Chapter 7
Visualization of Event–Related Changes in Brain Networks During Attention–Demanding Tasks: Visualization of Functional Connectivity During Attention Task Using EEG

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ABSTRACT
Attention is the primary cognitive process to induce a response to a stimulus, and maintaining the attentive state continuously for a prolonged period of time is known as sustained attention, which is vital for performing any task. This study aims at visualizing the event-related changes in brain networks during attention demanding task with the help of electroencephalography (EEG) recordings. The results showed significant increase (p<0.05) in relative theta and gamma power during task compared to rest time, whereas in alpha band the relative power was significantly higher (p<0.05) during rest when compared to task. The event-related synchronization (ERS) and event-related desynchronization (ERD) in relative theta power and relative alpha power respectively was observed particularly in the parietal cognitive processing electrodes. The study concludes that theta synchronization and alpha desynchronization noted at parietal cortex that is associated with attention resulted in improving the task performance with minimal errors.

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INTRODUCTION

Visualization of the activated brain regions when a specific function is performed using Electroencephalography (EEG) is a relatively new approach. Increase in difficulty is the employment of EEG to construct the medium required to depict this activation. The study focuses mainly on the state of the brain during the execution of an attention demanding task. Cognitive informatics deals with the mechanisms involved in the internal information processing and cognitive processes of the brain and natural intelligence (Wang, Y, 2002) focusing on the information acquisition, retrieval, and categorization (Wang, Y et al., 2012). Using informatics and computing science, Cognitive Informatics helps in understanding the mechanism of the human mind (Wang, Y, 2008). But for any cognitive process dependent on external stimuli to occur, attention is fundamental. Hence studying the underlying mechanisms involved during an attentive state of mind, is imperative to understand any other process such as memory, learning and communication. In this study, cognitive signal processing was instrumental in providing us with the necessary information that was required for the visualization of the activated brain regions during the performance of the tasks.

Attention covers the ability of humans to perceive complex messages and respond appropriately (Kahneman, D., & Treisman, A, 1984). It enables us to selectively process sensed stimuli. Sustained attention, specifically, involves the constant conservation of alertness over an epoch, given a specific set of variations in stimuli. A conventional and tested method to assess sustained attention involves the use of Continuous Performance Tests (CPT’s). These tests base the evaluation of attention on the recognition and response to visual stimuli that change sporadically. It also requires a dismissal of non-target stimuli that are also presented along with the correct stimuli over a period of time (Ballard, J. C., 1996). The synchronous firing of millions of cortical neurons gives rise to an electrical signal known as EEG. It is considered a non-stationary signal that can be recorded from the surface (Teplan, M., 2002). The signal can be decomposed into its spectral components by Fourier transformation. The major components taken into consideration are alpha (8-12 Hz), theta (4-7 Hz), beta (13-30 Hz) and gamma (greater than 30 Hz). Alpha and theta bands are representative of contrasting activities. Resting state rhythms are dominated by the alpha band, with low levels of activity in the theta band. Gaume et al., (2015) quantified visual sustained attention by using continuous performance task and concluded the Cognitive load on brain for varying task difficulty levels were calculate using EEG band power (theta, gamma, beta and alpha) at fronto – central and prefrontal electrode locations. Ko et al., (2017) studied the brain activity of healthy subjects during sustained attention task in actual classroom surroundings using EEG for 18 healthy volunteers and their EEG spectral powers were analyzed for various EEG bands. Results showed increase in delta and theta power over occipital regions and decrease in beta power at temporal and occipital areas. Behzadnia et al (2107) studied the EEG activity associated to sustained attention using conjunctive continuous performance task (CCPT) by placing electrodes only midline electrode locations (Fz, Cz and Pz). The theta and alpha power variation were significant at all these locations and they concluded that alpha and theta played a vital role sustained attention and this could be detected through EEG oscillations. Xie et al., (2018) studied the development of infant sustained attention in response to EEG oscillations with 59 infants for three attention phases (stimulus orienting, sustained attention, and attention termination) along with EEG heart rate changes were examined based on heart rate changes. Study results showed theta synchronization over frontal, parietal and temporal electrode locations and alpha desynchronization over central, frontal and parietal electrode locations during sustained attention.
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