An EEG study on fluid intelligence, inspection time and Alpha oscillations.

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Defining Oscillations, EEG and Inspection Time and Aims of Research

This study investigated the growing field in neuropsychology discussing the role of alpha oscillations in the brain and the relationship between fluid intelligence levels and inspection time task performance. Alpha oscillations are brain waves that are the highest concentrated in the posterior occipital lobes in the brain, located at the back of the head. Alpha is highest when eyes are closed, and operates at 8-12 Hz. Alpha is thought to be a control mechanism in the brain. Given there are so many things going on around you at any given moment, it is the Alpha brain waves that inhibit irrelevant things in order to focus attention on what you need to do. Theta oscillations were also studied, which are most highly clustered in the frontal lobe of the brain. Theta waves are involved in executive functions like thoughts, and operates at 4-7 Hz. Brain neural oscillations have been found to be highly linked to attention and intelligence and consciousness. 'Intelligence' measured by IQ, the 'intelligence quotient' refers to a person's reasoning ability measuring using problem solving tests compared to the statistical norm or average for their age. 'Fluid intelligence' refers to working tasks such as reasoning, while 'crystallised intelligence' relates to procedural skills and long term knowledge.

An electroencephalogram (EEG) is a neuroimaging technique that enables, using many sensors on the scalp, a measure of electrical activity from neurons in the brain. EEGs are used not only in research settings, but also clinical settings to help with the diagnosis of attentional difficulties and much more. The EEG machine can pick up where brainwaves are highest in frequency, which could be at the front part of the brain, the back, or anywhere in between. When brainwaves 'light up' in a region they show coherence, which means brain regions are operating together. EEG recordings can measure Alpha activity because it is the largest, most easily identifiable signal in the brain. Researchers have created computer based tasks where participants complete an experiment connected to an EEG machine which assesses in many cases their attention levels and ability. Some tasks involve clicking the mouse when a stimulus (picture) appears on the screen, others involving figuring out if two stimuluses were the same or not. The stimuli are usually presented very, very quickly in a rapid-serial presentation order. This is because if they were shown slowly, almost everyone could see them, but the purpose of the experiment is to test who actually saw it or not. If someone see's it quicker than someone else, they are known to have a fast 'inspection time duration', meaning it took them less time to detect the stimulus.

The aim of our study is to investigate the relationship between the brainwaves shown on the EEG machine, with fluid intelligence levels and inspection time duration. We used Alpha power and phase as well as Theta power and phase. The EEG cap we used was very comprehensive with 128-channels covering the entire head which allowed the frontal lobes to be analysed as well as the posterior so both brain waves could be analysed.

We hypothesise that higher levels of fluid intelligence will be related to a lower (quicker) inspection time duration. We predict that when Alpha power is high this will effect visual performance negatively, and Theta power will have the opposite relationship. We predict the phase the Alpha brain wave is in when the stimulus is detected on the screen will predict how well participants correctly identify it. We predict arousal levels will decrease as

the experiment goes on, and if a participant report's high anxiety this will have a negative relationship with inspection time duration, so higher anxiety; longer time trying to work out the stimulus.

Methodology

In total, 26 participants were shown an information sheet, and completed a consent form which showed the research had Murdoch University Ethics Committee approval before starting the experiment. The experiment duration was two hours. Subjective ratings of arousal, anxiety and fluid intelligence, as measured by questionnaires throughout the experimental task, were investigated. Participants were given an anxiety questionnaire, an arousal questionnaire and two fluid intelligence measures. These were all completed by the participant by themselves. Participants were then fitted for a correctly size EEG cap. The computer task was then explained to the participants and they were told to click one button if the Space Invader cartoon that appeared on the screen had the same length antennae, and another button if the antennae were different lengths. The participant then completed a minimum of 920 trials of the task and after the experiment completed another arousal questionnaire and were debriefed.

Findings

As we aimed to examine the relationship between various psychological constructs (assessed by the initial questionnaires) and neural oscillations and inspection time exposure duration thresholds. We found that we reinforced what is present in Psychology literature and found that people with higher levels of fluid intelligence performed better on the task and needed shorter inspection time durations. We found that when Alpha power was high, performance on the task declined, this was the result of many studies. In testing the idea that Theta power and inspection time duration were related, we unfortunately found insignificant results. We also didn't find the phase of the Alpha or Theta to affect inspection time performance, which was unexpected. We did find Theta power to significantly predict fluid intelligence. This was a great finding as it shows Theta may not have predicted speed of processing, but we still showed its relationship with other aspects of intelligence. We did find a decrease in arousal levels, but no significance with anxiety. The difference in our results could be from the fact we used a surface EEG which, is a limitation as in depth neuron activity can't be seen. Our difference in not finding Alpha or Theta phase could be due to our smaller sample size not lending to much power. Not showing significance with anxiety may have been from the fact it was a subjective scale, future studies could improve by clinician administered interviews and other physiological ratings of anxiety like heart rate. Our study combined many behavioural measures with EEG metrics and inspection time, which has never been done, and we reinforced current literature and found fluid intelligence can be assessed through inspection time performance not just questionnaires.