

Motor Imagery of Linked Movements Enhances Motor Adaptation

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Introduction

- Motor imagery and overt movements have been shown to be functionally equivalent¹.
- This equivalence is usually assessed by comparing brain activity of both motor tasks.
- However, to fully test this equivalence, one would need to demonstrate that a hybrid sequence, involving both overt movements and motor imagery, could lead to similar effects on motor learning as an overt movement sequence^{2,3}.

Hypotheses

- 1 A mental representation of a prior movement (i.e. motor imagery) can facilitate motor learning.
- 2 The strength of neural correlates relating to motor imagery can serve as a predictor of such learning.

Methods

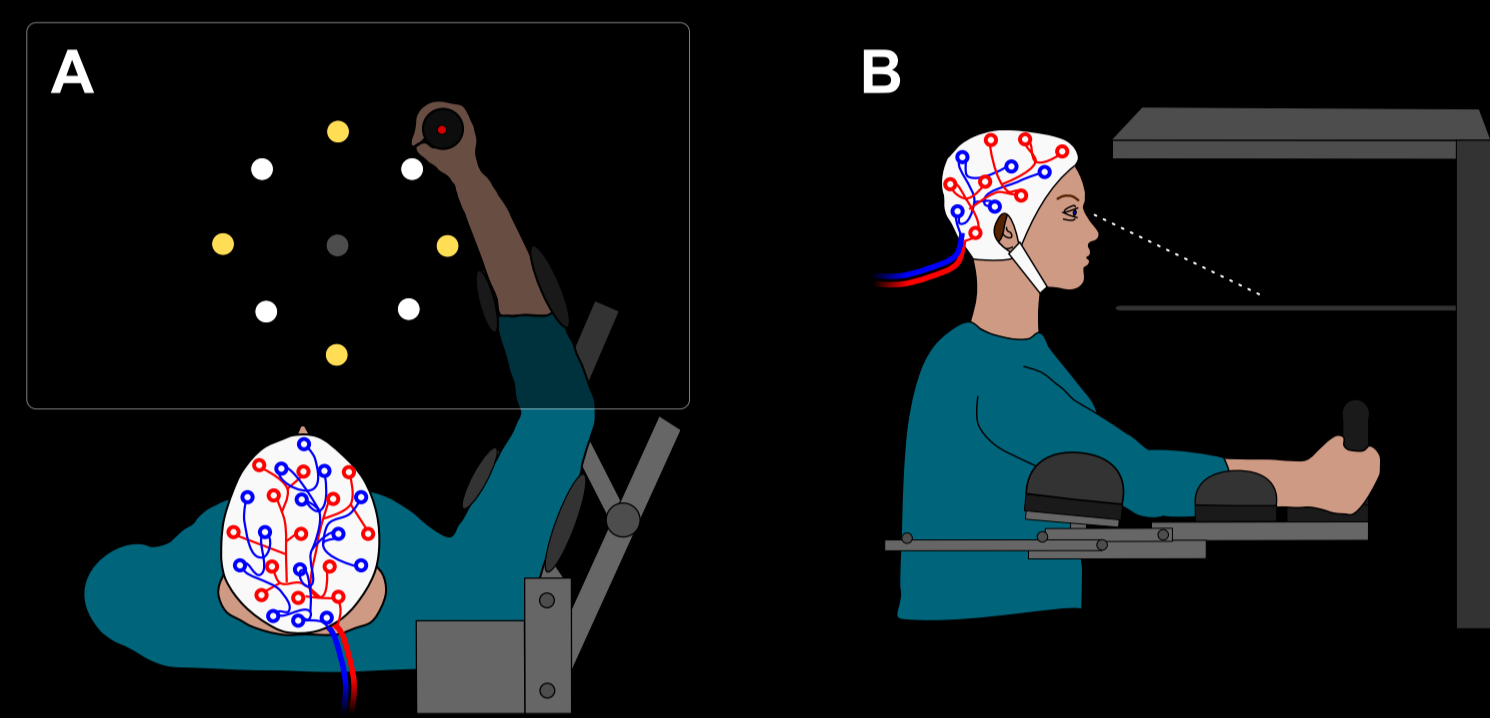
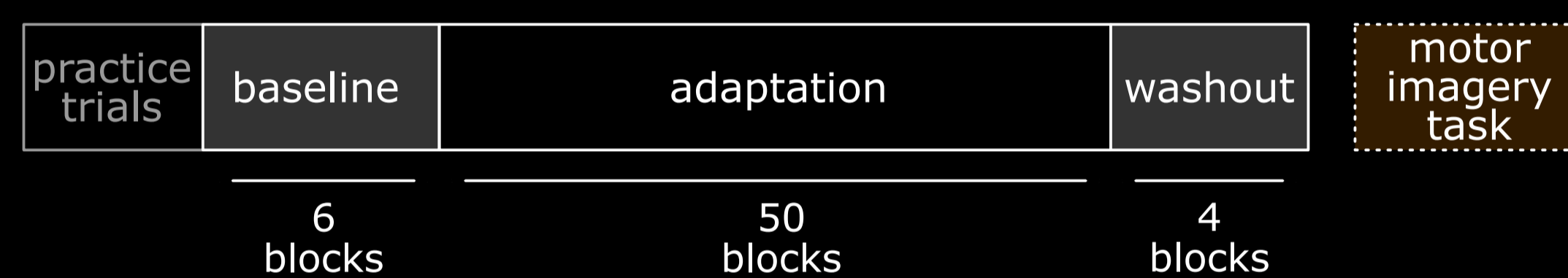


Fig. 1 | Experimental setup⁴.
60 right-handed participants performed reaches in an exoskeleton robot.
A) Top view.
B) Lateral view.

Fig. 2 | Experimental flow.



- Each block consisted of 18 trials: 16 normal + 2 clamp trials.
- Force fields were only present in adaptation trials.
- The motor imagery task was only performed by participants in the motor imagery group.

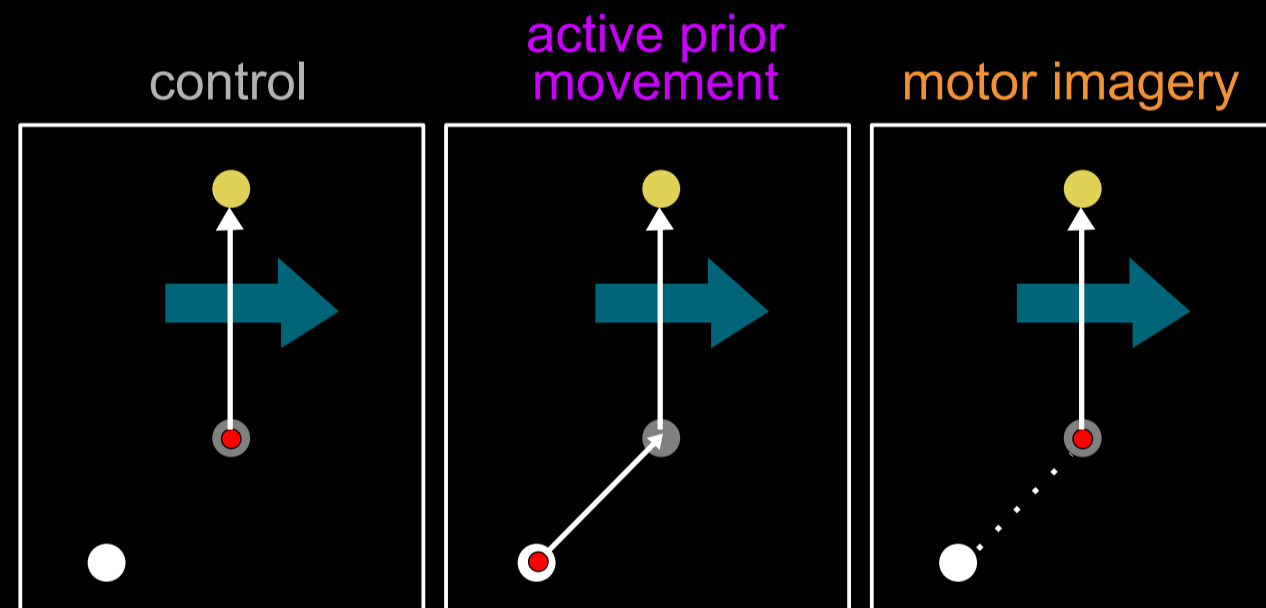


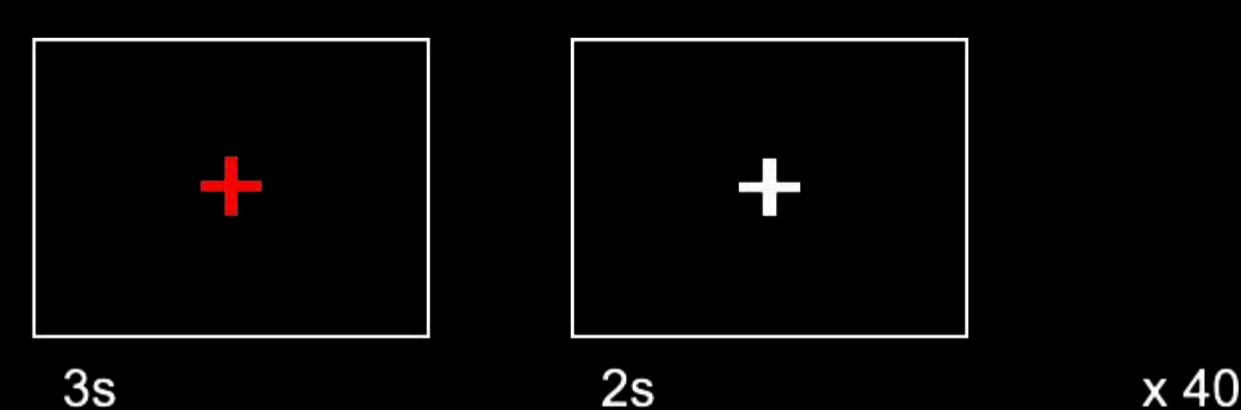
Fig. 3 | Example trial.
For each final target, the two opposite additional target locations were possible. The target's location was associated with the direction of the force field.

Dependent Variables:

- The **Maximal Perpendicular Error** measures the maximal deviation from a straight line between middle (right) and final target in normal trials.
- In clamp trials, no force fields were present. Instead, channel walls forced participants to reach in a straight line from the middle (right) to the final target. The force with which participants pressed against the channel walls was measured. The **Force Field Compensation** value reflects how well a force field would have been counteracted.

Fig. 4 | Motor imagery task.

Participants were asked to imagine to clench their right fist when they saw a red cross.



Discussion

- Our findings provide evidence that the idea of functional equivalence between motor imagery and overt movements can be extended to hybrid linked movements in the context of motor adaptation.
- This opens perspectives for novel motor rehabilitation practices.
- Moreover, the strength of neuronal correlates relating to motor imagery was predictive of the degree of motor adaptation.

Functional equivalence between motor imagery and overt movements extends to hybrid linked movements.

References

1 Jeannerod., *NeuroImage* (2001) 2 Howard et al., *J. Neurosci.* (2012) 3 Sheahan et al., *Sci. Reports* (2018) 4 Kinarm-Exoskeleton-Lab, Kinarm, Canada gippert@cbs.mpg.de

Results

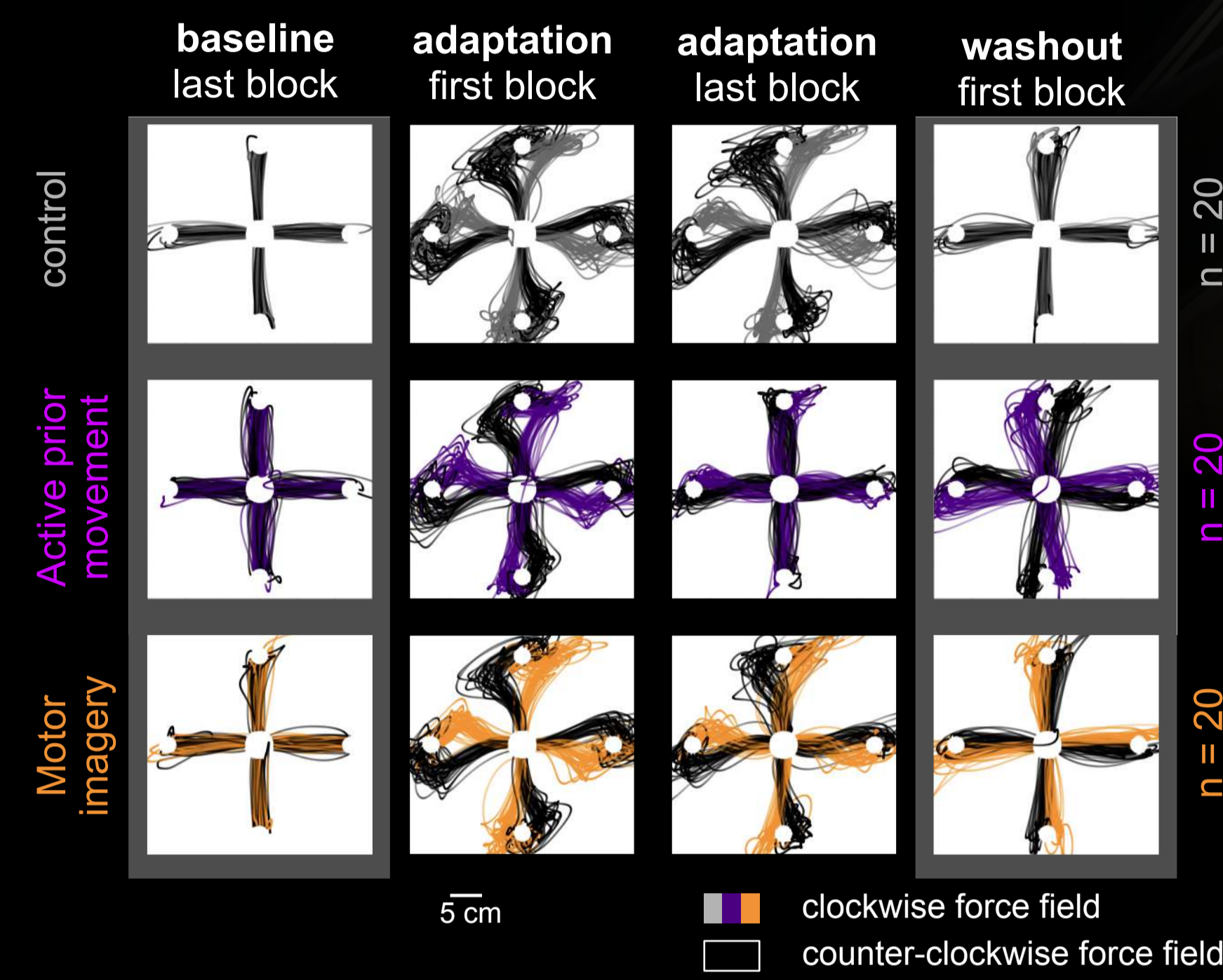


Fig. 6 | Hand movement paths.

Single trial trajectories from middle to final targets of all participants in selected blocks of the experiment.

- 1 • Force field specific adaptation occurred in the **active prior movement** and **motor imagery** group but not in the control group.
- Learning was stronger in the **active prior movement** than in the **motor imagery** group.

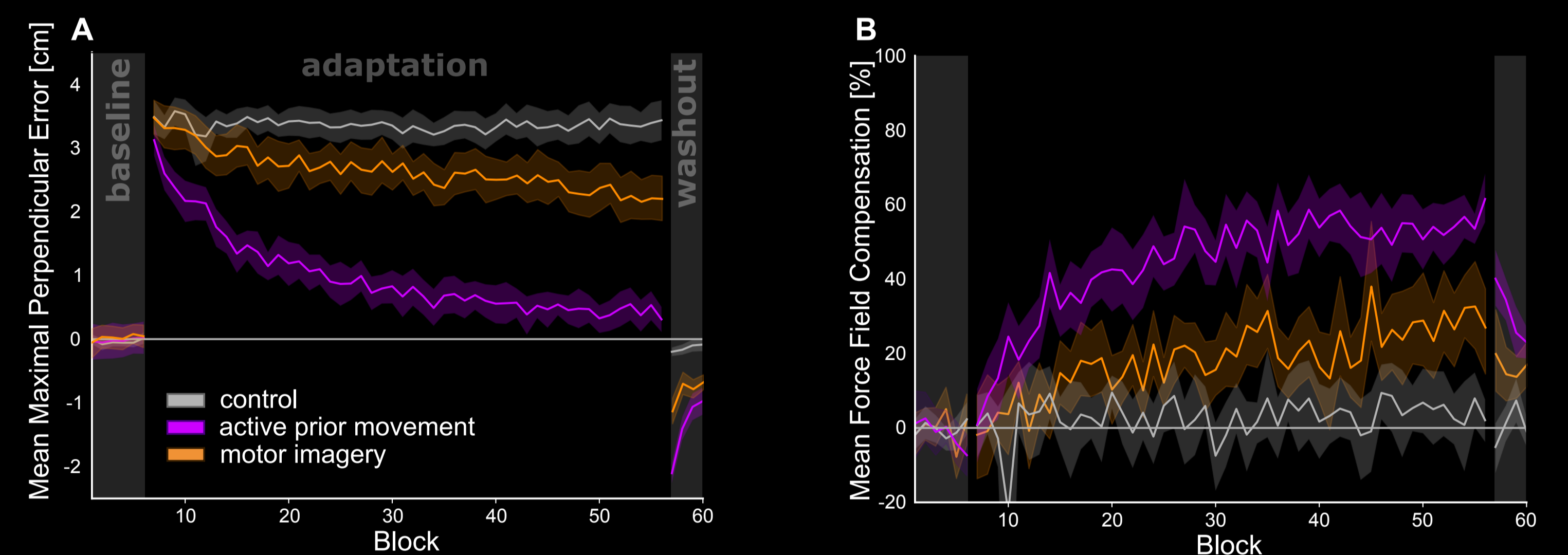


Fig. 7 | A) B) Mean value of each group in each block. Error bands depict SEs across participants.

- 2 • Strength of **Event Related Synchronization (ERS)** in alpha band in C3 in motor imagery task was related to motor learning in force field adaptation task.

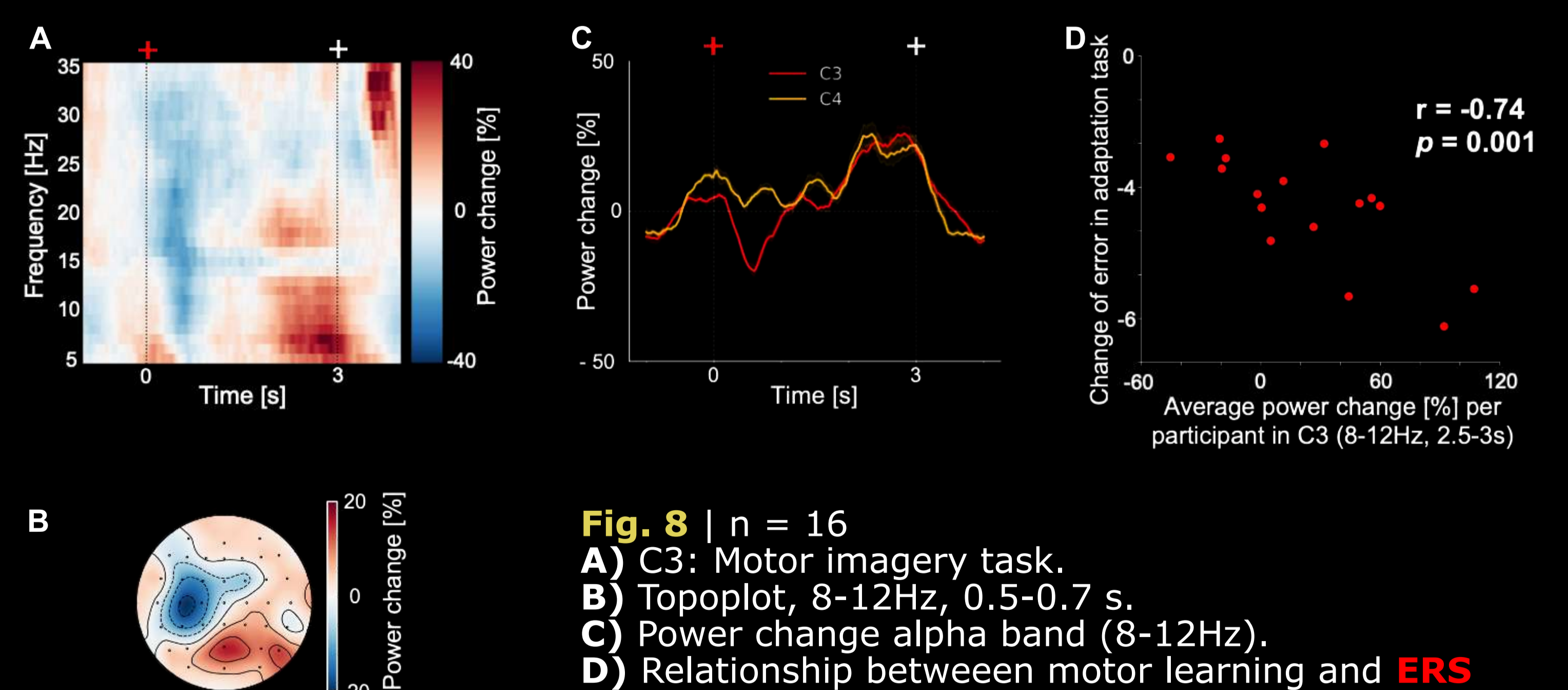


Fig. 8 | n = 16
A) C3: Motor imagery task.
B) Topoplot, 8-12Hz, 0.5-0.7 s.
C) Power change alpha band (8-12Hz).
D) Relationship between motor learning and **ERS**