Advancing Emotional Health with Machine Learning in Brain Imaging

Sailaja G[1]* and B. Narendra Kumar Rao[2]

[1]*School of Computing, Mohan Babu University,Tirupathi, AP 517102, India*
[2]*Head AIML, School of Computing, Mohan Babu University, AP 517102, India*

ABSTRACT

Current research in neuroscience provides deeper insights into the underlying mechanisms that govern human behaviour, cognition, and emotion. These findings are not only valuable to a diverse range of professionals, including scientists, educators, and clinicians, but they also hold significant relevance in clinical practice. Mental health professionals such as psychiatrists, psychologists, and counsellors are increasingly seeking operational models that integrate contemporary discoveries from the fields of physiology, cognition, and emotion. These models can serve as a unifying framework for interdisciplinary communication and understanding. We can identify the emotional and behavioural pathways that impact mental processing by examining individual characteristics, predispositions, and responses to stimuli. To gain deeper insights into variations in decision-making and mental health disorders, this article introduces a brain-path activation model. The significance of frontal lobe EEG asymmetry is examined in the first section, which summarizes decision-making models based on traits and states. It further offers a refined analysis that builds upon the conventional left-right brain framework. The reconciliation of sequential handling in the left side of the equator and equal handling in the right half of the globe during direction is a vital part of this model. It also suggests pathways that integrate past experiences with future considerations in the decision-making process.

Keywords: Behavioural pathways, cognition, decision-making, EEG asymmetry, psychopathology, state-based models

INTRODUCTION

There are many chances for examination to evaluate several realities of human understanding, emotion, and behaviour thanks to neuroscience. It also enhances our ability to understand character traits and the influence of natural factors on mental health, deep reactions, and behavioural patterns.

Improvements in frontal cortex research have led to a better understanding of the cycles and frameworks that govern human behaviour, discernment, and emotion. Neuroscientific studies reveal the normal underpinnings of mental cycles such as idea, thinking, and direction, as well as the implications for neurogenesis and neuronal structures. This examination clarifies the instruments hidden advantageous change, emphasizes the adequacy of treatment and heading, and advances the coordination of these spaces (Northoff, 2025). It also discusses how directing and psychotherapy are mental cycles, as well as frontal cortex-based drugs, that produce measurable and enduring improvements in cognitive ability and design.

Neuroscience technologies like fMRI, PET, and EEG neurofeedback are essential tools in understanding and treating various neurological conditions offer valuable methods for exploring the biological underpinnings of responses shaped by both traits (such as personality) and states (such as environmental factors). The article introduces a brain-way enactment model to explain individual differences in psychiatric disorders and navigation, focusing on frontal-lobe EEG asymmetry and introducing a framework for understanding human behaviour and psychological conditions, combining state- and trait-based decision-making models. By gaining a deeper understanding of brain functions and priorities, we can better comprehend the reasons behind people's thoughts, emotions, and actions(Tschacher et al., 2025). Even though people may believe they are in charge of their lives, making choices and establishing objectives, this sense of autonomy is dependent on the brain's healthy operation.

MODELS OF DECISION

Brain Asymmetry

Frontal-lobe EEG activity indicates that individuals often exhibit consistent responses in various situations, either with approach or withdrawal behaviours, across various situations. This trait-based model proposes that such responses reflect an individual's personality style or disposition. These tendencies can also be linked to factors that influence personal goals or survival. Conversely, individual differences in frontal EEG asymmetry are acknowledged by state-based or dispositional models, which also emphasize how these responses are impacted by the particular demands of various contexts (Surianarayanan et al., 2023). In a state-based framework, reactions shift according to the emotional challenges of a situation and the individual's momentary capacity for self-regulation. Characteristics address stable characteristics, reflected feeling consistent or initiation levels, though states are transient responses to explicit improvements, normally enduring just a brief time frame.

As shown in Figure 1, brain asymmetry highlights the functional distinctions between the left and right hemispheres, where the left is associated with logical and sequential processing, and the right emphasizes creativity, holistic perception, and emotional regulation. To deal with grasping individual varieties in front facing EEG Imbalance
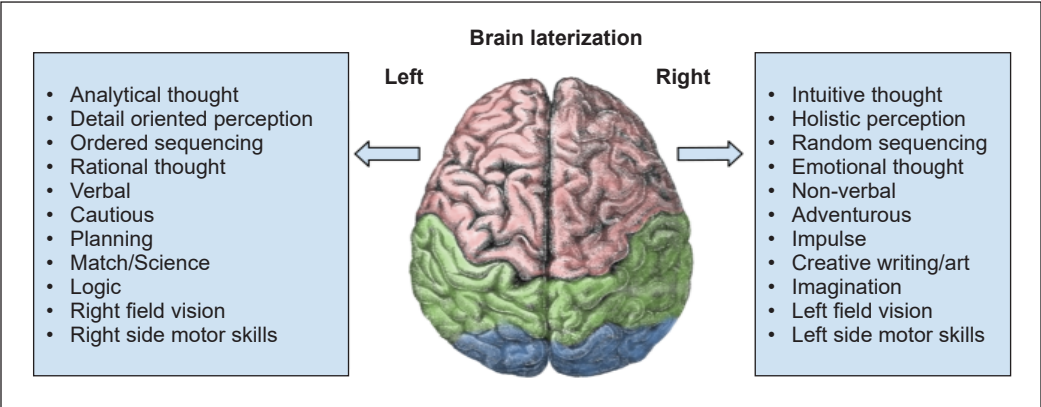
Figure 1. Brain asymmetry

characteristic and state-based models provide impressive solutions. Each highlight its importance among the feeling – the focus personal significance which people attach such as someone's personal experiences as crucial considerations influencing brain imbalance (Litwińczuk et al., 2022). From the perspectives of psychology and neuroscience, emotions frequently take precedence over data or reasoning when it comes to making decisions and creating connections with both internal and external circumstances. In this sense, emotions play a fundamental role in shaping human behaviour and emotional health.

Towards a Unified Framework for Decision-Making and Mental Health

For effective interdisciplinary communication, mental health professionals, including counsellors, require practical models to guide their work to incorporate the most influential neuroscientific conclusions and offer a common language. These integrated models provide a framework for evaluating, treating, and assessing the results of client care. They offer a thorough understanding of human functioning by connecting the mind and body. Psychotherapy functions as a biological intervention or a type of brain therapy, as Kandel highlights (Arndt et al., 2022). Similarly, Ivey and Zalaquett (2011) emphasized that counselling was fundamentally based on neuroscience. Both viewpoints acknowledge that therapeutic dialogues have the power to alter the mind and brain. Through interventions that change clients' reward systems (Tsfasman et al., 2022), cognitive functions, and emotional reactions that mold their needs and abilities, counsellors and psychotherapists Okawa and Iwata (2022) can have an impact on the physiology and function of the brain.

A QUANTITATIVE APPROACH

A neurologically-driven model provides an operational viewpoint on emotional decision-making by examining specific roles and routes Emotional regulation and decision-making

can be disrupted when these pathways or functions are disturbed or overactive (Cacioppo & Decety, 2023). Instead of becoming binary, these processes are quantitative and interpreted as probabilities. The probability of an individual reacting in a certain manner to specific stimuli—whether sensory inputs, thoughts, or emotions—depends on how these inputs are processed (Zhang, 2024).

This conceptual framework combines contemporary neurophysiological insights with social-interactionist perspectives. The resulting integrative model lays the groundwork for procedural methods that utilize neuroscientific knowledge in assessing and treating mental health challenges. A variety of clinical assessment tools are available to explore this model, which is particularly adaptable for quantitative analysis. While it can include symptomatic behaviours, internal experiences, and the creation of diagnostic categories, the primary focus is on functionality rather than symptoms or diagnoses (Bavelier & Neville, 2021). One such integration facilitates a diagnosis-free understanding of clients' states and processes, assisting clinicians in selecting the most suitable interventions or medications. The authors foresee ongoing advancements in assessment methods and treatment strategies that prioritize understanding the underlying processes influencing both internal experiences and external behaviours.

CONCLUSION

This approach emerged to identify emotional and behavioural patterns, linking them to imbalances in key model parameters. It distinguished between the brain and the mind, with physical processes driving causal mechanisms, while subjective experiences emerged from a higher plane. While the brain informs mental events, it did not fully determine them. Clients were viewed as biological systems, but their subjective experiences were considered to validate interventions. All interventions, even those based on stimuli like sound or light, were understood as physical. This framework encouraged a compassionate and empathetic approach, supporting clinical practices based on neuroscientific evidence to effectively address cognitive, sentimental, and psychological concerns.

ACKNOWLEDGEMENT

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