Feeling the drag: Effects of sustained task performance on periodic mechanisms of attention

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Background & Relevance:

- Sustained attention is unique and differentiates from other forms of attention as it necessitates an engagement to a certain task over the course of time.
- Sustaining attention over a prolonged duration can lead to mental fatigue and drowsiness.
- Mental fatigue can cause impairments in our cognitive function, producing errors and deterioration in performance.
- Although it is normal to experience fatigue, it is important to understand our limits as we focus for prolonged periods of time
- Many jobs involve prolonged periods of sustained attention, such as pilots, flight controllers and long-haul drivers. Road accidents often occur due to drowsiness, with an estimated 4 deaths and 100 injuries per day in the US [1].

Approach:

- EEG recorded during continuous task performance
- Spectral analysis to investigate brain rhythms across frequencies
- Alpha band brain oscillations used as a proxy of attention
- Target detection rates extracted from task performance data
- Regression performed to analyse alpha power and hit rate trends over time

Objectives:

We investigated whether the **brain's alpha band power (8-12Hz oscillations)**, a proxy for attention[2,3], would increase over the course of time. We also examined whether participants get worse in a visual target detection task over time, and whether this drop in performance was predicted by trends in alpha power.

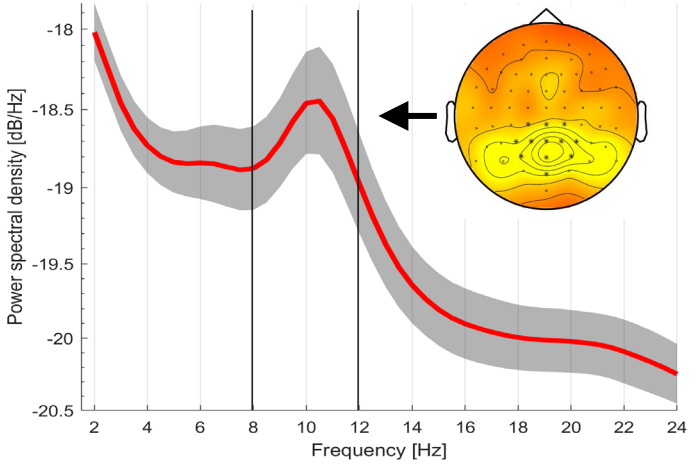

*Fig 1. **EEG power spectrum** (-1...0 sec post-cue trial baseline). showing typical peak of **alpha band power**. Scalp map of the alpha power indicates dominance in the occipital brain areas.*

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Why the alpha band?

- We use alpha band power as a proxy of attention because an increase in the alpha band is associated with attentional inhibition.[2]
- It is the only frequency domain which increases or decreases as a response to a task or a stimulus.[3]
- Therefore, high levels of alpha over time may strongly indicate a person's decrease in attention and increase in drowsiness.

Methods:

A green circle appears for *~500ms* between two checkerboard pattern patches as a cue. This cue tells the participant to anticipate and detect a target appearing on the left or on the right for a duration of ~3500ms. In some trials the target does not appear at the indicated location. At the end of a trial, the circle turns red allowing a 1 sec break.

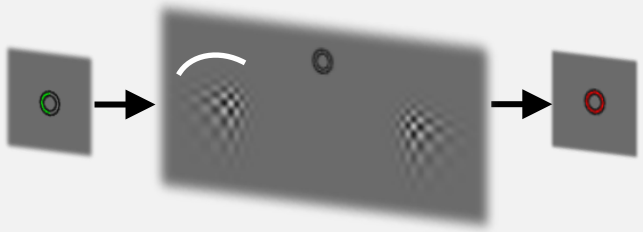

Fig 2. ***Experimental setup*** [4] *EEG and performance for a typical trial were recorded during a visual detection task (~2hrs, N = 37). A green circle cue indicated whether to attend to the left or right patch for each trial. A target would appear around the patch either at the correct or incorrect location according to the cue. Trials ended with a brief resting period (red circle, 1sec).*

Results:

- Alpha **increased** over the course of trials *(p=0.001)*
- Target detection rates **decreased** over time *(p=0.0007)*
- Participants' target detection performance was **predicted** by the preparatory alpha power *(p=0.002)*

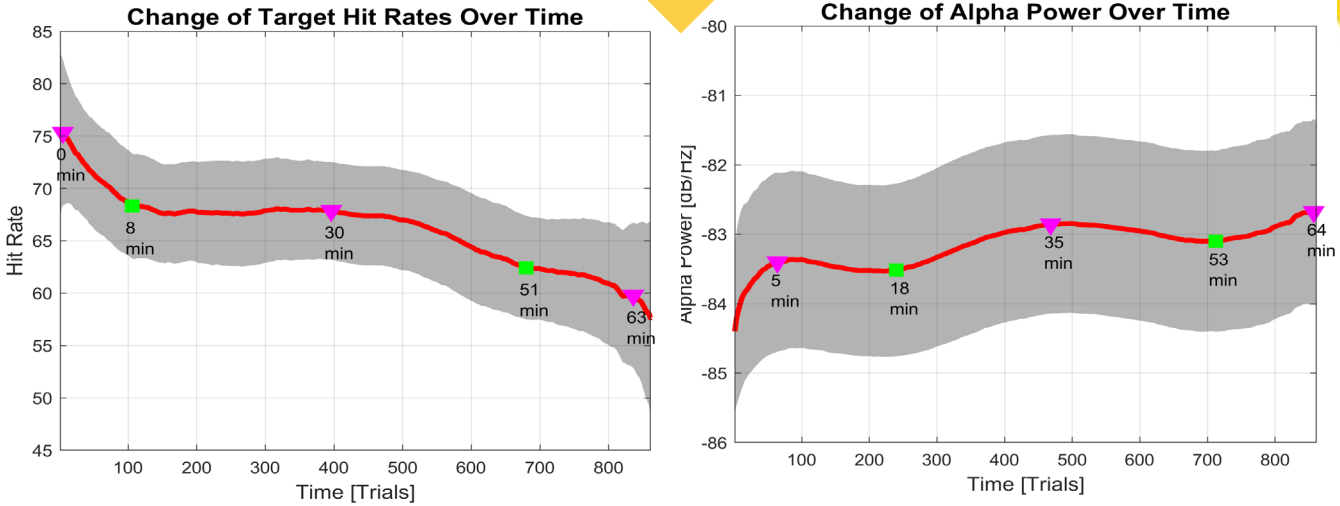

Fig 3 & 4. ***Time courses of the alpha band power (top) and the target hit rates (bottom)*** *during the experiment. The grey area indicates the 95% CI (confidence interval).. Alpha-band power increased over the course of trials/ time (top), while target hit rates gradually dropped over time (bottom) indicating a downward trend in task performance.*

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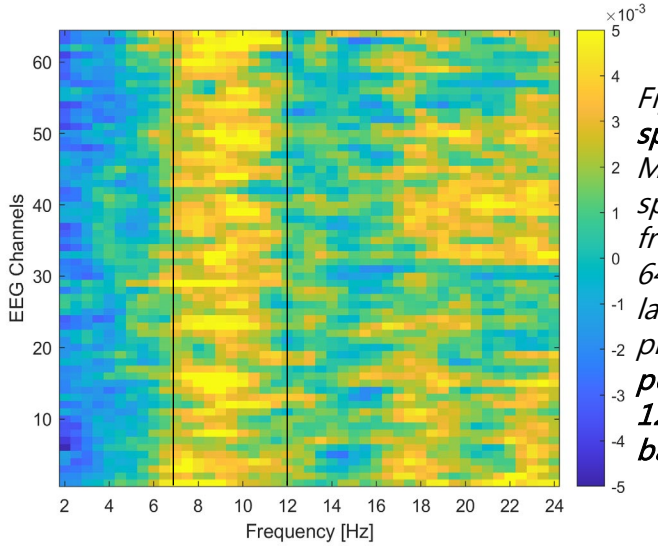

Fig 5. ***Representation of EEG spectral changes in time.*** *Mean regression fit slopes of spectral power over time/trials, for frequencies 2-24Hz (x-axis) and all 64 EEG sensors (y-axis) during the last preparatory 1 sec before target presentation.* ***Note the systematic positive slopes increase in the 7-12Hz frequency range (=alpha band) for most EEG channels.***

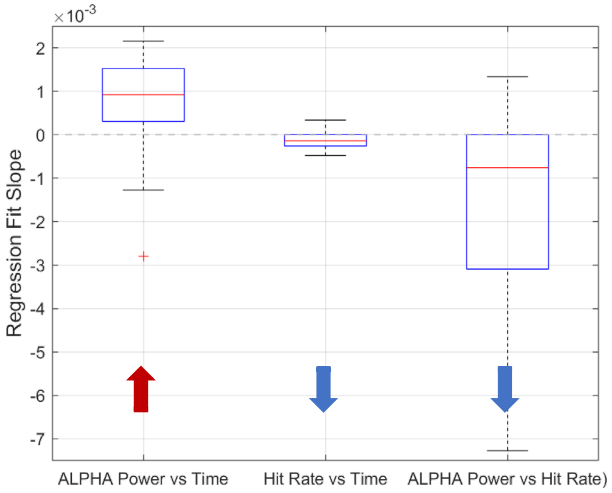

Fig 6: ***Regression fit slopes for 3 analyzed relationships: Alpha power vs Time, Target detection vs Time, and Alpha power vs Target detection.*** *Positive slopes (red arrow up) indicate direct relationships while negative slopes (blue arrow down) indicate reciprocal ones (as the explanatory variable increases, the response variable decreases). Red lines show the slope median values.*

Conclusions:

- Alpha power increased over the course of time
- Successful target detection decreased over the course of time
- As target detection rates decrease, alpha power increases
  ➡ reciprocal relationship between these two variables
- Alpha power is a neural marker for task performance

Research Impact:

We found that the drop in attention over time, related to work performance in human operators, could be predicted by the resting-state alpha waves of the brain. This research demonstrates a practical approach to recommend objectively a high-workload-task duration before the need for rest.

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References:

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