

# The theta-to-alpha ratio represents a convenient task independent measure of brain workload

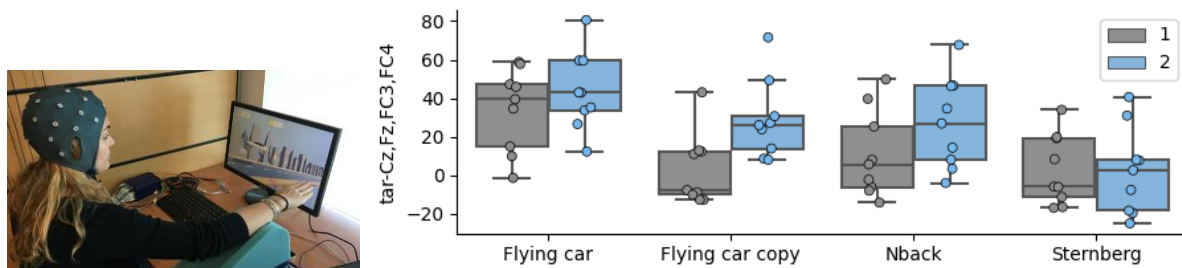
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**Introduction:** Human error is often a result of sustained cognitive stress and/or vigilance. In a working environment this can have dramatic consequences, whereas in video-game settings it can lead to a loss of motivation. In both fields, an objective and task independent way of measuring brain workload would help in creating adaptative systems to avoid these effects. The theta/alpha ratio (TAR) was proposed as an index of workload that increases with the number of simultaneous tasks [1,2]. We wondered if this index could be used as well to measure varying difficulties within a set of different tasks.

**Material and methods:** We measured 30-channel EEG in 9 healthy subjects while they were performing several tasks at two different levels of difficulty, followed by subjective workload report with NASATLX. The tasks consisted of two working memory tasks, Nback and Sternberg and two video game like tasks controlled by movement of the wrist, the flying car [3], (see Figure 1 left) and a gameplay copy of it without the engaging 3D environment. Frequency bands power and TAR were extracted, and their values compared in between levels.

**Results:** NASATLX rating and TAR were significantly higher in the difficult level compared to the easy one in every task except for Sternberg (Figure 1 right,  $p < 0.05$  for level effect), where only the TLX rating was different.



**Figure 1.** (Left) Experimental setup. (Right) Frontal TAR is higher at level two for all tasks except Sternberg. TAR is normalized on a resting period before the tasks and grouped by task and level 1 or 2. Repeated measure ANOVA: task  $F_{(3,24)} = 9.69$ ,  $p = 0.001$ ; level  $F_{(1, 8)} = 27.94$ ,  $p = 0.0007$ ; interaction  $F_{(3,24)} = 3$ ,  $p = 0.05$ .

**Discussion:** This result confirms that the TAR index is a highly promising measure of brain workload, and that it seems to be mostly independent of the type of task, requiring either more cognitive resources or more vigilance.

**Significance:** We hope to provide complementary insights on the TAR and contribute to revealing its usefulness as a marker of generic brain workload. Thanks to the possibility of measuring it using only one or two electrodes, and its ease of calculation, it represents a promising target to be implemented in a multi applications commercial EEG device.

## References

[1] A. Holm, K. Lukander, J. Korpela, M. Sallinen, K. Müller. Estimating brain load from the EEG. *ScientificWorldJournal* 9, 2009.

[2] B. Raufi, L. Longo. An Evaluation of the EEG Alpha-to-Theta and Theta-to-Alpha Band Ratios as Indexes of Mental Workload, *Front. Neuroinform*, 2022.

[3] From the MindMotion™ GO suite, part of MindMaze game-based digital therapies solution. <https://www.mindmaze.com/digital-therapies-for-neurorehabilitation/>