The Role of the Mu Rhythm Pattern in Neurological and Psychiatric Disorders

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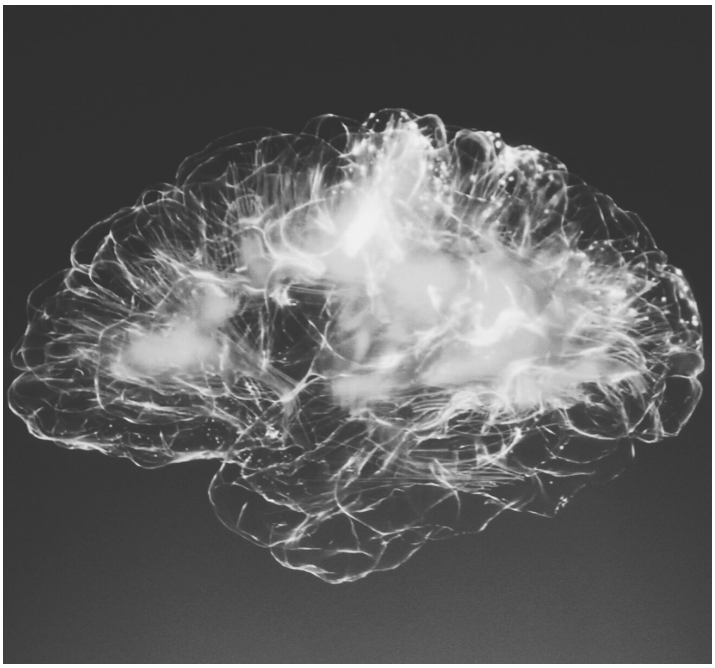

Since its development, back to the late 19th century, electroencephalography (EEG) has been employed in both research contexts and clinical settings to non-invasively record brain activity from a wide range of clinical populations. The signals displayed in the EEG tracings are the result of the amplification of the overall neuronal activity in a given region of the scalp, which can be measured with excellent temporal resolution [1].

Over the last few decades, the sensitivity of EEG systems has been progressively improved and recently developed technologies today allow to measure brain activity with much higher spatial and temporal resolution and reliability [1, 2]. Moreover, set up time has been greatly reduced in modern EEG systems, which allows to employ EEG recordings in previously unavailable clinical populations, including infants, children and adolescents [e.g., 3, 4, 5].

Because of its excellent ability to capture signal changes during specific behaviors or following the presentation of external stimuli, EEG can be employed in the effort to establish a link between behavioral symptoms and activity changes in discreet regions of the brain.

In this context a neuronal population that has been receiving increasing interest from the scientific community is the **mirror neuron system (MNS)** [6], a group of neurons that activate following both the execution or the observation of motor actions [7].

Utilizing EEG-based brain activity recording methods, researchers have identified a specific pattern of arch-shaped EEG waves oscillating in the alpha frequency band (8-12 Hz) that appear in trains over the pre and post-central region. This oscillation pattern named **mu rhythm** has been shown to be reduced in magnitude during the execution or observation of motor actions [8, 9].

Although the mu rhythm is fairly common in the general population, research also indicates that changes of this oscillation pattern may be related to **specific disorders and symptoms**. For instance, there is some evidence indicating that a prominent mu rhythm may be related to headaches, migraine, asthma, tinnitus, hypertension, hyperthyroidism, benign Rolandic epileptic seizures, and pain syndromes [10]. Below is a short overview of the evidence suggesting a role of mu rhythm anomalies in neurological and psychiatric disorders.

Neurological disorders

Delayed event-related desynchronization of mu rhythms prior to voluntary movements has been observed in **Parkinson's disease(PD)** patients [11]. In particular, event-related desynchronization of mu rhythms has been linked to **akinesia** (loss of ability to move voluntarily) and to the **difficulty of initiating movement** [12]. Interestingly, in idiopathic (PD) patients, mu desynchronization disappears or is greatly alleviated after the administration of L-Dopa [13], suggesting a role of this EEG measure in **drug response monitoring.**

Moreover, research with patients diagnosed with **multiple sclerosis (MS)** shows a correlation between mu rhythm event-related desynchronization and brain damage severity. In particular, there is evidence that the number of lesions in these patients is positively associated with the desynchronization delay in mu rhythms, which has been suggested to reflect the disruption of the cortical and subcortical pathways necessary for initiating voluntary movement [14].

Psychiatric populations

Changes in normal mu rhythms have also been shown to affect **higher brain function**. In particular, there is evidence that the mu rhythm occurs in the EEG of **adolescent psychiatric patients** more often than in the general population, and also that there might be a link between its occurrence and **ruminating behavior** [15]. In line with these data, a mu prevalence rate of 60.6% was found in **children who experienced abuse or neglect** and accumulating evidence also supports a possible relationship between the presence of mu rhythms and a **diagnosis of autism**, especially when it does not decrease in magnitude upon observing the movement of others [16, 17].

Given that abnormal mu reactivity might be related to the disruption of motor control in multiple disorders, it has been proposed that the mu rhythm reflects a fronto-motor disconnection [18]. This means that, individuals with prominent mu rhythm might be more likely to exhibit **impairment of executive functions**, including inattention, disinhibition, impulsivity, emotional disturbances and social difficulties.

A slow mu rhythm has also been suggested to be linked to the **disinhibition associated to hyperactivity and attention deficit disorder (ADHD)** children, perhaps as a result of the reduced coupling between the frontal lobe and motor cortical regions [16].

Finally, some research also suggests a link between mu delayed desynchronization and **obsessive compulsive disorder (OCD)**. Subjects diagnosed with OCD exhibit delayed desynchronization prior to movement (thumb extension), which might also suggest a link with compulsive movement and impaired behavioral inhibition [19].

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Conclusions

The mu rhythm pattern is a naturally occurring oscillation in the EEG waveform, measured in the central area of the scalp. However, abnormalities of this component have been associated to a wide range of neurological and psychiatric disorders, and could be an important target for pharmacological interventions aimed at normalizing or at least alleviating some of the related symptoms.

References

1. Biasiucci, A., B. Franceschiello, and M.M. Murray, Electroencephalography. Curr Biol, 2019. **29**(3): p. R80-R85.
2. Kennett, R., Modern electroencephalography. J Neurol, 2012. **259**(4): p. 783-9.
3. McPartland, J., et al., Event-related brain potentials reveal anomalies in temporal processing of faces in autism spectrum disorder. J Child Psychol Psychiatry, 2004. **45**(7): p. 1235-45.
4. Southgate, V., et al., Motor system activation reveals infants' on-line prediction of others' goals. Psychol Sci, 2010. **21**(3): p. 355-9.
5. Lenartowicz, A. and S.K. Loo, Use of EEG to diagnose ADHD. Curr Psychiatry Rep, 2014. **16**(11): p. 498.
6. Rizzolatti, G., et al., Premotor cortex and the recognition of motor actions. Brain Res Cogn Brain Res, 1996. **3**(2): p. 131-41.
7. Rizzolatti, G. and L. Craighero, The mirror-neuron system. Annu Rev Neurosci, 2004. **27**: p. 169-92.
8. Muthukumaraswamy, S.D., B.W. Johnson, and N.A. McNair, Mu rhythm modulation during observation of an object-directed grasp. Brain Res Cogn Brain Res, 2004. **19**(2): p. 195-201.
9. Pineda, J.A., The functional significance of mu rhythms: translating "seeing" and "hearing" into "doing". Brain Res Brain Res Rev, 2005. **50**(1): p. 57-68.
10. Niedermeyer, E. and L. da Silva, Electroencephalography: Basic principles, basic applications, and related fields. 2005, Baltimore: Lippincott Williams & Wilkins.
11. Defebvre, L., et al., Movement related desynchronisation pattern preceding voluntary movement in untreated Parkinson's disease. J Neurol Neurosurg Psychiatry, 1996. **60**(3): p. 307-12.
12. Niedermeyer, E., A. Goldszmidt, and D. Ryan, "Mu rhythm status" and clinical correlates. Clin EEG Neurosci, 2004. **35**(2): p. 84-7.
13. Devos, D., et al., Effect of L-Dopa on the pattern of movement-related (de)synchronisation in advanced Parkinson's disease. Neurophysiol Clin, 2003. **33**(5): p. 203-12.
14. Leocani, L., et al., Movement preparation is affected by tissue damage in multiple sclerosis: evidence from EEG event-related desynchronization. Clin Neurophysiol, 2005. **116**(7): p. 1515-9.
15. McDonald, T. and D. Bars, Evaluating the Precence of the mu Rhythm in and Adolescent Psychiatric Population, in Paper presented at the annual conference for the international Society for Neural Regulation (ISNR). 1998: Austin, TX.
16. Oberman, L.M., V.S. Ramachandran, and J.A. Pineda, Modulation of mu suppression in children with autism spectrum disorders in response to familiar or unfamiliar stimuli: the mirror neuron hypothesis. Neuropsychologia, 2008. **46**(5): p. 1558-65.
17. Coben, R. and B. Hudspeth, Mu-like Rhythms in Autistic Spectrum Disorder: EEG Analyses and Neurofeedback, in ISNR conference. 2006: Atlanta. Georgia.
18. Niedermeyer, E. and S.B. Naidu, Rett syndrome, EEG and the motor cortex as a model for better understanding of attention deficit hyperactivity disorder (ADHD). Eur Child Adolesc Psychiatry, 1998. **7**(2): p. 69-72.
19. Leocani, L., et al., Abnormal pattern of cortical activation associated with voluntary movement in obsessive-compulsive disorder: an EEG study. Am J Psychiatry, 2001. **158**(1): p. 140-2.