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Investigating the Effect of Input Device on Memory Retrieval: Evidence from Theta and Alpha Band Oscillations

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ABSTRACT

Using cognitive neuroscience as a reference discipline, this study aims to investigate the effect of input device on brain activity, and the effect of these brain activities on the cognitive process of memory retrieval.

Oscillations on the scalp are classified into four frequency bands: Delta (0 to < 4 Hz), Theta (4 to < 8Hz), Alpha (8 to 13 Hz), and beta (>13 Hz). Many studies have been performed to identify the functional significance of each frequency band oscillation in the brain. Theta and Alpha band activities are found to be associated with a large variety of functions such as memory load and memory performance (Klimesch et al. 1997). However, There are different and, in some ways, conflicting results about the function of Alpha band oscillations. Some researchers argue that looking at oscillations in Alpha and Theta bands individually may be misleading and causing the contradicting research findings (Berka et al. 2007). Consequently, the use of *Alpha/Theta ratio measures* has gained significant momentum in the neuroscience literature (Gruzelier 2009). Based on related works, we argue that Alpha desynchronization and Theta synchronization are associated with memory performance (Klimesch et al. 1997). Hence, to reconcile the conflicting results, we expect to observe a lower Alpha/Theta ratio for individuals with better memory performance.

The Alpha/Theta ratio itself may differ depending on whether the input device used is direct or indirect. During our daily activities, tactile memory is involved in exploring and touching objects. When an individual remembers something he/she had touched before, the information is retrieved from tactile memory. Generally, it is suggested that multisensory experiences improve memory performance compared to single sensory experiences (Lehmann & Murray 2005). Thus, we expect that individuals using direct input devices will have lower Alpha/Theta ratios than those using indirect input devices because of a richer multisensory encoding.

A one factor between-subject experiment with 22 participants was designed to investigate the effect of input device on memory performance in a recognition task. One group of participants used a direct input device (Touch screen) and the other group used an indirect input device (Mouse). First, participants performed a product choice task for 14 pairs of quite similar products. Then they participated in a brand logo recognition task. In this step, 70 product brand names and their logos were randomly presented to participants. 20% of brand names and their logos were previously shown in the product choice task and the rest were fictitious and not seen previously. During the recognition task, EEG data was recorded using a 32 electrodes using EGI's dense array electroencephalography (dEEG). Using stimuli presentation software (ePrime2), an Event-Related Potential (ERP) technique was utilized to expose the participants to the stimuli (brand names and their logos).

Our first hypothesis, proposing a negative correlation between the Alpha/Theta ratio and recognition rate, was supported with a non-parametric correlation test between Alpha/Theta ratios and recognition rate. For the second hypothesis, we expected lower Alpha/Theta ratios for the touch group than the mouse group. In fact, our analysis showed that the ratio was lower for the touch group, yet the difference was not statistically significant. However, with a larger sample size results might become statistically significant. Finally, our post-hoc analysis suggests that the relationship between the Alpha/Theta ratios and recognition rate may be influenced by the type of input device, a fact that is possibly explained by the type and number of sensory modalities used to encode information. Our study contributes to human-computer interaction research by shedding light on the relationship between brain oscillations and memory performance.

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