Neuroscience and the Buddhist Doctrine of Not-Self (*Anattā*): Toward an Integrative Research Review for Buddhist Studies

Narotam Singh[1], Deep Chand[2], Amita Kapoor[3]
[1]Ph.D. Candidate, Faculty of Psychology, Selinus University of Sciences and Literature, Italy
[2]Ex. Sr. Scientist, N.B.P.G.R., IARI Campus, New Delhi
[3]Former Associate Professor, SRCASW, University of Delhi

Abstract

The Buddhist doctrine of not-self (*Pāli*: *anattā*; Sanskrit: *anātman*), the third of the three marks of existence (*tilakkhaṇa*), denies that any permanent, independent self can be located within the psychophysical stream of experience. Rather than functioning as a merely metaphysical negation, *anattā* serves a soteriological purpose: by seeing the self as constructed, conditioned, and impermanent, one weakens attachment and thereby reduces suffering. In the past three decades, cognitive neuroscience has increasingly converged with this analysis, showing that self-related experience depends on distributed, context-sensitive brain networks, especially the default mode network (DMN), rather than a singular "self center." Contemporary neuroimaging (fMRI), electrophysiology (EEG/MEG), lesion and pharmacological studies, and meditation research collectively support a process view of selfhood: the "self" is an emergent, dynamically maintained model integrating autobiographical memory, interoception, prospective simulation, and social cognition. Further, Buddhist contemplative training systematically modulates these networks, producing experiences of diminished self-reference, ego-dissolution, and self-transcendence that resonate with classical descriptions of insight into *anattā*. This article synthesizes key empirical findings and theoretical frameworks, including predictive processing, self-model theory, and neurophenomenology, highlighting convergences, methodological challenges, and implications for Buddhist scholarship, mental health applications, and ethical life.

Keywords: *anattā*, not-self, default mode network, meditation, neurophenomenology, predictive processing, self-model theory, DMN, *jhāna*, *vipassanā*

Introduction

The doctrine of not-self (*anattā*) is among Buddhism's most philosophically provocative and practically transformative teachings. Alongside impermanence (anicca) and suffering (dukkha), *anattā*

undermines the intuitive belief in a stable inner "I" that owns experience and persists unchanged through time. Early Buddhist analysis dismantles personal identity into five aggregates (khandhas): form, feeling, perception, mental formations, and consciousness, none of which is permanent, autonomous, or self-identical. The doctrine, however, is not merely an abstract metaphysical thesis; it functions as a contemplative strategy. Seeing the self as conditioned and insubstantial weakens clinging and reactivity, thereby easing suffering and enabling liberation [16].

Modern neuroscience, though methodologically distinct from Buddhist contemplative inquiry, has produced findings that increasingly harmonize with a process-oriented understanding of self. Across neuroimaging and electrophysiology, self-related processing appears distributed, dynamic, and trainable [2], [24]. A major focus has been the default mode network (DMN), whose activity correlates with mind-wandering, autobiographical memory, future simulation, and self-referential thought [24]. Crucially, meditative practices grounded in Buddhist traditions modulate DMN activity and connectivity, often accompanying reports of reduced self-referentiality and self-boundary dissolution [4], [24], [26]. The convergence is not exact; Buddhist soteriology is not reducible to brain states, but it invites rigorous dialogue.

This review addresses five questions: (1) What neuroscientific evidence supports the view of self as a distributed and impermanent construct? (2) Which neural mechanisms help construct self-experience? (3) How do Buddhist meditation practices reshape these mechanisms and produce states aligned with *anattā*? (4) Which theoretical frameworks best bridge Buddhist phenomenology and neuroscience? (5) What cross-cultural, ethical, and clinical implications follow from this convergence?

Buddhist Foundations: *Anattā* and the Self as Process

In early Buddhist thought, "self" is investigated through direct experiential analysis. The five aggregates are examined in terms of impermanence, dependence, and unsatisfactoriness. Because they arise due to conditions and pass away, none can qualify as a permanent self [16]. Importantly, *anattā* does not deny conventional personhood; rather, it denies an ultimate, independent essence. The point is pragmatic: identification with an imagined core produces craving, aversion, pride, fear, and the entire architecture of dukkha. Insight into not-self thus has ethical and liberative consequences.

Contemporary philosophy aligned with Buddhist readings emphasizes that the "self-illusion" operates at multiple levels: as a wish for permanence, as a cognitive reification, and as a phenomenal "I-sense" that feels immediate and undeniable [21]. Struhl argues that the self-illusion may have evolutionary utility, helping organisms plan, coordinate, and navigate social reality, even while it misrepresents the nature of experience [21]. This sets up a key tension: Buddhist training aims to uproot clinging to self, yet the cognitive machinery producing self-models may remain functionally useful. This tension is mirrored in neuroscience: self-processing appears deeply embedded in predictive, regulatory, and social systems, yet it is also demonstrably malleable.

Neuroscientific Evidence for a Distributed and Impermanent Self

Recent advances in cognitive neuroscience provide converging evidence that the sense of self arises from distributed and dynamically interacting neural systems rather than from a single, stable locus. The following subsections examine this claim across complementary lines of inquiry: resting-state network research (especially the Default Mode Network), task-based neuroimaging of self-related processing, structural-functional plasticity associated with contemplative training, and pharmacological as well as interoceptive disruptions of self-experience. Together, these domains suggest that selfhood is constructed, modulable, and dependent upon network integration.

The Default Mode Network (DMN) and Self-Referential Processing

The Default Mode Network (DMN) is a group of brain regions - including the posterior cingulate cortex (PCC), medial prefrontal cortex (mPFC), precuneus, and medial temporal areas - that becomes active when the mind is at rest and engaged in internal thinking, such as remembering the past or imagining the future [24]. It typically becomes less active when we focus on an external task.

Because the DMN is active during autobiographical memory, future planning, and self-reflection, researchers often associate it with the "narrative self" - the ongoing story we tell about who we are. Importantly, this does not imply a permanent self-entity in the brain; rather, it reflects patterns of brain activity linked to self-related thinking.

Research shows that meditation can change how this network functions. Brewer et al. found that experienced meditators showed reduced DMN activity across several meditation styles compared to non-meditators, along with stronger connections between attention-control regions and the PCC [24]. This suggests meditation may reduce habitual self-focused mind-wandering and increase awareness of one's thoughts.

The DMN is not a single, uniform system. Fingelkurts et al. found that long-term meditation reduced overall DMN activity, but different parts changed in different ways: brain regions linked to bodily continuity became less synchronized, while frontal areas related to agency and first-person perspective became more synchronized [3]. This indicates that the sense of "self" is not a single unit but consists of multiple components that can be altered separately.

Neuroimaging of Self-Related Processing

Studies comparing judgments about oneself versus others show consistent brain patterns. Brewer et al. (2013) used real-time fMRI feedback and found that activity in the PCC increased when participants felt "caught up in" their experience - a subtle, absorbed state distinct from deliberate self-reflection [2]. This resembles the Buddhist idea of *upādāna* (identification), where attachment to experience occurs at a pre-reflective level.

Cultural and religious training also appears to shape self-processing in the brain. Han et al. studied Chinese Buddhists performing personality judgment tasks. Compared to non-Buddhists, they showed reduced activity in the ventromedial prefrontal cortex (VMPFC), a region commonly linked to self-relevance, and greater activation in regions involved in evaluation and conflict monitoring [8]. The authors suggest this may reflect the influence of the no-self doctrine or a reframing of what counts as "self" [8]. These findings indicate that philosophical commitments and contemplative practices can influence how the brain processes self-related information.

Structural changes may accompany these functional shifts. Berkovich-Ohana et al. found that greater mindfulness experience was associated with reduced gray matter density in the left precuneus, a central DMN hub involved in self-processing [23]. This suggests long-term practice may reduce reliance on certain self-related brain systems while refining others.

Pharmacological and Disruptive Pathways

If meditation can voluntarily reduce self-referential processing, pharmacological studies provide additional insight. Brewer et al. report that psilocybin reduces communication between the PCC and mPFC and is associated with experiences of "ego dissolution" [2]. Although psychedelic states differ from Buddhist insight, both may involve reduced integration within the DMN, suggesting that the sense of a solid "I" depends on network dynamics rather than a fixed center.

Research on brain–heart interactions further supports this view. Jiang et al. found that Tibetan Buddhist meditation alters how the brain responds to heartbeat signals in DMN regions [5]. Because awareness of bodily signals contributes to the basic sense of "being someone here," such findings suggest that even minimal selfhood is shaped by bodily processes and can be modified through training.

Mechanisms of Self-Construction: Narrative, Minimal, and Embodied Models

Contemporary neuroscience does not treat the self as a single entity, but as something constructed through multiple interacting processes. The following subsections examine three complementary approaches to this construction: (1) how large-scale brain networks reorganize through meditation, (2) the distinction between the narrative self and the minimal or experiential self, and (3) predictive-processing models that describe the self as an actively maintained internal model. Together, these perspectives suggest that selfhood is layered, dynamic, and open to systematic transformation through contemplative practice.

DMN Subsystems and Reorganization

Georg Northoff proposes that meditation reshapes how the brain organizes self-related processing. According to his model, ordinary experience emphasizes a narrative "mental self," while advanced meditation shifts activity toward a more embodied, present-centered mode grounded in bodily and sensory awareness [9], [13]. In other words, the focus moves from "my story" to immediate lived experience.

He also reports that in advanced meditators, the Default Mode Network (DMN) shows stronger positive coupling with the Central Executive Network (CEN), two systems that are usually opposed in non-meditators [13]. Rather than simply reducing self-related processing, deep meditation may reorganize how reflective self-awareness and attentional control interact. This reconfiguration may help explain reports of nondual awareness, where subject–object division becomes less pronounced.

Ahuja et al. propose a more speculative model (ExACT), suggesting that "enlightenment" involves a reversal of normal network dynamics: executive networks assume a default-like role, allowing awareness without the usual sense of a solid personal center [19]. Although this model remains theoretical, it represents an effort to connect classical Buddhist developmental stages with contemporary network neuroscience.

Narrative Self vs. Experiential Self

A widely accepted distinction in psychology separates the narrative self — the story-based identity that extends across time – from the experiential or minimal self, the immediate sense of presence and ownership in the present moment.

Tirch argues that mindfulness practice shifts attention from narrative processing (associated with medial prefrontal activity and conceptual thinking) toward direct experiential awareness linked to attentional and body-based systems [1]. In practical terms, thoughts are observed as passing events rather than interpreted as "mine." This closely parallels Buddhist training in sati (mindfulness) and *vipassanā* (insight).

Verhaeghen suggests that meditation can quiet the narrative self relatively quickly – sometimes within tens of hours – leading to improved well-being [16]. More advanced practice, however, may reduce even deeper aspects of self-experience, approaching states consistent with the Buddhist doctrine of *anattā* (non-self) [16]. This gradual reduction mirrors classical descriptions: first loosening identification with thoughts and personal stories, then investigating the subtle sense of "I" itself.

Predictive Processing and the Bayesian Self

Predictive processing models describe the brain as a system that constantly makes predictions about the world and updates them to reduce error. Within this framework, the self is understood as a high-level model that integrates bodily sensations, movement, and social information [12]. The

so-called “Bayesian self” is not a fixed entity but a continuously updated internal model. Its stability arises from constant maintenance.

Dennison applies this model to *jhāna* meditation, suggesting that ordinary consciousness involves evaluative processing similar to DMN activity, while deep absorption reduces the “personal” evaluative element that sustains ordinary self-experience [12], [27]. EEG recordings from *jhāna* practitioners showed unusual patterns — including spindle activity and high-voltage slow waves — even while practitioners reported heightened clarity and alertness [12], [27]. These findings challenge the view of meditation as simple relaxation and instead suggest large-scale reorganization of brain dynamics during deep absorption.

Trautwein et al. used MEG imaging to study advanced contemplative states involving suspension of agency, first-person perspective, and self-location. They observed reduced high beta-band activity in frontoparietal and posterior medial regions, particularly in individuals reporting strong disruption of embodied self-experience [26]. These changes correlated with lifetime meditation practice and phenomenological reports [26], helping identify neural candidates for minimal self-integration and its attenuation in advanced states.

Meditation as a Neuroscience of *Anattā*: Evidence Across Traditions

This section examines neuroscientific evidence from multiple contemplative traditions to assess whether meditation can systematically attenuate or reorganize self-related processing in ways consistent with the Buddhist doctrine of *anattā* (non-self). Drawing on studies of insight (*vipassanā*/mindfulness), concentration and absorption (samatha/*jhāna*), long-term structural plasticity, and neurophenomenological methodology, the following discussion explores how first-person reports of self-transformation correspond with measurable neural dynamics. Together, these findings illuminate both the possibilities and methodological challenges of bringing classical Buddhist accounts of selflessness into dialogue with contemporary neuroscience.

Vipassanā and Mindfulness: Deconstructing the Self Layers

Dor-Ziderman et al. conducted a neurophenomenological MEG study with long-term *vipassanā* practitioners and distinguished two forms of self attenuation: narrative self attenuation linked to mPFC high-gamma decreases, and minimal self attenuation linked to beta-band decreases in a wider network, with selflessness specifically tied to beta attenuation in right inferior parietal regions [4]. This is significant for Buddhist studies because it empirically supports a layered view of self: narrative and minimal aspects have distinct neural signatures and can be systematically modulated through insight practice.

Gao et al. found that long-term intuitive inquiry meditation (Zen/Chan-related practice) modulated EEG dynamics during self-schema processing, enabling flexible detachment from self-concepts and

reduced activity when viewing self-images [7]. Yang et al. demonstrated that even a 40-day mindfulness training program reduced functional connectivity between pgACC and dmPFC, regions implicated in depressive rumination and self-referential processing [18]. Together, these studies suggest that both long-term and relatively brief training can alter self-processing circuits, though deeper "not-self" phenomenology likely requires more intensive practice and refined methods.

Samatha and *Jhāna*: Withdrawing from Default Consciousness

Samatha and *jhāna* emphasize sustained attention and absorption. Dennison's EEG work suggests these practices can induce profound neurophysiological changes unlike those typically observed in mindfulness studies, implying distinct mechanisms for attenuating self and restructuring consciousness [12], [27]. For Buddhist scholarship, this supports the idea that different contemplative technologies may lead to different routes toward self-transformation: insight practices deconstruct conceptual identification, while absorption practices may temporarily suspend broader inferential loops supporting ordinary self-world structuring.

Long-Term Effects and Structural Plasticity

Long-term practice correlates with structural differences in DMN hubs (e.g., precuneus) and altered structure-function relationships [23]. Yet findings may be nonlinear. Lindström et al. reported quadratic relations between trait self-boundarylessness and DMN connectivity, suggesting that "more practice" does not map straightforwardly onto "less self" in linear fashion [25]. This complexity is important for Buddhist studies: meditative development is traditionally described as non-linear, with stages, plateaus, and qualitative shifts, an aspect neuroscience is only beginning to model.

Bridging First-Person Insight and Third-Person Measurement

The foregoing discussion highlights both the promise and the complexity of integrating contemplative insight with neuroscientific methodology. Research on neurophenomenology and self-model theory suggests that experiences described in Buddhist traditions as selflessness can be examined with increasing conceptual and empirical precision, provided that first-person expertise and third-person measurement are brought into careful dialogue. At the same time, the persistence of self-illusion despite intellectual understanding underscores the distinction between theoretical interpretation and lived realization, a distinction long emphasized in Buddhist thought. Continued progress in this area will depend upon methodological rigor, philosophical clarity, and sustained collaboration between contemplative scholars and cognitive scientists [4], [21], [26], [29].

Neurophenomenology and Rigorous First-Person Methods

A central challenge in researching *anattā* is the measurement of subjective selflessness. Wang notes limitations of relying purely on self-report and calls for culturally sensitive, interdisciplinary methodologies integrating contemplative expertise and objective measures [29]. Neurophenomenology offers one response: systematic phenomenological interviews combined with neural recording. Trautwein et al.'s work exemplifies how interview-derived measures of agency, self-location, and perspective can correlate with neural changes even when standard questionnaires do not [26]. This matters for Buddhist journals because classical descriptions of meditative insight are refined, technical, and often poorly captured by generic psychological instruments.

Self-Model Theory and the Illusion of an Entity

Metzinger's self-model theory aligns naturally with *anattā*: the self is a transparent model generated by the brain, mistaken for an entity. Meditation may render this model less transparent, revealing its constructed nature. Dor-Ziderman et al. explicitly connect their findings to such frameworks [4]. Struhl's analysis deepens this by arguing that the self-illusion can persist even when intellectually understood as illusory, analogous to perceptual illusions that continue despite cognitive insight [21]. This perspective resonates with Buddhist distinctions between conceptual understanding (pariyatti) and direct realization (*paṭivedha*).

Implications for Buddhist Studies, Mental Health, and Ethics

Taken together, these clinical, ethical, and methodological considerations demonstrate that the neuroscientific study of self-construction carries implications far beyond laboratory findings. Evidence that contemplative practice can reshape self-referential processing invites renewed dialogue between Buddhist philosophy and mental health frameworks, particularly those concerned with rumination, addiction, and identity formation [17], [18]. At the same time, ethical reflection and cultural sensitivity remain essential. Without careful attention to doctrinal context and practice-specific distinctions, scientific translation risks oversimplification [29]. A responsible interdisciplinary approach must therefore balance empirical rigor with philosophical fidelity, ensuring that the study of *anattā* remains both clinically meaningful and textually grounded [1], [29].

Clinical Relevance: Rumination, Addiction, and Self-Narratives

Mindfulness-based interventions (MBIs) may work partly by reducing maladaptive self-referential processing. Yang et al.'s findings on pgACC-dmPFC connectivity suggest antidepressant mechanisms involving reduced rumination and reactivity [18]. Garland et al. show that mindfulness-induced increases in frontal midline theta, associated with self-regulation and inversely related to DMN activity, can facilitate self-transcendent experiences and reduce addictive behavior [17]. Such results

invite Buddhist-informed clinical models that emphasize transformation of self-identification rather than mere symptom suppression.

Ethics and Identity: From Self-Construction to Compassion

If self is constructed and interdependent, ethical consequences follow. Recognizing the contingency of self may reduce rigid self-other boundaries and encourage compassion, echoing Buddhist ethical training. Tirch's framing of "self as context" and "interbeing" suggests contemplative practice can support a relational identity less governed by defensive self-protection [1]. For Buddhist scholarship, this points to an integrated view: *anattā* is not nihilism, but a foundation for compassion and non-harming.

Cultural Translation and Methodological Caution

Wang cautions that secular mindfulness may omit ethical and soteriological dimensions essential to Buddhist practice [29]. For journals in Buddhist studies, this raises a crucial question: how can neuroscience respect tradition-specific aims and categories without reducing them to generic wellbeing tools? Methodologically, the field must distinguish between meditation types (*vipassanā*, samatha, *jhāna*, nondual awareness practices) and their different neural signatures [29], rather than treating "meditation" as a single variable.

Discussion: Convergences, Divergences, and Limits

The convergence between neuroscience and *anattā* is substantial but not total. Neuroscience supports a process view: self-related processing is distributed, context-sensitive, and trainable [2], [24]. Meditation can reduce DMN activity/connectivity and correlate with phenomenology of diminished self-reference [4], [24], [26]. Structural plasticity findings further support the idea that self-experience is not fixed [23].

However, several cautions are needed. First, the evolutionary usefulness of self-models suggests that total elimination of self-processing may be neither feasible nor desirable in everyday functioning [21]. Second, many studies are cross-sectional, limiting causal inference, and advanced meditative states remain challenging to operationalize objectively [23], [29]. Third, the phenomenology of "ego dissolution" in psychedelics is not equivalent to liberative insight; similar neural pathways may produce different ethical and existential outcomes.

Still, the dialogue is generative. Neuroscience clarifies mechanisms of self-construction; Buddhism offers refined phenomenological maps and systematic contemplative technologies for transforming identification. Together they support a research program that is scientifically grounded and philosophically rich, capable of deepening our understanding of consciousness and the conditions for human flourishing.

Conclusion

Contemporary neuroscience increasingly supports the Buddhist doctrine of not-self (*anattā*) by demonstrating that self-experience is not localized in a single "self center" but emerges from distributed, dynamic brain networks, especially the DMN, and from embodied predictive integration [2], [24], [12]. Meditation practices rooted in Buddhist traditions systematically modulate these networks, producing experiences and traits aligned with reduced self-referential processing, self-boundary dissolution, and self-transcendence [4], [24], [26].

Theoretical frameworks such as predictive processing, self-model theory, and neurophenomenology provide conceptual bridges capable of translating between first-person contemplative insight and third-person measurement [12], [4], [26]. Yet rigorous methodological and cultural sensitivity remain essential: advanced states are difficult to measure; effects may be nonlinear; and Buddhist practice is embedded in ethics and liberation aims that secular research often overlooks [25], [29].

For Buddhist studies, these developments invite a renewed scholarly engagement: not to "prove" Buddhism through neuroscience, but to enrich interpretive frameworks, refine our understanding of *anattā*'s phenomenology and practice, and inform interdisciplinary discourse on identity, suffering, and transformation in contemporary life.

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