# Assessment and Enhancement of Cognitive Efficiency

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***Abstract* — Assessment of cognitive efficiency plays a crucial role in various fields including military, aviation and navigation. Cognitive efficiency of a subject is a direct measure of his/her cognitive performance. The main objective of this research work is to develop a brain computer interface which optimizes the cognitive efficiency during surveillance tasks. When the workload increases, task sharing or redistribution is implemented. However, during understimulation due to monotonous stimuli, vague or noisy images can be used. Here, we exploit the vagueness of the stimuli to achieve maximum cognitive efficiency. A detailed study is made to analyze how Event Related Potentials (ERP) can be used to assess cognitive workload and techniques to acquire single trial ERP are investigated.**

## I. Introduction

Current brain computer interface (BCI) systems face two main challenges: the relatively low control bandwidth and reduced accuracy due to low levels of cognitive efficiency [1]. It is seldom that a military target stimulus repeats and even repetition may not help a realistic BCI monitoring system. In addition, increased target stimuli rate can increase workload leading to a reduction of cognitive efficiency. Equally, extended periods of monitoring time without target stimuli may also lead to a state of insufficient cognitive workload. It has been proven that cognitive efficiency can deteriorate with time when continuous attention is required [2]. It is very interesting to realize that mental fatigue can be caused by both overstimulation leading to attention resource depletion or understimulation due to monotonous stimuli. Hence, we hypothesize that the maximum cognitive efficiency can be achieved if both overstimulation and understimulation of the brain are avoided. Researchers have already demonstrated that task sharing or redistribution mitigates cognitive workload and achieves cognitive enhancement. In this research, we propose to use controlled levels of "vague" stimuli in cases of understimlation to increase the level of cognitive workload and thus enhance cognitive efficiency.

## II. OBJECTIVES

The main objective of this research work is to enhance the cognitive efficiency of a subject performing monotonous surveillance tasks. That involves both task sharing and using challenging stimuli. In addition, alternative techniques to improve the signal quality of single trial ERPs will be investigated [3]. This will help in studying the signal properties and principal characteristics of EEG and ERP resulting from different degrees of cognitive workload including vague stimuli.

## III. Approach

The experimental setup used is shown in Fig. 1. 64-channel EEG and eye tracker data [4] will be collected from each subject while they are presented with a series of target and non-target images on the display monitor. Behavioral response and reaction times are also recorded. There are two experiments. The first one has two prime objectives: extracting event related potentials from single stimuli and investigating the influence of vague stimuli on brain cognitive workload. The second experiment involves military targets and is used to demonstrate influence of vague stimuli on increasing workload and enhancing cognitive efficiency.

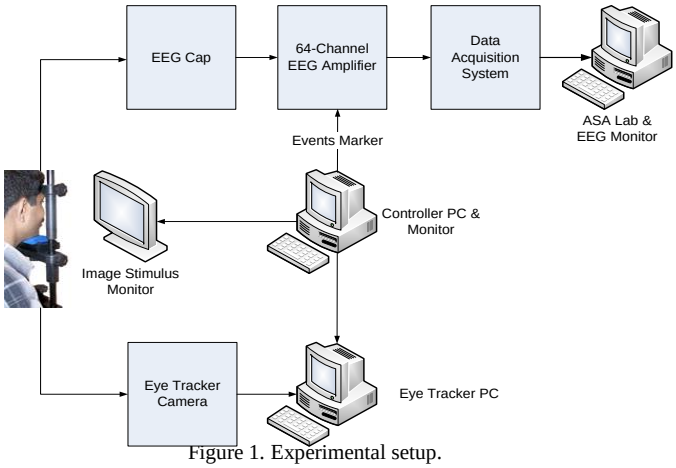


Figure 1. Experimental setup.

## IV. Acknowledgments

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## V. References

[1] Kleih S., Kaufmann T., Zickler C., Halder S., Leotta F., Cincotti F., Aloise F., Riccio A., Herbert C., Mattia D. and Kübler A.. *Out of the frying pan into the fire–the P300 based BCI faces real world challenges.* Prog. Brain Res. 194, pp. 27–46, 2012.

[2] Robert Langner, Klaus Willmes, Anjan Chatterjee, Simon B. Eickho, Walter Sturm, *Energetic effects of stimulus intensity on prolonged simple reaction-time performance*, Psychological Research, 74, pp. 499–512, 2010.

[3] Ke Yu, Kaiquan Shen, Shiyun Shao, Wu Chun Ng, Kenneth Kwok, Xiaoping Li, *A spatio-temporal filtering approach to denoising of single-trial ERP in rapid image triage*, Journal of Neuroscience Methods, 204, pp. 288– 295, 2012.

[4] Stefan M. Wierda, Hedderik van Rijn, Niels A. Taatgen and Sander Martens, *Pupil dilation deconvolution reveals the dynamics of attention at high temporal resolution*, PNAS, Vol. 109, no. 22, 2012.

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