Neuroscience and the Four Noble Truths

The Four Noble Truths concept provides a very coherent and psychologically sophisticated pathway for understanding and alleviating the distress and confusion that every person must contend with. The distress involves emotional reactivity, and the confusion is the result of the actual or potential conflict between how we are taught about the world and our direct subjective experience. The physical and emotional benefits of Buddhist concepts and practices are worth the time and effort involved in shifting our subjective identity from self-state conflict to self-state integration. The resulting quality of internally balanced well-being provides enough psychological stability and emotional non-reactivity to realize the spiritual goal of Buddhism: Nirvana, the direct experiential knowledge of the unconditioned nature of reality—“suchness”.

This overview explores the intersection between the Four Noble Truths and modern neuroscience, illustrating how ancient wisdom aligns with contemporary scientific insights. In recent years, advances in neuroscience have provided new perspectives on Buddhist teachings, revealing how very complex interactive neural processes in the brain relate to the experience of distress and confusion, providing ways and means for the cultivation of well-being and spiritual liberation.

Contemplating the correlation between what Buddhist doctrine describes about the human experience and the data provided by contemporary neuroscientific concepts and research helps support my understanding of anatta (ah-nah-tah), the absence of an enduring/autonomous self. There are several neural networks in different areas of the brain, and there interactions are driven by the “hardware” of the brain; Buddhist concepts and practices can be understood to impersonally transform a “software problem”—our self-identity and how the world is supposed to be.

This talk will focus on describing the neural associations in the brain associated with the first three Noble Truths. A future talk will review what contemporary neuroscientific research suggests about the fourth Noble Truth, the Noble Eightfold Path. This approach to the analysis seems appropriate considering the complexities of the Noble Eightfold Path from a neurological perspective. First, a brief overview the Four Noble Truths:

1. The Truth of Suffering (Dukkha): Life inevitably involves existential insecurity, experienced as distress and confusion. Dukkha is present due to physical injury, illness, or old age, as well as the psychological manifestations of distress and confusion—fundamentally, life is unpredictable and uncertain.
2. The Truth of the Origin of Suffering (Samudaya): Suffering arises from craving, attachment, and ignorance. Craving is experienced as either the feeling of attraction or repulsion, because of attachment to the view that there is an enduring/autonomous self; this misperception is represented as ignorance, the inability of the untrained mind to reliably and clearly understand the conditioned nature of subjective experience and behavior. I call the primary effect of craving and attachment “self-state conflict”.
3. The Truth of the Cessation of Suffering (Nirodha): It is possible to end suffering by letting go of craving and attachment, which requires careful investigation of how the selfing process operates, overcoming the effects of ignorance. This skillful introspective process cultivates self-state integration, the ability for the flow of emotions and thoughts to be beneficially regulated through neurological conditioning, through training provided by developing the practices described as the Fourth Noble Truth. The ultimate goal of the third Noble Truth is the realization of anatta. This realization is cultivated through the principles and practices of the fourth Noble Truth.
4. The Path of the Fourth Noble Truth (Magga): There is a practical path—the Noble Eightfold Path—for cultivating self-state integration, which can ultimately lead to self-state liberation, the experience of Nirvana, an experience that defies description—unconditioned, selfless, and timeless. Even if the only benefit of this discipline is a heightened sense of well-being and prosocial actions, the practice is successful.

## The Neuroscience of Dukkha, the First Noble Truth

There is an area of the brain called the Limbic System, situated between the basic biological functions in the brain stem and the more highly developed emotional and conceptual systems in the cerebral cortex. Within this system, the Salience Network (SN) functions to organize shifts of attentional focus. For example, as I am typing this, my mind is repeatedly and briefly drawn to the sounds of the tv in another room. This noticing process is the salience, making an initial analysis, “friend or foe, food or poison?” This network is strongly interconnected with the Default Mode Network (DMN), which organizes interpreting the sound, relating the incoming neural signal to previous experience, and on to the Central Executive Network, (CEN), then triggering the Task-Positive Network (TPN), which either activates or de-activates continued attention and behavior. Mindfulness and renunciation practice supports the intention to disregard the sound and refocus on the work at hand.

Research has shown that repetitive negative thought patterns, such as rumination and worry, are associated with dysfunctional interactions between the SN, DMN, and CEN due to ignorance—the absence of mindful introspection and self-discipline. This supports the idea that all psychological suffering involves a person’s inability to investigate, interrupt, and redirect the flow of attention to a more appropriate and effective mental and behavioral mode.

This introspective/transformative process relies on a neuroscientific principle called *neuroplasticity*, which I reviewed during a talk on November 4, 2025, titled “Neuroplasticity and Non-Self”, and posted on the website. This relates to *anatta* (ah-nah-tah*), the absence of an enduring/autonomous self*. Understanding how these dispersed networks of the brain and body interact strongly supports anatta, as there is no identifiable area of the brain or body that creates the self. Recognizing and skillfully managing these interactions is the primary goal of Buddhist Dharma practices.

## Craving, Attachment, and Brain Reward Systems—The Second Noble Truth

As mentioned above, the core elements of distress and confusion are craving, attachment and ignorance. Here are the neural networks associated with craving, attachment, and ignorance:

*Tanha* (than-hah) is the Pali word for *craving*, and Buddhist psychology understands tanha as an “*unquenchable thirst*”. A corresponding psychological term that is relevant to craving is *affect*, which is the brain’s reaction to the felt urgency regarding pleasant or unpleasant experience, either physical or emotional. Craving either acts to create desire or aversion to what is forming in the mind in every moment that is afflicted by ignorance. The craving process operates on a continuum from the subtle pull associated with self-identity to the highly dysfunctional craving of addiction.

This can be understood as the ongoing impersonal interactions between diverse neural networks: The SN stimulates initial activation of attention, and includes a neural cluster called the amygdala, which provides an initial affective response, either positive or negative, and the DMN is then stimulated to relate the response to prior experience, which is subjectively experienced as the “selfing story”. Simultaneously, another link between the amygdala and the nucleus accumbens operates to prepare the mind and body to respond behaviorally to the stimulation. The CEN receives a signal from the DFN and then provides a “gating” function that either activates or deactivates the nucleus accumbens—through the actions of the TPN (more about gating below). When the craving experience is strong and/or poorly regulated, the actions of the nucleus accumbens becomes overactivated, “stuck in go-mode”—this is a primary characteristic of addiction. Generally, because of ignorance (see below for those characteristics), the repetitive nature of craving “matures” into attachment, the next topic for review.

*Upadana* (oo-pah-dah-nah) is the Pali word for *attachment* or *clinging*. Buddhist psychology describes four different forms of upadana: 1) Attachment to pleasant or unpleasant sensory stimulation, 2) Attachment to a view or belief, 3) Attachment to more or less flexible patterned behaviors (In Buddhist terms, attachment to rites and rituals), 4) Believing that there is an enduring/autonomous self.

Upadana is dependent on ignorance regarding the process through which tanha quickly “solidifies” into the conviction that there is a self-identity. The repetitive shuttling between the neural networks associated with impulsive affective operation of the SN and the meaning-making functions of the DMN happens multiple times per second—an initial affective signal from the amygdala stimulates associations from memory in the DMN, then back to the amygdala, like a closed loop—that loop is attachment. Ignorance, the third of the conditions that promote dukkha, is a deficiency in the ability to quickly and awarely track this looping process, and overcoming ignorance is a primary goal of Buddhist practices, accomplished through the development of the principles and practices found in the fourth Noble Truth, the Noble Eightfold Path, which will be reviewed during a future talk.

*Avijja* (ah-vee-jah) is the Pali word for *ignorance*, which, in the context of Buddhist psychology, is deficiency in regard to the ability to beneficially regulate the affective impulses of tanha and the mental distortion represented by upadana. The primary aspect of avijja is the belief that there is an enduring/autonomous self, as mentioned above. Perhaps the most remarkable evolutionary aspect of humanity is the ability to cultivate heightened introspective awareness, which, along with the prosocial effect of Right Speech, Right Action, and Right Livelihood, has supported the cultural dynamics that created the world-dominating civilization that blankets the globe. Obviously, humanity has a lot more work to do regarding prosocial behaviors!

The inability to be introspectively aware and disciplined occurs as a result of “poorly trained neurons”, that is, the functions of the SN, DMN, and CEN are organized to defend or gratify what we call the ego, the self-identity, through the four forms of attachment described above. The Buddha called this “The tyranny of I, Me, and Mine”. I believe that Buddhist concepts and practices promote further development in humanity’s evolution. One 20th-century intellectual who said something about this evolutionary trend that is meaningful for me is Arnold J. Toynbee. He wrote that: *“The coming of Buddhism to the West may well prove to be the most important event of the Twentieth Century.”* Here we are a quarter way through the 21st century, and that potential still isn’t realized, yet is still possible.

Liberation From Dukkha and Neurological Gating Networks—The Third Noble Truth

Liberation from dukkha has different levels of manifestation. First, the flow of mental constructs in the brain must be modified through setting aside the Five Hindrances: sense desire, aversion/ill-will, sloth/torpor, restlessness/worry and skeptical doubt. This can be established temporarily through neural gating, which involves the interactions between the SN, CEN and TPN. One of the primary functions of the CEN is working memory, which, interestingly, is one way to understand the Pali word for mindfulness, sati (sah-tee), which can be translated as non-forgetfulness. The CEN reduces the “signal strength” travelling through the relevant neural networks associated with the hindrances. It has a particularly important regulatory effect on the nucleus accumbens, the “go, no go” part of the brain.

The “Gating” function in neuroscience involves *controlling or filtering information flow* — either sensory, affective, or cognitive. The Third Noble Truth parallels the release of maladaptive gating processes and the establishment of more “free” flow states. Functionally, the signal strength between the various interacting neural networks is less and less affected by craving and attachment, as meditation practice matures with more potential for developing the subtle introspective processes required for further liberation in the mind, towards Nirvana.

Direct experience of Nirvana is the ultimate goal of Buddhist spiritual practice. The previously described capacity to set aside the conditioning associated with the Five Hindrances supports the transition from self-state conflict towards self-state integration, which is well worth the time and effort associated with developing a more persistently beneficial approach to life’s challenges. A mind that is balanced and alert through the realization of self-state liberation creates the conditions for self-state liberation, the experience of Nirvana.

Because of the unconditioned characteristics of Nirvana it is hard to describe it. Here is what ChatGPT reports about possible neural substrates in a brain experiencing Nirvana:

* Cessation of craving, attachment, and suffering.
* Loss of the constructed “self” perspective (non-self / anattā).
* Timelessness, spacelessness, unconditioned quality.
* Often described as ineffable, beyond sensory or cognitive fabrication.

Here are some suggestions downloaded from ChatGPT regarding what happens in the various networks:

**A. Default Mode Network (DMN) Deactivation**

* **Key regions**: medial prefrontal cortex (mPFC), posterior cingulate cortex (PCC).
* Function: self-referential thought, autobiographical narrative.
* In advanced meditation and reported “cessation” states, DMN activity markedly diminishes.
* Suggests loss of narrative self and entry into non-dual awareness.

**B. Salience and Interoceptive Network Shifts**

* **Anterior insula** (interoceptive awareness) and **anterior cingulate cortex (ACC)** (conflict monitoring).
* In deep states, insular processing of body/self boundaries weakens, reducing salience of sensory events.
* ACC may disengage from ordinary conflict-monitoring, allowing suspension of dualistic “subject-object” structuring.

**C. Thalamocortical Gating / Sensory Deactivation**

* Reports of *nirodha-samāpatti* (cessation attainment) suggest thalamic filtering is dramatically altered.
* **Thalamus** is the relay for sensory inputs → suppression here may underlie the phenomenological “shutdown” of sensory experience.

**D. Prefrontal–Limbic Regulation**

* Ventromedial prefrontal cortex normally regulates amygdala-driven reactivity.
* In nirvāṇa-like states, limbic circuits (fear, craving, aversion) appear profoundly downregulated.
* Corresponds to cessation of emotional reactivity (nirodha of taṇhā).

**E. Brainstem–Vagal–Autonomic Integration**

* Polyvagal theory intersects here: advanced meditation often stabilizes the ventral vagal state.
* Brainstem centers (periaqueductal gray, nucleus tractus solitarius) may underlie the “deep safety/immobility without fear” quality of nirvāṇa reports.

**F. Predictive Coding Collapse**

* Predictive processing models suggest the brain constantly constructs a world-model based on priors.
* In cessation/Nirvāṇa, this predictive loop may temporarily *collapse*, producing the “unconditioned” or “unfabricated” quality (asaṅkhata).
* Neural correlates: reduced precision weighting in parietal & frontal cortices → suspension of perceptual inferences.

**3. Network-Level Integration**

* **DMN downregulation** → loss of self-referential narrative.
* **SN disengagement** → stimuli lose salience, no craving/aversion.
* **CEN inactivity** → no goal-directed effort, radical stillness.
* **Thalamocortical quieting** → sensory cessation.
* **Brainstem–vagal stability** → embodied equanimity.

**In short**: The nirvāṇa experience likely reflects a **whole-brain reorganization** where predictive self-models collapse, thalamocortical sensory relay quiets, limbic craving systems deactivate, and the organism rests in an autonomically safe, non-reactive state. What remains is not “nothingness,” but freedom from fabrication—an experience the brain may register as *unconditioned being*.