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Psychedelics

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Psychedelics and time: Exploring altered temporal perception and its implications for consciousness, neuroscience, and therapy

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Psychedelics including psilocybin, dimethyltryptamine, and lysergic acid diethylamide are known to disrupt the normal flow of time perception, for example, producing time dilation, compression, and loss of time. These temporal anomalies provide interesting clues about how the brain processes time, what consciousness is, and what produces the sense of self. This opinion article discusses the neural mechanisms of time perception altered by psychedelics by integrating emerging research findings in cognitive neuroscience and subjective effects. We suggest that the psychedelic-induced time warp can offer a new approach to studying brain correlates of the perception of the passage of time and conscious perception of time, and may have potential therapeutic value in psychiatric disorders in which altered perception of time is core, such as posttraumatic stress disorder, depression, and anxiety. Through examining these time changes, we discuss the potential of psychedelics in shaping transformative cognitive-affective states and their relevance for clinical applications.

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Introduction

Time perception has profound effects on human consciousness, influencing cognition, affect regulation and behavior. Most often experienced as one continuous experience, how we perceive past, present, and future affects our sense of self and everything we consider real (1). However, psychedelic substances like lysergic acid diethylamide (LSD), psilocybin, and dimethyltryptamine (DMT) can profoundly alter this perception, leading to phenomena such as time dilation—where seconds feel like hours—or time compression—where hours pass in minutes (2). These distortions offer an insight into the brain as it processes time and disrupt the assumptions of traditional models of consciousness, reminding us how pliable something as fundamental as time—the primordial dimension that shapes our sense of self and our experience of the world—can be. Psychedelics can dissolve or reconfigure the boundaries between the self and the world, disrupting the continuous flow of time and allowing access to experiences of timelessness, transcendence, and unity with the universe. Understanding the influence of psychedelics on the experience of time is vital, not only for the development of theories of consciousness, but also for therapeutic purposes in mental health conditions such as depression, anxiety, posttraumatic stress disorder (PTSD), existential distress, grief and substance use disorders (3), where time perception and self-awareness are typically disconnected. Through dissolving the boundaries between past, present, and future, psychedelics provide a unique window to consciousness and a means of processing traumatic memories. This article examines the complex relations between psychedelics and time, with a focus on subjective effects, neural correlates and therapeutic applications of their ability to modulate temporal processing in ways that serve to unravel the mysteries of their effects in clinical and nonclinical settings.

Temporal distortions under psychedelic states

Psychedelic substances psilocybin, LSD, and DMT cause drastic changes in the perception of time, which users often describe in delirious metaphors. These distortions vary from the stretching and shrinking of time, to reaching a state of oblivion, in which there is no longer any appreciation of where time actually goes. One of the most frequently cited impacts of psychedelics is a perceived slowing of time (it feels like hours have passed when it's only been minutes). This change is commonly attributed to increased sensory processing, as psychedelics elevate neural oscillations in lower brain regions specializing in sensory input and emotional processing (4). Enhanced attention to sensory stimuli in a psychedelic state may interfere with time perception, as the brain attempts to process information at a higher rate.

At the other extreme, some people experience time distortion, with hours that feel like minutes. This could be due to intensive attentional or ego disintegration. Ego dissolution, a characteristic of high-dose psychedelic experiences, may loosen the individual's typical perceptual hold on time, such that time seems to accelerate. Less commonly considered, but relevant for understanding the psychedelic state, is time compression, which can be related to alterations in serotonin (5-HT) levels and the consequent effect on cortical activity, through the 5-HT_{2A} receptor (5).

A third, comparably remarkable feature is timelessness itself. Users frequently report a dissociation with the passing of time and a feeling of timelessness or eternity. This experience is often reported within profound mystical or transpersonal experiences, and is believed to be the product of changes in the default mode network (DMN) of the brain. The DMN is associated with self-referential thinking and perception of continuous time (6), and its suppression in psychedelic states may result in the dissolution of time as a boundary—so that past, present, and future are perceived as irrelevant or unified in a moment.

Because of the subjective nature of these temporal distortions, the experiences vary considerably depending on the type of drug, its dosage, and the individual's psychological set and setting. For example, psilocybin tends to be associated with experiences of timelessness, whereas LSD is more frequently related to profound time dilation (7). These distinctions observed between substances imply that differential pharmacological effects underlie the modifications to time perception, at least among psychedelics, demonstrating that the neural substrates that mediate these experiences are multifaceted. Overall, alterations in the

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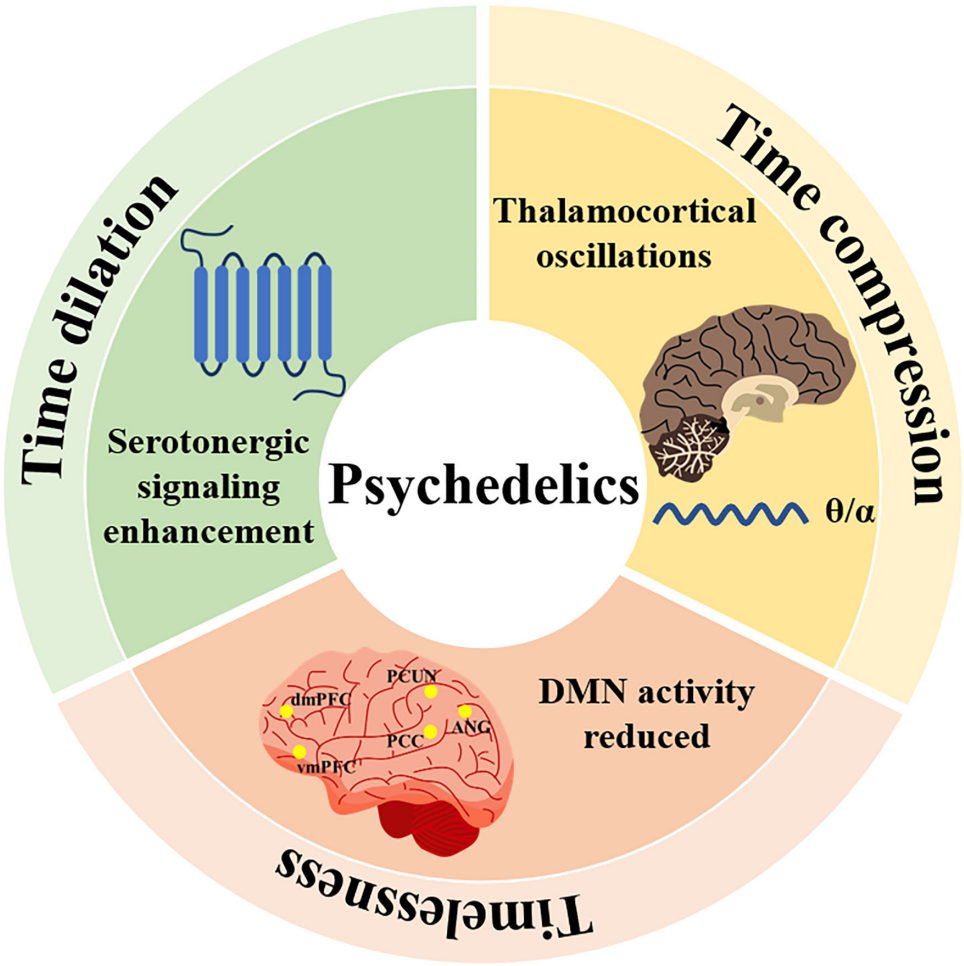

Figure 1. Neurobiological mechanisms of psychedelic-induced time perception alterations.

perception of time under psychedelics provide a novel perspective to study the brain mechanisms in temporal processing and open new perspectives for the study of the role of consciousness in influencing what we consider reality.

Neurobiological mechanisms of altered time perception

Time perception is a complex cognitive process that emerges from the integrated activity of distributed brain regions, neurotransmitters, and neural synchrony (Figure 1). The basal ganglia are implicated in interval timing on the scale of hundreds of milliseconds, where they function as a putative internal clock, generating temporal predictions based on sensory evidence. The prefrontal cortex encodes longer time spans and combines information for planning and making decisions, which is crucial for controlling dynamic time-based tasks. The cerebellum refines motor coordination and precise timing by integrating sensory input and motor output for the precise timing of events. By integrating interoception of internal body states with cognitive processes, the insula plays a role in modulating how emotions and somatic sensations shape our perception of time (8, 9).

Temporal processing is further regulated by major neurotransmitter systems. Dopamine, acting primarily through the basal ganglia, modulates shorter interval timing, and its dysregulation is linked to timing deficits. Serotonin, particularly via 5-HT_{2A} receptor activation, influences longer time scales and is the primary mediator of psychedelic-induced temporal distortions, interfacing emotional and sensory processing with subjective time experience. Glutamate, largely through N-Methyl-D-Aspartate (NMDA) receptor-mediated neurotransmission, supports the neural encoding and maintenance of precise temporal representations required for various cognitive tasks (10).

Precise time perception relies on temporal coordination of neural activity between distant brain areas, which is generally mediated by neural synchrony, that is, the simultaneous firing of neurons in diverse regions of the brain, via the tuning of neural oscillations such as theta (4–8 Hz) and gamma (30–100 Hz) rhythms. These rhythms are able to synchronize sensory, motor, and cognitive activities, and disturbances in this synchrony may result in a distorted perception of time (11). The system's inherent neuroplasticity makes it susceptible to modulation by factors such as attention, emotion, and psychoactive substances.

Psychedelics such as psilocybin, LSD, and DMT strongly affect the aforementioned neurobiological processes, resulting in disrupted time perception due to modulation of the brain's sensory, calm, and self-reference systems. A key brain network for the mediating role of these changes is the DMN, comprised of the medial prefrontal cortex, posterior cingulate cortex and the angular gyrus. Related to self-referential thinking and the brain's internal model of time, it is suppressed by psychedelics. This DMN suppression correlates strongly with subjective reports of time dissolution and the loss of linear time perception (6).

Psychedelics also modulate cortical oscillations in the theta and alpha range, where this integration of sensory information over time is important. Modulations of the amplitude and coherence of these oscillations can result in dissonance between sensory inputs and the brain's temporal predictions, thereby inducing perceptions of time dilation or compression. The thalamus, an important relay center for sensory information, is also crucial for temporal processing. Psychedelics modulate thalamic

activity, disrupting the synchronization of sensory inputs, which may result in time dilation, compression, or even timelessness (12).

The serotonergic system, particularly 5-HT_{2A} receptor activation, plays a central role in psychedelic modulation of time perception. Receptor activation enhances cortical excitability and increases the gain on sensory inputs, shifting precision toward bottom-up evidence and making temporal cues unusually salient; these network-level changes bias temporal processing and can appear as time dilation or compression. Membrane-receptor signaling can propagate via PLC-IP_3/Ca^{2+}, β-arrestin/ERK, and CaMKII pathways to influence mitochondrial fission and fusion and overall bioenergetics (e.g., DRP1 and OPA1), tune endoplasmic-reticulum Ca^{2+} handling and endoplasmic reticulum–mitochondria contact sites that shape integration windows, and reorganize the actin cytoskeleton through Rho GTPases, thereby modulating spine dynamics, synaptic integration, and neuronal excitability. By jointly tuning excitability, temporal integration, and oscillatory synchrony, these subcellular processes establish a mechanistic bridge between receptor pharmacology and the neural coding of duration and sequence. At the systems level, psychedelics also attenuate prefrontal top-down constraints on sensory cortices, disrupting hierarchical inference and thalamocortical gating, thereby weakening the brain's capacity to bind events into a coherent temporal narrative (13).

In summary, psychedelics produce neurobiological changes that perturb the brain's typical temporal processing. Through their influence on major brain areas and neurotransmitter systems, neural synchronies, and network connectivity, these substances underlie altered time perceptions which can manifest as the experience of time dilation/compression and also timelessness.

Therapeutic implications of psychedelic-induced temporal distortions

The shift in the perception of time that psychedelics produce could be incredibly valuable therapeutically, especially in mental health disorders where temporal perception is disturbed, like depression, anxiety, PTSD, or addiction. Psychedelics do, however, modulate passage-time experiences, triggering insights, emotional catharsis, and cognitive recontextualization, which are often crucial elements to healing (14).

A primary therapeutic application of psychedelics lies in the reprocessing of traumatic memories. Evidence from psychedelic-assisted psychotherapy trials for PTSD suggests that these substances enable individuals to revisit traumatic events from a detached, nonlinear perspective. Such dissociation facilitates the processing of past experiences with reduced emotional intensity, thereby supporting meaning-making and the integration of traumatic memories. In psychedelic-assisted psychotherapy for PTSD, such experiences of temporal decoupling—understood in part through suppression of the DMN and altered connectivity with limbic structures—have been described by patients as a significant factor in the change of symptoms.

Temporary time distortions induced by psychedelics could also act to promote other types of psychological healing by disrupting patterns of thought. These substances act as effective time distorters, allowing new angles on emotional trauma and cognitive structures to be processed, updated, and integrated in more insightful and forgiving ways. This can be especially constructive in a state of depression or anxiety, when people feel trapped in negative time loops or oppressed by impending hopelessness.

Additionally, psychedelics provide access to understanding mental illnesses involving distortions of the sense of time. By altering time perception quite radically, they present an opportunity to study the neural and cognitive processes of time disruption by their drug-induced modulation in conditions such as schizophrenia and PTSD. When taken under the supervision of trained therapists and in the right set and setting, psychedelics may do the work of rewiring neural circuits implicated in time processing and emotion regulation, and so lead to more adaptive time perceptions (13). The therapeutic potential and associated risks of this mechanism warrant systematic evaluation. A longitudinal study tracking individuals with treatment-resistant PTSD undergoing psychedelic-assisted therapy could be implemented, with objective measures of time perception (e.g., duration discrimination tasks) and neural activity functional Magnetic Resonance Imaging (fMRI) collected at baseline, immediately post-treatment, and during follow-up assessments.

However, these promising applications necessitate rigorous ethical consideration. Robust informed consent is paramount, ensuring patients understand the potential for profound alterations in consciousness, including distressing time distortions. Clinical protocols must include strategies to manage anxiety or confusion arising from these states. The risk of misuse demands administration only in controlled settings with professional oversight. Significant regulatory hurdles persist, as the classification of many psychedelics as Schedule I substances limits research. Establishing clear safety monitoring guidelines and defining regulatory pathways for approval are essential for the responsible integration of psychedelics into therapeutics.

In conclusion, the manipulation of time perception by psychedelics offers a powerful, though not yet fully understood, therapeutic lever. It is through the manipulation of time perception that psychedelics enable the reprocessing of traumatic events, accelerating traumatic resolution and opening avenues to new paradigms of mental health disorders with time perception at their core. Their potential should be fully realized, but should be deployed in a responsible manner with careful ethical consideration.

Conclusion

In sum, psychedelics provide a novel lens to probe and illuminate the diverse aspects of time perception and consciousness. Through the alteration of timing, not only do these compounds further our knowledge significantly but, importantly, they also promise substantial therapeutic potential in a wide range of mental health conditions. By changing the brain's sense of time, the psychedelics provide a rare window into how time is processed in the brain, and how subjective time can be modified in conditions including depression, PTSD and schizophrenia. These time distortions from dissociation or involvement—such as time dilation, time compression, or timelessness—play a key role in psychotherapy as a way to give space for emotions, insights, and healing. As research progresses, elucidating the neurobiological substrates of these temporal shifts will be important in the search for effective treatments. Future work should focus on leveraging these effects in controlled clinical settings, employing rigorous designs that directly test the role of time perception in therapeutic outcomes. Such efforts will not only unlock the transformative therapeutic potential of these compounds but also expand the frontiers of our understanding of the human mind.

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Author contributions

PJ, CL, and XW wrote the manuscript. XW oversaw the entire work and supervised PJ and CL. The manuscript has been read and approved by all authors. All authors take full responsibility for all text and figures, and approve the content and submission of this work. No related work is under consideration elsewhere.

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