

Parietal alpha-oscillations as correlates of cognitive effort

N. Zhozhikashvili^{1,2}, I. Zakharov¹, V. Ismatullina¹, M. Arsalidou²

¹Psychological Institute of Russian Academy of Education, Moscow, Russia

²National Research University Higher School of Economics, Moscow, Russia

nzhozhik@gmail.com

Introduction

This study is devoted to the analysis of the dependence of parietal alpha oscillations (associated with working memory, WM) on task difficulty, as well as the influence of mental toughness on this dependence.

Sternberg task requires sequential activation of the following cognitive processes and modulations of the alpha rhythm power:

- Stimulus encoding (alpha event-related desynchronization, aERD)
- Stimulus maintaining (alpha synchronization, aERS)
- Stimulus retrieving, response (aERD)

(see Fig. «Electrode P4»).

These effects are enhanced for difficult tasks. But in some subjects, aERD drops for the most subjectively difficult tasks.

It can be assumed that this effect is related to cognitive effort, which increases with task difficulty, but decreases with unjustifiably difficult tasks.

It is assumed that this process is influenced by motivational factors associated with difficulties perception.

Hypothesis

aERD during stimulus encoding, aERS during stimulus maintaining, aERD during response reflect cognitive effort when performing a WM task:

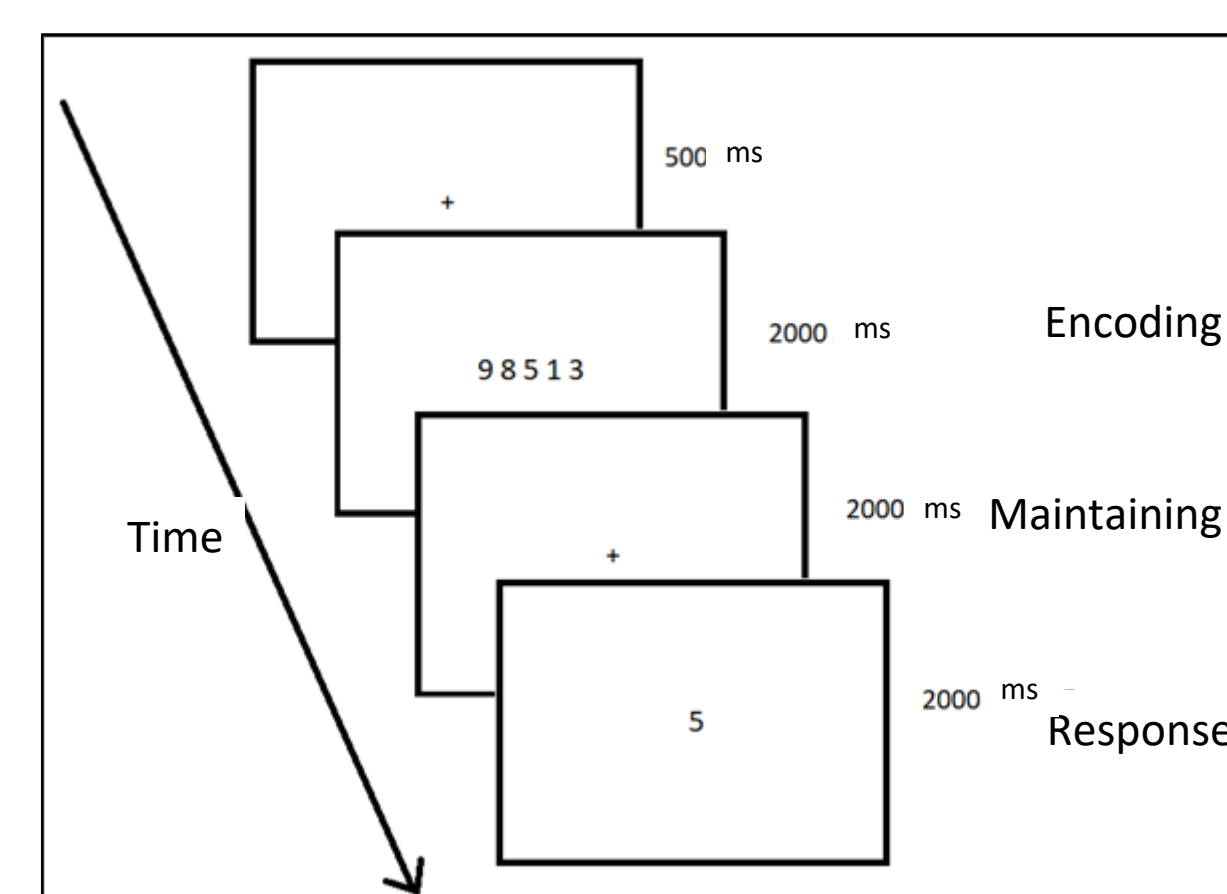
1. These EEG effects (as well as reaction time) increase with task difficulty
2. Mental toughness (MT) affects this dependence: low MT leads to a decrease in these EEG effects in the most difficult task conditions.

Methods

The Sternberg task with different levels of complexity (3, 4, 5, 6 digits) was used.

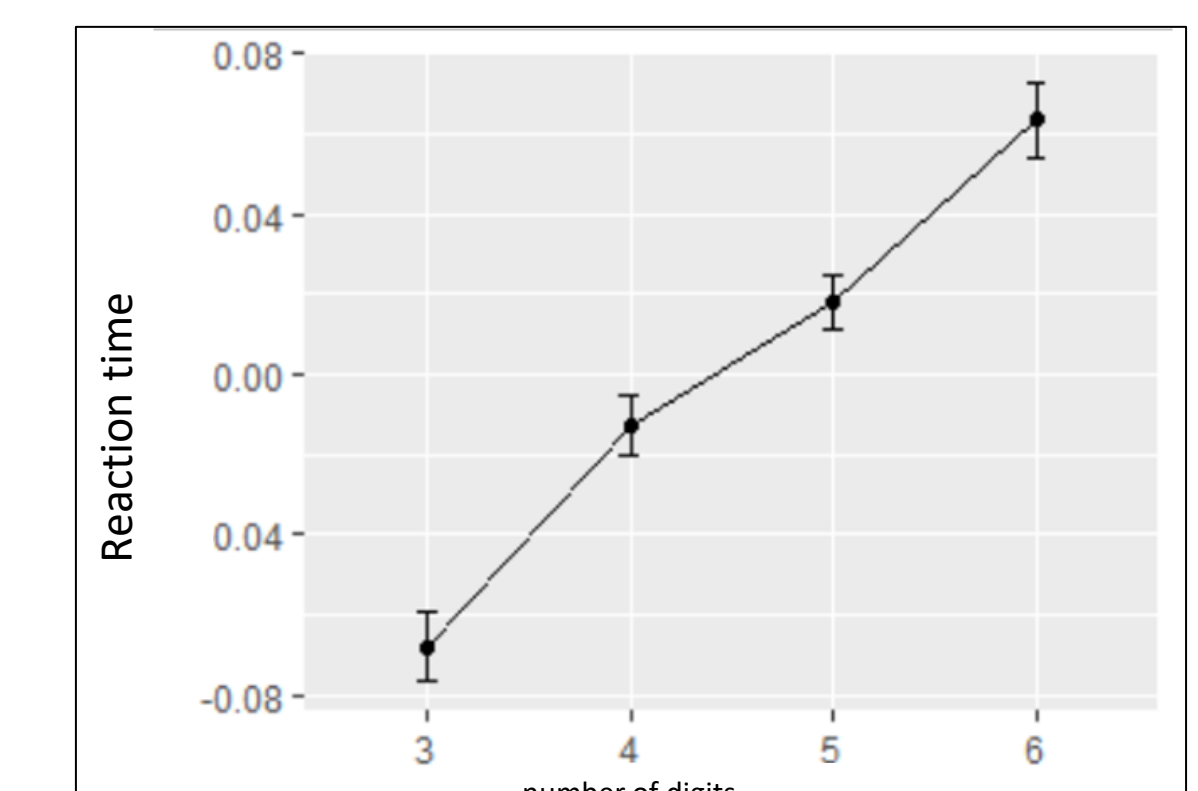
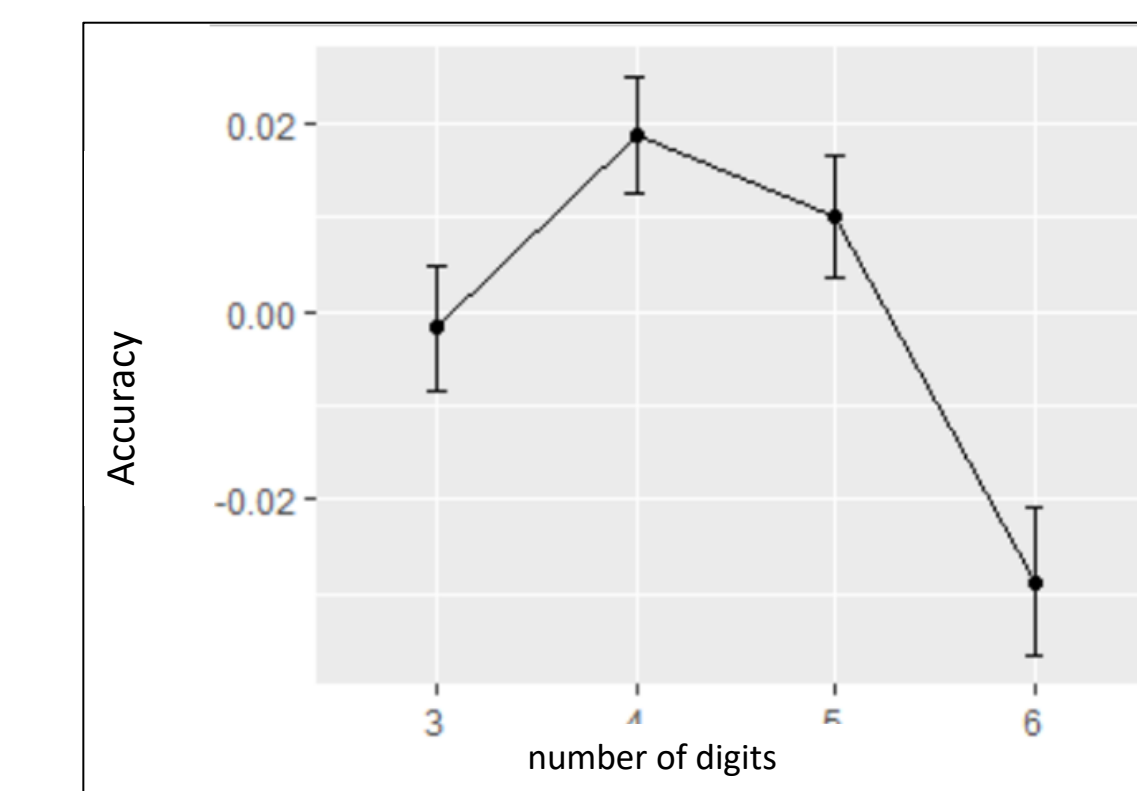
EEG (BrainProducts, ActiChamp 64) and behavioral data, including the mental toughness scores (MTQ48), were collected from 80 subjects.

The main statistical method used is mixed linear models taking into account individual differences between subjects as a random effect.



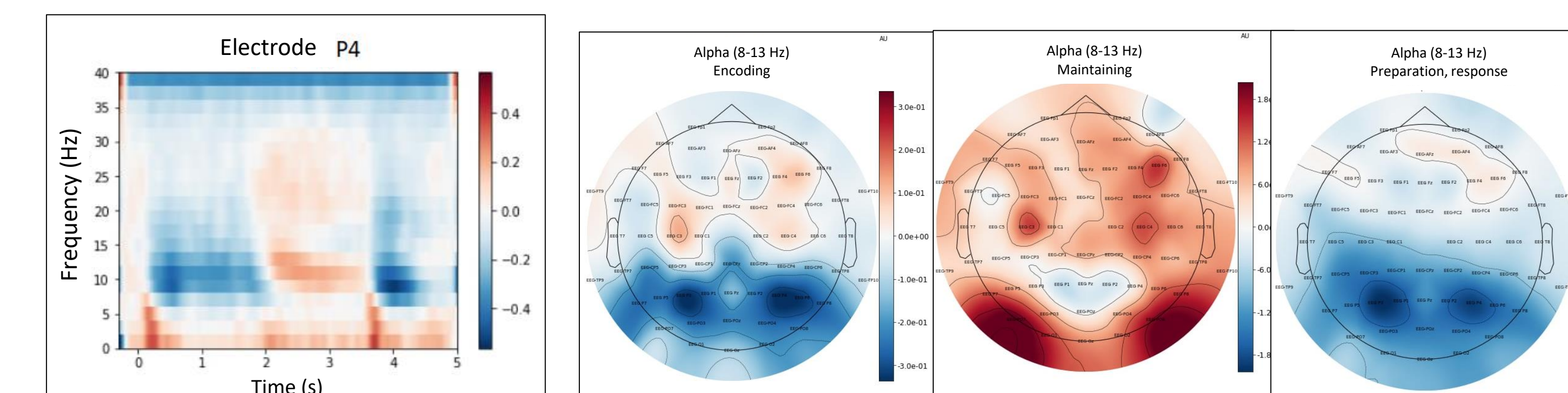
Accuracy and reaction time

- The easiest condition (3 digits) was performed worse than more difficult conditions. Probably, this condition was perceived as too simple, which led to insufficient investment of cognitive effort.
- The reaction time increased with the number of digits. Presumably, reaction time reflects cognitive effort invested in task performance and depending on its subjective difficulty.



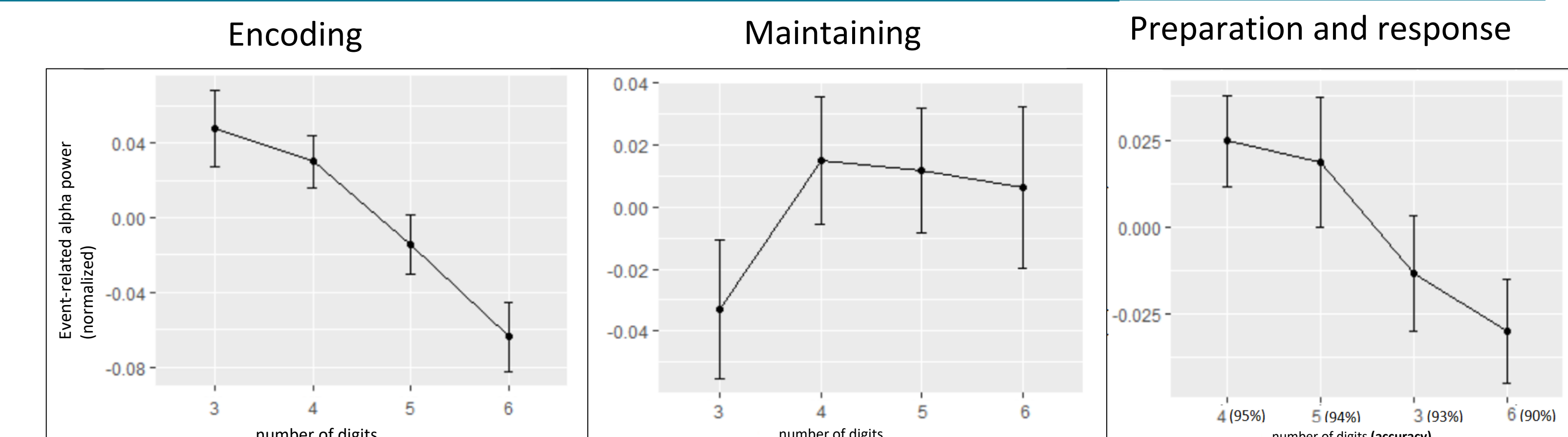
Oscillatory correlates of Sternberg task performance

- During the stimulus encoding period, aERD (with a peak at the parietal electrodes) was observed.
- During stimulus maintaining period, aERS (with a peak at the posterior parietal electrodes) was observed.
- During the preparation and response period, aERD (with a peak at the parietal electrodes) was observed.



Dependence of alpha oscillations on task difficulty/ result

- Encoding: aERD increased with task difficulty. Presumably, this EEG effect reflects cognitive effort invested into stimulus encoding.
- Maintaining: aERS increased with task difficulty, but decreased at the most difficult level. This effect may reflect the phenomenon of the cognitive effort drop during the most difficult tasks. It may mean that maintaining is a highly resource-intensive process.
- Preparation and response: aERD increased with decreasing accuracy. This effect may reflect cognitive effort invested in activating attention (cognitive control) and retrieving information.



Influence of mental toughness

- Maintaining: It seems that low MT contributed to the observed phenomenon of the cognitive effort drop during stimulus maintaining.
- Preparation and response: It appears that low MT contributed to the observed effect of increased aERD with decreasing likelihood of success.

