

Puzzled? Turn on the gamma waves

External amplification of gamma wave frequencies applied to the temporal lobe can increase one's ability to find a solution to a problem, inducing a Eureka! moment.

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From puzzles to jokes, we have all been left in the proverbial dust when it comes to understanding. Some of us remain without a clue, but most of us experience a Eureka moment. Eureka moments are described as abstract leaps, a sudden moment of clarity that allows us to see a problem as we never had before1. In an article recently published in Nature, Santarnecchi and colleagues attempt to use functional magnetic resonance imaging (fMRI) and brain activity recordings using an electroencephalogram (EEG), to try and capture the moment when unconscious turns to conscious by stimulating the right temporal and right parietal brain regions. In this study, the authors found that when stimulation is applied at frequencies related to gamma waves, increased accuracy was associated with the number of correct answers achieved with insight problem solving on a compound remote association problem. The significance of this finding is that the previously correlated studies now have physiological evidence that links the gamma waves to the neural processing required to solve problems with insight rather than logical reasoning.

Insight problem solving is the sudden and unexpected understanding of a problem leading to its solution₂. Research has attempted to find what causes this Eureka moment, with various theories about its neural basis1. What is known is that unconscious processing must occur prior to conscious knowledge. Therefore, the solution to a subconsciously problem is known before consciously indicating the answer3. Previous research has identified the high frequency waves, gamma waves, emitted by our brains as we reach this Aha moment and a specific region of the brain where this takes place_{1,3}. However, some studies only focused on the differences between insight





Figure 8. Brain stimulation was applied at the parietal-occipital region (1) and the temporal region (2). The star indicates the area stimulated to improve accuracy of CRA puzzles.

problem solving and non-insight problem solving, where non-insight is defined as solving the problem in a step-wise logical manner₁. As shown in this study, electrical activity can be used to record brain activity. Electrical activity recorded from the brain is shown in five types of brain waves: alpha, beta, delta, gamma and theta₄. Alpha waves are present during a relaxed and wakeful state. Beta waves occur when attention is directed towards a certain task. Delta waves are slow and generally occur during dreamless sleep. Theta waves also occur during sleep, but are present during the deeper sleep stages. Lastly, gamma waves are high frequency waves associated with information processing₅.

Santarnecchi and the other researchers used EEG and fMRI to visualize these brain waves during their study. EEG is ideal because it is a non-invasive method that can record brain activity. Using electrodes placed on the scalp, electrical brain activity can be recorded in response to environmental stimuli. One drawback of this mechanism is its inability to be specific about which brain areas are activated. By coupling the EEG with the fMRI, more precise spatial information can be gathered about activated areas since the fMRI records changes in blood oxygen fluctuation related to brain activity₆.

Participants in the study performed compound remote association (CRA) tasks and rebus puzzles while receiving a fake stimulation or gradual 2 mA stimulation was applied for two minutes to the temporal and parietal regions (Figure 1). A CRA problem is a verbal problem where three words are given and the object is to find a single word that is associated to all three words_{3,7}. For example, the given words are play, hog and floor and one solution is ground. A rebus puzzle is where words are used to cryptically represent another word or saying₈. An example of that would be the word "MIND" physically over the word "MATTER" and the solution is the phrase Mind Over Matter. To test the repetitive and timed motion of the brain wave activity seen in previous research that indicated a switch in wave pattern, the stimulations were given in the same manner. Following each CRA or rebus puzzle the participant indicated whether they had achieved the answer through insight or non-insight reasoning.

Participants correctly solved 54% of the rebus puzzles and 55% of the CRA problems. Of the correct answers, approximately 63% and 52% participants reported using insight problem solving in the CRA and rebus puzzles. The condition in which stimulation was used over the temporal lobe had a significant effect on accuracy during the CRA problem task at gamma wave frequencies. The effect during the rebus task was not significant and there was no significant difference from the sham condition at frequencies more closely associated with the alpha waves. EEG results showed a significant effect of the stimulation at gamma wave frequencies and trended towards significance at alpha wave frequencies.

The implications of this study provide possible causal link between a switch in brain wave patterns and the Eureka moment we experience during insight problem solving. Future research show include controls for other confounding factors like mood and age that could have an effect on the solution style implemented in CRA problems. The data here are somewhat convincing but many of the results were not statistically significant suggesting more evidence needs to be found to fully show that a burst of gamma waves in the temporal lobe lead to the switch of information from unconscious to conscious thought.

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