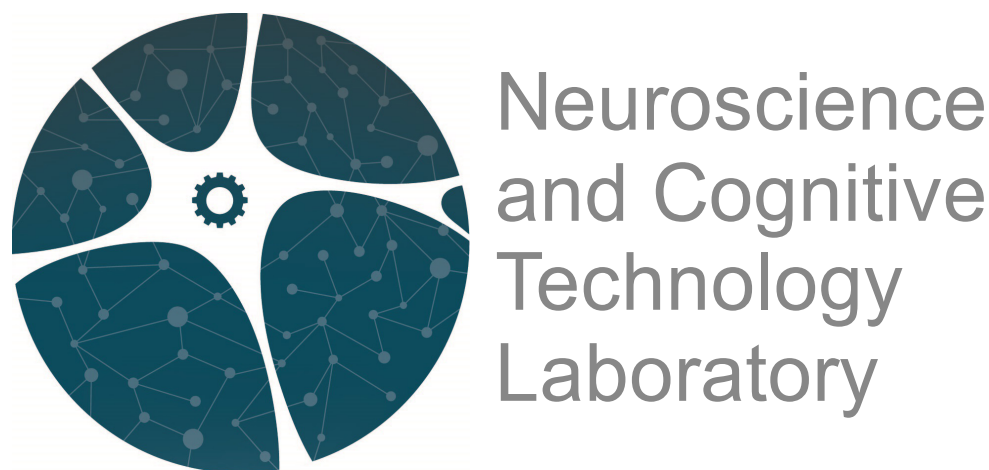


# A study of the brain's adaptive mechanisms during solving prolonged cognitive task based on fNIRS and Eyetracker

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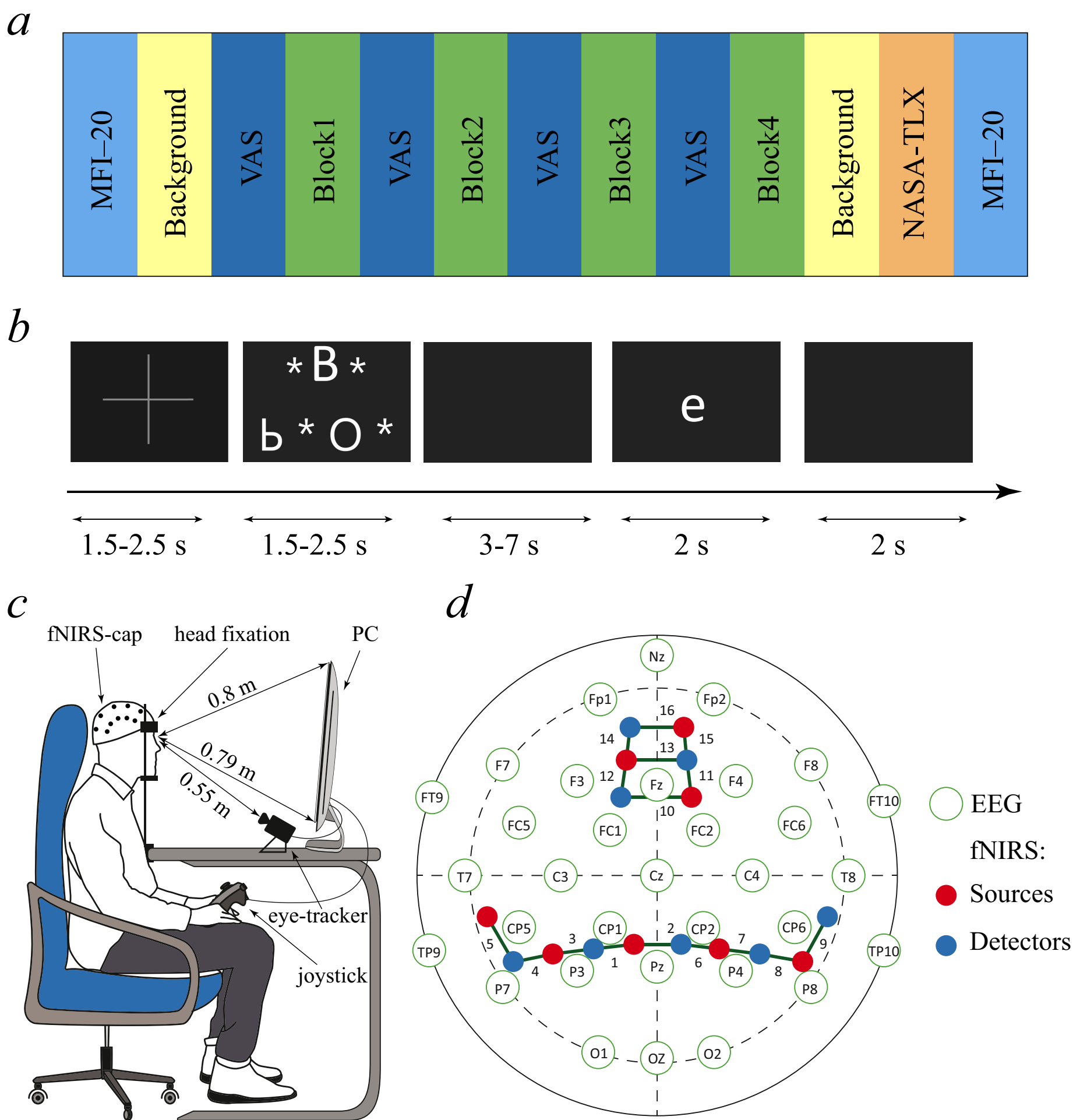
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(A) General scheme of the experimental study: the main part, consisting of 4 blocks of tasks (block1-4); background activity at the beginning and at the end of the main part (bgr1 and bgr2); NASA TLX test (NASA); two MFI tests (MFI1 and MFI2); visual subjective assessment of fatigue (VAS);

(B) Scheme of one trial from the block of the main part: a cross for fixing the attention, presentation of a set of letters, a pause, a test, a pause for an answer. The layout of the EEG electrodes (shown in green circles with the name of the electrode) and fNIRS optodes (sources - red circles, detectors - blue circles, formed fNIRS channels - dark green lines with a channel number).



$$r_{XY} = \frac{\text{cov}_{XY}}{\sigma_X \sigma_Y} = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2}}$$

The strength of the connection between the channels fNIRS

$$r_{Parietal} = \frac{1}{n} \sum_{i \in Parietal} \sum_{j \in Parietal} r_{i,j}$$

Average strength of the connection in the parietal lobe

$$r_{Frontal} = \frac{1}{n} \sum_{i \in Frontal} \sum_{j \in Frontal} r_{i,j}$$

Average strength of the connection in the frontal lobe

$$r_{Frontal-Parietal} = \frac{1}{n} \sum_{i \in Parietal} \sum_{j \in Frontal} r_{i,j}$$

Average strength of the connection between the parietal and frontal lobes

$$C = \frac{1}{n} \sum_{i \in N} C_i = \frac{1}{n} \sum_{i \in N} \frac{2t_i}{k_i(k_i - 1)},$$

Global clustering coefficient

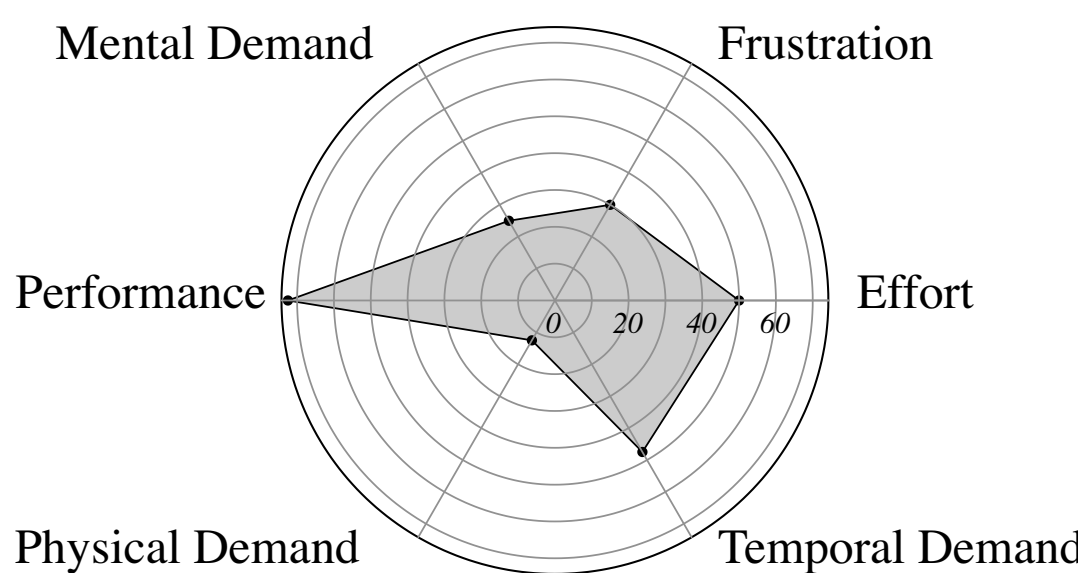
where  $C_i$  is the clustering coefficient of node  $i$  ( $C_i = 0$  for  $k_i < 2$ ).

$$E = \frac{1}{n} \sum_{i \in N} E_i = \frac{1}{n} \sum_{i \in N} \frac{\sum_{j \in N, j \neq i} d_{ij}^{-1}}{n - 1},$$

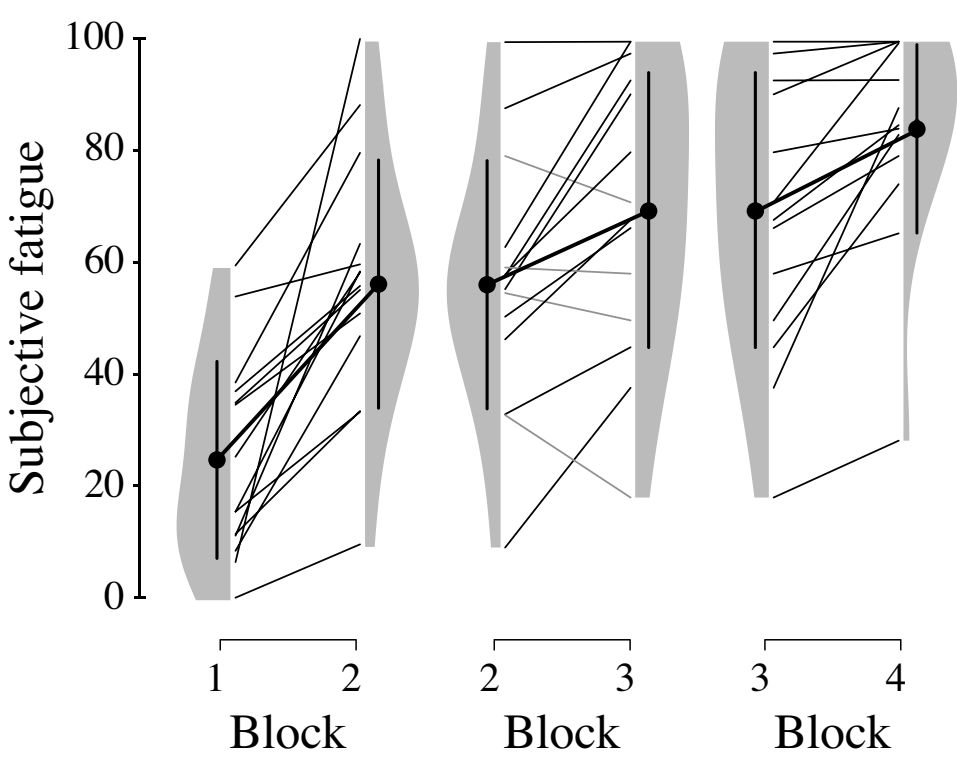
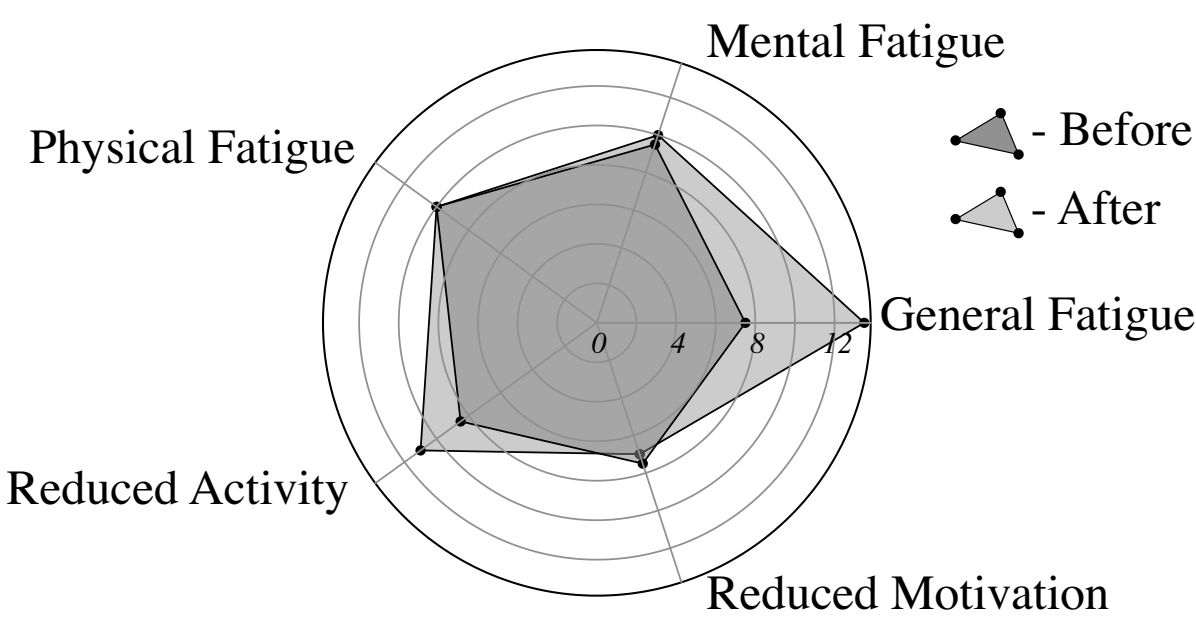
Global efficiency

a

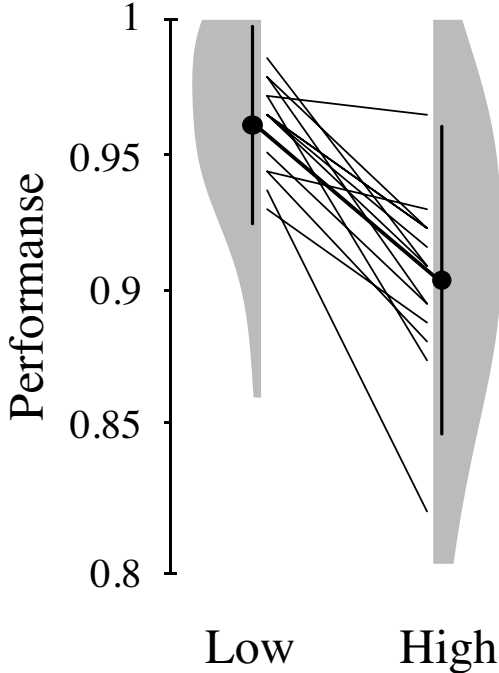
NASA Task Load Index



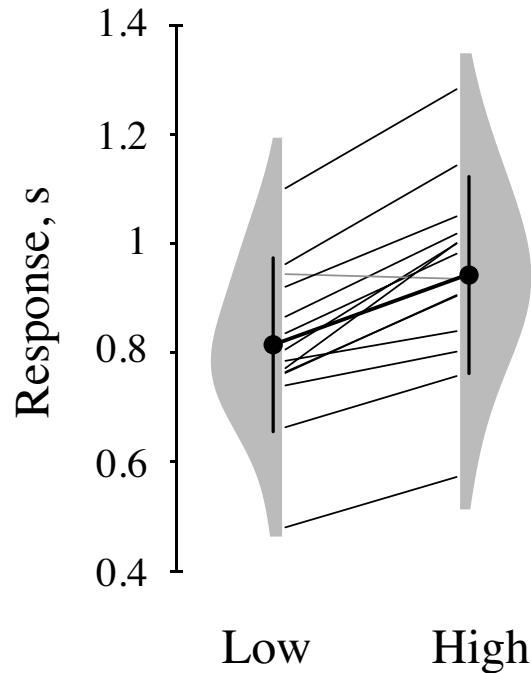
MFI-20



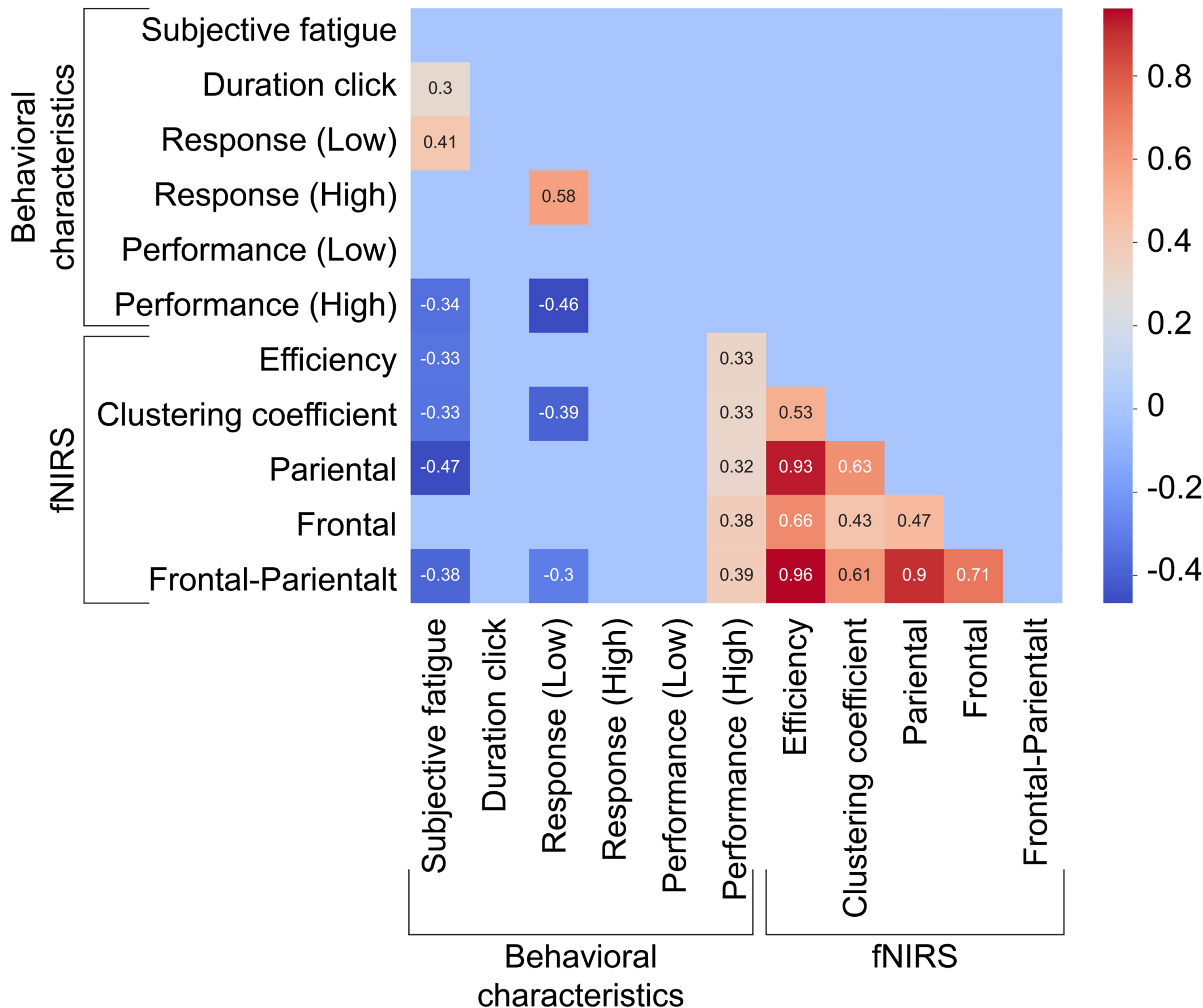
c



d



Repeated Measures Correlation



## Conclusion

This paper presents the results of the analysis of changes in the characteristics of the identified functional networks during long-term and continuous performance of cognitive tasks based on the Sternberg paradigm, and also determines their relationships with the behavioral characteristics of volunteers on the basis of correlation analysis and identifies biomarkers of fatigue.

Changes in the response time of the subject in the process of long-term and continuous execution of cognitive tasks based on the Sternberg paradigm were revealed.

Analysis of changes in the characteristics of the identified functional networks during the experiment was carried out.

The correlations with the behavioral characteristics of the volunteers were determined on the basis of correlation analysis, and biomarkers of fatigue were identified.

This result can be used to develop a method for assessing fatigue based on network analysis of fNIRS signals. A similar approach can find application in the brain-computer interface.