: 23785166]
- [81] de Araujo, D.B.; Ribeiro, S.; Cecchi, G.A.; Carvalho, F.M.; Sanchez, T.A.; Pinto, J.P.; de Martinis, B.S.; Crippa, J.A.; Hallak, J.E.; Santos, A.C. Seeing with the eyes shut: neural basis of enhanced imagery following Ayahuasca ingestion. *Hum. Brain Mapp.*, **2012**, 33(11), 2550-2560. [http://dx.doi.org/10.1002/hbm.21381] [PMID: 21922603]
- [82] Dentico, D.; Cheung, B.L.; Chang, J.-Y.; Guokas, J.; Boly, M.; Tononi, G.; Van Veen, B. Reversal of cortical information flow during visual imagery as compared to visual perception. *Neuroimage*, **2014**, 100, 237-243. [http://dx.doi.org/10.1016/j.neuroimage.2014.05.081] [PMID: 24910071]
- [83] Johnson, M.R.; Mitchell, K.J.; Raye, C.L.; D'Esposito, M.; Johnson, M.K. A brief thought can modulate activity in extrastriate visual areas: Top-down effects of refreshing just-seen visual stimuli. *Neuroimage*, **2007**, 37(1), 290-299. [http://dx.doi.org/10.1016/j.neuroimage.2007.05.017] [PMID: 17574442]
- [84] Mechelli, A.; Price, C.J.; Friston, K.J.; Ishai, A. Where bottom-up meets top-down: neuronal interactions during perception and imagery. *Cereb. Cortex*, **2004**, 14(11), 1256-1265. [http://dx.doi.org/10.1093/cercor/bbh087] [PMID: 15192010]
- [85] Vollenweider, F.X.; Komater, M. The neurobiology of psychedelic drugs: implications for the treatment of mood disorders. *Nat. Rev. Neurosci.*, **2010**, 11(9), 642-651. [http://dx.doi.org/10.1038/nrn2884] [PMID: 20717121]
- [86] Blanke, O.; Landis, T.; Seeck, M. Electrical cortical stimulation of the human prefrontal cortex evokes complex visual hallucinations. *Epilepsy Behav.*, **2000**, 1(5), 356-361. [http://dx.doi.org/10.1006/ebep.2000.0109] [PMID: 12609167]
- [87] Aminoff, E.M.; Li, Y.; Pyles, J.A.; Ward, M.J.; Richardson, R.M.; Ghuman, A.S. Associative hallucinations result from stimulating left ventromedial temporal cortex. *Cortex*, **2016**, 83, 139-144. [http://dx.doi.org/10.1016/j.cortex.2016.07.012] [PMID: 27533133]
- [88] Fischer, R. A cartography of the ecstatic and meditative states. *Science*, **1971**, 174(4012), 897-904. [http://dx.doi.org/10.1126/science.174.4012.897] [PMID: 5123809]
- [89] Rorschach, H. *Psychodiagnostik: Tafeln*; Hans Huber, Medizinischer Verlag: Bern, **1921**.
- [90] Fischer, R.; Kappeler, T.; Wisecup, P.; Thatcher, K. Personality trait dependent performance under psilocybin. *Dis. Nerv. Syst.*, **1970**, 31(2), 92-101. [PMID: 5438334]
- [91] Fischer, R.; Marks, P.A.; Hill, R.M.; Rockey, M.A. Personality structure as the main determinant of drug induced (model) psychoses. *Nature*, **1968**, 218(5138), 296-298. [http://dx.doi.org/10.1038/218296a0] [PMID: 4384807]
- [92] Halberstadt, A.L.; Geyer, M.A. Serotonergic hallucinogens as translational models relevant to schizophrenia. *Int. J. Neuropsychopharmacol.*, **2013**, 16(10), 2165-2180. [http://dx.doi.org/10.1017/S1461145713000722] [PMID: 23942028]
- [93] Leuner, H. *Die experimentelle Psychose: Monographien aus dem Gesamtgebiete der Neurologie und Psychiatrie*; Springer: Berlin, **1962**. [http://dx.doi.org/10.1007/978-3-642-86258-8]
- [94] Dolder, P.C.; Schmid, Y.; Haschke, M.; Rentsch, K.M.; Liechti, M.E. Pharmacokinetics and concentration-effect relationship of oral LSD in humans. *Int. J. Neuropsychopharmacol.*, **2015**, 19(1), 1-7. [PMID: 26108222]
- [95] Studerus, E.; Komater, M.; Hasler, F.; Vollenweider, F.X. Acute, subacute and long-term subjective effects of psilocybin in healthy humans: a pooled analysis of experimental studies. *J. Psychopharmacol. (Oxford)*, **2011**, 25(11), 1434-1452. [http://dx.doi.org/10.1177/0269881110382466] [PMID: 20855349]
- [96] Riba, J.; Rodríguez-Fornells, A.; Urbano, G.; Morte, A.; Antonijoan, R.; Montero, M.; Callaway, J.C.; Barbano, M.J. Subjective effects and tolerability of the South American psychoactive beverage Ayahuasca in healthy volunteers. *Psychopharmacology (Berl.)*, **2001**, 154(1), 85-95. [http://dx.doi.org/10.1007/s002130000606] [PMID: 11292011]
- [97] Dolder, P.C.; Schmid, Y.; Müller, F.; Borgwardt, S.; Liechti, M.E. LSD acutely impairs fear recognition and enhances emotional empathy and sociality. *Neuropsychopharmacology*, **2016**, 41(11), 2638-2646. [http://dx.doi.org/10.1038/npp.2016.82] [PMID: 27249781]
- [98] Preller, K.H.; Pokorny, T.; Hock, A.; Kraehenmann, R.; Stämpfli, P.; Seifritz, E.; Scheidegger, M.; Vollenweider, F.X. Effects of serotonin 2A/1A receptor stimulation on social exclusion processing. *Proc. Natl. Acad. Sci. USA*, **2016**, 113(18), 5119-5124. [http://dx.doi.org/10.1073/pnas.1524187113] [PMID: 27091970]
- [99] Kraehenmann, R.; Schmidt, A.; Friston, K.; Preller, K.H.; Seifritz, E.; Vollenweider, F.X. The mixed serotonin receptor agonist psilocybin reduces threat-induced modulation of amygdala connectivity. *Neuroimage Clin.*, **2015**, 11, 53-60. [http://dx.doi.org/10.1016/j.nicl.2015.08.009] [PMID: 26909323]
- [100] Kraehenmann, R.; Preller, K.H.; Scheidegger, M.; Pokorny, T.; Bosch, O.G.; Seifritz, E.; Vollenweider, F.X. Psilocybin-induced decrease in amygdala reactivity correlates with enhanced positive mood in healthy volunteers. *Biol. Psychiatry*, **2015**, 78(8), 572-581. [http://dx.doi.org/10.1016/j.biopsych.2014.04.010] [PMID: 24882567]
- [101] Bernasconi, F.; Schmidt, A.; Pokorny, T.; Komater, M.; Seifritz, E.; Vollenweider, F.X. Spatiotemporal brain dynamics of emotional face processing modulations induced by the serotonin 1A/2A receptor agonist psilocybin. *Cereb. Cortex*, **2014**, 24(12), 3221-3231. [http://dx.doi.org/10.1093/cercor/bht178] [PMID: 23861318]
- [102] Schmidt, A.; Komater, M.; Bachmann, R.; Seifritz, E.; Vollenweider, F. The NMDA antagonist ketamine and the 5-HT agonist psilocybin produce dissociable effects on structural encoding of emotional face expressions. *Psychopharmacology (Berl.)*, **2013**, 225(1), 227-239. [http://dx.doi.org/10.1007/s00213-012-2811-0] [PMID: 22836372]

- [103] Zhang, G.; Stackman, R.W., Jr. The role of serotonin 5-HT<sub>2A</sub> receptors in memory and cognition. *Front. Pharmacol.*, **2015**, *6*, 225. [http://dx.doi.org/10.3389/fphar.2015.00225] [PMID: 26500553]
- [104] Zhang, G.; Ásgeirsdóttir, H.N.; Cohen, S.J.; Munchow, A.H.; Barrera, M.P.; Stackman, R.W., Jr. Stimulation of serotonin 2A receptors facilitates consolidation and extinction of fear memory in C57BL/6J mice. *Neuropharmacology*, **2013**, *64*, 403-413. [http://dx.doi.org/10.1016/j.neuropharm.2012.06.007] [PMID: 22722027]
- [105] Catlow, B.J.; Song, S.; Paredes, D.A.; Kirstein, C.L.; Sanchez-Ramos, J. Effects of psilocybin on hippocampal neurogenesis and extinction of trace fear conditioning. *Exp. Brain Res.*, **2013**, *228*(4), 481-491. [http://dx.doi.org/10.1007/s00221-013-3579-0] [PMID: 23727882]
- [106] Harvey, J.A. Role of the serotonin 5-HT<sub>2A</sub> receptor in learning. *Learn. Mem.*, **2003**, *10*(5), 355-362. [http://dx.doi.org/10.1101/lm.60803] [PMID: 14557608]
- [107] Bouso, J.C.; Fábregas, J.M.; Antonijoan, R.M.; Rodríguez-Fornells, A.; Riba, J. Acute effects of ayahuasca on neuropsychological performance: differences in executive function between experienced and occasional users. *Psychopharmacology (Berl.)*, **2013**, *230*(3), 415-424. [http://dx.doi.org/10.1007/s00213-013-3167-9] [PMID: 23793226]
- [108] Wittmann, M.; Carter, O.; Hasler, F.; Cahn, B.R.; Grimberg, U.; Spring, P.; Hell, D.; Flohr, H.; Vollenweider, F.X. Effects of psilocybin on time perception and temporal control of behaviour in humans. *J. Psychopharmacol. (Oxford)*, **2007**, *21*(1), 50-64. [http://dx.doi.org/10.1177/0269881106065859] [PMID: 16714323]
- [109] Carter, O.L.; Hasler, F.; Pettigrew, J.D.; Wallis, G.M.; Liu, G.B.; Vollenweider, F.X. Psilocybin links binocular rivalry switch rate to attention and subjective arousal levels in humans. *Psychopharmacology (Berl.)*, **2007**, *195*(3), 415-424. [http://dx.doi.org/10.1007/s00213-007-0930-9] [PMID: 17874073]
- [110] Carter, O.L.; Burr, D.C.; Pettigrew, J.D.; Wallis, G.M.; Hasler, F.; Vollenweider, F.X. Using psilocybin to investigate the relationship between attention, working memory, and the serotonin 1A and 2A receptors. *J. Cogn. Neurosci.*, **2005**, *17*(10), 1497-1508. [http://dx.doi.org/10.1162/0899892905774597191] [PMID: 16269092]
- [111] Umbrecht, D.; Vollenweider, F.X.; Schmid, L.; Grübel, C.; Skrabo, A.; Huber, T.; Koller, R. Effects of the 5-HT<sub>2A</sub> agonist psilocybin on mismatch negativity generation and AX-continuous performance task: implications for the neuropharmacology of cognitive deficits in schizophrenia. *Neuropsychopharmacology*, **2003**, *28*(1), 170-181. [http://dx.doi.org/10.1038/sj.npp.1300005] [PMID: 12496954]
- [112] Vollenweider, F.X.; Vollenweider-Scherpenhuyzen, M.F.; Bäbler, A.; Vogel, H.; Hell, D. Psilocybin induces schizophrenia-like psychosis in humans via a serotonin-2 agonist action. *Neuroreport*, **1998**, *9*(17), 3897-3902. [http://dx.doi.org/10.1097/00001756-199812010-00024] [PMID: 9875725]
- [113] Family, N.; Vinson, D.; Vigliocco, G.; Kaelin, M.; Bolstridge, M.; Nutt, D.J.; Carhart-Harris, R.L. Semantic activation in LSD: evidence from picture naming. *Lang. Cogn. Neurosci.*, **2016**, *31*, 1320-1327. [http://dx.doi.org/10.1080/23273798.2016.1217030]
- [114] Spitzer, M.; Thimm, M.; Hermle, L.; Holzmann, P.; Kovar, K.-A.; Heimann, H.; Gouzoulis-Mayfrank, E.; Kischka, U.; Schneider, F. Increased activation of indirect semantic associations under psilocybin. *Biol. Psychiatry*, **1996**, *39*(12), 1055-1057. [http://dx.doi.org/10.1016/0006-3223(95)00418-1] [PMID: 8780843]
- [115] Martindale, C.; Fischer, R. The effects of psilocybin on primary process content in language. *Confin. Psychiatr.*, **1977**, *20*(4), 195-202. [PMID: 608346]
- [116] Frecka, E.; Mór, C.E.; Vargha, A.; Luna, L.E. Enhancement of creative expression and entoptic phenomena as after-effects of repeated ayahuasca ceremonies. *J. Psychoactive Drugs*, **2012**, *44*(3), 191-199. [http://dx.doi.org/10.1080/02791072.2012.703099] [PMID: 23061318]
- [117] Krippner, S. Psychedelic drugs and creativity. *J. Psychoactive Drugs*, **1985**, *17*(4), 235-245. [http://dx.doi.org/10.1080/02791072.1985.10524328] [PMID: 4087078]
- [118] Tagliazucchi, E.; Carhart-Harris, R.; Leech, R.; Nutt, D.; Chialvo, D.R. Enhanced repertoire of brain dynamical states during the psychedelic experience. *Hum. Brain Mapp.*, **2014**, *35*(11), 5442-5456. [http://dx.doi.org/10.1002/hbm.22562] [PMID: 24989126]
- [119] Muthukumaraswamy, S.D.; Carhart-Harris, R.L.; Moran, R.J.; Brookes, M.J.; Williams, T.M.; Erntzoe, D.; Sessa, B.; Papadopoulos, A.; Bolstridge, M.; Singh, K.D.; Feilding, A.; Friston, K.J.; Nutt, D.J. Broadband cortical desynchronization underlies the human psychedelic state. *J. Neurosci.*, **2013**, *33*(38), 15171-15183. [http://dx.doi.org/10.1523/JNEUROSCI.2063-13.2013] [PMID: 24048847]
- [120] Dos Santos, R.G.; Osório, F.L.; Crippa, J.A.; Hallak, J.E. Classical hallucinogens and neuroimaging: a systematic review of human studies: Hallucinogens and neuroimaging. *Neurosci. Biobehav. Rev.*, **2016**, *71*, 715-728. [http://dx.doi.org/10.1016/j.neubiorev.2016.10.026] [PMID: 27810345]
- [121] Kraehenmann, R.; Pokorny, D.; Vollenweider, L.; Preller, K.H.; Pokorny, T.; Seifritz, E.; Vollenweider, F.X. Dreamlike effects of LSD on waking imagery in humans depend on serotonin 2A receptor activation. *Psychopharmacology (Berl.)*, **2017**, *234*(13), 2031-2046. [http://dx.doi.org/10.1007/s00213-017-4610-0] [PMID: 28386699]
- [122] Hermle, L.; Spitzer, M.; Borchardt, D.; Gouzoulis, E. Beziehungen der Modell- bzw. Drogenpsychosen zu schizophrenen Erkrankungen. *Fortschr. Neurol. Psychiatr.*, **1992**, *60*(10), 383-392. [http://dx.doi.org/10.1055/s-2007-1000662] [PMID: 1427555]
- [123] Savage, C. Variations in ego feeling induced by D-lysergic acid diethylamide (LSD-25). *Psychoanal. Rev.*, **1955**, *42*(1), 1-16. [PMID: 14371878]
- [124] Dambrun, M.; Ricard, M.; Candland, D.K. Self-centeredness and selflessness: a theory of self-based psychological functioning and its consequences for happiness. *Rev. Gen. Psychol.*, **2011**, *15*, 138-157. [http://dx.doi.org/10.1037/a0023059]
- [125] Pahnke, W.N.; Kurland, A.A.; Unger, S.; Savage, C.; Grof, S. The experimental use of psychedelic (LSD) psychotherapy. *Int. Z. Klin. Pharmakol. Ther. Toxikol.*, **1971**, *4*(4), 446-454. [PMID: 5566727]
- [126] Le, T.N.; Levenson, M.R. Wisdom as self-transcendence: what's love (& individualism) got to do with it? *J. Res. Pers.*, **2005**, *39*, 443-457. [http://dx.doi.org/10.1016/j.jrp.2004.05.003]
- [127] Sweat, N.W.; Bates, L.W.; Hendricks, P.S. The associations of naturalistic classic psychedelic use, mystical experience, and creative problem solving. *J. Psychoactive Drugs*, **2016**, *48*(5), 344-350. [http://dx.doi.org/10.1080/02791072.2016.1234090] [PMID: 27719438]
- [128] Baggott, M.J. Psychedelics and creativity: a review of the quantitative literature. *Peer. J. Pre. Prints*, **2015**, *3*, e1202v1.
- [129] Sessa, B. Is it time to revisit the role of psychedelic drugs in enhancing human creativity? *J. Psychopharmacol. (Oxford)*, **2008**, *22*(8), 821-827. [http://dx.doi.org/10.1177/0269881108091597] [PMID: 18562421]
- [130] Leuner, H. Creativity and modification of consciousness. *Confin. Psychiatr.*, **1973**, *16*(3), 141-158. [PMID: 4783720]
- [131] Preller, K.H.; Herdener, M.; Pokorny, T.; Planzer, A.; Kraehenmann, R.; Stämpfli, P.; Liechti, M.E.; Seifritz, E.; Vollenweider, F.X. The fabric of meaning and subjective effects in LSD-induced states depend on serotonin 2A receptor activation. *Curr. Biol.*, **2017**, *27*(3), 451-457. [http://dx.doi.org/10.1016/j.cub.2016.12.030] [PMID: 28132813]
- [132] Grinspoon, L.; Bakalar, J.B. *Psychedelic drugs reconsidered*; Basic Books: New York, **1979**.
- [133] Thomas, S.; Pollak, M.; Kahan, T.L. Subjective qualities of dreams with and without awareness. *Dreaming*, **2015**. [http://dx.doi.org/10.1037/a0039242]
- [134] Hobson, J.A.; Friston, K.J. Waking and dreaming consciousness: neurobiological and functional considerations. *Prog. Neurobiol.*, **2012**, *98*(1), 82-98. [http://dx.doi.org/10.1016/j.pneurobio.2012.05.003] [PMID: 22609044]
- [135] Hartmann, E. The dream always makes new connections. *Sleep Med. Clin.*, **2010**, *5*, 241-248. [http://dx.doi.org/10.1016/j.jsmc.2010.01.009]
- [136] Soskin, R.A. Short-term psychotherapy with LSD: a case study. *J. Relig. Health*, **1973**, *12*(1), 41-62. [http://dx.doi.org/10.1007/BF01532556] [PMID: 24414932]
- [137] Johnson, M.; Richards, W.; Griffiths, R. Human hallucinogen research: guidelines for safety. *J. Psychopharmacol. (Oxford)*, **2008**, *22*(6), 603-620. [http://dx.doi.org/10.1177/0269881108093587] [PMID: 18593734]
- [138] Novak, S.J. LSD before Leary. Sidney Cohen's critique of 1950s psychedelic drug research. *Isis*, **1997**, *88*(1), 87-110. [http://dx.doi.org/10.1086/383628] [PMID: 9154737]

- [139] Sandison, R.A.; Whitelaw, J.D. Further studies in the therapeutic value of lysergic acid diethylamide in mental illness. *J. Ment. Sci.*, **1957**, *103*(431), 332-343. [PMID: 13429304]
- [140] Sandison, R.A.; Spencer, A.M.; Whitelaw, J.D. The therapeutic value of lysergic acid diethylamide in mental illness. *J. Ment. Sci.*, **1954**, *100*(419), 491-507. [PMID: 13175011]
- [141] Chandler, A.L.; Hartman, M.A. Lysergic acid diethylamide (LSD-25) as a facilitating agent in psychotherapy. *Arch. Gen. Psychiatry*, **1960**, *2*, 286-299. [http://dx.doi.org/10.1001/archpsyc.1960.03590090042008]
- [142] Stigler, M. Emotions and primary process in guided imagery psychotherapy. *Psychother. Res.*, **2001**, *11*, 415-431. [http://dx.doi.org/10.1093/ptr/11.4.415]
- [143] Griffiths, R.R.; Johnson, M.W.; Carducci, M.A.; Umbricht, A.; Richards, W.A.; Richards, B.D.; Cosimano, M.P.; Klinedinst, M.A. Psilocybin produces substantial and sustained decreases in depression and anxiety in patients with life-threatening cancer: A randomized double-blind trial. *J. Psychopharmacol. (Oxford)*, **2016**, *30*(12), 1181-1197. [http://dx.doi.org/10.1177/0269881116675513] [PMID: 27909165]
- [144] Ross, S.; Bossis, A.; Guss, J.; Agin-Liebes, G.; Malone, T.; Cohen, B.; Mennenga, S.E.; Belser, A.; Kalliontzi, K.; Babb, J.; Su, Z.; Corby, P.; Schmidt, B.L. Rapid and sustained symptom reduction following psilocybin treatment for anxiety and depression in patients with life-threatening cancer: a randomized controlled trial. *J. Psychopharmacol. (Oxford)*, **2016**, *30*(12), 1165-1180. [http://dx.doi.org/10.1177/0269881116675512] [PMID: 27909164]
- [145] Carhart-Harris, R.L.; Bolstridge, M.; Rucker, J.; Day, C.M.; Erritzoe, D.; Kaelen, M.; Bloomfield, M.; Rickard, J.A.; Forbes, B.; Feilding, A.; Taylor, D.; Pilling, S.; Curran, V.H.; Nutt, D.J. Psilocybin with psychological support for treatment-resistant depression: an open-label feasibility study. *Lancet Psychiatry*, **2016**, *3*(7), 619-627. [http://dx.doi.org/10.1016/S2215-0366(16)30065-7] [PMID: 27210031]
- [146] Gasser, P.; Kirchner, K.; Passie, T. LSD-assisted psychotherapy for anxiety associated with a life-threatening disease: a qualitative study of acute and sustained subjective effects. *J. Psychopharmacol. (Oxford)*, **2015**, *29*(1), 57-68. [http://dx.doi.org/10.1177/0269881114555249] [PMID: 25389218]
- [147] Osório, F.de.L.; Sanches, R.F.; Macedo, L.R.; Santos, R.G.; Maia-de-Oliveira, J.P.; Wichert-Ana, L.; Araujo, D.B.; Riba, J.; Crippa, J.A.; Hallak, J.E. Antidepressant effects of a single dose of ayahuasca in patients with recurrent depression: a preliminary report. *Rev. Bras. Psiquiatr.*, **2015**, *37*(1), 13-20. [http://dx.doi.org/10.1590/1516-4446-2014-1496] [PMID: 25806551]