

Within- and Cross-Session Single-Trial Decoding of Working-Memory Updating

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Introduction: Working-memory updating enables people to revise currently relevant information as environmental demands change and is therefore central to adaptive, goal-directed behaviour. Identifying working-memory updating at the level of individual trials may contribute to the development of adaptive neurotechnology and objective measures of executive-function processes. Although oscillatory EEG correlates of working-memory updating have been identified, relatively little is known about whether updating can be decoded from individual trials and whether the underlying neural signatures remain stable across sessions.

Methods: Seventeen healthy participants completed a modified reference-back task during 32-channel EEG recording in two separated sessions. Trials requiring working-memory updating were compared with trials without working-memory updating. Mean power and peak power in the theta, alpha, beta, and gamma bands were extracted from selected electrodes of the main scalp regions. Regularised machine-learning models were evaluated separately within Session 1 and Session 2 using cross-validation to discriminate updating versus no-updating trials. To assess cross-session generalisability, a model developed exclusively on Session 1 data was applied to unseen data from Session 2.

Results: Preliminary analyses suggest that working-memory updating trials were associated with slower responses and differences in spectral activity compared with no-updating trials, while classification performance appeared broadly comparable in both sessions, indicating that working-memory updating-related information may be detectable from EEG trials. Models trained on Session 1 also showed preliminary evidence of generalisation to unseen Session 2 data, although cross-session performance appeared lower than within-session performance. Theta-band activity over frontal and parietal regions were potentially most informative for classification. Behavioural accuracy and reaction time provided evidence that the experimental manipulation successfully induced executive demands. These initial findings suggest that the task successfully elicited updating demands and that the associated EEG patterns may be partly reproducible across sessions.

Conclusions: These preliminary findings suggest that working-memory updating is characterised by a detectable EEG patterns that are partly reproducible across recording sessions. Demonstrating such cross-session generalisability would be an important step toward reliable single-trial monitoring of executive processes and their future application in adaptive brain–computer interfaces.