Review Article
Clinical applications of EEG as an excellent tool for event related potentials in psychiatric and neurotic disorders

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Abstract: Electroencephalography is an excellent tool for assessing neurobiological and neurotransmission dysfunction. Event-related potentials (ERPs) are a simple, non-invasive method of studying neurophysiology. ERPs reflect complex activity of neural networks to blame for discriminative behavior of people and recognition of novel stimuli. They are defined as brain voltage fluctuations linked in time with some physical or mental event. EEG is used to assess ERPs, and its use has grown in popularity since the 1960s. This article provides an overview of the ERP methods as well as the properties of the various ERP components (contingent negative variation, namely wave P300, Bereitschafts potential, and mismatch negativity). It also describes ERP alterations linked with neurologic and psychiatric disorders and discusses the possibility of using this technique in experimental psychology. ERPs may reveal psychophysiological characteristics in obsessive compulsive disorder patients, which may have therapeutic and pharmacological consequences. The P3 wave is the most significant and researched component of the ERP record. It is divided into two parts: P3a and P3b. The P3 wave has therapeutic significance, in addition to its application in neurophysiological and psychophysiological research. One neurophysiology indicator of cognitive impairment in depression is the P300 component of the ERPs. The severity of the illness as well as sociodemographic disparities is likely to influence individuals with neurotic disorders' access to psychiatric care in the general community.

Keywords: Electroencephalography, event-related potentials, mismatch negativity, contingent negative variation, Bereitschafts potential

Introduction

It is widely known that exercise has a positive impact on cognition; abundant human and animal research has shown that exercise has a positive impact on cognitive and brain functioning [1].

Physical exercise is one of the elements for maintaining and improving brain functioning, and there is growing interest in studying lifestyle factors and methods to improve the cognitive ability of older people and decrease the risk of age-related neurodegenerative illnesses [2]. Moderate-intensity aerobic workouts done continuously or at intervals have proven to be the most effective. This may be related to the activation of hippocampal synaptic plasticity, which improves synaptic effectiveness [3, 4] as well as the expression of molecules that improve learning and memory, thus decreasing the mental decline associated with age. Exercise enhances elements of mental functioning, such as mood, self-esteem, and overall psychological well-being, in addition to physical fitness.

Many mental and neurotic illnesses cause alterations in ERPs, which may be improved with exercise. The goal of this review is to explore the clinical uses of ERPs in various diseases.

Electroencephalogram (EEG)

The EEG is a generic representation of the electrical brain neurons activity in the cerebral cortex or on the surface of scalp, and it includes a wealth of pathological, physiological, and psychological data. EEG signals may be induced by a variety of human muscular, cognitive, and emotional activities. It is feasible to read people's minds and accomplish certain control objectives using useful feature classification and extraction of data from EEG. EEG signals are increasingly being used for recognition and categorization tiredness [5], emotions of human [6], target pictures [7], and identity verification [8] due to their high objectivity, non-forgery, and ease of collection.

Additionally, EEG signals are extremely non-stationary, time dependent, and sensitive to noise interference. It is a challenge to extract and identify critical segments or time points in the EEG sequence that have a strong emotional connection. As a result, developing a model that can correctly predict emotional categories of EEG is a huge task. EEG signals are assumed to be stationary by certain linear inverse techniques, such as Minimum Norm Estimation (NME), Dynamic Statistical Parametric Maps (DSPM), and Vector Modulation and Phase Shift [9]. Although the sliding window technique partially addressed certain non-stationary EEG issues, its statistical effectiveness is poor and incomplete. To enhance the effectiveness of EEG sequence modelling, Zhang Y, Liu B, Ji X, and Huang D coupled an autoregressive model with wavelet decomposition [10]. Based on this, the researchers developed a technique to extract cross-day robust emotion-related electroencephalogram features using a combination of common space pattern and wavelet packet decomposition, which minimized the impact of non-stationarity of EEG signals on emotion categorization [6].

An EEG is a test that uses small metal discs (electrodes) placed to your scalp to detect electrical activity in your brain. Even while you're sleeping, electrical impulses allow your brain cells to communicate with one another. On an EEG recording, this activity appears as wavy lines [11].

Electrodes put on the scalp may readily capture the electrical activity of the brain. The potential difference between two pairs of scalp electrodes [bipolar derivation] or between two pairs of scalp electrodes and a comparatively passive reference point (referential derivation) is amplified and shown on a computer screen, oscilloscope, or piece of paper. The features of a typical EEG are determined by the patient's age and degree of excitation. The post-synaptic potential of the cerebral cortex's vertically oriented pyramidal cells is represented by rhythmic activity, which is defined by its frequency.

Event-related potentials [ERPs]

The method of monitoring the signals of EEG linked with the presentation of particular impulses or stimuli is known as ERPs. Gaudreault PO, Gagnon JF, Montplaisir J, Vendette M, Postuma RB, and Gagnon K claimed that this method can capture brain activities with millisecond accuracy (2013) [12]. ERPs are therefore a kind of EEG that may be viewed as a subset of evoked potentials [13].

ERPs are voltage fluctuations that occur in time in response to a physical or mental event. They are extremely tiny voltages produced in brain regions in response to particular stimuli. Additionally, they are thought to represent activity in sophisticated neural networks that detect new stimuli and allow people to differentiate between important and irrelevant inputs. Furthermore, ERPs are unaffected by cultural or educational effects, and they may provide a non-invasive method of investigating cognitive processes [14].

The online analysis of ERPs collected from the human scalp has been another method to the type and timing of neural events in neuropsychological performance investigations utilizing behavioral data. The so-called oddball paradigm is one of the most used paradigms in ERP research.

The subject is shown a series of repeated (standard) stimuli that are replaced with a new (deviant) stimulus at random and with a low proba-

Table 1. Studies on event relation potentials and electroencephalogram

Author	Research	References
Friedman D 2003	According to new research, the ERPs method may be used to detect brain activity that reflects different cognitive functions that are impacted by ageing.	[58]
Karl A, Malta LS, Maercker A. 2006	ERPs alter during posttraumatic stress disorder, according to their meta-analytic study [PTSD]. In the presence of trauma-related distractors, there was evidence of decreased P50 suppression as well as higher P300 amplitudes to both target stimuli and distractors.	[59]
Ally BA, Jones GE, Cole JA, Budson AE. 2006	P300 may be able to detect preclinical alterations in those who are at a high risk of developing the illness owing to a genetic predisposition. P300 is generally thought to be a good measure for assessing Alzheimer's disease.	[60]
Garrido-Vásquez P, Pell MD, Paulmann S, Strecker K, Schwarz J, Kotz SA. 2009	The MMN is an electrical measure of sensory learning and perceptual accuracy that indicates the brain's capacity to make automatic comparisons between successive stimuli.	[61]
Martín-Loeches M, Molina V, Muñoz F, Hinojosa JA, Reig S, Desco M. 2001	The function of P3 as a marker for neurodegenerative processes was investigated.	[62]
Chen J, Jiang D, Zhang Y. 2018	Presented a feature of EEG extraction technique integrating data space CSP [common spatial patterns] and adaptation [DSA] algorithms, which reduced the deterioration of emotion classification ability caused by cross-day EEG signal fluctuations and variations.	[63]
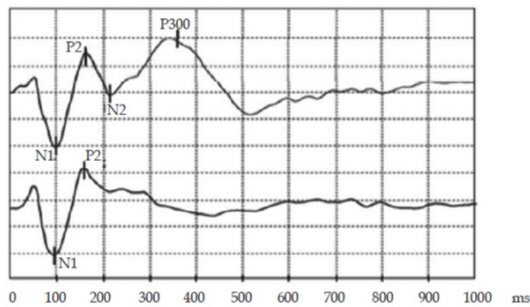
Figure 1. In the first trace in response to rare stimuli [a 2000 Hz pure tone with 80 Db HL intensity], there is presence of peaks N1, P2 passively generated and peaks N2, P300 generated by the mental count of the stimuli. In the second trace, obtained in response to a frequent stimuli [a 1000 Hz pure tone with 80 dB HL intensity] there is only one peaks N1, P2 which are not associated with the task of counting sound stimuli.

bility. The goal of the subject is typically to identify these abnormal stimuli (targets).

As mentioned in **Table 1**, the stimuli elicit a number of ERP components, each of which is thought to represent a distinct cognitive function. Several components of the ERPs have been found to be sensitive to Alzheimer's disease - N200, P300, P200, P600, N400, and late positive component are some of these components; each one taps into a distinct element of cognitive or late sensory processing.

Filtering and averaging of the data may be used to obtain ERPs from EEG [15]. The most common method for extracting the signal is to record a series of electroencephalogram epochs, every point is time-locked to repeat the similar event, and then normalize the waveforms [16].

The electrical information recorded on the EEG comes from a variety of locations on the scalp; derivations are the technical name for these points. ERPs are divided into two categories [17]. The early waves are referred to as 'exogenous' or 'sensory' since they are mainly dependent on physical characteristics and are governed by the eliciting stimuli physical nature (peaking during the first 100-200 milliseconds following stimulation). ERPs that occur afterwards are classified as 'endogenous' or 'cognitive'.

These ERPs are sensitive to changes in the subject's mental state, which reflect the meaning of 'stimulus' [18]. It looks at how the subject processes information and how the subject assesses the stimuli. The waveforms may be classified based on their latency and amplitude.

Other papers in this issue go into the technological foundation, benefits, and drawbacks of the ERP method in depth. It's enough to say that ERPs' temporal resolution is unrivalled, with millisecond resolution allowing for an immediate readout of summated brain activity (in contrast to blood flow-based methods, which have a response start of roughly 2 seconds). Cognitive event-related potentials are very sensitive to cognitive slowdown. Rather than summated action potentials, ERPs are mainly made up of summated inhibitory and excitatory postsynaptic potentials [19].

Components of ERPs

As shown in **Figure 1**, three components were visually identified: N1, P2, N2, and P3 (P300). The N1 and P2 were scored in the ERP wave-

form to non-target stimuli, while N2 and P3 were identified in the waveform to target stimuli.

● N100 or N1 is a large negative-going evoked potential measured by electroencephalography; it peaks in adults between 80 and 120 milliseconds after the onset of a stimulus and is distributed mostly over the fronto-central region of the scalp. In the absence of task demands, it is elicited by some unexpected stimuli.

● N200 or N2 typically evoked 180 to 325 ms following the presentation of a specific visual or auditory stimulus; the N200 [or N2] negativity results from a deviation in form or context of a prevailing stimulus.

● P200 or P2 is a positive electrical potential that peaks after the onset of any external stimulus at about 200 milliseconds (ranging between about 150 and 275 ms).

● P300 - the ERP is a sequence of peaks and troughs that appear in the EEG in response to the occurrence of a discreet event, such as the stimulus presentation [visual, auditory, etc.] or the psychological stimulus reaction. The former ERP is called exogenous [or even evoked potential], while the latter is called the endogenous ERP. In the exogenous ERP, the form of the response varies depending on the stimulus dimension.

Alzheimer's disease P300 studies

The P300 wave has been identified as the most prominent and well-studied. According to their polarity, the letter 'N' denotes negative waves, whereas the letter 'P' in abbreviations denotes positive waves. The numbers represent either the component's delay (in milliseconds) or its waveform ordinal position. P3 wave is also called P300, the P3 wave, or the wave with a delay of 300 milliseconds [20]. In the human ERP, the P300 wave has a positive deflection. When a participant identifies an infrequent "target" stimulus in a normal standard stimuli train, it is acquired in a "oddball" paradigm. If the individual is actively engaged in the job of identifying targets, the P300 wave will appear. The experimental subject's goal is to respond to the presence of a target stimulus by performing a specific motor activity, such as pushing a

button. The wave's amplitude changes with the target's improbability, and its latency varies with the struggle of distinguishing the target stimulus from the standard stimuli. In grown-up adult individuals performing a basic discriminate, the typical peak delay is 300 milliseconds. P300 wave pathological alterations may develop in people with Alzheimer's disease and other dementias, schizophrenia, depression, or Parkinson's disease, for example. When basic stimulus categorization tasks are conducted, the component of "P3b" or P300 is a positive scalp that is usually greatest approximately 300 millisecond post stimuli at Centro parietal midline locations.

An unlikely stimulus target amid a stream of standard stimuli is the most frequent elicitor of the P300 (e.g., low-pitched standards in the auditory oddball paradigm among high-pitched target tones). Although the exact cognitive mechanisms underpinning the P3 component are unknown, it is obviously affected by working memory load and attentional resource allocation [21]. Subjective likelihood, stimulus saliency, attentiveness, and inter stimulus interval are all aspects that impact the latency or size of P300, although the P300 is largely unaffected by sensory input properties [22].

Contingent negative variation

The first one to explain contingent negative variation was "Walter [1964a, b]"; he defined it as a sustained potential change [primarily involving the frontal cortex] during which the surface of the brain becomes electro-negative by about 20 V in comparison to deeper structures or remote reference electrode. It is a gradual negative deviation of scalp activity of EEG that occurs between the (S1) warning stimulus and (S2) urgent stimulus, and is followed by a motor or mental reaction. The polarity (negative or positive going voltage), sensitivity, scalp distribution, and timing to task changes are all used to classify ERP components [23]. The complex of long- and middle-latency evoked potentials, contingent negative variation, wave P300, Bereitschafts potential, and mismatch negativity are all examples [24].

Contingent negative variation is a multifaceted endogenous potential that represents a wide range of cognitive and mental activities and processes, including attention, expectation,

discrimination, stress, and sensation. The average of multiple EEG segments is used to calculate contingent negative variation. These segments are believed to be an EEG recording that occurs 1.5 to 1 second before the warning stimulus and 1 to 2 seconds after the urgent signal.

Bereitschafts potential

Bereitschafts potential is a slow wave that occurs before a voluntary motor act. It is also known as RP [readiness potential] or PMP [premotor potential]. Its absence is due to malfunctioning motor planning processes in the brain [25]. Bereitschafts potential is divided into two parts: a late and an early component. The supplementary motor area (SMA) activity takes place in the early section, highest at the vertex amplitude [overlying supplementary motor area], with no consideration for the body parts participating in the movements. The late section is lateralized to the opposite hemisphere to the side of the movements and believed to characterize primary motor cortices activity in particular [26]. N1 (N100 wave), N2 (N200 wave), P50 wave, P (P200) wave, P600, N300, and N400 waves post-imperative negative variation and movement-related cortical potentials are all identified as additional components of an ERP trace by other authors.

Mismatch negativity

The brain's response to violating a rule established by a sequence of sensory inputs is known as mismatch negativity [mainly in the auditory domain]. Even when there is no attention, it may be used as an objective indication of auditory sensory memory and sound-discriminating accuracy [27]. Mismatch negativity occurs when a recurrent component of an auditory stimulus shows a detectable change. The discriminable change may be frequency, duration, strength, apparent silent gap instead of a tone, or a sound-source location. Any disturbance of auditory regularity or pattern is believed to activate the mismatch negativity.

ERPs in neurologic and psychiatric disorders

Alterations in ERPs are thought to be connected to neurologic and psychiatric disorders. Parkinson's disease patients, for instance, have a reduced early Bereitschafts potential [28].

Despite the lack of cognitive deficits, people with mild Parkinson's disease had a significantly higher P3 amplitude in certain studies. As a consequence, P3 amplitude is more sensitive than neuropsychological tests for detecting modest brain damage early in Parkinson's disease [29].

Tanaka H, Koenig T, Pascual-Marqui RD, Hirata K, Kochi K, and Lehmann D discovered that Parkinson's disease patients who were not demented had greater P3 and N1 amplitude (2000). ERPs may be used to assess cognitive loss in people with Alzheimer's disease, as well as other diseases [30].

Zhang Y, Liu B, Ji X, and Huang D utilized ERPs to assess probable Alzheimer's disease patients and those with moderate cognitive impairment (2010). In both likely cognitive impairment and Alzheimer's disease individuals, P300 latencies were found to be significantly longer. The P300 delay may accurately represent cognitive decline, making it a useful tool for defining the seriousness of Alzheimer's disease [14].

Furthermore, although it is usually accepted that P300 latency rises in Alzheimer's disease patients as they age, there is presently no consensus on P300 amplitude [31].

Similarly, the majority of studies in epilepsy patients revealed no significant reductions in P300 amplitude but longer P300 latencies [32]. Another frequent finding is changes in mismatch negativity. In the frontal region, epilepsy patients exhibited longer mismatch negativity duration and amplitude. In this way, mismatch negativity may be applied for epilepsy differential diagnosis.

P300 delay lengthening and P300 amplitude reduction were often found in schizophrenia individuals in terms of mental disorders [33]. In comparison to healthy people, patients with chronic schizophrenia show a one-standard-deviation reduction in P300 amplitude [34].

P300 latency and amplitude have been shown to be altered in bipolar patients [35]. ERP abnormalities related to depression include significantly decreased P300 amplitude and longer P300 latency when compared to healthy individuals [36].

Across the life span of adult, the P300 auditory has been found to be responsive to normal ageing. The rise in P300 latency with age is around 1-2 millisecond/year, and it is linear between the ages of 20 and 75 years. P300 amplitude has been shown to be reduced in a variety of psychiatric and neurologic disorders [e.g., vascular dementia, Alzheimer's disease, and schizophrenia]. Distinguishing Alzheimer's disease and other dementia patients from mental illnesses like depression has had varying degrees of effectiveness. The employment of various methods (e.g., behavioral tasks, electroencephalogram recording, and data analysis techniques) and the severity of the illness, patient profile, and sample size are among the reasons.

The P300 latency was shown to be positively linked to the subject's age and depression level, while the P300 amplitude was found to be inversely related to age [37]. Additional modifications were made to address N2, but the effects were hotly contested. For example, few studies reported a growth in amplitude N2, while Sachs G, Anderer P, Dantendorfer K, and Saletu B in 2003 found no changes. Patients with social phobia had lower N1 and N2, and longer P300 latencies and P300 amplitudes, as well as other mental illnesses linked to ERP alterations [38]. Field of study with specific fears (snakes and spiders) had larger P300 amplitudes after exposure to chronic alcoholics, feared stimuli frequently had (but not all the time) P300 smaller than healthy subjects, and alcohol consistently causes attenuation of P2 amplitudes and N1 amplitudes [39].

Obsessive-compulsive disorder patients had shorter P300 durations than healthy controls [40], while those with generalized disorder of anxiety had lower P300 amplitudes than healthy people [41].

Furthermore, post-traumatic stress disorder patients had lower P300 latencies and amplitudes in response to stimuli neutral target. ERPs may also be used to distinguish between different illnesses. For example, attempted to assess the neurophysiological distinctions between generalized anxiety disorder and panic disorder [42]. When panic disorder patients were compared to generalized anxiety disorder and individuals' control, they discovered that the mean N2 and latencies of P2 and P3 were

shorter in panic disorder patients. Equally, schizophrenia and bipolar disorder were differentiated in research, in which the P200, N100, and N200 amplitudes were decreased in patients with schizophrenia but not in patients with bipolar disorder.

The application of ERPs in experimental psychology

For experimental psychology and allied disciplines, the ERP method offers a unique and lucrative instrument. Experiments on cognitive processes, attention, emotions, and ultimately personality characteristics are common examples. ERPs are also commonly used in emotion research to investigate emotional responses to negative and positive stimuli [43, 44] effects of emotional content on declarative memory, emotional memory, emotion processing, and emotion regulation. ERP recordings from healthy individuals have become more significant in the research of attention [45]. Herrmann CS, Knight RT (2010) investigated attentional processes of alerting and orienting in this way [46]. The role of specific brain regions in attentional processes as well as the impact of ageing on ERP signals of attentional selection were further studied [47].

Clinical use of the P3

Physiological changes of the P3: The variations in P3 latency with age may be summarized as follows: latency reduces throughout development, reaches a minimum between the ages of 20 and 25 years, and subsequently rises [48]. As a result of ageing, signal transmission between ERP generators is delayed. The reason for the delayed processing is mostly unclear. A change in myelin lipid composition, a reduction in a particular neurotransmitter, such as acetylcholine, or a decrease in energy utilization are all potential reasons [49].

Pathological changes of the P3 wave: Several mental and neurologic diseases impact the P3 wave, which are related to alterations in neurotransmitter levels. P3 wave amplitude and latency changes have been seen in a variety of mental and other diseases [50]. Only a few of the results will be discussed here. The odd-ball paradigm and the auditory modality were employed in all of the investigations, which are often used in the study of diseases.

Table 2. Type of disorders and the proportion of people receiving each therapy [56]

Types of treatment	Generalized anxiety disorder		Phobia		Mixed anxiety and depressive order		Depressive episode		Obsessive compulsive disorder		Panic		Total	
	pop	pcp	pop	pcp	pop	pcp	pop	pcp	pop	pcp	pop	pcp	pop	pcp
Antidepressant	3.0	6.8	8.7	21.4	3.3	9.1	15.1	29.2	6.8	15.7	7.5	18.5	5.7	14.6
Any psychotropic medication	6.0	12.5	14.3	33.3	5.6	13.5	20.9	34.7	11.9	27.5	9.9	23.1	9.0	20.3
Any counselling or therapy	5.3	9.6	14.3	31.0	6.3	12.2	13.2	18.9	10.2	17.6	5.0	15.4	7.7	15.2
Anxiolytics and hypnotics	3.3	6.7	5.8	11.9	2.4	4.1	8.8	10.5	7.6	17.6	2.5	3.8	4.1	7.8
Any treatment base	8.3	17.3	22.1	47.6	10.6	21.6	27.8	41.7	18.6	37.3	13.6	30.8	13.9	28.5
	302	104	105	42	752	222	206	96	118	51	81	26	1563	541

pcp - kind of therapy given to individuals with different types of neurotic disorders after seeing their primary care physician; pop - types of therapy in the general population [gp] by kind of neurotic disorder.

Neurological diseases

Alzheimer's diseases and other dementias

In Alzheimer's diseases and other cortical dementias, the most noticeable alteration in the auditory modality is a lengthening of latency, which corresponds to memory and attention impairment. This deterioration is linked to decreased cholinergic transmission, which is prevalent in Alzheimer's disease [51]. P3 may also be utilized to differentiate between dementias with cortical and subcortical origins. Pseudo-dementia [a condition that often occurs in people suffering from severe depression] may also be recognized [52]. The latency is not prolonged in pseudo-dementia, but the amplitude decreases.

Parkinson's disease

Amplitude flattening is the most common P3 sign in Parkinson's disease. According to several researches, amplitude alterations in Parkinson's disease are linked to dementia caused by the illness rather than the disease itself. Visual paradigms with longer inter-stimulus intervals also had greater delay. This result is consistent with the disease's general cognitive decline. According to a recent study, visual P3 may be helpful in distinguishing between essential tremor and Parkinson's disease [53]. In addition, the latency change with age is higher in Parkinson's disease patients than in healthy people.

Psychiatric diseases

Schizophrenia

The existence of P3 alterations in schizophrenia is the most contentious topic surrounding the use of the P3 as a diagnostic tool. Amplitude flattening is the most striking discovery. This seems to be linked to the occurrence of so-called unpleasant symptoms [54]. Positive symptoms in connection to P3 are less well understood. P3 amplitudes vary in tandem with the intensity of clinical symptoms, according to longitudinal investigations [55]. Only the auditory P3 may be considered a schizophrenia sign. The "Total Brief Psychiatric Rating Measure", which was shown to be linked to the P3, is one clinical scale that is related to negative symptoms. This scale is linked to unpleasant symptoms and verbal memory performance.

Type of disorders and the proportion of people receiving each therapy [56]

Some findings were published by Bebbington P 2003; the studies on the severity of the illness, as well as sociodemographic disparities, are likely to influence individuals with neurotic disorders' access to psychiatric care in the general community [56]. In **Table 2**, they showed the different types of therapy that individuals received based on their diagnosis. They defined that each participant was assigned to a single group for the purposes of this study using a hierarchical approach. This guaranteed that anybody with co-morbid illnesses received the diagnosis that we considered to be the most disturbing in general. As a result, depressive episodes in their moderate and severe forms were at the top of the hierarchy. The study showed that just a small percentage of patients in each of these categories were getting psychiatric care. Just over a quarter of those who had a depressive episode were getting therapy, and around a fifth were taking medication. As a result, it was identified that there was no indication of treatment specificity: the ratio of anti-

depressant to anxiolytic prescriptions did not change in the anticipated manner by diagnostic class. As an observation, they found that almost three-quarters of those in the most serious group got no care at all. The studies clearly demonstrate two points: First, even among the most severely symptomatic individuals in the general community, only a tiny percentage received psychiatric care. Second, severity, regardless of how it was assessed, was a significant predictor of whether therapy was provided.

Conclusion

ERPs may identify a variety of minor neurological and cognitive impairments. Alzheimer's illness, for example, is marked by a prolonged P3 delay. The P3 amplitude is flattened in Parkinson's disease. Because the ERP changes in schizophrenia are many and irregular, additional techniques should be used in addition to ERP analysis. P3 amplitude flattening is the most apparent alteration in depression, and amplitude flattening is accompanied with lateral asymmetry of ERP in schizophrenia.

ERPs are a versatile and effective method with excellent temporal resolution that may be used to investigate modest "subclinical" cognitive disorders. Despite the fact that ERPs have been used to assist identify and treat Alzheimer's disease patients for over 25 years, the full ERP potential in diagnosing and treating them has yet to be achieved. Electrophysiological data are critical in furthering our knowledge of cognition in this age of fast developing brain-imaging methods. Techniques for mapping the brain that can tell us where and when important cognitive processes happen are finally becoming available. The creation of sensible combinational therapy of cognitive enhancing medicines is another example of a possible therapeutic use of cognitive ERPs. P300 studies in epilepsy have been useful in classifying anticonvulsant medication cognitive side effects [57].

For full-scale clinical trials in Alzheimer's disease, pharmacological studies that utilize 2 × 2 combinational designs, which evaluate the outcomes of medication A, drug B, and A + B, are presently prohibitively costly. Precise ERP measurements are expected to speed up drug development in a variety of ways. To investigate the effects of cognitive of each particular medi-cation combination, smaller samples may be utilized at a cheaper cost. Repeated within-subject ERP measurements may perhaps identify optimal dosages of combinational treatment. Longitudinal variations in the event relation potentials have ability as a sign of individual reactivity to a specific substance, with diagnostic potential (e.g., dopaminergic therapy or testing response to cholinergic). This and several more horizons remain accessible to well-organized investigations. ERP is a millisecond-by-millisecond record of neural information processing that may be linked to specific tasks including inhibitory responses, working memory, and sensory encoding updating. As a result, it offers a non-invasive way to assess brain activity in individuals with cognitive impairments, and it may be used to predict prognosis in a select instance. ERP is a neuropsychiatric research technique that has a bright future ahead of it.

Disclosure of conflict of interest

None.

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