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Integrating Meditation and Psychedelics Knowledge to Identify Core Neurocognitive Mechanisms of Minimal Selfhood

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This article proposes conceptual and research design principles to identify the core neurocognitive mechanisms that support minimal self-consciousness and how this might be attenuated via computational explanations of selfless states using two different induction methods—meditation and psychedelics. As a proof-of-concept of the utility of this framework, we examine how selfless states induced by these methods might elucidate core neurocognitive mechanisms of minimal selfhood, using two broad computational frameworks that instantiate, first, predictive processing and, second, global workspace modeling. This analysis isolates hierarchical flattening and metastable workspace dynamics as core mechanisms in the predictive processing and global workspace frameworks, respectively. We close by first offering several broad but testable predictions that might be used to guide future research and advance our understanding of the neuroscientific basis of minimal self-consciousness and then discussing challenges that remain in this pursuit.

Keywords: meditation, minimal self, nondual awareness, prereflective self-as-subject, psychedelic ego dissolution

When experiencing normal perception, cognition, or affect, one has an underlying sense that the experiences are being had by an entity that can be called the "self." This ever-present sense of self is immediate and implicit and requires no conscious reflection to detect. This sense has been labeled the *minimal selfhood* and is formally defined as the immediate, prereflective sense of being the subject of an experience (Gallagher, 2000). To understand the role of minimal selfhood in human consciousness, it should first be distinguished from the various perceptual, cognitive, or affective experiences that one has awareness of (Bayne et al., 2016). These latter qualitative experiences are *conscious contents*, or the phenomenal objects that can be described as something that "feel like." Importantly, minimal selfhood is a quality that almost always accompanies these conscious contents, with awareness of these contents usually being accompanied by a quality of first-personal *givenness*. That is, the experience of something is what that something "is like" *for me* (Zahavi & Kriegel, 2015). The minimal self is thus present when one accesses conscious contents with an implicit sense that they exist in relation to the subject "I." With no sense of "I" having an experience, a state that is devoid of the minimal self can therefore be considered a *selfless state.*

There is growing acceptance that one's sense of minimal selfhood can vary in strength or even be extinguished (i.e., disrupted) through various

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practices (Hafner et al., 2022; Lang & Viertbauer, 2022). For example, minimal self disruption or selfless states that are induced by psychedelic drugs and meditation commonly occur within certain instances of *psychedelic ego dissolution* and *nondual awareness*, respectively (Josipovic & Miskovic, 2020; Letheby & Gerrans, 2017). Importantly, our aim is not to explain how these methods disrupt the minimal self; our aim is instead more modest—to describe how these methods might be used to better understand the disruption of the prereflective sense of self-as-subject and, by doing this, to then discuss the potential value of such states for advancing cognitive science.

The problem of identifying the neural systems that mediate the minimal self has been challenging for at least two reasons. First, common experimental paradigms that have been used to identify the neural activity that supports minimal selfhood may fail to do so accurately (Girn & Christoff, 2018). Second, the causal mechanisms that support minimal selfhood may not reflect the fundamental neural processes that generate and sustain it (Millière, 2017). This article will attempt to address both potential shortcomings by proposing a novel theoretical approach that integrates information gained from recent advances in our understanding of certain classes of psychedelic ego dissolution, on one hand, and of meditative nondual awareness, on the other.

The First Challenge: Finding Genuine Cases of Minimal Self Disruption

The first challenge is that mainstream cognitive science distinguishes but often conflates two dimensions of selfhood: (a) the sense of self being reflective versus prereflective (Gallagher, 2000) and (b) the sense of self experienced as subject versus object (Legrand, 2007). These two dimensions will be explained in the sections below.

The Reflectiveness Dimension: Reflective Versus Prereflective Selfhood

The distinction between reflective and prereflective selfhood reflects the nature and immediacy of self-awareness (Millière, 2020). *Reflective selfhood* involves higher order cognitive processes, such as introspection, self-attribution, and the deliberate consideration of oneself as an object of thought. This mode of self-awareness is explicit and often tied to autobiographical memory or evaluative judgments about one's mental or physical characteristics. In contrast, *prereflective selfhood* refers to the fundamental, immediate sense of self that accompanies conscious experience. As such, prereflective selfhood is not the result of reflecting upon or conceptualizing one's mental states but is instead intrinsic to the subjective nature of conscious experience itself. As Zahavi (2011) argued, this prereflective form of selfhood is characterized by conscious experiences being accessed in a first-person manner. Prereflective selfhood is thus a basic awareness that happens automatically. It is how a person feels, with those felt experiences being intrinsically their own without having to think or analyze the experiences to determine ownership.

Cognitive scientists have proposed that investigating the disruption of minimal selfhood may provide a way to increase our understanding of its physical instantiation (Hafner et al., 2022; Lebedev et al., 2015). However, because minimal selfhood is by definition prereflective, this approach requires the examination of cases that clearly involve the disruption of prereflective selfhood (Gallagher, 2000). Fulfilling this requirement has been difficult, because the majority of experimental manipulations of selfhood actually manipulate reflective processes (Girn & Christoff, 2018; Nour & Carhart-Harris, 2017). For example, Kelley et al. (2002) used a trait-adjective judgment paradigm where participants indicated whether specific traits (e.g., "polite") described themselves, others, or generic cases. This task explicitly engages reflective self-referential processes by requiring individuals to consciously evaluate attributes in relation to themselves and others. In other words, rather than probing the immediate and automatic experience of selfhood, this task taps into higher order introspection about personal characteristics, causing participants to situate the self as an object of evaluation. Other paradigms that similarly involve reflective self-referential processes are reviewed by Northoff et al. (2006).

These paradigms have been used in neuroimaging experiments to record brain activity related to participants' conscious evaluations of themselves (Nour & Carhart-Harris, 2017). As a result, much of the available neuroscientific evidence related to selfhood concerns brain activity related to the engagement of reflective self-attribution rather than prereflective selfhood. This limitation led Legrand and Ruby (2009) to

suggest that attempts to measure reflective self-attribution provide only limited insight into their neural correlates as these same correlates have also been implicated in general inferential reasoning and the recall of information (e.g., about others) from memory.

Other than the minimal self, bodily self-consciousness is a good example of prereflective selfhood (Seth & Tsakiris, 2018). *Bodily self-consciousness* involves awareness of the self as being localized within one's own body. This awareness is normally implicit and nonconceptual in nature and thus does not typically require conscious reflection (Legrand, 2006). Given its prereflective nature, disruptions in bodily self (e.g., full-body illusions) might appear to provide valuable insights into the neural correlates of minimal selfhood. This potential has not been realized, however, due to the fact that cognitive science has—as mentioned previously—also distinguished between the sense of self as a subject and the sense of self as an object. This distinction was most notably described by William James (1890) and Ludwig Wittgenstein (1958) in their discussion of the philosophy of language.

The Subject–Object Dimension: Self-as-Subject Versus Self-as-Object

James (1890) attempted to distinguish between two aspects of selfhood by investigating the language that is used to describe self-related experience. For James, referring to the self as "me" versus "I" reflects two distinct types of self-knowing. When using the pronoun "me," one perceives the self as a subject that is defined by its physical and mental characteristics. For instance, by stating that a body is either "me" or "not me," one differentiates between physical entities that correspond to one's self versus some other entity. In contrast, when using the pronoun "I," one is referring to the fact that whatever is being described is being experienced with the sense of being the agent of that experience.

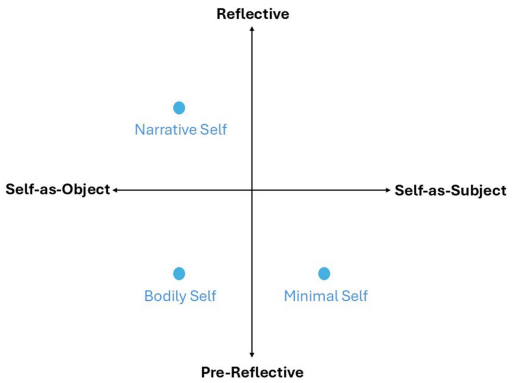
Wittgenstein (1958) similarly argued that one can experience the sense of self-as-object or the sense of self-as-subject. The sense of *self-as-object* is a type of self-knowing that entails a cognitively available notion of what the self is, allowing selfhood to be conceptualized in an abstract manner (e.g., thinking about one's future self). In the example of body ownership, the self is defined by attribution of the subject to a physical body or body schema (Limanowski, 2014). In a similar way, the sense of narrative identity attributes the self to internal concepts of one's personality and autobiographical memories (Rubin, 2019). Therefore, the bodily and narrative self are inherently defined by ascribing the self to a physical or mental object. In contrast, the *self-as-subject* entails the feeling that the contents of consciousness are experienced by the self rather than being bound to a specific object or representation (Wittgenstein, 1958).

In current cognitive scientific literature, James's (1890) distinction between the self as "I" and the self as "me" has often been mapped onto Wittgenstein's distinction, with "I" corresponding to the sense of self-as-subject and "me" corresponding to the sense of self-as-object (Christoff et al., 2011; Liang, 2016; Sui & Gu, 2017). Importantly for the current discussion, because the minimal self is strictly defined as the immediate, prereflective sense of being a subject (Gallagher, 2000), it by definition excludes any form of selfhood that involves internal representation, including even the most basic conceptualization of oneself as an object (Liang, 2016). Cognitive scientists have therefore used the distinctions made by James and Wittgenstein to inform their attempts to measure selfhood (Liang, 2016; Tsakiris, 2013). For example, distortions in self-representation, like the loss of body ownership, are conceptualized as being disruptions in self-as-object (Liang et al., 2021), whereas distortions in the sense of being the subject of an experience (e.g., reluctance to use the word "I") are conceptualized as being disruptions in self-as-subject (Liang, 2016; Millière et al., 2018).

Placing the Minimal Self: Prereflective Self-as-Subject

As Figure 1 shows, the distinctions between self-as-subject and self-as-object do not parallel the difference between reflective and prereflective selfhood. As shown, narrative selfhood is reflective, with the self being ascribed to mental objects that correspond to a distinct identity that is constituted of autobiographical memories, idiosyncratic characteristics (e.g., likes, dislikes), and personality traits (Zahavi, 2010). In contrast, the more basic aspects of bodily self-consciousness, such as body ownership, self-other boundaries,

Figure 1
Self-Constructs in Relation to the Reflectiveness and Subject-Object Dimensions



Note. See the online article for the color version of this figure.

and self-location, are prereflective in that they are not the product of deliberative conscious thought but are instead immediate, lived experiences (Legrand, 2006). For example, we know that our limbs belong to us simply by perceiving them as our own, without having to reflect on their ownership. Similarly, in social contexts, we automatically distinguish our bodies from others' without having to make this distinction via engaging in higher order cognition. These forms of self-consciousness are thus provided directly through experience rather than reflective processes (Legrand, 2006). Yet, these are examples of the self as an object because they attribute the self to a distinct body or entity in the world. As Legrand (2007, p. 586) noted, the prereflective self-as-subject is "non-objectifying in the sense that it does not correspond to any form of consciousness of some object towards which I would occupy the position or perspective of a spectator or in(tro)spector." Body ownership thus grounds the self as inhabiting or being defined as a bounded, physical object. For example, self-other boundaries and self-location both define the self as a discrete form relative to others within a relational and/or spatial framework. In contrast, minimal self-consciousness is not derived from such attributions but instead corresponds to the sense of experience that happens to a subject. Indeed, even if an individual loses their sense of being embodied (e.g., out-of-body experiences; Moix et al., 2025), their loss does not necessarily eradicate the sense of being the subject of that experience. Even if the experience is not embodied per se, the individual still feels the experience as a subject through what de Medeiros and de Almeida Silveira (2015, p. 227) called "extracorporeal perception." Thus, returning to Figure 1, the narrative and bodily self respectively relate to the questions "Who am I?" and "What am I?," whereas the minimal self relates to the question "Am I?"[1]

Because the distinctions between self-as-subject/self-as-object and prereflective/reflective selfhood are not the same (e.g., self-as-object is not inherently reflective), studies of the minimal self must consider both dimensions. For example, to confidently attribute some neuroscientific evidence to the minimal self, that evidence must reflect the prereflective sense of self-as-subject and not reflective processes or processes related to the bodily self. One possible method for doing this is to track the neural correlates of specific situations that involve experiential changes in the prereflective self. Two possible examples of this approach, which will now be explored, are selfless states induced by meditation and psychedelics.

Psychedelics and Meditation as Genuine Disruptors of Minimal Selfhood

This section aims to substantiate the hypothesis that there are classes of psychedelic ego dissolution and nondual awareness that correspond to extreme modulations of (i.e., disruptions to) the prereflective sense of self-as-subject. Before doing this, we specify four conditions of the present account. First, meditative nondual states unfold along a gradient, from empty or near-contentless awareness to states where content remains but is no longer shaped by higher order interpretation (Josipovic, 2021). Across this gradient, the defining feature is the dissolution of the subject–object structure. We do not restrict nondual awareness to contentless states; experiences with phenomenal content are equally included and, for our purposes, especially relevant, as they allow us to isolate the shift from perception being experienced for "me" to a mode in which contents and awareness appear as a single, undifferentiated field. We also do not functionally distinguish nondual states with reflexive awareness from those without it because the experience of

[1] The final quadrant in Figure 1, where the reflective self intersects with self-as-subject, corresponds to those states in which one reflects upon one's immediate experiences. Although this quadrant is inherently fascinating, it is not the focus of this article and thus will not be discussed further.

reflexivity does not seem to be a necessary phenomenological feature of minimal self-disruption experiences (Josipovic, 2021). Second, we consider psychedelic ego dissolution as induced by classic and nonclassic psychedelics because accounts of ego dissolution have been reported for both lysergic acid diethylamide (LSD) and psilocybin (classic; Lebedev et al., 2015; Tagliazucchi et al., 2016) and ketamine and 5-methoxy-N,N-dimethyltryptamine (nonclassic; Ermakova et al., 2022; Marguilho et al., 2023). Third, the present analysis applies to states of waking consciousness rather than the experience of conscious contents during nonwakefulness (e.g., sleep or coma).

Finally, and most importantly, it is necessary to clarify that the terms "ego dissolution" and "nondual awareness" have been used ambiguously in the literature, in part because these states denote multiple, qualitatively distinct modulations of selfhood. For example, these terms have often been used to emphasize the loss of narrative or autobiographical identity (e.g., Josipovic & Miskovic, 2020; Stoliker et al., 2022). Moreover, both terms have been used to refer to aspects of the unitive or "extended self," such as self-other merging, boundary dissolution, or a noetic sense of oneness with the universe (Yaden et al., 2017). Although unitive experiences can be considered modulations in prereflective selfhood, they are not of interest here because they usually reflect scope extension (i.e., broadening of the experiential reference frame to include others or the world) rather than the attenuation of the prereflective mineness of conscious contents (i.e., prereflective self-as-subject).

By contrast, we use the terms "ego dissolution" and "nondual awareness" to denote cases in which the prereflective sense of self-as-subject is markedly diminished or absent (Letheby, 2020). That is, we operationalize the states of interest as ranging from attenuation to abolition of prereflective mineness and not scope extension of the minimal self (i.e., unitive/extended self) or alterations confined to the autobiographical/narrative self. Below, we draw on contemporary reports and canonical Buddhist descriptions to exemplify these states of interest.

Psychedelic Selfless States

Millière (2017) noted that, in many self-reports of psychedelic ego dissolution, there is often a reluctance to use the first-person pronoun "I" when describing the experience. For example, one report involving the use of psilocybin reads, "There existed no one, not even me … so would it be proper to still speak of 'I,' even as the notion of 'I' seemed so palpably illusory?" (https://www.erowid.org; Report #42740). Another report about an experience following 5-methoxy-N,N-dimethyltryptamine ingestion reads, "It felt as if 'I' no longer existed. There was purely my sensory perception of my environment, but sensory input was not translated into needs, feelings, or actions by 'me'" (Millière et al., 2018, p. 10).

Recall James's (1890) distinction between self as "me," the subject perceived through its own physical and mental characteristics giving rise to the self of self-as-object, and self as "I," the experience of *being* a subject giving rise to the sense of self-as-subject. Reports of reluctance to use the pronoun "I" may indicate an alteration in individuals' otherwise normal and implicit attribution of phenomenal content to a unique subject who experiences that content. The experience is instead reduced to an impersonal occurrence, such that there is an awareness of qualitative content without the sense that it can be attributed to a particular subject who uniquely accesses or owns the experience. Indeed, if the sense of self-as-subject is what is disrupted during this type of ego dissolution, then any attempt to later recall the qualitative contents present during the ego dissolution might be expected to be marked by a reluctance to attribute the contents to a subject and consequently a reduced propensity to use the pronoun "I."

In his popular book on psychedelics, Michael Pollan (2018) described a particularly powerful 5-methoxy-N,N-dimethyltryptamine experience that supports this notion that, during ego dissociation, phenomenal contents occur impersonally rather than in reference to a unique subject:

> "I" was no more, blasted to a confetti cloud by an explosive force. I could no longer locate [myself] in my head, because it had exploded that too, expanding to become all that there was. Whatever this was, it was not a hallucination. A hallucination implies a reality and a point of reference and an entity to have it. None of those things remained. … In fact every touchstone that tells us "I exist" was annihilated, and yet I remained conscious. "Is this what death feels like? Could this be it?" That was the thought, though there was no longer a thinker to have it. (pp. 276–277)

The experiences described in these reports tend to share the feature of lacking (to some degree) the sense that there was someone who had them. The subjects instead report that, while phenomenal

contents were present, it did not feel as though there was a distinct subject to which they were connected. For example, Pollan described his awareness of a thought "without a thinker to have it," highlighting that, although one's conscious experience might include awareness of qualitative content (e.g., Pollan's question about death), the experience is completely devoid of a subject to whom the content can be attributed. If this analysis is correct, then it seems reasonable to argue that individuals who are undergoing this particular type of ego dissolution experience a disruption in their usual prereflective sense of self-as-subject in relation to qualitative conscious contents. Therefore, this specific class of psychedelic ego dissolution experiences is marked by a disruption in minimal selfhood (Letheby, 2020; Millière, 2017).

Meditative Selfless States

The past few decades have witnessed several attempts to integrate various Buddhist philosophies with Western cognitive science (e.g., see Kabat-Zinn & Burney, 1981; Varela et al., 1991; see also Rhys Davids, 1914). This more integrative approach to understanding consciousness introduced new ideas about the nature of the self that were not easily reconciled within the scientific understanding of that time (Chadha, 2017). For example, as described in the Dhammapada canon (one of the most historically significant Buddhist texts), the Buddha taught that there are three markers of existence that apply to every living being: (a) impermanence (i.e., *anicca*), (b) suffering (i.e., *dukkha*), and (c) not-self (i.e., *anattā*; Mills, 1977).[2] These terms form the core of a doctrine that is used to guide meditation practice toward the goal of understanding these markers through direct experience. Furthermore, not-self, or *anattā*, is considered by some Buddhist scholars as the Buddha's most profound insight (Mills, 1977). Anattā is the realization that even the most basic sense of self is an illusion constructed by the mind (Mills, 1977). The process that then allows for minimal self-awareness is the insight that there is an "experiencer" to experience or an "observer" to observe. In other words, the concept of anattā argues that our implicit sense of there being a subject to which conscious experience is experienced (i.e., minimal selfhood) is not inherent. It is instead mentally constructed. The sense of self-as-subject here emerges through self-referent interpretation of what the Buddha called the five aggregates (i.e., *khandas*) of experience: (a) form (i.e., the physical world), (b) feeling (i.e., our simplest responses to an experience, such as like, dislike, or indifference), (c) perception (i.e., recognition of sensory objects), (d) volitions (i.e., intentions), and (e) consciousness (i.e., any kind of mental activity; Mills, 1977).

Self-referent interpretation of these aggregates normally occurs as they naturally arise in one's experience (MacKenzie, 2010). Specifically, one will subconsciously interpret an aggregate or combination of aggregates in the following ways: (a) The individual and aggregate(s) are identical, (b) the individual possesses the aggregate(s), (c) the individual exists within the aggregate(s), or (d) the aggregate(s) exist within the individual. This self-referential processing is what Buddhist texts term "I-making" (*ahaṃkāra*) because it is during such identification with the aggregates that a sense of self as a subject to experiential objects emerges (MacKenzie, 2010; Mills, 1977). In summary, according to Buddhist tradition, the sense of "I" originates from the implicit, prereflective interpretation of aggregates that emerge from the stream of experience.

According to core canonical texts, with enough mindfulness, it is possible to both observe and halt the process of "I-making" (Mills, 1977). Not-self is described canonically and by practitioners as resulting from the concurrent observation of the constant interaction of the five aggregates in the absence of a concrete self in that moment (i.e., *dependent origination*; see Chadha, 2017; Shulman, 2008). The moment is thus simply observed as an impersonal interaction between form, feeling, perception, volitions, and consciousness. Each aggregate arises, interacts with another, and then passes in constant flux, with no persisting subject or agent to be detected. Even volitions, which in Western psychology are assumed to be a core part of selfhood, are felt as just arising and passing phenomena that have no personal relevance (Chadha, 2017). The Buddhist doctrine on anattā is thus as follows: The sense of "I" arises through the awareness of qualia, relying on self-referent interpretation of the five experiential aggregates and, by extension, the aggregates themselves. However, qualia can still

[2] These and the other Buddhist terms that will be introduced in this article are from Pali, the ancient canonical language of the Theravada Buddhist tradition that is closely related to modern Sanskrit.

be experienced independently of a sense of "I" (Mills, 1977). The realization of anattā is therefore described as a state in which one has abandoned the perspective that an experience is happening in relation to a subject (i.e., there is no sense of minimal self; Chadha, 2017).

Accounts of the dissolution or loss of the "I" during meditation, although largely anecdotal and embedded within religious and philosophical contexts, are regarded as critical milestones in the traditional Buddhist path toward liberation (i.e., *nirvāṇa*; Albahari, 2014). Such experiences are often described as pivotal in the contemplative progression of committed practitioners (i.e., *bhikkhus* or advanced meditators; Sharf, 1995). However, a more recent study provides some empirical evidence of the occurrence of meditation-induced states in which the minimal self is disrupted. Dor-Ziderman et al. (2013) had 12 highly experienced meditators of the Buddhist Vipassana tradition practice a variety of states to differentially manipulate self-experience. Of relevance to the present discussion, a "selfless" condition was induced by asking participants to interpret their present experience impersonally, without reference to themselves as the center of that experience. Analysis of retrospective phenomenological reports provided after the task resulted in the classification of three kinds of altered self-experience. Interestingly, reports in the "loss of ownership" class described experiences having intact phenomenal content but with a specific subtraction of a sensed subject. For example, one participant reported, "It was emptiness, as if the self fell out of the picture. There was an experience but it had no address, it was not attached to a center or subject" (Dor-Ziderman et al., 2013 p. 6).

This type of phenomenological evidence is further corroborated by neural evidence, which indicates that loss of ownership experiences are associated with a distinct attenuation of β-band power in the left dorsomedial thalamus and right inferior parietal lobule. These findings indicate that disruptions to the self-as-subject are not merely a theoretical construct but are instead a specific and identifiable type of selfless state that is distinguishable both phenomenologically and neurologically from other states. These findings also align with canonical contemplative traditions, which regard such states as advanced milestones in the meditative progression toward liberation.

The Neural Correlates of Minimal Self Disruptions Inform Processes Involved in Minimal Selfhood

Considering the discussion so far, certain classes of psychedelic ego dissolution and meditative nondual awareness may both be considered states in which the minimal self is disrupted. Observing the brain activity of individuals reportedly undergoing these states in comparison to the brain state of normal controls can help to pinpoint the neural systems that support the minimal self. This general approach has been widely adopted in neuropsychiatric research, which seeks to identify correlations between mental functions and neural activity in order to understand and cure psychiatric conditions. These correlations in turn provide empirical "benchmarks" that are useful for building theories and testing hypotheses that attribute mental functions to individual brain regions or the interactions of those regions.

For instance, the increased global connectivity among frontal, parietal, and inferior temporal cortices with ego dissolution under the influence of the psychedelic LSD may motivate both the prediction that changes in global connectivity are responsible for variations of minimal selfhood (Tagliazucchi et al., 2016) and the hypothesis that the minimal self reflects the coordinated activity of these cortical areas. This example illustrates how the neural correlates of psychedelic ego dissolution and meditative nondual awareness might be used to shape accounts of the physical processes responsible for modulation of minimal selfhood. This approach has been used in studies reported by Deane (2020) and Carhart-Harris and Friston (2019) for psychedelic ego dissolution and in studies reported by Dorjee (2016), Josipovic and Miskovic (2020), Laukkonen and Slagter (2021), Paoletti et al. (2022), and Meling (2022) for nondual awareness. Although this approach has been productive, it has to date only been applied separately to either psychedelics or meditation. Moreover, these studies use broad definitions of nondual awareness and psychedelic ego dissolution, which may encompass narrative or bodily self alterations. The next section therefore advances the proposal that, by comparing alterations in minimal selfhood using psychedelics and meditation, one might stand to refine these mechanistic analyses.

The Second Challenge: Disentangling Core Mechanisms Underlying Minimal Selfhood From Its Enabling Conditions

So far, we have argued that the neural correlates of certain classes of psychedelic ego dissolution and meditative nondual awareness provide unique insights into the neural systems responsible for minimal selfhood. However, Millière (2017) noted that, for example, even if one were to know the neural correlates of this class of psychedelic ego dissolution, it would still be difficult to determine which of those correlates represent *minimally sufficient* mechanisms for minimal selfhood.

To understand this claim, it is important to note that Chalmers (2000) seminally differentiated between the "core mechanism" and "enabling conditions" of consciousness. He noted that the total difference in neuronal activity held between a subject experiencing a particular state of consciousness and one that cannot be considered to represent a minimally sufficient marker of that mental state. That is, functional differences in neural activity related to variations in subjective experience represent both the activity directly responsible for the variation and the activity that enables the variation. This difference between core mechanisms and enabling conditions can be clarified using the analogy of sugar's solubility (Hohwy, 2007). Enabling conditions, like water in this analogy, create an environment that is conducive for sugar dissolution to occur. The core mechanism is then the breakdown in the sugar's molecular structure, which occurs when it is exposed to materials (i.e., solvents such as water) that break its polar bonds. This breaking of the molecular bonds is thus the core mechanism that is responsible for the dissolution of sugar in water, as evidenced by the fact that sugar can be dissolved in other substances (e.g., ethanol).

Applying the lesson of this example to our present discussion, the neural correlates of a state of self-consciousness can be assumed to encompass both information about the changes in the environment (i.e., neural prerequisites), which are conducive to a core mechanism, as well as the core mechanism itself. For example, when measuring the effects of ego dissolution under psychedelics, the two types of information are entangled. Millière (2017, p. 9) explicitly acknowledged this fact by noting that:

> it is impossible to know which of the functional differences between [non-ego-dissolution and ego-dissolution] subjects, if any, directly underlie the loss of the sense of self—that is which of them, if any, is minimally sufficient for having a sense of self.

Saying this plainly, it is simply not possible to use the neural correlates of selfless states as induced by psychedelics to directly infer the core mechanism of self. The same logic, of course, applies with selfless states during meditation because data that might be used to identify the core mechanism of self would not be able to disentangle that mechanism from its enabling condition. This conundrum then raises the question: How can the neural correlates of selfless states across meditation and psychedelics be used to make inferences about the neural systems that support minimal selfhood? As discussed in the next section, we contend that there is a way forward.

The Potential Solution: Identifying Context-Independent Mechanisms

We propose that core mechanisms may be disentangled from their enabling conditions by focusing on those neural markers that correspond to changes in minimal selfhood across two or more independent contexts. Specifically, we suggest that the core neural basis for the sense of minimal selfhood can be identified by examining consistent changes in neural information (in empirical data but perhaps also in computational models) associated with the attenuation of the prereflective sense of self-as-subject across two contexts in which this attenuation occurs—for example, the selfless states within psychedelic ego dissolution and nondual awareness meditation. The remainder of this section will attempt to provide support for this proposal.

Returning to our previous sugar analogy, the dissolution of sugar is caused by changes in its molecular structure and is not specific to particular solvents. The core mechanism responsible for its dissolution, however, only becomes clear after observing its dissolution across multiple contexts; the breakdown of polar bonds across different solvents indicates that the dissolution of sugar is contingent upon a specific change in its chemical structure. And in the same vein, changes associated with the dissolution of self across contexts may provide insight into the physical

properties that sustain it. Psychedelic ego dissolution and nondual awareness thus provide two examples of how loss of minimal selfhood can occur in different contexts. The neural changes that occur during the transitions from normal consciousness to these states may provide the means to identify the core mechanism responsible for the loss of phenomenal subjectivity. Moreover, although these neural changes can be directly compared across contexts, doing so provides only a list of overlapping regions or connectivity patterns. Situating these commonalities within a computational framework is advantageous because it allows the overlaps to be expressed in terms of shared functional operations or network configurations, rather than as common anatomical features. This makes it possible to identify which aspects of the shared neural pattern plausibly reflect a common underlying mechanism and which aspects are likely to be context-specific consequences of the particular method of induction. The remainder of this article will provide a proof-of-concept by using our approach to generate testable hypotheses.

Before proceeding, however, two clarifications are needed regarding the distinction between core mechanisms and enabling conditions. First, regarding *what* varies, by "core mechanism of minimal selfhood," we mean the mechanism underlying variation in the felt sense of being a subject. Second, regarding the *relation*, we retain the classical sense of a core mechanism as the minimally sufficient cause of this variation (Chalmers, 2000). Minimal sufficiency cannot be read directly from correlational data, and as noted above, anatomical overlap across contexts is on its own an unreliable guide because regions may coincide for unrelated reasons rather than because a common mechanism is engaged. It is precisely the reexpression of such overlap as a shared functional operation within a computational framework that allows context-invariance to serve as a heuristic marker for minimal sufficiency. In other words, a *functional operation* that recurs across contexts with otherwise independent enabling conditions is a more plausible candidate for the minimally sufficient mechanism than features that vary across them, which are instead more likely to reflect enabling conditions. On this basis, cross-context convergence licenses an inference of prioritization rather than proof: It identifies which correlates most warrant the causal investigation required to establish minimal sufficiency rather than those more likely to constitute enabling conditions.

Although it is worth preemptively noting that the validity of our approach is contingent upon the neural states afforded by psychedelic- and meditative-induced minimal self disruption being sufficiently different from each other, three facts support this precondition. First, the fact that one method of minimal self disruption involves chemically induced alterations (requiring no effort) whereas the other relies on the volitional modulation of attention (which requires effort) suggests that these states are likely to be dissimilar (Millière et al., 2018). Second, these differences can be interpreted as reflecting independent enabling mechanisms at a macrolevel and thus already qualify as valid comparators. Third, neural states are characterized by different sensory processing markers because, relative to normal states of consciousness, psychedelic ego dissolution often co-occurs with higher sensory experience (i.e., greater presence or complexity of conscious content; e.g., Studerus et al., 2010), whereas nondual awareness can co-occur with lower sensory experience (e.g., minimal phenomenal experience; Metzinger, 2020). Although these findings support the condition of neural state independence, our account remains conditional upon this independence, thus necessitating its confirmation by future research. But assuming this independence for the purposes of this article, the next section attempts to identify similarities in cognitive computational frameworks that might correspond to minimal self disruption within selfless states as induced by meditation and psychedelics.

Proof-of-Concept: Identification of Commonalities Across Contexts Involving Minimal Self Disruptions

The proof-of-concept offered here will be situated within the *predictive processing* framework. This framework attempts to explain neural activity using computational and statistical principles (e.g., the free energy principle; Friston, 2010). A core concept in predictive processing frameworks is *precision weighting*. As suggested by its name, precision weighting determines the relative influence of sensory evidence versus prior beliefs on how the perceptual uncertainty between incoming signals and expectations about those signals is resolved. These predictive

weightings thus influence the recursive dynamics of this resolution between higher and lower levels of processing (Friston, 2013). More specifically, greater precision weighting of a prior will cause the sensory input to be reflected consciously in a way that confirms the prior. Conversely, greater precision weighting for the error will cause the prior to be updated to change the belief and what is represented consciously (Friston, 2013; Seth & Hohwy, 2021). The following sections will describe two theories that use the predictive processing framework to explain the full spectrum of selfless states under psychedelics and meditation. Following this, we also provide an alternative proof-of-concept comparing these conditions under the *global workspace* model of consciousness (Baars, 2005).

Extracting Commonalities Under a Predictive Processing Framework

Relaxed Beliefs Under Psychedelics: Psychedelics and Predictive Processing. The Relaxed Beliefs Under Psychedelics (REBUS) model (Carhart-Harris & Friston, 2019) attempts to explain a wide range of the psychological effects induced by the use of psychedelics (e.g., loss of selfhood) by assuming that the brain operates according to a predictive processing framework. The model does this using four reliable empirical findings. First, the psychological effects of psychedelics reflect their capacity to activate the serotonin receptor subtype 5-hydroxytryptamine 2A (5-HT2AR; Vargas et al., 2023). Second, the self is represented within a functional hierarchy called the default mode network (DMN) that is distributed across the parietal, temporal, and frontal cortices (Carhart-Harris & Friston, 2010; Fingelkurts et al., 2012). Third, 5-HT2AR receptors are highly concentrated within the DMN (Beliveau et al., 2017). Fourth, the loss of self-consciousness has been demonstrated to be positively correlated with the functional disintegration of the DMN (Lebedev et al., 2015). Additionally, REBUS incorporates the assumption of predictive processing because activation of 5-HT2AR receptors increases the neuronal excitability (i.e., sensitivity to ascending input) of deep pyramidal neurons—neurons that are thought to represent priors related to self (Carhart-Harris & Friston, 2019). This increase in the activity of deep pyramidal neurons then decreases the brain's oscillatory activity in the α and β bands. Because α and β activity are modulated by the DMN (Muthukumaraswamy et al., 2013) and provide top-down inhibition of sensory processing (Carhart-Harris & Friston, 2019), this relationship suggests that psychedelics increase the sensitivity to prediction errors by increasing 5-HT2AR activation in the DMN (i.e., by decreasing the precision weighting of the priors), thereby reducing their top-down, constraining influence. If this account is correct, then psychedelics effectively decrease the precision weighting of self-related priors encoded by the DMN and consequently disable their top-down influence. The net effect of these changes is to reduce one's consciousness of selfhood.

The extinguishment of minimal selfhood corresponds to total ego dissolution, wherein one's conscious experience no longer includes being an embodied agent in any capacity (Letheby & Gerrans, 2017). According to REBUS, this state corresponds to the complete disintegration of the self-related hierarchical structure. Indeed, according to the model, ego dissolution results from hierarchical "flattening." In other words, the extreme reduction in the precision weighting of DMN-located high-level predictions about the self that are caused by psychedelics leads to a cascade effect of prior revision at lower levels of the hierarchy (Carhart-Harris & Friston, 2019). The hierarchy thus "flattens" because information processing at the lower levels no longer conforms to higher level predictions about the self. Consequently, predictions about "self" cannot influence processing at any level of the hierarchy, preventing the self from being consciously represented in any form. This results in the loss of all sense of "for-me-ness" in that moment, with no "self" being evident in conscious experience.

Many to (N)One: Meditation and Predictive Processing. The many to (n)one (MN) model (Laukkonen & Slagter, 2021) attempts to explain the psychological effects of mindfulness meditation practice on the brain's predictive processes. By this account, unexpected sensory stimuli are typically encoded by superficial pyramidal neurons, which suggests their involvement in propagating prediction errors within the framework of predictive processing. Because heightened attention directed toward unexpected sensory stimuli leads to an increase in the synaptic gain among the sensory neurons (Feldman & Friston, 2010), these increases in synaptic gain have been argued to be mathematically equivalent to increases in the precision weighting of prediction error (e.g., see Friston, 2023).

Classically, Buddhism considers the perception of duality (i.e., the subject–object distinction) as a learned interpretation of reality that occurs in response to dependent arising (Chadha, 2017; Mills, 1977). *Dependent arising* is the notion of creating a relation among learned concepts, exemplified by the expression "If this exists, that exists; if this ceases to exist, that also ceases to exist" (Keenan, 2000, p. 29). For example, as one learns that there is a concept of "you" that is separate from oneself, then necessarily there must be a concept of "me" (Mills, 1977). Thus, in Buddhism, a central premise is that the division between the observer and the observed, which is the distinction that enables the identification of a subject, is encoded as a prior belief that is learned from previous experience. Laukkonen and Slagter (2021) implicitly assumed this prior to be encoded at a high level and active in the processing of most, if not all, modes of perception.

The MN model posits that mindfulness meditation entails the intentional directing of attention toward sensory information *as it arises* or what it is *now* and not at what has been abstracted from the sensory information or what that information means within a higher level representation of the world. That is, sensory information is attended to before it corresponds to a prior, thus being focused on nonpredicted information (i.e., what is represented by the prediction error). As discussed, attention increases the precision weighing of this information, encouraging parameter revision in the priors held by the model, which would otherwise attenuate information. With attention directed toward unexpected or novel information at many levels of perception, the precision weighting of the errors that propagate upward tends to increase, causing the system to move toward prior revision (Laukkonen & Slagter, 2021). Thus, sensory input is less attenuated by higher level priors, and consequently, what is predicted by the system becomes less of a function of these priors. In this way, the predictive hierarchy flattens, resulting in a mode of conscious experience in which any abstraction ceases, including the experience of the subject as an experiential object (Laukkonen & Slagter, 2021). This process results in a state of consciousness in which an input may be received without the processing of it as an object to be perceived by a subject, yielding an absence of phenomenological duality.

Hierarchical Flattening as the Core Mechanism. Our analysis identified how the REBUS and MN models might explain minimal self disruption by suggesting a common core mechanism: hierarchical flattening. By this tentative account, the hierarchical dynamic of information processing ceases within the contexts of psychedelic ego dissolution and meditative states of nondual awareness. Whereas during normal conditions sensory information is propagated upward through the processing hierarchy via recursive error resolution that is guided by higher level priors, in states of ego dissolution or nondual awareness, these priors no longer function to guide the resolution of unexpected information. Instead, unpredicted information propagates more easily through the entire neural system due to the lack of top-down constraint. Psychedelics disable this top-down constraint through their neuropharmacological effects on neural networks that encode the high-level priors, while meditation disables it through attentional modulations of error propagation. These two independent conditions activate distinct neural precursors, which both enable hierarchical flattening of predictive processing. Crucially, the flattening action is the core mechanism of minimal selfhood disruption rather than an enabling condition.

Within the meditation literature, Tal et al. (2026) arrived at a closely related conclusion despite proceeding from a different inductive route and phenomenological focus. By synthesizing recent computational interpretations of neurocognitive effects of meditation, they distinguish between "high-route" and "low-route" transformations into selfless states, which map onto distinct self-dimensions in our framework. The high route, specifically exemplified by focused attention practices, primarily targets the reflective self-as-object. This route involves the addition of higher order model layers via increased meta-awareness that renders the system's own modeling process an object of observation. Although this route does not directly target the prereflective self-as-subject, sustained meta-awareness (i.e., turning attention toward awareness itself) is argued to reduce variance at higher hierarchical levels, driving Bayesian model reduction and a progressive flattening of the generative hierarchy. By contrast, the low route, associated with deconstructive practices (e.g., open monitoring or nondual meditation and the active process of "letting go"), more directly engages the prereflective self-as-subject. This is achieved by shifting precision toward the lowest hierarchical levels, such that

higher order conceptual bindings fail to stabilize and temporally deep self-models become inaccessible.

Crucially, despite operating on different self-dimensions using distinct strategies, both psychedelics and meditative practices converge on hierarchical flattening as the core computational mechanism. This convergence mirrors the mechanism identified in the present framework across both methods of induction, supporting hierarchical flattening as a shared computational pathway toward the destabilization and, in sufficiently extreme cases, dissolution of minimal selfhood. Therefore, substituting Tal et al.'s (2026) synthesis for the MN model alone does not alter our conclusion that hierarchical flattening is the shared mechanism across different methods of inducing self-loss. Tal et al. showed that later meditation models, which consider different meditation styles, converge on layer-specific precision reweighting, with defabrication (i.e., progressive deconstruction of experience through releasing grasping and identification; Prest & Berryman, 2024) and minimal phenomenal experience (i.e., nonconceptual "pure awareness" characterized by minimal content; Metzinger, 2020) accounts specifying precision shifts that facilitate prediction-error propagation and contract temporal depth, whereas REBUS specifies reduced precision on high-level self-related priors, with both routes converging on a flattened inferential hierarchy.

Under conditions that enable hierarchical flattening, conscious experiences that violate prior beliefs would nonetheless be experienced. Because the minimal self relies upon self-modeling, specifying the self in a phenomenological field of awareness, a failure to match internal models results in the conscious experience of not-self. Importantly, neither the REBUS nor the MN model posits that psychedelic or meditative conditions selectively target the neural systems that encode minimal selfhood. Rather, they stipulate the enabling conditions for radical extinguishment of the active influence of prior beliefs in general. Both models stipulate that the minimal self is a corollary of hierarchical processing, which is active during most, if not all, modes of perception. As such, sensory information during normal conditions is represented consciously in the context of someone having those experiences. However, a failure to impose priors on any mode of sensory perception results in the sensory information being represented consciously in the absence of an experienc*er* of the experience.

Predictions From the Hierarchical Disintegration Approach. The above analysis identified a core mechanism of minimal selfhood. This final section will provide three testable hypotheses that might be used to assess the relationship between minimal selfhood and hierarchical neural dynamics. Our predictions make use of three key parameters within the framework of a neural processing hierarchy: (a) *hierarchical depth*, or the network architecture and the strength of top-down feedback across processing levels; (b) *precision*, or the degree of confidence in the high-level priors of the processing architecture; and (c) the degree of *stimulus-level attenuation*.

Our first prediction is that the flattening of hierarchical depth expressed through reduced top-down influence from high-level transmodal systems should reduce prereflective "for-me-ness" while leaving the experience otherwise intact. For anatomical specificity, we anchor this prediction to the DMN, not as a unitary locus of selfhood but as a candidate instantiation of deep, domain-general hierarchical models of self-referential processing (Carhart-Harris & Friston, 2019). Evidence supporting this hypothesis would be the finding that the strength of "for-me-ness" during perception of a given stimulus is negatively associated with the disintegration of hierarchical dynamics in the distributed DMN-sensory cortical circuit that are normally engaged in processing the stimulus. For instance, given a visual stimulus, one might expect reduced top-down effective connectivity from the DMN to the visual cortex, as indexed using directed-connectivity methods (e.g., spectral dynamic causal modeling or spectral Granger causality), with appropriate controls for global-signal and hemodynamic-electrophysiological confounds (e.g., preprocessing strategies outlined by Friston, 2013).

Our second prediction is that reducing the precision of high-level priors should reduce the sense of "for-me-ness." Evidence supporting this hypothesis would be the finding of a positive association between self-reported "for-me-ness" and neural markers of precision weighting of high-level priors, with any reduction of those markers resulting in reductions in "for-me-ness." For anatomical specificity, these effects are expected to be most evident in transmodal association cortices commonly implicated in high-level predictive control, including medial prefrontal, posterior

cingulate, and inferior parietal regions, rather than in early sensory areas (Buckner & DiNicola, 2019). For instance, within these transmodal regions, one may track changes in positron emission tomography measures linked to 5-HT2A activity, which has been used as a proxy for high-level precision in recent work (e.g., Vargas et al., 2023). These markers show relatively consistent timing patterns, with early reductions in α and β activity often interpreted as reduced weighting of high-level predictions (Bastos et al., 2015).

Finally, our third prediction is that, for a stimulus of a given modality (e.g., visual), decreasing the sensory attenuation or precision in its sensory processing should reduce the sense that the stimulus is happening "for me," resulting in a local loss of first-personal givenness of the stimulus (modality-specific), rather than a global (experience-wide) selfless state. Evidence for this hypothesis would be the finding that lower sensory attenuation (e.g., as indexed using a force-matching paradigm; McNaughton et al., 2023) is both associated with increased reports of local disruptions in "for-me-ness" and correlates positively with markers of attenuation within the relevant system. Adding a low-prediction control condition to the design would allow for statistical delineation between local attenuation and global precision changes (McNaughton et al., 2023).

It is important to note that each of the parameters used to generate our predictions maps onto largely distinct measures: Hierarchical depth maps onto effective connectivity and indices of feedback, precision maps onto gain or markers of confidence, and stimulus-level attenuation maps onto sensory-attenuation or force-matching responses. These mappings are also not completely independent: Depth indices can shift with changes in precision, precision can covary with feedback strength, and attenuation may reflect global precision or local feedback. It will therefore be necessary to verify any observed dissociations using a common set of manipulation checks and planned orthogonal contrasts. Moreover, we acknowledge that these suggestions involve substantial practical and methodological challenges and would require considerable nuance in implementation; they are intended here only as initial starting points for further exploration. Additionally, one radical implication of our hypotheses is that minimal self-awareness may not, at its core, be driven by a specific network (e.g., the DMN) or localized cortical regions. Instead, the sense of being a subject of qualia may be a consequence of the fact that qualia are being processed in a hierarchical manner. This is not a new idea; for example, Metzinger (2003) seminally proposed that minimal selfhood is a natural corollary of prediction in that a cognitive system must model itself to anticipate future states. It follows logically from this that, with a reduction in prediction, there should be less self-modeling (i.e., less modeling of "self"; Gallagher & Marcel, 1999) and thus less conscious representation of a "self." As such, the hypotheses described here may provide a novel method for testing the theoretical proposition of Metzinger.

Extracting Commonalities Under a Global Workspace Framework

A second, more exploratory, application of the present framework entails comparing findings related to self-loss as induced by meditation and psychedelics, as respectively reported by Josipovic (2014) and Tagliazucchi et al. (2016). To our knowledge, global workspace models (Baars, 2005) have not been used to explain selfhood loss. However, Josipovic explicitly interpreted nondual awareness in global workspace terms, describing a central precuneus network whose self-sustained activity "broadcasts its own broadcasting" to the rest of the brain. By contrast, although Tagliazucchi et al. did not frame their findings in terms of a global workspace, their findings focus precisely on those properties that are central to workspace-style theories, namely, global functional connectivity, modular and rich-club organization, and the balance between integration and segregation that underwrites unitary conscious states (Baars, 2005; Deco et al., 2021).

Nondual awareness is characterized by Josipovic (2014, 2021) as a basic, nonconceptual awareness in which perceptual, affective, and cognitive contents can arise without structuring experience through a subject–object framework. In other words, his account explains experiences of phenomenal objects without a sense that they happen "for me." At the neural level, this type of nondual awareness is proposed to depend on a central precuneus network linking with dorsolateral prefrontal cortex, dorsal anterior cingulate cortex or dorsomedial prefrontal cortex, and inferior parietal cortex or temporoparietal junction (TPJ) regions (Josipovic, 2014). This network forms a macrocircuit at the interface of

intrinsic, self-referential processing systems and extrinsic, attention, or executive systems. The network is described as having extensive recurrent connections that can enter self-sustaining oscillatory resonance (Josipovic, 2014, 2021). During an experience of nondual awareness, the central precuneus network is said to rest in a tonic, subthreshold, self-sustained oscillatory state that functions as an integrative conscious space and, in global workspace terms, broadcasts its own availability to process information (Josipovic, 2014, 2021). Crucially, the state of strong integration between local hubs, which broadcast intrinsic and extrinsic content in the central precuneus, would theoretically enable a phenomenological dissolution between self and other, allowing phenomenal objects to be broadcasted in consciousness without the sense that there is *someone* to experience them.

Turning now to Tagliazucchi et al. (2016), their study showed that, relative to placebo, intravenous injections of LSD produced widespread increases in global functional connectivity density (FCD), with the largest changes occurring in high-level association cortices and the thalamus. These FCD increases reflect certain regions becoming more globally connected to the rest of the brain under the influence of LSD. The globally connected regions showed increased coupling with multiple sensory networks, indicating enhanced communication across systems that are segregated in the placebo condition. Moreover, these findings demonstrated reduced modularity, increased participation coefficients in frontal and midline regions, and reduced rich-club organization, consistent with a shift toward greater between-network integration. Importantly, self-reported ratings of the intensity of ego dissolution during the LSD experience correlated positively with regional FCD increases in the bilateral angular gyrus or TPJ and bilateral insula, and this association remained selective with no other subjective ratings showing significant correlations after correction for multiple comparisons. Ego dissolution was therefore specifically associated with increased global connectivity in TPJ-centered and insula-centered transmodal hubs, within a broader pattern of reduced network segregation and expanded cross-system communication.

On this basis, a more concrete common mechanism can be identified without overstating anatomical convergence. Both accounts implicate transmodal association hubs involved in self-related and multisensory integration. For nondual awareness, Josipovic's (2014, 2021) model centers on a posterior medial association network linking the central precuneus with inferior parietal and TPJ regions, which, during nondual awareness, is proposed to enter a subthreshold, low-power, self-sustained oscillatory regime that nevertheless remains globally accessible. And as demonstrated by Tagliazucchi et al. (2016), ego dissolution intensity scores correlate positively with LSD-induced increases in global FCD of the angular gyrus or TPJ, accompanied by enhanced cross-network communication. In both demonstrations, these hubs do not necessarily show increased local activity. Rather, they become more globally coupled and participate in a highly integrated, cross-network configuration spanning internally oriented networks, externally oriented control systems, and, under LSD, multiple sensory networks.

In dynamical terms, this can be described as a *metastable workspace state*. Coordinated global patterns that are centered on these hubs form and remain integrated long enough to support widespread broadcast yet continue to change over time rather than freezing into a single static pattern or disintegrating into uncorrelated activity. The core mechanism is thus specified as an increase in long-range coupling and global participation of a posterior association network comprising the central precuneus and extending into inferior parietal and TPJ regions. This yields a strongly integrated, metastable configuration in which multiple systems are jointly engaged. The enabling mechanisms are thus distinct. During nondual awareness, the recurrent architecture and connectivity profile of the central precuneus network, together with its recruitment in contemplative practice, are proposed to support a tonic, low-power, self-sustained regime. Under LSD, 5-HT2A-mediated pharmacological effects expand global connectivity, reduce modular segregation, and alter hub structure, producing a state in which increased global connectivity of the TPJ and related hubs relates positively to ego dissolution intensity. Interestingly, a neurophenomenological inference can be drawn when reflecting on the Buddhist idea of "I-making" discussed earlier in this article, in which a metastable workspace, with dynamically evolving global patterns, corresponds to aggregates arising and passing without being interpreted self-referentially, thereby halting the process of "I-making" (Mills, 1977).

Because the shared neural configuration observed across nondual awareness and psychedelic ego dissolution reflects a state in which minimal self is weakened, the core mechanism of minimal selfhood can be reverse-engineered as the relative absence of this metastable, globally integrated workspace configuration centered on a posterior association network linking the central precuneus and inferior parietal and TPJ regions. According to this analysis, future research should examine correlations between reported minimal self loss and global workspace parameters indexing reduced occupancy of the globally integrated metastable regime of this network. Relevant parameters that should be examined include dynamic measures of global integration and reconfiguration, such as time-varying participation coefficients and degree or strength centrality for the central precuneus and TPJ, dwell times and transition probabilities of connectivity states in which these hubs show high global participation, and temporal variability of effective connectivity from these hubs under conditions of preserved average integration.

By contrast, the enabling conditions would be indexed by broader network-structural parameters, such as changes in modular segregation and rich-club organization (e.g., graph modularity Q, rich-club coefficients, and global efficiency, which are altered by LSD in Tagliazucchi et al., 2016), shifts in global FCD not shared across nondual awareness and psychedelic ego dissolution, and oscillatory or recurrence properties specific to the central precuneus macrocircuit during nondual awareness. These conditions should influence whether the system enters or sustains the metastable regime but should not constitute the core mechanism underlying the variation in minimal selfhood.

While the main purpose of applying the proposed approach within two different computational frameworks was to demonstrate its feasibility and utility, it is worth clarifying how the two resulting mechanisms (hierarchical flattening and metastable workspace dynamics) relate. The hierarchical-flattening and metastable-workspace mechanisms are best understood not as competing accounts but as framework-relative descriptions of the same underlying process. Both implicate the same transmodal integrative hubs (i.e., higher order association regions that integrate information across sensory modalities rather than processing a single modality) such as the precuneus, posterior cingulate, and inferior parietal cortex. Deco et al. (2021) showed that the global workspace is not separate from the brain's functional hierarchy but is instead its integrative apex. A flattening of top-down hierarchical control and a loss of the integrated workspace regime can therefore be viewed as alternative descriptions of the same process: the same loss of organizing control by high-level transmodal hubs, described by predictive processing as relaxed top-down priors and by the global workspace account as a departure from the normal integrated configuration.

Limitations and Future Directions

Taken together, this proof-of-concept illustrates the utility of extracting neural commonalities of selfless states across contexts within explicit computational models to provide predictions more aligned with core mechanisms of minimal selfhood, rather than its enabling conditions. A key limitation, however, is that the hypotheses derived from the present analysis mainly address the second problem (distinguishing core from enabling mechanisms of self-consciousness) while largely ignoring the first problem (operationalizing genuine cases of minimal self loss). With the exception of Josipovic (2021), who systematically nominates a neural correlate to a type of nondual awareness relevant to minimal self loss, the models and findings considered here remain underspecified in their ability to distinguish variations of minimal self from other forms of self-related change.

In particular, the predictive processing accounts analyzed here do not strictly claim to explain *total* self-loss and are subject to considerable limitations regarding explanatory specificity of the multidimensionality of selfhood. First, reviews suggest that most contemporary reports of "self-loss" under psychedelics and meditation reflect both selective and overlapping disruptions of narrative, embodied, or spatial aspects of self-consciousness (Millière, 2020; Millière et al., 2018). However, as argued earlier in the article, it is possible that reports of disruption in any one of these dimensions do not necessarily reflect a disruption in the prereflective sense of self-as-subject itself. Because minimal selfhood can in principle persist despite the alterations in these dimensions, existing empirical data do not establish when, or even *if*, minimal self is lost in the states typically used to validate

predictive-processing accounts. Second, models such as REBUS and MN nominate hierarchical flattening as a mechanism of selfless states, and our synthesis treats this as the shared and thus core computational signature of a putative loss of minimal self. However, without measures that isolate the presence or absence of minimal self specifically, these models are effectively being validated against heterogeneous alterations of self-related content rather than the phenomenon we purport to explain. The limitation, therefore, is not the plausibility of hierarchical flattening itself but the absence of construct-specific data required to determine whether this mechanism genuinely corresponds to minimal self loss. Moving forward, valid implementation of cross-contextual computational model comparison will require the use of more complete models of psychedelic and meditative effects in which distinct dimensions of self-loss are represented explicitly, such as in Josipovic's (2021) model of nondual awareness, rather than collapsed into a single undifferentiated construct.

We note that our account of minimal selfhood differs slightly in emphasis from some predictive processing accounts of selfless states, though the two are compatible. Limanowski and Friston (2020), for example, suggested that "selfless" states should not be characterized as cases in which self-modeling is completely abolished but rather as cases in which normally aligned computational self-modeling and phenomenal selfhood come apart. On this view, hierarchical flattening or reduced precision does not entail that a system has ceased to model its own states for the purposes of inference and action but instead that there is a divergence between ongoing background self-modeling and its accessible phenomenal expression. As a result, predictive processing frameworks can accommodate pronounced alterations or attenuations of self-experience while remaining compatible with the continuation of self-modeling beneath them (Limanowski & Friston, 2020). Limanowski and Friston may well be correct that some self-modeling continues in this way without conscious access. However, their account does not necessarily reduce hierarchical flattening to an enabling condition: The persistence of background self-modeling is a separate matter from whether flattening is the operation that converges across induction contexts, which is the basis on which we propose it as a core mechanism. By contrast, our concern is with identifying the computational processes that underlie the phenomenal aspect of minimal selfhood.

In regard to future directions, this article has outlined a conceptual and research design framework to identify the core neurocognitive mechanisms that support minimal self-consciousness. Our hope is that this framework will inform meaningful empirical investigation of minimal selfhood. In this final section, we sketch out a program of research that might productively test these ideas. The aim of this work would be the development of lab-based experiments that concretely identify and manipulate core processes of minimal selfhood. We propose three key elements of this empirical approach: (a) valid methods for operationalizing minimal self disruption, (b) an empirical strategy for distinguishing enabling processes from core processes of minimal selfhood, and (c) an experimental approach to establish causal relationships between candidate neurocognitive mechanisms and subjective experience of minimal selfhood disruption.

Operationalizing Minimal Self Disruption

To operationalize minimal self disruption, we propose a multimethod approach drawing on converging psychometric and qualitative evidence. Existing self-report instruments (e.g., the Ego-Dissolution Inventory: Nour et al., 2016; the Non-Dual Awareness Dimensional Assessment: Hanley et al., 2018) aggregate the multiple self-dimensions affected by psychedelics and meditation (Millière et al., 2018) and may use language that is too broad to isolate minimal selfhood (e.g., "I experienced a dissolution of my 'self' or ego" in the Ego-Dissolution Inventory). Measures that instead track the loss of ownership over experience, as described by expert meditators (Dor-Ziderman et al., 2013), may provide a more targeted proxy and could be administered alongside instruments under development for this purpose (e.g., the Non-Ownership of Sensations Questionnaire; Bunting & Polito, 2026). Moreover, drawing on the phenomenological classification framework introduced earlier in the article (Figure 1), targeted items such as "it felt as though I was out of my body, but the experience still belonged to me" or "I no longer knew who I was, yet the sensations still felt like mine" would help identify cases where other dimensions of

selfhood are altered (e.g., the bodily self) while minimal selfhood remains intact.

Self-report instruments offer scalable but coarse access to minimal selfhood and could be complemented by interview methods able to resolve finer experiential detail. Because minimal selfhood is a subtle, prereflective feature of experience rather than a salient content, we suggest a micro-phenomenology-informed interview (Petitmengin, 2006): one that retains the method's sensitivity to fine-grained, prereflective structure and its techniques for guiding participants to reevoke a specific moment while being thematically oriented toward the sense of ownership and the presence or absence of a sensed subject.

Crucially, such reports could then be coded along the dimensions of our framework, distinguishing reflective from prereflective and attributional (self-as-object) from nonattributional (self-as-subject) alterations of experience. This coding would serve two purposes. Within a given context, it would function as a manipulation check, separating genuine disruptions of the prereflective sense of being a subject from alterations of narrative, embodied, or spatial selfhood. Across contexts, the same coding would establish that the selfless states being compared are genuinely comparable by confirming that both occupy the same region of this phenomenological space, namely, disruption at the level of prereflective self-as-subject, rather than collapsing distinct alterations under a single label.

Empirical Testing to Distinguish Core and Enabling Processes

To distinguish between enabling and core processes of minimal selfhood alteration, we propose focusing on patterns of shared versus doubly dissociated neurophysiological activity across induction methods. We have proposed hierarchical flattening anchored in the DMN as a candidate core process. This would be supported by accumulating evidence of similar patterns of DMN activity following both meditation and ingestion of psychedelics. By contrast, enabling processes would be those that are specifically activated by either psychedelics or meditation but not by both. The simplest evidence for core compared to enabling neurophysiological processes would be patterns of activity that are convergent versus dissociable across induction contexts. Specifically, we would expect to see that psychedelics are associated with enabling mechanisms connected to bottom-up pharmacological action, whereby agonism at 5-HT2A receptors densely expressed on Layer-5 cortical pyramidal neurons increases neural entropy (Banushi & Polito, 2023). By contrast, meditation would likely be associated with enabling mechanisms connected to top-down recruitment of attention and meta-awareness through increased activity in the dorsolateral prefrontal cortex, anterior cingulate, and fronto-parietal control network (Lutz et al., 2008).

With regard to identifying core processes, univariate DMN convergence is suggestive but ambiguous because the same region can carry different representational codes in each state. More sophisticated analytic approaches might employ representational similarity analysis or multivariate pattern separation to identify core neurophysiological regions with isomorphic relational structures across states (Kriegeskorte et al., 2008).

This dissociation logic is not limited to the psychedelic and meditation contrast considered here. Because the approach relies on contrasting induction methods with independent enabling pathways, any such pair can, in principle, serve, and widening the set of contrasts strengthens the inference that a convergent mechanism is core rather than tied to a particular induction route. Comparisons of minimal self loss induced by classic and nonclassic psychedelics, for instance, could function as a further pair of independent enabling conditions, since classic psychedelics alter consciousness primarily through 5-HT2AR agonism, whereas ketamine does so through N-methyl-D-aspartate antagonism (Marguilho et al., 2023).

Causal Testing of Candidate Core Mechanisms

Once candidate enabling and core processes have been identified, an important progression would be for empirical work to establish direct causal links between these specific neurocognitive mechanisms and subjective reports of minimal selfhood disruption. There are multiple potentially informative ways this could be explored. One approach might be to investigate direct manipulation (e.g., by transcranial magnetic stimulation or focused ultrasound) of candidate core regions. This should disrupt self-experience across both induction contexts. Alternatively, receptor-specific

modulation could isolate enabling pathways. For example, ketanserin, a selective 5-HT2A antagonist, blocks the subjective effects of psychedelics by occupying these receptor sites (Preller et al., 2017). Accordingly, administration of this substance would be expected to mitigate minimal selfhood disruption in the context of psychedelics (which depends on serotonergic enabling mechanisms) but should have no effect in meditation (which depends on a different set of enabling mechanisms).

Conclusion

This article has aimed to address two major obstacles that currently limit neuroscientific research programs of minimal selfhood. First, it specified a phenomenological marker of genuine minimal self disruption and argued that only experiences that satisfy this profile should be treated as candidates when nominating neural correlates. Second, it argued that when common correlates of that marker are compared against each other within an explicit computational framework of consciousness (e.g., predictive processing or global workspace), functional overlap can be understood as shared processing network configurations defined by model-based parameters rather than as raw anatomical intersections. This allows putative core mechanisms to be specified as recurring computational configurations, while context-specific neural changes are treated as enabling conditions that drive the system into those configurations. Two challenges remain, namely, the development of more specific measures and more complete models of self-related change under psychedelics and meditation. Nonetheless, we contend that a stronger research program on minimal selfhood can be built by adopting the two solutions proposed here while systematically addressing these remaining problems. If our basic approach is valid, then future research should seek to provide a unified account of selfless states using the same neuroscientific framework; such a framework will motivate new predictions about the core neural mechanisms sustaining the minimal self.

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