



Brain-Computer Interface Integrated Neuropsychological Assessment for Quasi-Psychotic Symptoms

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Abstract: In clinical psychology/psychiatry, quasi-psychotic symptoms refer to experiences such as suspiciousness or paranoia, brief hallucination-like experiences, ideas of reference, odd beliefs that are not fixed or delusional, experiences that resolve quickly, and insight usually retained. Studies using structured tools show that subclinical psychotic-like experiences (PLEs) occur in a portion of people in India. The present paper explores the potential of BCI-derived neural markers as objective indicators of quasi-psychotic states. BCI systems enable real-time acquisition and interpretation of neural signals, particularly electroencephalographic (EEG) patterns associated with perception, cognition, and self-referential processing. Alterations in neural oscillations, functional connectivity, and event-related potentials captured through BCI paradigms may reflect disruptions in reality testing, perceptual integration, and cognitive control. In quasi-psychosis, BCI would monitor Neural Oscillatory Dysregulation (including increased theta activity, reduced alpha coherence, and aberrant gamma activity), Event-Related Potential (ERP) alterations (including reduced P300 amplitude and mismatch negativity changes), and Functional Connectivity Shifts (including alterations in prefrontal regions and temporal-parietal regions). BCI systems can track moment-to-moment neural instability, detect onset, intensity, and resolution of quasi-psychotic states, differentiate quasi-psychosis from anxiety or dissociation, full psychosis, and normative stress responses. This is particularly valuable in disorders like borderline personality disorder, trauma-related conditions, and mood disorders, where quasi-psychosis is episodic. The conventional diagnosis using neuroimaging tools such as fMRI and CT scans is time-consuming, and error prone. Hence, Machine Learning models in BCI like Supervised Learning models (Support Vector Machines, Random Forests, Logistic Regression), Deep Learning models (Convolutional Neural Networks, Recurrent Neural Networks, Hybrid CNN-LSTM models), and Unsupervised Learning models (K-Means/Hierarchical clustering, Autoencoders)

can be used to generate risk scores, and understand temporal trajectories. On a concluding note, this paper offers an interdisciplinary view of how BCIs can be helpful in assessing quasi-psychotic symptoms.

Keywords: *Brain-Computer Interface, Quasi-Psychosis, ML models, EEG*

1. Introduction

Quasi-psychotic experiences, for instance, hallucinations, ideas of persecution, perceptual anomalies, derealisation, and thought disorder, arise in varying forms of psychiatric conditions, including borderline personality disorder, trauma-related conditions, mood disorders, and attenuated psychosis syndromes (American Psychiatric Association [APA], 2022; Fonagy et al., 2017). These experiences generally tend to be responsive to stress, of an episodic nature, with partial preservation of reality testing, which further complicates differential diagnosis, making it less feasible for exclusive assessment on an interviewing or self-report basis (Paris, 2018). Hence, an increasing need has been observed for an objective neurobiologically based technique with potentialities to also assess episodic situations of quasi-psychotic experiential phenomena.

Traditional neuropsychological assessments have typically focused on behavioral indices of functioning in attention, executive control, working memory, and perceptual processing, among others (Lezak et al., 2012). While these approaches are essential for delineating cognitive deficits that accompany psychosis-spectrum phenomena, they stop short of capturing the transient neural instability hypothesized to underpin subthreshold psychotic symptoms (Nelson et al., 2019). Incorporating electrophysiological measures within neuropsychological assessment provides a route toward surmounting this limitation by offering direct, temporally sensitive indices of abnormal neural processing.

For instance, the use of Electroencephalography (EEG)-based Brain-Computer Interfaces (BCIs) allows for the acquisition and analysis of brain signals connected to the process of sensory perception, attention, and regulation, and self-referential cognition in real time (Wolpaw & Wolpaw, 2012; Makeig et al., 2019). BCIs based on EEG are especially valuable in a clinical setting and have a number of advantages: they are non-invasive and have a high temporal resolution and repeatability. Most significantly, it is possible to identify EEG patterns strongly linked to psychosis.

Among these, gamma oscillations with a frequency of approximately 30-80 Hz have a prominent role in percept binding, working memory, and inter-sensory integration. Pathological gamma oscillations have long been identified in people with schizophrenia, with

prodromal psychosis, and with sub-clinical psychosis symptoms, which signal disrupted inter-cortical synchronization and a failure to properly integrate internal and external stimuli (Uhlhaas & Singer, 2015). In relation to quasi-psychotic symptoms, disrupted gamma oscillations can be a determining factor in issues with percept formation and hallucination illusions, thus representing a valuable model to be considered using BCI-based assessment.

The P300 event-related potential, a positive wave that peaks around 300 ms after the presentation of the stimuli, is commonly viewed as an indicator of attention allocation and working memory updating. P300 amplitude reduction and increased P300 latency have been found in psychotic disorders and in subjects at clinical high risk for psychosis, reflecting cognitive control and stimulation evaluation problems (Polich, 2007; Bramon et al., 2014). Adding P300 parameters to the set of BCI-assisted neuropsychological analysis procedures would enable the use of objective indices for assessing attention dysregulation and cognitive inefficiency symptomatic for quasi-psychotic states.

Another important electrophysiological indicator involves the impairment of mismatch negativity (MMN), a component of the event-related potential (ERP) that occurs in response to changes in the patterns of either auditory or visual stimuli. Pre-attentive sensory differences are detected through the evaluation of MMN. MMN deficits have been found to be one of the most consistent and replicable markers of schizophrenia and are also found among people with reduced psychotic symptoms as well as other psychiatric conditions and perceptual dysfunctions (Näätänen et al., 2011; Erickson et al., 2016). The inclusion of MMN deficits in testing paradigms for BCI-based systems may help in the earlier identification of neurocognitive risk associated with quasi-psychotic phenomena.

The integration of EEG-based markers such as gamma band activity, P300 components, and MMN in BCI-based neuropsychological assessment provides a multi-modal and dimensional approach towards psychopathology. Interestingly, adopting such a dimensional approach has proven consistent with modern perspectives such as that of the Research Domain Criteria initiative that view psychopathology through the perspectives of neural circuitries and cognitive processes rather than merely adhering to strict boundaries set by traditional categories of psychopathology (Insel et al., 2010). Such a BCI-based integration in neuropsychological assessment has shown potential in increasing the sensitivity of assessment towards quasi-psychotic symptoms.

BCI-Integrated Neuropsychological Assessment Model

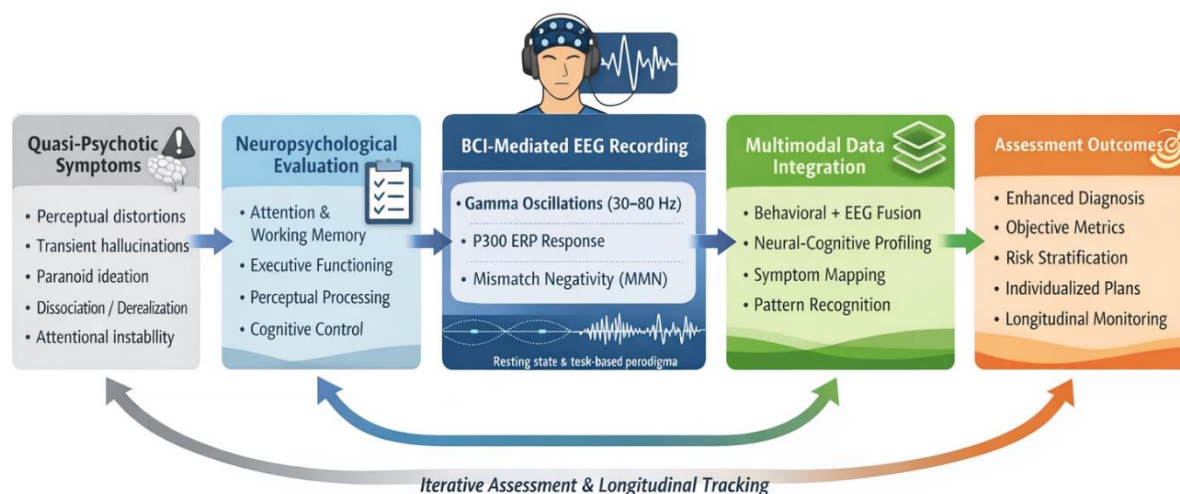


Figure 1: *BCI Integrated Neuropsychological Assessment Model*

2. Literature Review

2.1 Electroencephalography and Neuropsychological Biomarkers in Psychosis

EEG has been studied for decades as a modality to detect neurophysiological aberrancies associated with psychosis and related cognitive disturbances. Recent systematic reviews demonstrate that EEG biomarkers, including event-related potentials such as P300 and mismatch negativity, show consistent alterations in psychiatric populations, which reflect underlying cognitive deficits in attention, working memory, and sensory processing. Such biomarkers have shown sensitivity not only to full-blown psychotic disorders but also to subclinical and prodromal symptoms, suggesting their utility in dimensional assessment across the psychosis spectrum (Turner et al., 2025). The P300 ERP, typically elicited in oddball paradigms, has been robustly associated with attentional allocation and working memory updating processes. Among the most consistent findings in schizophrenia and also in prodromal psychotic states are reduced P300 amplitude and prolonged latency, reflecting widespread cognitive dysregulation, particularly of auditory attention processes. Another important ERP component is the mismatch negativity, considered a pre-attentive marker of impaired sensory discrimination and predictive coding. Reduced MMN amplitude has been found in clinical high-risk populations and may predict clinical outcomes, thereby underlining its potential value as a prognostic indicator of emerging psychotic processes.

2.2 *Gamma Oscillations and Neural Synchrony*

Apart from components of ERP, oscillatory processes of EEG, especially gamma band activity (30-80Hz), have also been explored as promising neurocognitive end-points of psychosis-related dysfunctions. Gamma band oscillations are suggested to play a role in the coordination of cortices and sensory integration that are impaired in schizophrenia and other psychiatric as well as neurological illnesses. Lower gamma band synchronies and power have been noted in schizophrenia patients that represent poor coordination of involved brain circuits for perception and cognitive control tasks and have been found to be altered in unaffected relatives of such patients as well.

2.3 *EEG Biomarkers in Prodromal and At-Risk States*

EEG biomarkers have also been explored in the context of individuals at a clinical high risk (CHR) for psychosis. These individuals are usually identified by the presence of subthreshold or quasi-psychotic phenomena. Research has shown that deficits in the P300 and MMN components could potentially precede the overt transition to psychotic illnesses and may represent useful prognostic indicators. These EEG changes are presumed to represent a disturbance in neurotransmitter systems, for example, by the dysfunction of the NMDA receptor, and underscore the utility of EEG biomarkers in providing insight into physiological mechanisms.

2.4 *Integration of EEG with Brain-Computer Interfaces*

Although the literature on EEG biomarkers is largely concerned with their use in diagnosis and prognostic capabilities, studies on Brain-Computer Interfaces (BCIs) recognize the possibility of real-time acquisition and analysis of neural signals in clinical and assessment environments. BCIs, largely using non-invasive EEG, have played an important role in communication and assistive therapies, exemplifying the ability of EEG to be decoded and utilized for significant purposes (e.g., controlling motor or communicative functions). Although BCIs are largely developed or applied to motor dysfunction or unconsciousness pathology, they establish the basic paradigms of real-time observation of neural functions, which can be extended to cognitive or psychiatric assessment frameworks. Presently, novel approaches for multimodal EEG, incorporating machine learning models and data fusion approaches, are poised to increase the specificity and sensitivity of EEG biomarkers. Presently available multimodal or ML-fused models of EEG have depicted higher efficacy of classification or clinical interpretation when combining neural signals to other data or complex models of pattern recognition, implying their possible application to more complex clinical phenomena, such as quasi-psychotic experiences.

2.5 Strengths, Limitations, and Translational Challenges

Despite the promising findings, some limitations make it difficult to immediately translate EEG biomarkers and BCI technology into psychiatry. There is an indication in some reviews that not all EEG measures are capable of distinguishing at-risk groups effectively, and many inconsistencies can be attributed to variations in EEG methods of data acquisition, in addition to the resolution issue since EEG methods offer high temporal resolution, which can sometimes make it difficult to interpret complex disruptions in cognition in the context of quasi-psychotic experiences. However, the combination of BCI and EEG biomarkers offers hope in developing dynamic, more objective, and more valid methods of assessment that can move beyond neuropsychological tests. The BCI can offer insight into real-time neural representations associated with cognitive and perceptual instability.

3. Methodology

3.1 Research Design

This paper will make use of a conceptual and methodological research design so as to come up with an integrated framework for the assessment of the symptoms of quasi-psychotic disorders through Brain-Computer Interface Technology. The aim of this research design is to come up with an assessment framework for the symptoms of quasi-psychotic disorders that is theoretically well-founded. This research design will not make use of an empirical research process and will not involve the collection of data.

3.2 Theoretical Framework

The methodology is based on a biopsychological and neurocognitive orientation, whereby quasi-psychotic symptoms are conceptualized as a function of the interaction between neural activity, cognitive processes, and subjective experiential parameters. From this orientation, BCI technology is viewed as a complementary tool for symptom assessment with real-time sensitivity to the neural parameters related to cognitive/perceptual symptoms. Mathematical modelling is applied to combine these parameters with those of neuropsychological testing for greater accuracy and ecologicity.

3.3 Operationalization of Quasi-Psychotic Symptoms

For the purpose of the proposed framework, quasi-psychotic symptoms are considered to be subclinical or attenuated psychotic experiences that do not reach the intensity needed to fulfil the diagnostic criteria of any psychotic disorder but are distinguished by temporary perceptions of thought content and processing abnormalities in relation to the self, such that

the symptoms can consist of perceptual distortions, referential thinking, mild paranoid ideas, intrusions of a dissociative kind, and cognitive or perceptual disrupted processing.

3.4 Neuropsychological Assessment Component

The proposed methodology calls for the inclusion of standardized domains that are particularly pertinent to psychosis-spectrum functional capacity and include attention/vigilance, executive processing, working memory, reality monitoring, and sensory integration. Tasks are conceptually chosen based on well-established links between those tasks and psychotic experience and cognitive-perceptual dysregulation patterns of endophenotypes.

3.5 Psychometric Assessment Component

The framework embeds standardized psychometric instruments to assess subjective experiences associated with quasi-psychotic symptoms, regarding symptom frequency, severity, and related distress. These measures are conceptually integrated to help the linking of self-reported symptom profiles and neurophysiological patterns recorded via BCI.

4. Brain–Computer Interface (BCI) Component

A non-invasive EEG-based BCI is proposed to serve as the primary modality for the acquisition of neurophysiological data. The BCI aspect is conceived to have the ability to tap into the cortical process measures while in resting and task engagement cognitive states. The neural measures of interest include event-related potentials and oscillations reflecting the process measures for attention control, perception, and cognition. The proposed inclusion of BCI technology aims at the supplementation of the usual measures through the use of objective neural indices reflective of quasi-psychotic symptom expression.

4.1 Data Integration Strategy

The proposed methodological approach embraces a multimodal integration strategy, which conceptualizes the neuropsychological performance parameters, the psychometric symptom patterns, as well as the derived parameters from a BCI interface, within a collective framework. This collective model aims to provide a diversified interpretation toward the comprehension of the neuropsychological foundations underlying the symptoms associated with a quasi-psychotic state.

4.2 Analytical Framework (Conceptual)

Despite the lack of empirical data analysis presented in this study, the methodology also covers hypothetical approaches in data analysis. The approaches are aimed at ensuring the feasibility of the proposed model. The approaches include correlation mapping between the neural measures and symptom dimensions, pattern-based classification using computational

models, and neurocognitive profiling on symptom clusters. All the data analysis approaches are hypothetical.

4.3 Ethical Considerations

The proposed framework recognises the ethical issues relevant for the empirical implementation stage, such as the obtaining of consent for neural data recording, the privacy of the research participants, the secure storage of the neurophysiological data, and the challenge of determinism. The proposed experimental technique underlines the distinction between research evaluation and clinical diagnosis.

4.4 Methodological Contribution and Scope

This conceptual approach to methodology offers something to the current body of literature in that it offers a conceptual tool that seeks to integrate the areas of neuropsychology, cognitive neuroscience, and BCIs in its assessment approach. The proposed method is not reliant on either self-reported data or behavioral measurements alone and offers future validation potential. As this is merely a conceptual proposal, there are not requirements in regards to participant variables or any requirements of either sampling or size.

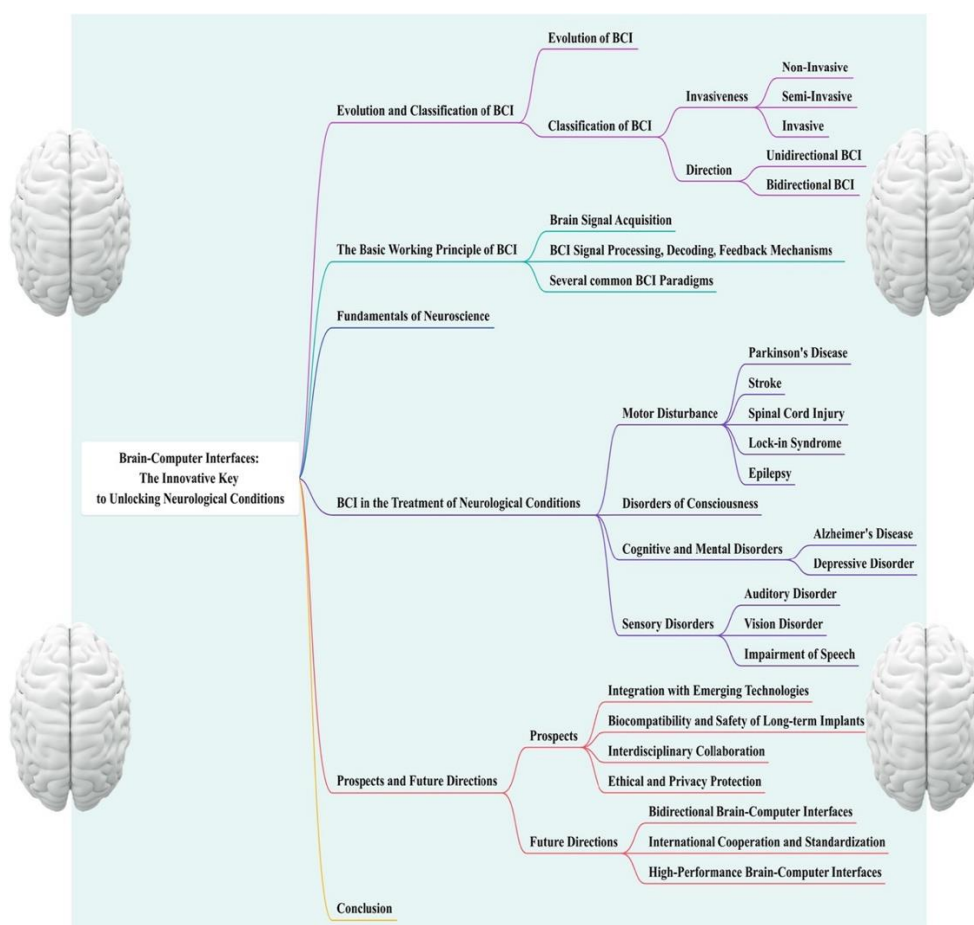


Figure 2: Shows how Brain-Computer Interfaces impact neurological and psychological conditions.

Major Findings from Reviews

S. No.	Title	Author	Year of Publication	Summary
1.	Brain-computer Interface Advances in Neurology and Mental Health	Emeka Onyebuchi Enechukwu, Mercy Omoye Omoruyi, Vivian Ukamaka Nwokedi, Victor Ayoola Owosagba, Taiwo Elizabeth Oyefeso, Damilare Oluwaseun Bakre, Ololade Funke Olaitan, and Enibokun Theresa Orobator	2025	The article discusses the most up-to-date developments in the field of brain-computer interface technology and declares how such technology is revolutionizing not only the field of neurology but also psychological practice itself. Brain-computer interface technology refers to technology that enables control signals to be generated from brain activity for the purpose of controlling external devices.
2.	Ethical governance of clinical research on the brain–computer interface for mental disorders: a modified Delphi study	Qing Zhang, Chen Zhang, Haiqing Ji, Jing Chen, Xingchao Wang, Tianhong Zhang, Pinan Liu, Zhen Wang, and Yifeng Xu.	2025	The study applies to the ethics of clinical brain computer interface studies in mental illness, which is an emergent and interdisciplinary field that intersects neuroscience, engineering, and psychiatric care. The researchers observe that while brain computer interfaces (such as implantable devices or non-invasive neuronal interfaces) have potential in the care of depression or schizophrenia patients, there is currently a lack of detail in ethics in this area. The aims of the study were to identify an ethical framework that could systematically cover this field.
3.	Prospects and Problems of Brain	Iroju Olaronke, Ikono Rhoda, Ishaya Gambo, Ojerinde	2018	The adoption of BCI is very important in the health sector. BCI platforms are cheaper in terms of health expenditure

	Computer Interface in Healthcare	Oluwaseun, and Olaleke Janet.		<p>and promote the health of people living with severe motor disorders. The thesis discusses the overall idea of BCI, BCI techniques, methods of acquiring signals in BCI, and the advantages and challenges of BCI in the health sector. The outcome of the review revealed that BCI can aid in communication, the restoration of sensory and motor skills of individuals suffering from neurological disorders, and BCI can also aid in neurorehabilitation to promote the highest possible level of motor skills and autonomy in stroke patients. The study further showed that BCI can aid in pain relief, tracking sleep patterns and emotion of patients, and BCI can aid patients to control household environmental apparatus like thermostat, lights, and television. However, the study showed that accuracy, reliability, standardization, privacy, and neuro-crime are some of the challenges faced in BCI in the health sector.</p>
4.	Brain-computer interfaces: the innovative key to unlocking neurological conditions	Zhang, Hongyu; Jiao, Le; Yang, Songxiang; Li, Haopeng; Jiang, Xinzhan; Feng, Jing; Zou, Shuhuai; Xu, Qiang; Gu, Jianheng; Wang, Xuefeng; Wei, Baojian	2024	<p>This paper discusses how Brain-Computer Interface (BCI) technology, which allows for direct interaction between the brain and external devices, is one of the fastest-developing technologies in neurology with promise as a powerful tool. The authors review principles and classification for BCIs-</p>

				<p>invasive, semi-invasive, and non-invasive-and discuss major applications in treatment and rehabilitation in neurological conditions: movement disorders like Parkinson's and stroke, spinal cord injury, disorders of consciousness, and cognitive/mental disorders like Alzheimer's and depression.</p>
5.	<p>Informed consent competency assessment for brain-computer interface clinical research and application in psychiatric disorders: A systematic review</p>	<p>Jia-Yue Si, Zi-Yan Lin, Di-Ga Gan, Xin-Yang Zhang, Yan-Nan Liu, Yu-Xin Hu, Yan-Ping Bao, Xue-Qin Wang, Hong-Qiang Sun, Xin Yu, Lin Lu</p>	2025	<p>The article systematically presents information on how informed consent competency (ICC) is tested in brain-computer interface (BCI) clinical studies with psychiatric disorders. The authors have made efforts in order to find the essential factors that affect a patient's capacity for valid informed consent in BCI experiments and have developed a multi-dimensional framework for future research in light of the specific challenges of BCI technology.</p>
6.	<p>Brain-Computer Interface and Neurofeedback Technologies: Current State, Problems and Clinical Prospects (Review).</p>	<p>A.I. Fedotchev; S.B. Parin; S.A. Plevaya; S.D. Velikova</p>	2016	<p>BCI and NFB are two promising neuro-technologies not based on drugs, growing in clinical importance. While BCI aims at restoration of functions outside the individual, NFB places much more emphasis on the self-regulation of one's brain activity. Further methodological improvement and personalization may facilitate both technologies in playing an increasingly important role in neurorehabilitation</p>

				and treatment of mental disorders in the years to come.
7.	Mood Input-Output (MoodIO): A Brain-Computer Interface Application for Personalized Emotional Regulation in Children	Shazneen Sheik, and Sheik Ahamed Azigar Ali	2025	The paper offers a definition for MoodIO, which stands for brain-computer interface technology, a system that employs non-invasive EEG sensors to track alpha, beta, and theta wave patterns in a child's brain and analyze their emotional state. The article states that MoodIO incorporates artificial intelligence technology with brain-computer interface technology to analyze the readings obtained by the EEG sensors, emitting beneficial signals that help the child manage emotional imbalances. The authors state that in a pilot test involving two children aged 9 and 12, MoodIO indicated a shift in brainwave patterns characteristic of relaxation and emotional management. These results have limited significance due to the small test group.
8.	Brain-computer interfaces: communication and restoration of movement in paralysis	Niels Birbaumer, and Leonardo G. Cohen	2007	This paper will be a review of literature concerning the research efforts in the brain-computer interface (BCI). In the BCI, it is tried to translate the brain signals into control signals for an external device (for example, communication system or a prosthetic device). Though there have been findings in animal models such as monkeys that have demonstrated control over movements through recorded brain

				signals without peripheral muscle activity, there are not many findings in humans in the clinical setting.
9.	Review of Machine Learning Algorithms for Diagnosing Mental Illness	Gyeongcheol Cho, Jinyeong Yim, Younyoung Choi, Jungmin Ko, Seoung-Hwan Lee	2019	To this end, the authors pointed out that even as ML is being applied to greater extents in the area of mental health, there are misunderstandings among researchers as to the workings of these machine learning approaches, for example, as to whether these approaches are able to address small sample size issues or whether Deep Learning is ML.
10.	Role of machine learning and deep learning techniques in EEG-based BCI emotion recognition system: a review.	Priyadarsini Samal & Mohamad Farukh Hashmi	2024	This paper presents a thorough analysis of various available studies conducted around the topic of emotion recognition through the analysis of EEG signals recorded using Brain-Computer Interface (BCI) systems. The paper mainly concentrates on those studies where machine learning (ML) and deep learning (DL) algorithms have been utilized to identify human emotions.

5. Discussion

Brain-computer interface (BCI) neuropsychological evaluation: This appears to be a novel, evolving process by which researchers can better comprehend quasi-psychotic phenomena by combining cognitive evaluation with neural assessments. Attenuated hallucinations, abnormal percept experiences, suspiciousness, and mild disturbances of thought, which tend to lie below threshold but imply a predisposition towards more severe types of psycho-pathology, tend to be more common among this population. Traditional neuropsychological evaluation procedures tend to be based on behavioral observation and subjective assessments, making it less sensitive towards subtle abnormalities of neural

function, which tend to give rise to quasi-psychotic phenomena. Incorporation of BCI procedures might give researchers immediate access to neural function.

BCI systems, mostly using non-invasive electroencephalography, allow recording and interpreting neural signals related to attention, perception, executive functioning, and reality monitoring-domains frequently disrupted in quasi-psychotic states. Neural markers such as event-related potentials, oscillatory activity, and functional connectivity patterns provide objective indices of sensory processing and cognitive control deficits that may not be overtly observable at the behavioral level. For example, changes in processing of prediction error, sensory gating, and cortical synchrony are associated with psychosis-spectrum phenomena and can be probed with BCI-based paradigms during structured neuropsychological tasks. This integration enhances the ecological and diagnostic validity of assessments by linking cognitive performance to the underlying neural dynamics.

In terms of clinical and research utility, BCI-integrated assessment has a number of advantages in the early screening and stratification of individuals at risk for psychotic disorders. This is because subclinical neural abnormalities typically manifest preceding the appearance of overt symptoms, and this is where the utility of BCI suits the screening for underlying vulnerabilities in the adolescent and young adult populations. Further, the application of machine learning algorithms has the ability to combine neural and behavioral measures, and this has advantages for the enhancement of classification performance and the generation of risk profiles. This fits into the agenda for precision psychiatry, where specific neurocognitive and neurophysiological profiles are used for the generation of preventive and interventional strategies.

Although promising, the use of BCI-integrated neuropsychological assessment for quasi-psychotic symptoms is far from problem-free. Practical issues involving signal noise, intersubject variability, and the standardization of assessment procedures still pose a challenge. Ethical issues involving data privacy and misuse, patient consent, and the risk of accurate subject classification also need careful consideration, especially for at-risk groups. However, advancements are expected in the areas of signal processing algorithms for brain signals and the availability of wearable BCIs.

6. Conclusion

In summing up, the combination of brain-computer interface technology and neuropsychological methods introduces a new and objective assessment tool for the evaluation of quasi-psychotic phenomena. Through the detection of the subtle neuropsychological

dysfunction underlying the experience of attenuated psychosis, it is possible to close a significant gap between cognitive and neuropsychology. With the increase in the level of empirical findings, the potential to increase the efficiency in the diagnosis and preventive treatment in the field of psychosis-spectrum studies is evidentially significant.

6.1 Implications

The integration of BCI technology with neuropsychological evaluation has far-reaching implications in terms of research, clinical application, and preventive mental health care. At the research front, the integration of BCI technology makes it possible to search for biomarkers in neuropsychology that correlate to subclinical psychosis, making it possible to accurately trace the trajectories for preventive measures. At the clinic front, BCI-based neuropsychological evaluation can provide a supplement to current diagnostic practice, making it possible to trace the trajectories for early intervention and customized treatment regimens. At a broader level, it is in line with the thrust area for the development of precision psychiatry, where the focus is to trace the trajectories based on neural processes rather than the intensity of the symptoms.

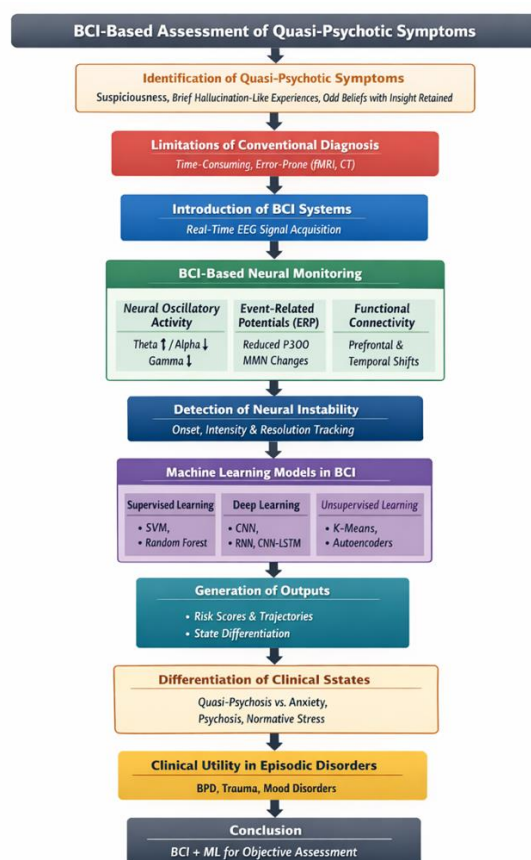


Figure 3: shows a flowchart elaborating the BCI-based assessment of Quasi-Psychotic Symptoms.

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