# **Psychedelics and Quantum Brain Models: A Comprehensive Overview**

## **1. Historical Context**

**Ancient and Early Insights:** Psychedelic substances have been used for millennia in ritual and healing contexts (e.g. *soma* in ancient India, ayahuasca in the Amazon)western science “rediscovered” psychedelics after Albert Hofmann’s 1943 synthesis of LSD and the identification of psilocybin mushrooms. Early researchers noticed these drugs produced profound alterations in consciousness. Initial terminology framed them as *psychotomimetics* (mimicking psychosis), reflecting the view that they induced a schizophrenia-like state. This shifted when **Humphry Osmond** and **Aldous Huxley** collaborated to describe the mind-altering effects more positively. Osmond famously coined the term **“psychedelic”** in 1957, from Greek roots meaning “mind manifesting,” to denote the drugs’ ability to reveal or manifest aspects of the mind. Huxley’s writings (e.g. erception\*, 1954) proposed a *“reducing valve”* theory of the brain – that the brain usually filters reality, and psychedelics **open that filter**, exposing the user to a “Mind at Large,” a broader spectrum of consciousness. Such early ideas portrayed psychedelicousness rather than simply cause hallucinations.

**1960s and Backlash:** By the 1960s, psychedelics like LSD and psilocybin escaped the lab and became emblematic of the counterculture. Promoters like Timothy Leary advocated for their consciousness-expanding potential. However, uncontrolled use and political concerns led to a **backlash**. In 1971, the United Nations Convention on Psychotropic Substances banned psychedelics internationally, halting most research. Governments labeled the drugs as dangerous, and research was lar decades. The term “psychedelic” itself took on countercultural connotations, and scientific inquiry into their effects on consciousness nearly vanished.

**Modern Renaissance:** In the 1990s and especially the 2000s, interest in psychedelics cautiously re-emerged, marking what many call a “psychedelic renaissance.” Researchers obtained regulatory approvals to resume clinical studies (e.g. the first modern U.S. psilocybin study in 2000 by Roland Griffiths at Johns Hopkins). Over the last 5–10 years, scientific publications on psychedelics have surged. Researchers reframed these substances as potential **therapeutic tools** and probes for understanding the mind, rather than just drugs of abuse. By the late 2010s, major institutions even established dedicated psychedelic rs. This renaissance marries modern neuroscience with questions that hark back to the mid-20th century: Can psychedelics reveal the neural basis of consciousness? Can they heal psychiatric disorders? In sum, ideas about psychedelics have evolved from early mystical and psychoanalytic interpretations, through a period of prohibition, to a contemporary evidence-based exploration of their **impact on brain, mind, and consciousness**.

## **2. Experimental Findings under Psychedelics**

### **Brain Imaging: fMRI and MEG Insights**

Modern neuroimaging has shed light on how psychedelics alter brain activity. A consistent finding is that psychedelics **disrupt the Default Mode Network (DMN)** – a set of interconnected brain regions (including medial prefrontal and posterior cingulate cortex) active during self-referential thinking and mind-wandering. Functional MRI (fMRI) studies with psilocybin showed *decreased* connectivity and blood flow within the DMN. Notably, psilocybin causes a **decoupling** of major DMN hubs (medial prefrontal cortex andulate cortex), essentially reducing the tight communication normally present between these “hub” regions. As the DMN’s internal cohesion drops, fMRI and magnetoencephalography (MEG) indicate that the brain enterly integrated state: regions that ordinarily work separately begin communicating more freely. In one fMRI study, **lysergic acid diethylamide (LSD)** dramatically **increased global functional connectivity** acrosf modular organization was correlated with participants’ reports of *“ego dissolution”* – the feeling that the boundary between self and environment had vanished. In other words, when LSD made normally segregated brain networks communicate broadly, people experienced a loss of the ego or self. Such findings astudies: across different classic psychedelics (LSD, psilocybin, ayahuasca), acute use **reduces within-network connectivity in theses cross-talk between networks**, essentially “ungluing” tightly organized circuits and promoting a more integrated, flexible brain state.

Importantly, these changes are linked to the drugs’ molecular action. Classic psychedelics are **serotonin 5-HT\_2A receptor agonists**, and these receptors are densely expres regions including the DMN. Imaging studies have found that the areas showing the greatest increase in connectivity under psychedelics overlap with regions richest in 5-HT\_2A receptors. This suggests a \*\*mechanistic ling these receptors loosens the normal constraints on brain network activity, consistent with both the subjective effects (ego-dissolution, altered self-conspotential therapeutic effects (breaking out of rigid thought patterns, as discussed later).

### **Neural Coherence and Unconventional Dynamics**

Beyond static connectivity, psychedelics induce striking changes in brain **rhythms and signal diversity**. Electroencephalography (EEG) and MEG studies report that psychedelics **decrease power and coherence in low-frequency bands** (especially alpha waves ~10 Hz, which are associated with idle, introspective brain states) while **increasing high-frequency oscillations**. For example, under psilocybin or LSD, alpha-band synchrony across the cortex tends to drop, reflecting a loss of the usual resting rhythm, whereas **gamma-band (high-frequency) coherence increases**. One EEG study of ayahuasca (a DMT-containing brew) noted a global increase in gamma coherence (40+ Hz) during the psychedelic state. These shifts to higher-frequency synchrony and more disorganized lower-frequency acusual compared to normal waking or even other altered states, hinting at **unconventional neurodynamics** in the psychedelic brain. have quantified brain signal complexity using measures like **entropy** or Lempel-Ziv complexity. Results consistently show that psychedelic states are marked by **elevated brain entropy** – the neural activity is less predictable and more diverse in patterns than during normal consciousness. In the **“Entropic Brain” hypothesis** proposed by Carhart-Harris et al., this heightened neural entropy is the signature of a “primary” state of consciousness – a state of **greater disorder and flexibility** reminiscent of early childhoodreaming. Indeed, under psychedelics the brain explores a larger repertoire of connectivity configurations (functional networks form and dissolve rapidly) than it does in the more constrained normal waking state. This has led to analogies with the physics concept y\*\*. The psychedelic brain seems poised near a **critical point between order and disorder**, where it can easily shift configurations. Empirical support comes from MEG studies: one showed that LSD and ease **spontaneous signal diversity** (randomness of brain signals) beyond that of normal wakefulness, an effect not seen in ordinary states or even sleep. Such \*\*“turbulent” or chaotic neural activity the creative, unconstrained cognition and novel experiential insights that users report. In sum, modern experiments depict the psychedelic brain as **less synchronized in habitual rhythms, more globally interconnected, and more entropic or information-rich** than usual – a profile quseline consciousness.

## **3. Theoretical Models**

### **Quantum Brain Hypotheses (Orch-OR Theory)**

At the more radical end of theory, some researchers have speculated that consciousness arises from **quantum processes in the brain**. The most notable hypothesis in this realm is the **Orchestrated Objective Reduction (Orch-OR)** model put forward by physicist **Roger Penrose** and anesthesiologist **Stuart Hameroff**. Orch-OR suggests that quantum computations occur in cellular structures called **microtubules** (protein lattices within neurons), and that when these quantum states **collapse** (reduce), they produce conscious moments. In this view, the brain isn’t just an electrochemical machine; it’s also tapping into quantum mechanics. Penrose and Hameroff proposed that microtubules can exist in quantum superposition (isolated from environmental noise enough to maintain quantum states) and that an objective physical threshold (related their collapse, “orchestrated” by neuronal inputs. The outcome of each collapse is influenced by a non-computable element – essentially tying consciousness to fundamental spacetime geometry, in Penrose’s interpretation.

This theory was controversial from its inception in the 1990s. Critics argued the warm, wet brain would rapidly decohere any quantum states (hence “too noisy” for quon). However, Penrose and Hameroff have persisted, and some recent findings offer intriguing (if debated) support. A 2014 review highlighted the **discovery of quantum icrotubules** within neurons. Experiments by Bandyopadhyay’s group in Japan found evidence of oscillations in microtubules that could indicate quantum coherence at warm temperatures, countering the idea that quantum effects are impossible in the brain’s conditions. This has been interpreted by Orch-OR proponents as validation that **quantum states can exist in neurons** and potentially influde EEG rhythms. In theory, psychedelics could then influence consciousness at this microtubule level – for instance, by altering how neurons fire and thereby the orchestrated quantum states – though **no direct evidence** links psychedtum microtubule activity yet. It remains a highly speculative connection. Orch-OR stands as a provocative alternative to classical models: it suggests conscered or not) is rooted in quantum events inside neurons, providing a possible bridge between brain activity and the fundamental physics of the universe. While mainstream neuroscience has not embraced these ideas fully, Penrose and Hameroff’s hypothesis keeps the discussion open that **quantum brain processes** might underlie the mind, and altered states could someday be studied in that light.

### **Quantum-Like Cognition Models**

Distinct from Penrose and Hameroff’s *physical* quantum brain theory is the field of **quantum cognition**, which applies the *mathematics* of quantum theory to psychological processes. Researchers like Jerome Busemeyer, Zheng Wang, and Harald Atmanspacher have used quantum probability models to explain puzzling human behaviors (such as decision-making paradoxeclassic Boolean logic or probability theory. For example, human judgments often violate the rules of classical probability (e.g., the *conjunction fallacy* in decision making). Quantum cognition posits that the **mind’s logic can be modeled as if it follows quantum probability laws** – with states that superpose and probabilities that interfere – which sometimes predicts human behavior better than standard models. Importantly, this approach **does not c quantum computer**. It merely borrows the *formalisms* of quantum theory as a metaphor or toolkit for cognitive science. For instance, a person’s ambiguous mental state can be likened to a quantum superposition of multiple thoughts, which “collapses” to a decision when a question is asked.

In the context of psychedelics, some theorists have mused that the \*mind-bendiperience of interconnectedness under these drugs evoke **quantum-like attributes**. Ideas such as “entangled thoughts” or non-linear cognition have been poetically compared to quantum entaneling, where the mind might jump between ideas in a non-classical way. While intriguing, these are largely analogies. **Quantum-like models of cognition** remain agnostic about neurobiology – they don’t necessitate microtubule qubits or true physical quantum events in the brain. Thus, one might say psychedelic states *inspire* quantum metaphors (because they feel non-rational and holistic), but from a research standpoint, applying quantum math to describe thought patterns is still a developing approach. The relevance of quantum cognition models to altered states is an open question. It may offer a fresh framework to describe the probabilistic, fluid thinking under psychedelics, but so far it runs in parallel to – rather than integrated with – mainstrea ([The potential of using quantum theory to build models of cognition - PubMed](https://pubmed.ncbi.nlm.nih.gov/24027215/#:~:text=Quantum%20cognition%20research%20applies%20abstract%2C,cognitive%20model%20can%20be%20developed)) findings.

### **Classical Neuroscientific Explanations**

The bulk of scientific evidence supports classical, biochemical and network-based explanations for psychedelic effects. At the receptor level, **classical psychedelics (LSD, psilocybin, DMT, etc.) are potent agonists at 5-HT\_2A receptors**, a subtype of serotonin receptor densely distributed in the cortex. This action triggers a cascade of changes in cortical neurons – especially pyramidal neurons in layer V of the cortex – leading to increased excitability and altered release of neurotransmitters like glutamate. Through these molecular mechanisms, psychedelics perturb the brain’s normal information processing. **Network disintegration and integration** models, supported by fMRI/EEG data, then explain how consciousness is altered: the \*\*Default Mode Network’s orderly activity is reduced or “cousing a loss of the usual ego-bound, self-referential processing. Meanwhile, other brain networks (attention, salience, limbic circuits) can communicate more freely, **“hijacking” the normal hierarchy** of brain function. One influential theory, the **Entropic Brain hypothesis**, weaves these observations together: it proposes that psychedelics push the brain into a higher-entropy state characterized by more chaotic yet flexible neural dynamics. In this view, normal waking consciousness is like a highly organized, low-entropy state (governed by strong priors and the DM, whereas a psychedelic state is a high-entropy state where the mind enters a more **primitive, free-flowing mode** of cognition (akin to dreaming or early childhood). This explains phenomena like **synesthesia, unconstrained imagination, and ego-dissolution** as arising from the brain operating with fewer filters and greater connectivity than usual.

A complementary perspective cdictive coding and the REBUS model\*\* (“Relaxed Beliefs Under Psychedelics”). Proposed by Carhart-Harris and Friston, REBUS suggests that psychedelics **soften high-level priors** in the brain’s predictive coding hierarchy. Under normal conditions, our prior beliefs and expectations (held in high-level cortlike the DMN) strongly shape perception, effectively enforcing a stable sense of self and reality. Psychedelics, via their entropic effect on cortical activity, **reduce the “precision weighting” of these priors**, meaning the brain becomes less certain about its preconceived models of the world. As a result, bottom-up sensory information (and limbic input) gains influence, and the mind can break out of habitual patterns. This mechanistic account asical neuromodulation: by flooding 5-HT\_2A receptors, psychedelics destabilize the networks that normally enforce order, allowing new patterns to form. Unlike quantum theories, these models stay at the level of neurons and networks, and they are supported by substantial empirical data. They explain altered consciousness **without invoking exotic physics**: the dissolution of the ego, for examped to **decoupling of the DMN “self” network from other regions** and increased connectivity between normally segregated neuralummary, classical neuroscience frameworks attribute the mind-altering effects of psychedelics to **neurotransmitter-driven cortical disinhibition, network disintegration (especially of the DMN), increased global connectivity, and elevated entropy** in brain activity. These changes in information flow and hierarchy are sufficient to account for the profound shifts in perception and cognition, according to current evidence.

## **4. Clinical Applications and Implications**

### **Therapeutic Uses of Psychedelics**

After decades of dormancy, psychedelics are now at the forefront of novel ptments. **Depression:** Clinical trials using psilocybin (the active compound in “magic mushrooms”) have shown rapid and sustained reductions in depressive symptoms, even in *treatment-resistant depression*. For instance, recent studies found that a single high-dose psilocybin session, combined with psychotherapy, can alleviate depression for months in patients who hadn’t responded to conventional antidepressants. These effects are thought to result from the drug’s ability to “reset” dysfunctional brain network activity (such as an overactive DMN associated with rumination) and to catalyze profound psychological insights during the psychedelic experience. **Post-Traumatic Stress Disorder (PTSD):** While psilocybin is being explored for PTSD, the most notable results come from MDMA-assisted therapy. MDMA (Ecstasy) is an empathogen rather than a classic psychedelic, but it induces an altered state conducive to processing trauma. Phase 3 trials of MDMA-assisted psychotherapy for PTSD reported very high efficacy, cant portion of participants no longer meeting PTSD criteria after treatment (these studies were sponsored by MAPS and led by researchers like Michael Mithoefer and colleagues in 2018–2021). These successes have brought MDMA to the brink of potential FDA approval for PTSD treatment. **Anxiety and Existential Distress:** Psychedelics have been used in patients with terminal illness to relieve anxiety and fear of death. Pioneering trials at Johns Hopkins and NYU gave psilocybin to late-stage cancer patients, resulting in large reductions in depression and anxiety about mortality, often accompanied by a **“mystical” experience** that gave patients a renewed sense of peace. Follow-ups showed these improvements can last for years, indicating a single profound psychedelic session can have enduring mental h. **Addictions:** There is promising evidence that psychedelics can disrupt addiction pathways. In the 1950s, Osmond reported LSD therapy helped alcoholics, and modern studies echo that: a 2015 clinical trial found psilocybin-assisted therapy led to significantly higher abstinence rates in alcohol use disorder compared to placebo. At Johns Hopkins, Matthew Johnson and colleagues used psilocybin in a controlled trial to help longtime smokers quit – resulting in remarkable success rattandard smoking cessation therapies. These outcomes are attributed to the **transformative psychological insights** and increased mental flexibility that psychedelics induce, allowing individuals to break out of rigid addictive thought loops. **Other Conditions:** Preliminary research is examining psychedelic therapy for obsessive-compulsive disorder, eating disorders, and even neurodegenerative disorders. While much is still exploratory, the broad trend is that psychedelic“reboot” maladaptive neural patterns\*\* and promote cognitive openness, making them applicable to a range of entrenched psychiatric conditions.

### **Altered States, Cognition, and Self-Perception**

The clinical gains from psychedelics also feed back into fundamental neuroscience – they force us to refine theories of consciousness, cognition, and the self. One salient aspect is **ego-dissolution**: under high doses of psychedelics, users often report that their usual sense of self (“ego”) completely dissipates, yielding a feeling of unity with the universe or other people. Neuroscientifically, this has been linked to the **silencing of the DMN’s self-referential processes**. The fact that a compound can transiently **disable the neural and psychological construct of the “self”** is profound. It suggests that our sense of having a unified, narrative self is contingent on specific brain patterns that can be altered. This insight aligns with cognitive theories that the self is a model the brain generates – a model that can temporarily vanish, as seen in psychedelic ego-dissolution or deep meditative states. For clinical practice, experiencing this state can be therapeutic: patients often report that losing their ego allowed them to see their life problems from a radically new, detached perspective, facilitating breakthroughsr example, recognizing subconscious trauma or adopting new values).

Psychedelics also highlight the connection between **altered belief dynamics and mental health**. The REBUS model’s notion of “relaxed priors” suggests that in disorders like depression or PTSD, patients are “stuck” in overly rigid beliefs (e.g., “I am worthless” or persistent fear responses). A psychedelic experience biologically relaxes these entrenched beliefs, while the accompanying psychotherapy helps the person reconceptualize and update them. This exemplifies how altered states of consciousness can directly lead to **cognitive reframing**. It provides empirical support for the idea that the brain has a hierarchical predictive coding system – and that changing the high-level priors (through a drug-induced state) can induce plasticity and rapid learning or unlearning of patterns. The strong **mystical or spiritual experiences** often reported (feeling of unity, transcendence of time and space, sacredness) also spur discussions in psychology and neuroscience about the nature of such experiences and their role in human coese simply neural artifacts, or do they tap into a deeper aspect of consciousness? While science doesn’t endorse any metaphysical claims, it’s clear that such experiences can **transform a person’s worldview and self-perception** in lasting ways, often shifting core values and increasing traits like openness and empathy.

From a research perspective, using psychedelics in controlled settings offers a unique **window into the mind**. As one review noted, psychedelics likely won’t magically solve the “hard problem” of why brain activity produces subjective experience, but they are extremely useful tools for probing the “easy problems” – the neural correlates and cognitive features of consciousness. By observing how specific brain networks and oscillations correspond to alterations in perception (visual hallucinations, synesthesia), thought (free associations, mystical insight), and sense of self (ego-dissolution), scientists can refine their models of normal cognition and selfhood. In summary, the clinical use of psychedelics not only is opening new avenues for **treating depression, anxiety, PTSD, and addiction**, but is also informing broader theories of how flexible our consciousness is and how tightly brain, mind, and perception are interlinked. The remarkable therapeutic outcomes seen reinforce the notion that **changing consciousness** (even temporarily) can have end effects – underlining the profound connection between brain physiology, subjective experience, and psychological well-being.

## **5. Key Researchers and Institutions**

* **Roger Penrose (University of Oxford)** – A mathematical physicist who brought quantum theory into the consciousness debate. Penrose argued that classical physics cannot fully explain consciousness and proposed that **quantum gravity-induced collapse of wavefunctions** might be key. Along with Hameroff, he developed the Orch-OR model, suggesting that microtubule quantum computations are orchestrated to produce conscious moments. Penrose is a major figure linking fundamental physics to brain science, though his ideas are controversial. He is known for works like *The Emperor’s New Mind* (1989) that speculate about quantum mechanisms in the brain. ameroff (University of Arizona)\*\* – An anesthesiologist and consciousness researcher, Hameroff is Penrose’s chief collaborator on Orch-OR. He provided the biological plausibility for Penrose’s theory by identifying **microtubules** as potential quantum processors in neurons. Hameroff has spent decades researching consciousness, anesthesia, and quantum biology. As Director of the Center for Consciousness Studies in Arizona, he advocates that psychedelic states *could* be relbule-level changes (by analogy to how anesthetics act on microtubules to *turn off* consciousness). While mainstream scientists often critique Orch-OR, Hameroff remains its staunch defender, spurring ongoing research into quantum effects in neuroscience.
* **Robin Carhart-Harris (Imperial College London / UC San Francisco)** – A neuroscientist who has been at the forefront of modern psychedelic science. He led many of the pioneering fMRI and MEG studies of psilocybin, LSD, and DMT that revealed **DMN dicreased global connectivity** under psychedelics. Carhart-Harris formulated the **Entropic Brain theory** to explain altered consciousness in terms of increased brain entropy, and later, with Karl Friston, developed the **REBUS model** integrating psychedelics with predictive coding (proposing that psychedelics rel priors to unleash bottom-up information). He was the Founding Director of the Centre for Psychedelic Research at Imperial College London (established 2019, one of the first such centers globally), and in 2020 moved to University of California, San Francisco to continue groundbreaking research in psychedelic therapy. Under his guidance, Imperial College became a leading institution for studying psychedelics’ neural effects and therapeutic potential.
* \*\*David Nutt (Impeuropsychopharmacologist and former UK Chief Drug Advisor, Nutt has been a prominent figure in psychedelic research and drug pe supervised many of the UK’s first modern studies on psychedelics, including brain imaging experiments with LSD and psilocybin (in collaboration with Carhart-Harris). One notable study by his tincreases global brain connectivity and induces ego-dissolution, correlating with specific connectivity changes. Nutt has advocated using scientific evidence to re-evaluate the legal classification of psychedelics, noting their low physiological toxicity and high therapeutic potential relative to many legal substances. As chair of Neuropsychopharmacology at Imperial, and through the charity **Beckley Foundation** (with Amanda Feilding), he has helped secure funding and legitimacy for psychedelic science in the UK.
* **Roland R. Griffiths (Johns Hopkins University)** – A trailblazing psychopharmacologist who in 2000 led the first FDA-approved psilocybin study after the decades-long research hiatus. Griffiths’ rigorous studies demonstrated that a high dose of psilocybin can occasion **mystical-type experiences** in healthy volunteers, with positive changes in attitudes and behavior lasting months. He later shos efficacy for **depression and anxiety in cancer patients, and for addiction (smoking cessation)**. His work lent credibility to the field and attracted significant funding – including a $17 million donation that established the **Center for Psychedelic and Consciousness Research at Johns Hopkins in 2019**, the first center of its kind in the U.S.. As founding director, Griffiths helped make Johns Hopkins a flagship institution for psychedelic research, publishing landmark papers and training a new generation of scientists. *(Note: Dr. Griffiths passed away in 2023, but his legacy continues through the thriving research center he built.)*
* **Other Key Contributors and Institutions:** Numerous other figures have shaped this intersection of psychedelics and consciousness. **Alexander Shulgin** (chemistry) discovered many novel psychedelics, providing tools for research. **Stanislav Grof** (psychiatry) in the 19red LSD psychotherapy and transpersonal psychology, laying early clinical groundwork. In Switzerland, **Dr. Franz Vollenweider (University of Zurich)** has conducted influential neuroimaging studies on psilocybin and ketamine since the 1990s. The **Mary Association for Psychedelic Studies (MAPS)**, led by **Rick Doblin**, has spearheaded clinical trials (especially with MDMA for PTSD) and will likely achieve the first regulatory approvals for psychedelic-assisted therapy. Academic centers are now proliferating: beyond Imperial and Johns Hopkins, dedicated psychedelic research centers exist at institutions like UCSF, Yale, and Maastricht University, signaling a broad acceptance of this research area. On the theoretical side, scholars like **Harald Atmanspacher** and **Henry Stapp** have bridged physics and consciousness, exploring quantum mind ideas and engaging with the implications of altered states. While the **quantum brain models** remain speculative, their proponents (Penrose, Hameroff, and others) are notable for challenging the limits of our neuroscience paradigms and ensuring that the conversation about consciousness remains expansive.

In conclusion, the study of psychedelics at both experimental and theoretical levels is yielding a richer understanding of the brain-mind relationship. Historically stigmatized compounds are now key research tools unlocking how altering neuronal activity can transiently dissolve the self, induce unity experiences, and recalibrate pathological brain states. Whether through **classical neuroscience or unconventional quantum theories**, the intersection of psychedelics and brain models is a fertile ground for insights – from the nature of consciousness to practical healing of the mind. The coming years will undoubtedly expand this frontier, guided by the groundwork laid by the key figures and institutions highlighted above, and supported by a growing body of rigorous, fascinating science.

**References:** (Each reference corresponds to source material supporting the statements above, formatted as per the prompt and numbered in sequence)