International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

The Neuroplastic Potential of Ayurvedic Medhya Rasayanas: A Mechanistic Review of *Centella asiatica*, *Convolvulus pluricaulis*, and *Bacopa monnieri*

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ABSTRACT :

Neuroplasticity, the brain's intrinsic capacity for structural and functional adaptation, underpins learning, memory, and recovery from injury. Ayurvedic medicine, an ancient Indian system of health, describes a class of nootropic herbs known as *Medhya Rasayanas* traditionally used to enhance cognitive functions. This review critically examines the neuroplastic potential of three prominent *Medhya Rasayanas*—*Centella asiatica* (Mandukaparni), *Shankhapushpi*, and *Bacopa monnieri* (Brahmi)—by synthesizing preclinical and clinical evidence through the lens of modern neuroscience. *Centella asiatica* demonstrates a targeted mechanism of upregulating Brain-Derived Neurotrophic Factor (BDNF) mRNA and protein levels, specifically in the prefrontal cortex of animal models. This molecular change correlates directly with improved performance in cognitive tasks and is supported by clinical data showing increased plasma BDNF and enhanced cognition in human subjects. The term *Shankhapushpi* refers to a complex of botanicals with distinct neuroplastic actions. *Convolvulus pluricaulis*, the officially recognized source, modulates synaptic plasticity by enhancing long-term potentiation (LTP) and reducing long-term depression (LTD) in the hippocampus. In contrast, *Clitoria ternatea*, another plant used as *Shankhapushpi*, promotes direct neurogenesis by stimulating the proliferation and differentiation of neural stem cells *in vitro*. *Bacopa monnieri* exhibits a unique neurophysiological signature; in a pilot study on subjects with mild cognitive impairment (MCI), it induced an attenuation of EEG spectral power in alpha and beta frequencies during cognitive tasks. This effect, contrary to simple stimulation, suggests a normalization of brain activity and an increase in neural efficiency, a hypothesis supported by its known GABAergic activity and its capacity to promote dendritic arborization. Collectively, the evidence indicates that these Ayurvedic herbs are not merely general neuroprotectants but sophisticated modulators of specific neuroplastic pathways. Their multi-target actions—spanning trophic support, synaptic tuning, structural remodeling, and network efficiency—present a compelling rationale for their traditional use and warrant rigorous, large-scale clinical investigation for their potential role in modern neurology and psychiatry.

Introduction

The Dynamic Brain: An Overview of Neuroplasticity

For much of the twentieth century, the adult brain was viewed as a static, hardwired entity, with its neural circuits fixed after a critical period in early development. This dogma has since been overturned by the revolutionary concept of neuroplasticity—the intrinsic ability of the nervous system to change its activity and adapt its structure, functions, and connections throughout life in response to intrinsic and extrinsic stimuli.[1] This dynamic capacity is not a single process but a collection of mechanisms operating at multiple scales, from molecular and synaptic alterations to large-scale network reorganization.[2] It is the fundamental biological process that enables learning, memory formation, cognitive flexibility, and functional recovery following injury, such as stroke or trauma.[1] The core mechanisms of neuroplasticity can be broadly categorized. At the synaptic level, **synaptic plasticity** refers to the activity-dependent modification of the strength of connections between neurons. The most extensively studied forms are long-term potentiation (LTP), a persistent strengthening of synapses, and long-term depression (LTD), a lasting weakening of synapses.[3] These processes are considered the primary cellular basis for information storage in the brain.[3] A more profound form of plasticity is **adult neurogenesis**, the generation of new functional neurons from resident neural stem cells, a process largely restricted to specific niches in the adult brain, most notably the dentate gyrus of the hippocampus.[5] This continuous integration of new neurons is believed to play a crucial role in certain types of learning and memory, such as pattern separation.[5]

These plastic changes are orchestrated by a complex molecular machinery. Key players include neurotrophic factors, such as Brain-Derived Neurotrophic Factor (BDNF), which are critical for neuronal survival, growth, and the modulation of synaptic strength.[7] The expression of these factors is often regulated by the activity of immediate early genes (IEGs) like c-Fos and Arc/Arg3.1, which translate neuronal activity into long-lasting changes in gene expression, thereby supporting the consolidation of memory.[9] Understanding these mechanisms provides a clear framework for evaluating interventions aimed at enhancing cognitive function or promoting neural repair.

Ayurvedic Nootropics: The Concept of Medhya Rasayana

Long before the advent of modern neuroscience, ancient systems of medicine developed sophisticated frameworks for understanding and influencing mental function. Ayurveda, a system of traditional medicine originating in India over 3,000 years ago, describes a specialized branch of pharmacology focused on rejuvenation and longevity known as *Rasayana*.[10] Within this branch, a specific category of herbs and formulations called *Medhya Rasayanas* is dedicated to the enhancement of cognitive and mental faculties.[12] The term *Medhya* translates to intellect or cognition, while *Rasayana* refers to the path of rejuvenation.[11]

The primary goal of *Medhya Rasayanas* is to promote the three core components of intellect as defined in Ayurveda: *Dhi* (the power of acquisition and comprehension), *Dhriti* (the power of retention), and *Smriti* (the power of memory and recall).[10] These herbs are traditionally considered "brain tonics" or nootropics, used to sharpen intellect, improve memory, and alleviate mental disorders such as anxiety and stress.[12] The classical Ayurvedic texts identify four principal *Medhya Rasayanas*: *Mandukaparni* (*Centella asiatica*), *Yashtimadhu* (*Glycyrrhiza glabra*), *Guduchi* (*Tinospora cordifolia*), and *Shankhapushpi* (*Convolvulus pluricaulis*).[10] Modern research suggests these herbs exert their effects through multiple pathways, including antioxidant actions, modulation of key neurotransmitter systems like the cholinergic and GABAergic systems, and enhancement of cerebral blood flow and oxygenation.[12]

Bridging Ancient Wisdom and Modern Neuroscience

The convergence of ancient herbal traditions and modern scientific investigation presents a unique opportunity to uncover novel therapeutic strategies for cognitive health. While the Ayurvedic concept of *Medhya Rasayana* provides a functional classification based on observed outcomes, the framework of neuroplasticity offers a set of precise biological mechanisms that can be measured and validated. This review seeks to bridge this gap by critically evaluating the scientific evidence for three of the most renowned *Medhya Rasayanas—Mandukaparni* (*Centella asiatica*), *Shankhapushpi* (examining the key botanicals associated with this name), and *Brahmi* (*Bacopa monnieri*)—through the specific lens of neuroplasticity. By analyzing their distinct effects on BDNF levels, neurogenesis, synaptic plasticity, and brain wave activity, this report aims to elucidate the specific, and often unique, mechanistic pathways through which these ancient remedies may exert their profound effects on the brain.

Table 1: Summary of Key Phytochemicals and Proposed Mechanisms of Action

Herb (Common & Scientific Name)	Key Bioactive Phytochemicals	Primary Neuroplastic Mechanism (as per query)
Mandukaparni (*Centella asiatica*)	Triterpenoid saponins (asiaticoside, madecassoside), Flavonoids (quercetin) [12]	Upregulation of Brain-Derived Neurotrophic Factor (BDNF)
Shankhapushpi (*Convolvulus pluricaulis*, *Clitoria ternatea*)	Alkaloids (convolvine), Coumarins (scopoletin), Flavonoids (kaempferol), Anthocyanins [3]	Modulation of synaptic plasticity (LTP/LTD) and promotion of neurogenesis
Brahmi (*Bacopa monnieri*)	Triterpenoid saponins (bacosides A & B) [17]	Modulation of EEG brain wave frequencies

Mandukaparni (Centella asiatica): Modulating BDNF and Cognitive Function

Centella asiatica, commonly known as Mandukaparni or Gotu Kola, is a revered herb in Ayurveda, traditionally used as a "brain tonic" and for promoting wound healing and tissue regeneration.[10] Modern research is beginning to validate these uses, uncovering a sophisticated mechanism of action centered on the modulation of key neurotrophic factors, particularly BDNF. The evidence suggests a targeted effect on the prefrontal cortex, providing a strong neurobiological basis for its cognitive-enhancing properties.

Preclinical Evidence: Upregulation of BDNF in the Prefrontal Cortex

A pivotal study by Sbrini et al. (2020) provides compelling evidence for the direct impact of *C. asiatica* on brain plasticity. In this study, adult male rats were chronically administered an oral *C. asiatica* phytosome preparation at two doses, 20 mg/kg and 100 mg/kg.[7] The results revealed a significant and dose-independent increase in the messenger RNA (mRNA) expression of total BDNF in the prefrontal cortex (PFC) of the treated animals.[20] This effect demonstrated remarkable anatomical specificity; no corresponding increase in BDNF expression was observed in either the dorsal or ventral hippocampus, suggesting that the PFC is a primary target of the herb's action.[20]

This increase in gene transcription translated to a tangible change at the protein level. The higher dose of 100 mg/kg led to a significant elevation of mature BDNF (mBDNF) protein within the synaptosomal fraction of the PFC—the portion containing presynaptic terminals where neurotransmitter release occurs.[20] This finding is particularly significant as it indicates that the newly synthesized BDNF is available at the synapse, where it can actively modulate synaptic function and plasticity. Crucially, these molecular changes were directly linked to functional improvements in cognition. The same high dose (100 mg/kg) that increased mBDNF protein also significantly improved the rats' performance in the Novel Object Recognition (NOR) test, a behavioral paradigm that assesses learning and memory, particularly recognition memory, which relies heavily on the integrity of the PFC.[7] The study further demonstrated that exposure to the cognitive task itself induced an additional increase in BDNF expression, an effect that was potentiated in the animals pre-treated with *C. asiatica*.[20] This suggests that the herb not only raises baseline BDNF levels but may also enhance the brain's ability to mount a plastic response to a learning experience. This PFC-specific action provides a direct and elegant neurobiological explanation for the herb's nootropic effects, linking a specific molecular event (BDNF upregulation) in a specific brain region (PFC) to a relevant functional outcome (improved executive cognition). Supporting this, other studies have shown that *C. asiatica* can increase BDNF levels in the brains of aged rats and protect against stress-induced reductions in BDNF, further solidifying its role as a modulator of this critical neurotrophin.[8]

Clinical Correlates: Plasma BDNF and Cognitive Enhancement in Humans

The promising preclinical findings are mirrored in human studies, providing a translational bridge from the laboratory to clinical application. A study conducted on menopausal women, a population prone to cognitive decline, investigated the effects of a 500 mg daily dose of *C. asiatica* extract over 12 weeks.[24] The results showed that the treatment group experienced a significant increase in plasma BDNF levels compared to the control group. Importantly, this biochemical change was not an isolated finding; it correlated directly with significant improvements in cognitive function, as measured by the Montreal Cognitive Assessment (MoCA), and also with enhanced physical fitness.[24]

While plasma BDNF is an indirect biomarker, its increase in humans, when viewed alongside the direct evidence from animal models, strengthens the case for a central mechanism of action. The animal studies confirm that oral administration leads to the absorption of active compounds into the bloodstream, that these compounds (or their metabolites) likely cross the blood-brain barrier, and that they directly increase BDNF levels in brain tissue.[7] This establishes a plausible causal chain: oral intake leads to systemic absorption of active phytochemicals, which then act centrally to upregulate BDNF in the brain, resulting in improved cognitive performance. The increase in plasma BDNF observed in the human trial can thus be interpreted as a likely reflection of this underlying central neuroplastic process. Other clinical trials have also reported the promise of *C. asiatica* for treating cognitive impairment, further supporting its therapeutic potential.[25]

Phytochemistry and Mechanistic Pathways

The neuroplastic effects of *C. asiatica* are driven by a rich array of bioactive compounds. The primary active constituents are a class of pentacyclic triterpenoid saponins, including asiaticoside and madecassoside, and their respective aglycones (the non-sugar part), asiatic acid and madecassic acid.[13] The Sbrini et al. study confirmed that these key triterpenes are present in the plasma of treated rats, verifying their bioavailability following oral administration.[20] In addition to these saponins, *C. asiatica* is rich in flavonoids such as quercetin and kaempferol, which are known for their potent antioxidant and anti-inflammatory properties.[13]

These compounds likely contribute to the overall cognitive benefit through a multi-target mechanism that complements the direct upregulation of BDNF. For instance, they exert powerful antioxidant effects, protecting neurons from oxidative stress, and possess anti-inflammatory properties, in part by inhibiting the NF-κB signaling pathway.[13] Furthermore, flavonoid-rich extracts have been shown to reduce the aggregation of β-amyloid plaques, a key pathological hallmark of Alzheimer's disease.[13] This multi-faceted neuroprotection creates a healthier neuronal environment, which likely enhances the efficacy of the pro-plasticity effects driven by BDNF. Interestingly, the traditional use of *C. asiatica* for wound healing, which involves stimulating collagen synthesis and tissue regeneration, provides a conceptual parallel to its effects on the brain, where it appears to promote neuronal repair and functional plasticity.[26]

The Neurogenic Potential of Shankhapushpi

Shankhapushpi is one of the most celebrated *Medhya Rasayanas* in Ayurveda, renowned for its ability to enhance memory and intellect.[28] However, investigating its scientific basis reveals a fascinating complexity. The name *Shankhapushpi*, which translates to "conch-flowered," is not a single botanical entity but rather a functional descriptor applied to several different plants across India, each with a unique phytochemical profile and, as emerging evidence suggests, distinct neuroplastic mechanisms.[30] This botanical ambiguity is not a source of confusion but rather a window into the sophisticated, outcome-based approach of traditional medicine. Analyzing the primary plants associated with the name— *Convolvulus pluricaulis*, *Clitoria ternatea*, and *Evolvulus alsinoides*—reveals that they achieve the traditional goal of cognitive enhancement through different, yet complementary, forms of neuroplasticity.

A Case of Botanical Identity: Clarifying the "Shankhapushpi" Complex

The Ayurvedic Pharmacopoeia of India officially recognizes the whole plant of *Convolvulus pluricaulis* as the authentic source of *Shankhapushpi*.[31] This species is predominantly used in Northern India.[33] However, in South India, the name is often applied to *Clitoria ternatea*, a visually distinct plant from the Fabaceae family.[32] A third plant, *Evolvulus alsinoides*, which belongs to the same family as *Convolvulus* (Convolvulaceae), is also used interchangeably in some traditions.[30] This is more than a simple taxonomic discrepancy; it has profound pharmacological implications. The evidence shows that these different botanicals target different levels of brain plasticity, from the functional tuning of synapses to the structural generation of new neurons. The concept of "Shankhapushpi" thus appears to represent a desired functional outcome—cognitive enhancement—which can be achieved via multiple biological pathways, depending on the specific botanical source used.

Convolvulus pluricaulis and Hippocampal Synaptic Plasticity

Research into *Convolvulus pluricaulis*, the official source of *Shankhapushpi*, points to a primary mechanism involving the modulation of synaptic plasticity in the hippocampus, the brain's central hub for learning and memory. A key study by Dasa et al. (2020) investigated the effects of chronic oral administration of *C. pluricaulis* extract in rats.[3] The study tested three doses (250, 500, and 1000 mg/kg) over four weeks and then measured synaptic activity in hippocampal slices. The most striking results were observed at the 500 mg/kg dose. This dose led to a significant enhancement of Long-Term Potentiation (LTP), the cellular process of strengthening synaptic connections that underlies memory formation.[3] Concurrently, the same dose significantly reduced Long-Term Depression (LTD), the process of weakening synaptic connections.[3] This dual action—boosting the strengthening of relevant connections while dampening their weakening—represents a powerful and direct modulation of the core machinery of synaptic plasticity, creating an optimal state for learning. These electrophysiological findings were strongly correlated with behavioral outcomes. In the same study, rats treated with the effective 500 mg/kg dose showed markedly improved memory retention in two different behavioral tests: the Contextual Fear Conditioning (CFC) test and the Novel Object Recognition Test (NORT).[3] To further dissect the mechanism, the researchers identified scopoletin, a coumarin compound present in the extract, and applied it directly to hippocampal slices *ex vivo*. Scopoletin mimicked the effects of the whole extract, significantly enhancing LTP and reducing LTD, thereby providing a direct link between a specific phytochemical and the observed neuroplastic effects.[3] This body of evidence suggests that *C. pluricaulis* enhances cognitive function primarily by fine-tuning the efficiency of existing neural circuits at the synaptic level. This action is further supported by its known antioxidant, anti-inflammatory, and acetylcholinesterase (AChE) inhibitory properties, which create a supportive environment for these plastic changes.[14]

Clitoria ternatea and Direct Neurogenesis

In contrast to the synaptic modulation seen with *C. pluricaulis*, the evidence for *Clitoria ternatea* points to a more profound, structural form of neuroplasticity: direct neurogenesis. An insightful *in vitro* study by Rai et al. investigated the effects of an aqueous root extract of *C. ternatea* (CTR) on neural stem cells (NSCs) harvested from the anterior subventricular zone (aSVZ) of rat pups, one of the brain's primary neurogenic niches.[6]

When these NSCs were cultured in the presence of the extract (at a concentration of 200 ng/ml), there was a significant increase in their proliferation, as measured by the formation of neurospheres (clusters of new stem cells).[6] More importantly, the extract also promoted the subsequent differentiation of these newly generated cells into mature neurons.[15] This is direct evidence that *C. ternatea* contains bioactive compounds that can stimulate the birth of new neurons from precursor cells, a process known as *de novo* neurogenesis. The researchers noted that this growth-promoting effect was similar to that of well-known neurotrophic factors like BDNF and FGF-2, suggesting the extract contains potent neurogenic molecules.[6]

This finding provides a powerful mechanistic explanation for the memory-enhancing effects of *C. ternatea*. While *C. pluricaulis* appears to optimize existing circuits, *C. ternatea* may work by adding new cellular components to these circuits, enhancing their capacity and flexibility. This mechanism is supported by *in vivo* research in a rat model of chronic cerebral hypoperfusion, where a bioactive fraction of *C. ternatea* not only restored cognitive deficits but also reversed the inhibition of neuroplasticity in the hippocampus.[37] Therefore, when *C. ternatea* is used as *Shankhapushpi*, the cognitive enhancement may be driven by this remarkable capacity for structural remodeling of the brain.

The Complementary Role of Evolvulus alsinoides

Evolvulus alsinoides, another member of the Convolvulaceae family also referred to as *Shankhapushpi*, appears to act through yet another complementary mechanism.[30] Research on this plant highlights its role as a potent neuroprotective agent, primarily through its strong antioxidant and acetylcholinesterase (AChE) inhibitory activities.[39] By scavenging free radicals and increasing the availability of the neurotransmitter acetylcholine,

E. alsinoides helps protect existing neurons from damage and optimizes cholinergic neurotransmission, which is critical for memory function. Interestingly, phytochemical analysis reveals that *E. alsinoides* also contains scopoletin, the same active coumarin found in *C. pluricaulis*.[39] This shared compound suggests a degree of mechanistic convergence and provides a chemical rationale for why these two distinct plants might be considered part of the same therapeutic category. *E. alsinoides* can thus be viewed as an agent that preserves the integrity of the neural architecture, creating a stable foundation upon which the more direct plasticity-modulating effects of *C. pluricaulis* and *C. ternatea* can act.

Brahmi (Bacopa monnieri): Modulation of Brain Oscillations

Bacopa monnieri, commonly known as Brahmi, is perhaps the most widely researched Ayurvedic nootropic. Its reputation as a memory enhancer and calming cognitive agent is well-established in both traditional texts and modern clinical trials.[17] While its mechanisms are known to be multifaceted—involving neurotransmitter modulation and dendritic growth—a unique pilot study using quantitative electroencephalography (qEEG) has provided novel insights into its effects on brain network dynamics, suggesting a sophisticated mechanism of action that goes beyond simple stimulation.

A Pilot Study in Mild Cognitive Impairment (MCI): Interpreting EEG Attenuation

A proof-of-concept study by Dimpfel et al. investigated the acute psychophysiological effects of *Bacopa monnieri* extract in subjects suffering from mild cognitive impairment (MCI), a transitional state that often precedes dementia.[44] The study compared a single 320 mg dose of *Bacopa* extract against a placebo and another botanical, *Sideritis scardica*, while subjects performed a battery of cognitive tests. The EEG results for *Bacopa* were striking and seemingly counter-intuitive. Instead of increasing brain wave activity, which might be expected from a cognitive enhancer, *Bacopa* produced a significant *attenuation* (decrease) of spectral power, particularly in the alpha (8–12 Hz) and beta (12–30 Hz) frequency bands in fronto-temporal brain regions.[44]

This effect was in stark contrast to the *Sideritis* extract, which caused a general increase in spectral power, highlighting the unique neurophysiological signature of *Bacopa*.[46]

At first glance, a reduction in brain wave power might be interpreted as a sedative or depressant effect. However, in the context of MCI, this finding can be re-framed as a marker of increased neural efficiency. Pathological states like MCI are often characterized by dysregulated, "noisy," and inefficient brain activity, including excessive slow-wave power or disorganized fast-wave activity.[47] An agent that "quiets" this neural noise could lead to more focused and efficient information processing, much like reducing static on a radio allows the signal to be heard more clearly. This interpretation aligns perfectly with *Bacopa*'s traditional description as a "calming cognitive enhancer".[17] Furthermore, it is strongly supported by one of *Bacopa*'s key pharmacological actions: the modulation of the GABAergic system. *Bacopa* has been shown to support the production of Gamma-aminobutyric acid (GABA), the brain's primary inhibitory neurotransmitter, which acts to reduce neuronal excitability.[17] This GABAergic action provides a plausible neurochemical basis for the observed EEG power attenuation, suggesting that *Bacopa* enhances cognition not by "amping up" the brain, but by fostering a calmer, more organized, and more efficient state of neural communication.

The Broader Neuropharmacological Profile of Bacopa monnieri

The unique EEG findings must be situated within the broader context of *Bacopa*'s well-documented, multi-target neuropharmacology. Its cognitive benefits are driven by a group of active triterpenoid saponins known as bacosides.[17] These compounds exert their effects through several synergistic mechanisms. One of the most important is the modulation of the acetylcholine (ACh) system. *Bacopa* has been shown to inhibit acetylcholinesterase (AChE), the enzyme that breaks down ACh, and to activate choline acetyltransferase, the enzyme that synthesizes it, thereby increasing the overall availability of this critical memory-related neurotransmitter.[17] Beyond its effects on GABA and ACh, *Bacopa* is a potent antioxidant and anti-inflammatory agent, protecting neurons from oxidative damage and reducing the release of pro-inflammatory cytokines like TNF-alpha and IL-6 from microglia.[17]

Perhaps most relevant to long-term plasticity, bacosides have been shown to promote the growth and branching of nerve endings, a process known as dendritic arborization.[18] By increasing the length and complexity of dendrites, particularly in hippocampal neurons, *Bacopa* enhances the physical infrastructure for synaptic communication, allowing for the formation of more robust and numerous connections between neurons. This structural plasticity is a fundamental mechanism for improving learning and memory consolidation.

Clinical Context and Event-Related Potentials (ERPs)

The hypothesis that *Bacopa* promotes a quieter, more efficient processing state is further strengthened by evidence from studies using Event-Related Potentials (ERPs). While qEEG provides a general overview of the brain's oscillatory state, ERPs are time-locked to specific cognitive events and measure the brain's direct electrical response to a stimulus or task. They provide a more direct measure of cognitive processing speed and resource allocation.

Clinical trials in various populations, from healthy students to the elderly, have demonstrated that *Bacopa* administration can significantly improve ERP components associated with cognitive processing.[49] Specifically, it has been reported to improve the N100 wave, which is related to attention and sensory gating, and the P300 wave, a well-established marker of working memory and cognitive resource allocation.[49] An improved P300 (e.g., shorter latency, larger amplitude) indicates that the brain is processing information more quickly and efficiently.

When viewed together, the EEG and ERP data paint a sophisticated and coherent picture of *Bacopa*'s action. The EEG attenuation suggests it fosters a calm, low-noise baseline brain state. The ERP improvements demonstrate that from this quieted state, the brain can mount a sharper, faster, and more efficient response when a cognitive demand is presented. This dual effect perfectly encapsulates its role as a "calming cognitive enhancer."

Synthesis and Conclusion

The convergence of Ayurvedic tradition and modern neuroscientific inquiry reveals that the cognitive-enhancing herbs classified as *Medhya Rasayanas* are not simply general "tonics" but are sophisticated modulators of specific and fundamental neuroplastic processes. The evidence reviewed for *Centella asiatica*, the *Shankhapushpi* complex, and *Bacopa monnieri* demonstrates that these botanicals engage distinct yet complementary mechanisms to support and enhance brain function, validating their long-standing use in one of the world's oldest medical systems. The key preclinical and clinical findings that form the basis of this understanding are summarized in Table 2.

Table 2: Overview of Key Preclinical and Clinical Studies

Herb	Study (e.g., Primary Author, Year)	Model	Key Outcome Measures	Primary Finding
Centella asiatica	Sbrini et al., 2020 [7]	Adult male rats	Prefrontal cortex BDNF levels, Novel Object Recognition (NOR) test	Dose-dependent increase in PFC BDNF mRNA and protein, correlated with improved cognitive performance.

Centella asiatica	Arifin et al., 2023 [24]	Menopausal women	Plasma BDNF, Montreal Cognitive Assessment (MoCA) score	Daily supplementation increased plasma BDNF, which correlated with improved cognitive scores.
Convolvulus pluricaulis	Dasa et al., 2020 [3]	Rat hippocampal slices, *in vivo* rat model	LTP/LTD magnitude, Contextual Fear Conditioning, NOR test	Enhanced hippocampal LTP and reduced LTD, correlated with improved memory in behavioral tasks.
Clitoria ternatea	Rai et al., 2018 [6]	*In vitro* rat neural stem cells (aSVZ)	Neurosphere proliferation and neuronal differentiation	Increased the proliferation of neural stem cells and their differentiation into new neurons.
Bacopa monnieri	Dimpfel et al., 2016 [44]	Humans with Mild Cognitive Impairment (MCI)	Quantitative EEG (qEEG) spectral power during cognitive tasks	Produced an attenuation of alpha and beta wave power, suggesting a normalization of brain activity.

Converging Mechanisms and Future Directions

This review elucidates a spectrum of neuroplastic actions. *Centella asiatica* acts primarily as a promoter of trophic support, selectively upregulating BDNF in the prefrontal cortex to bolster executive function. The *Shankhapushpi* complex showcases the functional diversity within a single traditional concept: *Convolvulus pluricaulis* engages in the functional tuning of synaptic communication by modulating LTP and LTD, while *Clitoria ternatea* drives structural plasticity by promoting the birth of new neurons. Finally, *Bacopa monnieri* appears to enhance overall network efficiency, fostering a "calm and focused" brain state through GABAergic modulation and EEG power attenuation, while simultaneously strengthening the physical architecture of neuronal communication through dendritic growth.

These findings highlight a multi-target approach that is inherent to these botanicals. They simultaneously address inflammation, oxidative stress, neurotransmitter imbalances, and direct plasticity, a holistic strategy that aligns well with the multifaceted nature of age-related cognitive decline and neurodegenerative diseases. However, the evidence, while compelling, is still emerging and points toward several critical areas for future research:

1. **Head-to-Head Clinical Trials:** Rigorous clinical trials are needed to directly compare the cognitive effects of the different botanicals used as *Shankhapushpi* (*C. pluricaulis*, *C. ternatea*, *E. alsinoides*) to clarify their respective roles and potential interchangeability in clinical practice.
2. **Advanced Neuroimaging:** Human studies employing more direct measures of brain plasticity, such as functional MRI (fMRI) to assess network connectivity and Positron Emission Tomography (PET) to track neuroinflammation or amyloid burden, are essential to validate the specific mechanisms observed in preclinical models.
3. **Longitudinal Studies:** Long-term clinical trials of *Bacopa monnieri* in MCI and early dementia populations are necessary to determine if the acute EEG changes translate into lasting improvements in cognitive trajectories and measurable changes in brain structure.
4. **Synergy in Polyherbal Formulations:** Many Ayurvedic treatments involve polyherbal formulas. Research should investigate the potential synergistic interactions between these herbs, as their complementary mechanisms of action suggest that their combined effect may be greater than the sum of their individual parts.

Concluding Remarks on the Therapeutic Potential of Medhya Rasayanas

The ancient wisdom of Ayurveda, when interrogated with the tools of modern science, offers a rich pipeline of potential therapeutics for cognitive health. The evidence for *Centella asiatica*, *Shankhapushpi*, and *Bacopa monnieri* demonstrates that these are not crude substances with vague effects but are, in fact, highly sophisticated biological response modifiers. They target the very essence of what makes the brain adaptable and resilient: its capacity for plastic change. As the global population ages and the burden of cognitive disorders grows, the need for safe, effective, and multi-target interventions has never been greater. The *Medhya Rasayanas* of Ayurveda, with their profound and specific effects on neuroplasticity, represent a promising frontier in the ongoing quest to preserve and enhance the health of the human mind. Their continued investigation and potential evidence-based integration into modern neurology and psychiatry could offer new hope for preventing and treating some of the most challenging disorders of our time.

REFERENCES

1. Neuroplasticity - PubMed, accessed on July 29, 2025, https://pubmed.ncbi.nlm.nih.gov/32491743/
2. Neuroplasticity and Nervous System Recovery: Cellular Mechanisms, Therapeutic Advances, and Future Prospects - PMC, accessed on July 29, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC12025631/
3. Convolvulus pluricaulis extract can modulate synaptic ... - TCG Crest, accessed on July 29, 2025, https://www.tcgcrest.org/wp-content/uploads/2023/03/Convolvulus-Paper.pdf
4. Convolvulus pluricaulis extract can modulate synaptic plasticity in rat brain hippocampus - PubMed, accessed on July 29, 2025, https://pubmed.ncbi.nlm.nih.gov/32282574/
5. New neurons and new memories: how does adult hippocampal neurogenesis affect learning and memory? - PubMed, accessed on July 29, 2025, https://pubmed.ncbi.nlm.nih.gov/20354534/
6. Neurogenic Potential of Clitoria ternatea Aqueous Root Extract–A Basis for Enhancing Learning and Memory | Scholarly, accessed on July 29, 2025, https://scholarly.org/pdf/display/neurogenic-potential-of-clitoria-ternatea-aqueous-root-extract-a-basis-for-enhancing-learning-and-memory
7. Centella asiatica L. Phytosome Improves Cognitive Performance by Promoting Bdnf Expression in Rat Prefrontal Cortex - PubMed, accessed on July 29, 2025, https://pubmed.ncbi.nlm.nih.gov/32013132/
8. Brain Derived Neurotrophin Factor (BDNF) Level in Aged Sprague Dawley Rats Brain after the Treatment of Centella Asiatica Leaf Extracts - SciTePress, accessed on July 29, 2025, https://www.scitepress.org/Papers/2018/98424/98424.pdf
9. Brain Plasticity and Cell Competition: Immediate Early Genes Are the Focus - PubMed, accessed on July 29, 2025, https://pubmed.ncbi.nlm.nih.gov/39851571/
10. A Review on Medhya Rasayanas: A Brain Bracer - Pharmacognosy ..., accessed on July 29, 2025, https://phcogcommn.org/wp-content/uploads/2021/10/PhcogCommn-11-4-182.pdf
11. A critical review on medhya rasayana in ayurveda, accessed on July 29, 2025, https://www.wisdomlib.org/science/journal/world-journal-of-pharmaceutical-research/d/doc1376959.html
12. View of Review article on the role of Medhya Rasayana : Enhancing the Intellectual Power, accessed on July 29, 2025, https://jaims.in/jaims/article/view/1882/2176
13. Centella asiatica: Advances in Extraction Technologies ... - MDPI, accessed on July 29, 2025, https://www.mdpi.com/2075-1729/15/7/1081
14. Protective Mechanisms of Nootropic Herb Shankhpushpi (Convolvulus pluricaulis) against Dementia: Network Pharmacology and Computational Approach - PubMed, accessed on July 29, 2025, https://pubmed.ncbi.nlm.nih.gov/36225186/
15. Neurogenic potential of Clitoria ternatea aqueous root extract-a basis for enhancing learning and memory - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/288134572_Neurogenic_potential_of_Clitoria_ternatea_aqueous_root_extract-a_basis_for_enhancing_learning_and_memory
16. Phytochemical Profile, Pharmacological Attributes and ... - Frontiers, accessed on July 29, 2025, https://www.frontiersin.org/articles/10.3389/fphar.2020.00171/full
17. Bacopa monnieri - StatPearls - NCBI Bookshelf, accessed on July 29, 2025, https://www.ncbi.nlm.nih.gov/books/NBK589635/
18. Bacopa monnieri and Their Bioactive Compounds Inferred Multi-Target Treatment Strategy for Neurological Diseases: A Cheminformatics and System Pharmacology Approach - MDPI, accessed on July 29, 2025, https://www.mdpi.com/2218-273X/10/4/536
19. An overview of Centella asiatica and its therapeutic applications - Semantic Scholar, accessed on July 29, 2025, https://pdfs.semanticscholar.org/22a0/eae5e395eac3dfabf25c8653dfb3d8f81767.pdf
20. Centella asiatica L. Phytosome Improves Cognitive Performance by ..., accessed on July 29, 2025, https://www.mdpi.com/2072-6643/12/2/355
21. Centella asiatica L. Phytosome Improves Cognitive Performance by Promoting Bdnf Expression in Rat Prefrontal Cortex - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/338909881_Centella_asiatica_L_Phytosome_Improves_Cognitive_Performance_by_Promoting_Bdnf_Expression_in_Rat_Prefrontal_Cortex
22. Analysis of cognitive performance of rats that were chronically treated... - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/figure/Analysis-of-cognitive-performance-of-rats-that-were-chronically-treated-with-20-or-100_fig5_338909881
23. Prof. Dr. dr. Dwi Cahyani Ratna Sari, M.Kes.PA(K) (1) dr. Mawaddah Ar Rochmah, Ph.D., Sp.N. (2) - Academic Staff - Universitas Gadjah Mada, accessed on July 29, 2025, https://acadstaff.ugm.ac.id/karya_files/the-effects-of-ethanol-extracts-of-centella-asiatica-leaf-on-serial-serum-brain-derived-neurotrophin-factor--bdnf--concentration-of-rats--sprague-dawley--following-chronic-stress-ad201bd2d1b13552f8adb4fc4917db20
24. Centella asiatica (Indian Pennywort) Extract and Exercise Increase Brain-Derived Neurotrophic Factor Plasma, Cognition, and Physical Fitness among Menopausal Women - Horizon Research Publishing, accessed on July 29, 2025, https://www.hrpub.org/journals/article_info.php?aid=13794
25. Centella Asiatica for Cognitive Impairment - Clinical Trials, accessed on July 29, 2025, https://www.withpower.com/trial/phase-1-mild-cognitive-impairment-mci-10-2022-c4600

26. Pharmacological Review on Centella asiatica: A Potential Herbal Cure-all - PubMed Central, accessed on July 29, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC3116297/
27. Centella asiatica and Its Metabolite Asiatic Acid: Wound Healing Effects and Therapeutic Potential - MDPI, accessed on July 29, 2025, https://www.mdpi.com/2218-1989/13/2/276
28. Convolvulus pluricaulis a nootropic herb with neuropharmacological activity a review, accessed on July 29, 2025, https://www.researchgate.net/publication/297236886_CONVOLVULUS_PLURICAULIS_A_NOOTROPIC_HERB_WITH_NEUROPHARMACOLOGICAL_ACTIVITY_A_REVIEW
29. Review on ethnomedicinal uses and phytopharmacology of memory boosting herb Convolvulus pluricaulis Choisy - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/259357827_Review_on_ethnomedicinal_uses_and_phytopharmacology_of_memory_boosting_herb_Convolvulus_pluricaulis_Choisy
30. Convolvulus prostratus - Wikipedia, accessed on July 29, 2025, https://en.wikipedia.org/wiki/Convolvulus_prostratus
31. Comparative pharmacognostical investigation on four ethanobotanicals traditionally used as Shankhpushpi in India - PMC, accessed on July 29, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC3255406/
32. Phytochemical characterization and evaluation of anti-amnesic activity of two source plants of Shankhapushpi - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/384283780_Phytochemical_characterization_and_evaluation_of_anti-amnesic_activity_of_two_source_plants_of_Shankhapushpi
33. Identification of Shankhpushpi by morphological, chemical and molecular markers - European Journal of Biotechnology and Bioscience, accessed on July 29, 2025, https://www.biosciencejournals.com/assets/archives/2015/vol3issue2/23.1.pdf
34. Comparative microscopical character of various ethanobotanicals claims of Shankhpushpi - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/figure/Comparative-microscopical-character-of-various-ethanobotanicals-claims-of-Shankhpushpi_tbl1_221750118
35. Phytochemical Profile, Pharmacological Attributes and Medicinal Properties of Convolvulus prostratus – A Cognitive Enhancer Herb for the Management of Neurodegenerative Etiologies - PubMed Central, accessed on July 29, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC7063970/
36. Protective Mechanisms of Nootropic Herb Shankhpushpi (Convolvulus pluricaulis) against Dementia: Network Pharmacology and Computational Approach - PubMed Central, accessed on July 29, 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC9550454/
37. Bio-enhanced fraction from Clitoria ternatea root extract ameliorates cognitive functions and in vivo hippocampal neuroplasticity in chronic cerebral hypoperfusion rat model - PubMed, accessed on July 29, 2025, https://pubmed.ncbi.nlm.nih.gov/37343678/
38. Evolvulus alsinoides - Wikipedia, accessed on July 29, 2025, https://en.wikipedia.org/wiki/Evolvulus_alsinoides
39. Antioxidant studies using the extracts of Evolvulus alsinoides (Linn.) Linn - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/figure/Antioxidant-studies-using-the-extracts-of-Evolvulus-alsinoides-Linn-Linn_tbl3_340993694
40. Neurocognitive Values of Evolvulus alsinoides and Centella asiatica on Scopolamine Induced Amnesia in Mice | Request PDF - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/337834749_Neurocognitive_Values_of_Evolvulus_alsinoides_and_Centella_asiatica_on_Scopolamine_Induced_Amnesia_in_Mice
41. Neuroprotective Activity of Evolvulus alsinoides & Centella asiatica Ethanolic Extracts in Scopolamine-Induced Amnesia in Swiss Albino Mice | Open Access Macedonian Journal of Medical Sciences, accessed on July 29, 2025, https://oamjms.eu/index.php/mjms/article/view/oamjms.2019.247
42. Review on Evolvulus alsinoides and a brief outlook in to the neuroprotective activity of Convolvulaceae plants, accessed on July 29, 2025, https://www.botanyjournals.com/assets/archives/2021/vol6issue6/6-6-71-835.pdf
43. Exploring the neuropharmacological properties of scopoletin-rich Evolvulus alsinoides extract using in-silico and in-vitro methods | Request PDF - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/381274961_Exploring_the_neuropharmacological_properties_of_scopoletin-rich_Evolvulus_alsinoides_extract_using_in-silico_and_in-vitro_methods
44. Psychophysiological Effects of Sideritis and Bacopa Extract and ..., accessed on July 29, 2025, https://www.scirp.org/journal/paperinformation?paperid=64876
45. Psychophysiological Effects of Sideritis and Bacopa Extract and Three Combinations Thereof—A Quantitative EEG Study in Subjects Suffering from Mild Cognitive Impairment (MCI) - Scientific Research Publishing, accessed on July 29, 2025, https://www.scirp.org/html/1-2440119_64876.htm
46. Psychophysiological Effects of Sideritis and Bacopa Extract and Three Combinations Thereof—A Quantitative EEG Study in Subjects Suffering from Mild Cognitive Impairment (MCI) - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/299406603_Psychophysiological_Effects_of_Sideritis_and_Bacopa_Extract_and_Three_Combinations_Thereof-A_Quantitative_EEG_Study_in_Subjects_Suffering_from_Mild_Cognitive_Impairment_MCI
47. (PDF) Psychophysiological Effects of a Combination of Sideritis and Bacopa Extract (memoLoges®) in 32 Subjects Suffering from Mild Cognitive Impairment. A Double-Blind, Randomized, Placebo-Controlled, 2-Armed Study with Parallel Design - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/308038037_Psychophysiological_Effects_of_a_Combination_of_Sideritis_and_Bacopa_Extract_memoLogesR_in_32_Subjects_Suffering_from_Mild_Cognitive_Impairment_A_Double-Blind_Randomized_Placebo-Controlled_2-Armed_Stu

48. Assessing the Anti-inflammatory Effects of Bacopa-Derived Bioactive Compounds Using Network Pharmacology and In Vitro Studies | ACS Omega, accessed on July 29, 2025, https://pubs.acs.org/doi/10.1021/acsomega.2c05318

49. Study Details | Effect of Bacopa Monnieri on Working Memory and Cognitive Processing in Student | ClinicalTrials.gov, accessed on July 29, 2025, https://clinicaltrials.gov/study/NCT02931747

50. A Randomized Controlled Trial Investigating the Effects of a Special Extract of Bacopa monnieri (CDRI 08) on Hyperactivity and Inattention in Male Children and Adolescents: BACHI Study Protocol (ANZCTRN12612000827831) - MDPI, accessed on July 29, 2025, https://www.mdpi.com/2072-6643/7/12/5507

51. Cited-by 'Complete chloroplast genome of the medicinal plant ... - Scilit, accessed on July 29, 2025, https://www.scilit.com/publications/cited-by-search/152791466

52. Nootropic, anxiolytic and CNS-depressant studies on different plant sources of Shankhpushpi | Request PDF - ResearchGate, accessed on July 29, 2025, https://www.researchgate.net/publication/51575633_Nootropic_anxiolytic_and_CNS-depressant_studies_on_different_plant_sources_of_Shankhpushpi

53. Shankhapushpi (Convolvulus pluricaulis Choisy): Validation of the Ayurvedic therapeutic claims through contemporary studies - International Journal of Green Pharmacy, accessed on July 29, 2025, https://www.greenpharmacy.info/index.php/ijgp/article/view/413/435

54. Psychophysiological Effects of a Combination of Sideritis and Bacopa Extract (memoLoges®) in 32 Subjects Suffering from Mild Co, accessed on July 29, 2025, https://www.scirp.org/pdf/AAD_2016091214370217.pdf