

SHOULD ATTEMPTED MOVEMENTS REPLACE MOTOR IMAGERY IN BCI?

(THE ISSUE OF COMPATIBILITY WITH GAZE USE)

Sergei L. Shishkin¹, Artem S. Yashin¹, Yulia G. Shevtsova¹, Anatoly N. Vasilyev^{1,2}

¹ Neurocognitive Interfaces Group, MEG Center, Moscow State University of Psychology and Education, Moscow, Russia

² Lab. for Neurophysiology and Neuro-Computer Interfaces, Faculty of Biology, M.V. Lomonosov Moscow State University, Moscow, Russia

bci.megmoscow.ru

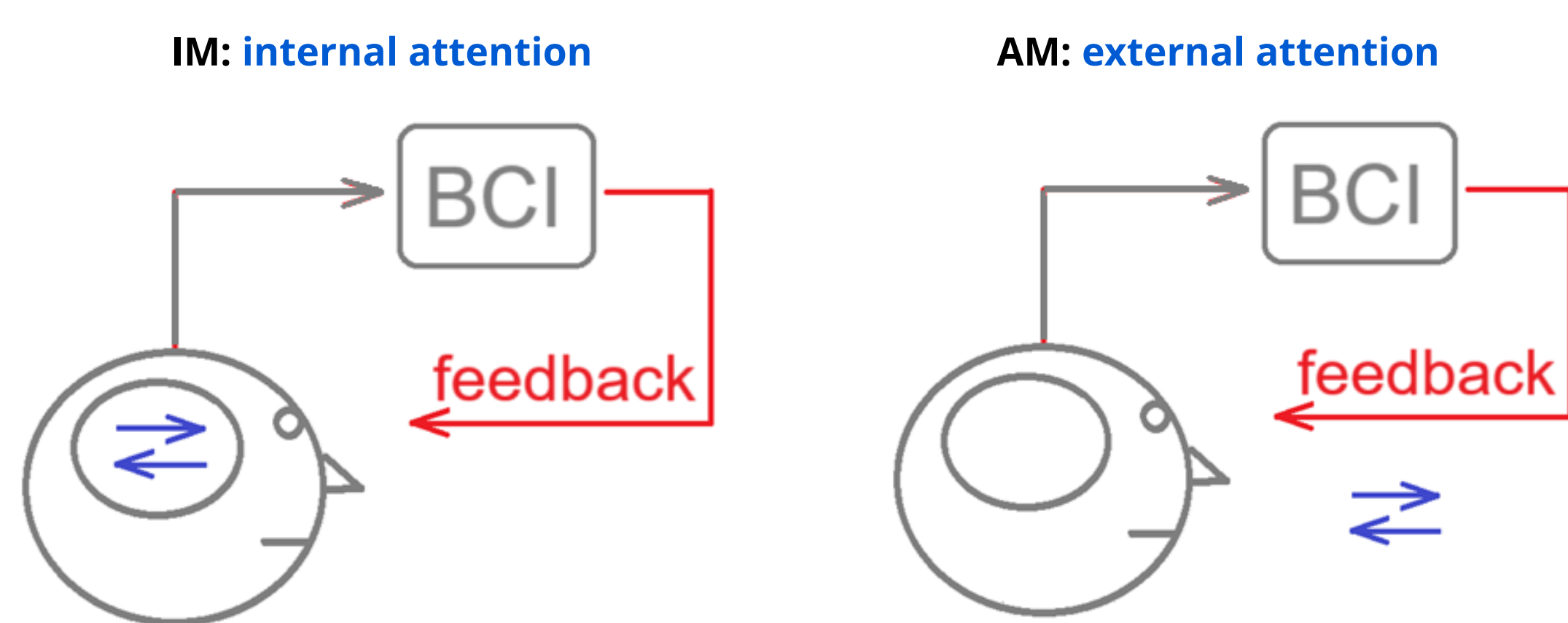
[This poster \(with links\)](#)



Introduction

Main ideas

- BCI use is associated with attention to external world, therefore **imaginary movements (IM)** may be not well suited for it.
- As external cognition, **attempted movements (AM)** should be more compatible with BCI than IM.
- AM should be especially better than IM in hybrid eye-brain-computer interfaces.
- All this can be studied using **quasi-movements (QM)**, as a model of AM in non-paralyzed individuals.



Hypothesis

AM, modeled as QM, will be more compatible than IM with external cognition, represented by voluntary eye movements. Therefore, at least one of the following effects will be observed in a double task (saccade task + motor task):

- ERD will deteriorate more in IM than in QM.
- Saccade task will be performed worse in IM than in QM.
- Task with IM will be perceived more difficult and lead to stronger fatigue than task with QM.

QM as a model of AM in non-paralyzed

QM are "volitional movements which are minimized by the subject to such an extent that finally they become **undetectable** by objective measures" (Nikulin et al., *Neuropsychologia*, 2008).

In QM, ERD does not disappear and is even **larger than in IM**.

Other reasons to use AM

Generally in BCI: higher amplitude and better classification compared to IM.

In BCI post-stroke rehabilitation: possibly, physiologically closer to **overt movements (OM)**.

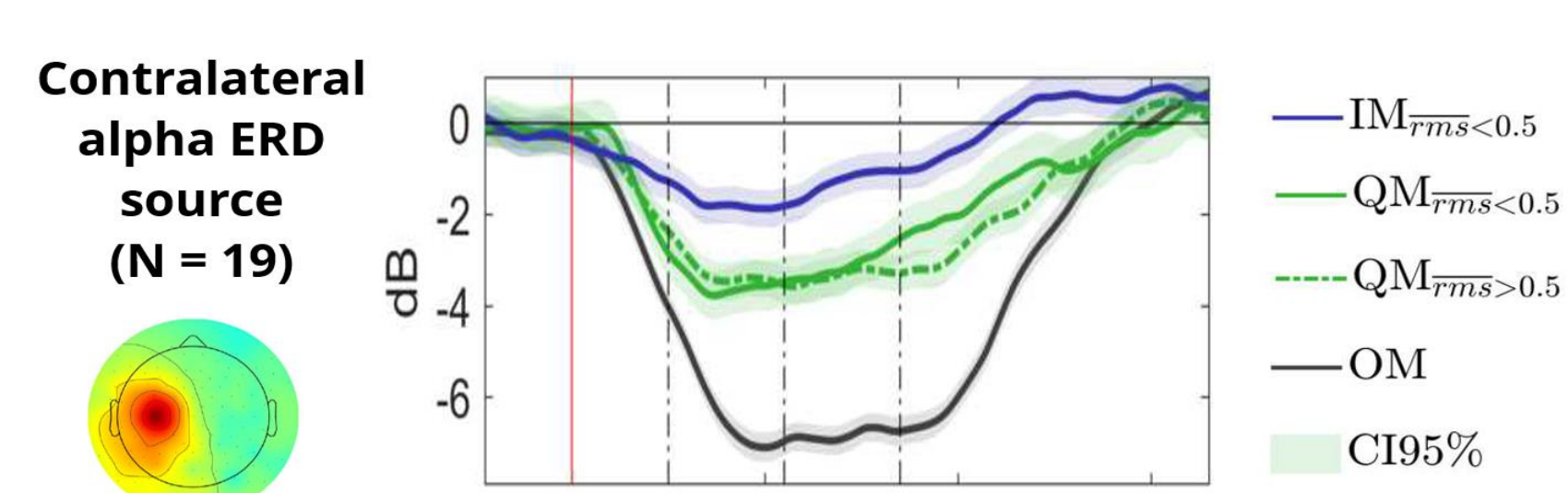
Some examples:

- Better classification of AM in healthy under temporal paralysis (Blokland et al., *Scientific Reports*, 2015).
- Better classification of QM (Nikulin et al., *Neuropsychologia*, 2008).
- Better clinical outcome for AM than for IM in post-stroke rehabilitation studies (review: Mansour et al., *Clin. EEG and Neurosci.*, 2021).

Our prior work

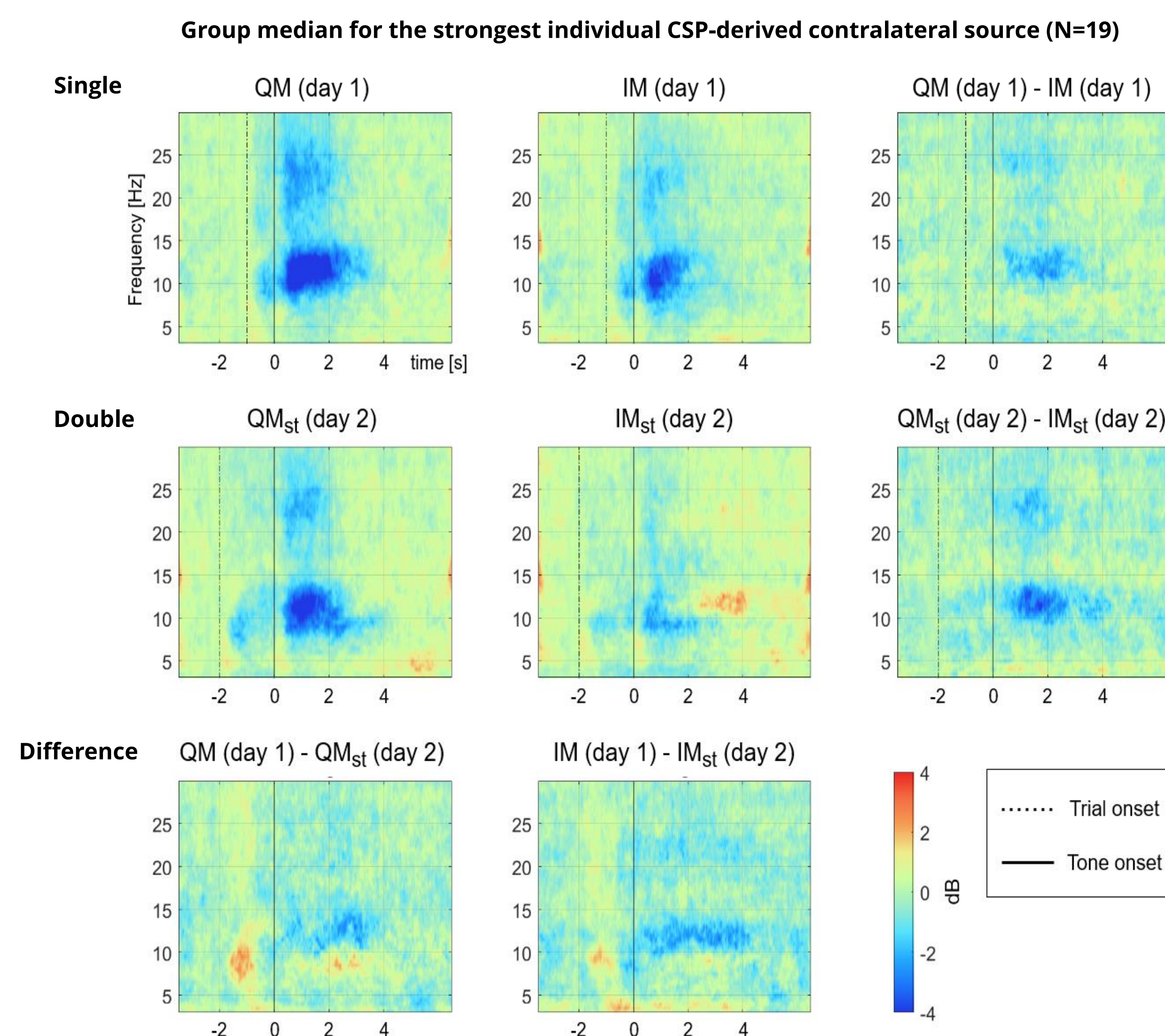
Different intentions: in IM intention is to **imagine** (= internally model) a movement, while in QM it is to **make** a movement (although unusually small) (Yashin et al., *Consc. Cogn.*, 2023). (For patient's AM the difference from IM should be even deeper).

While residual **muscle activation** is higher in QM than in IM, it has practically no effect on the ERD (Vasilyev et al., *Life*, 2023):



Results

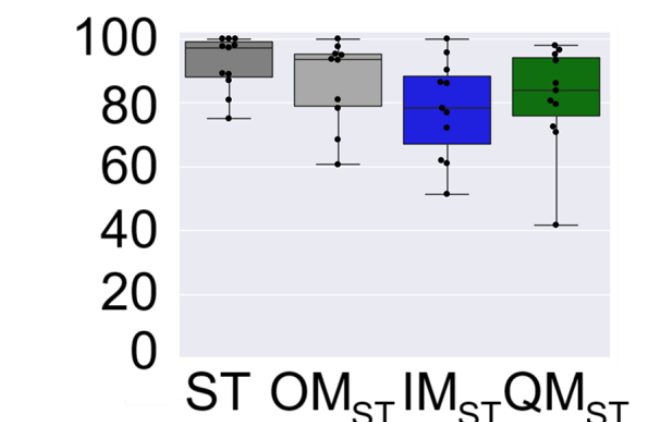
Sensorimotor ERD



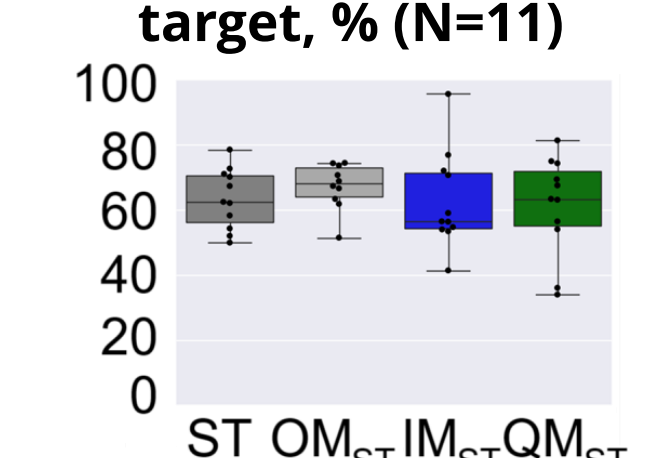
Gaze

(analysis in progress)

Trials with gaze on cross before saccade, % (N=11)

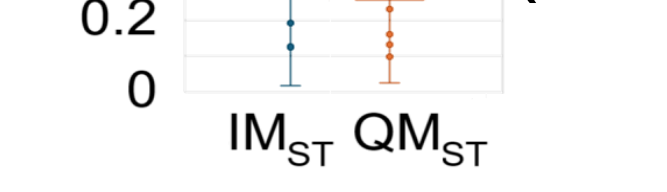


Saccades landed on target, % (N=11)

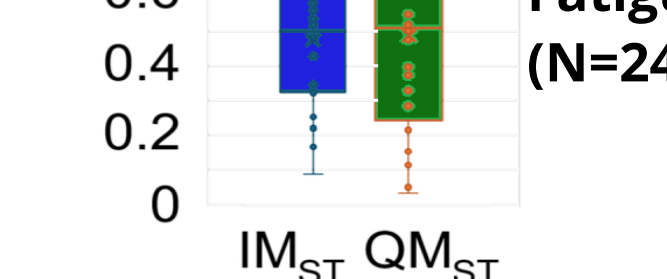


Survey

Difficulty (N=24)



Fatigue (N=24)

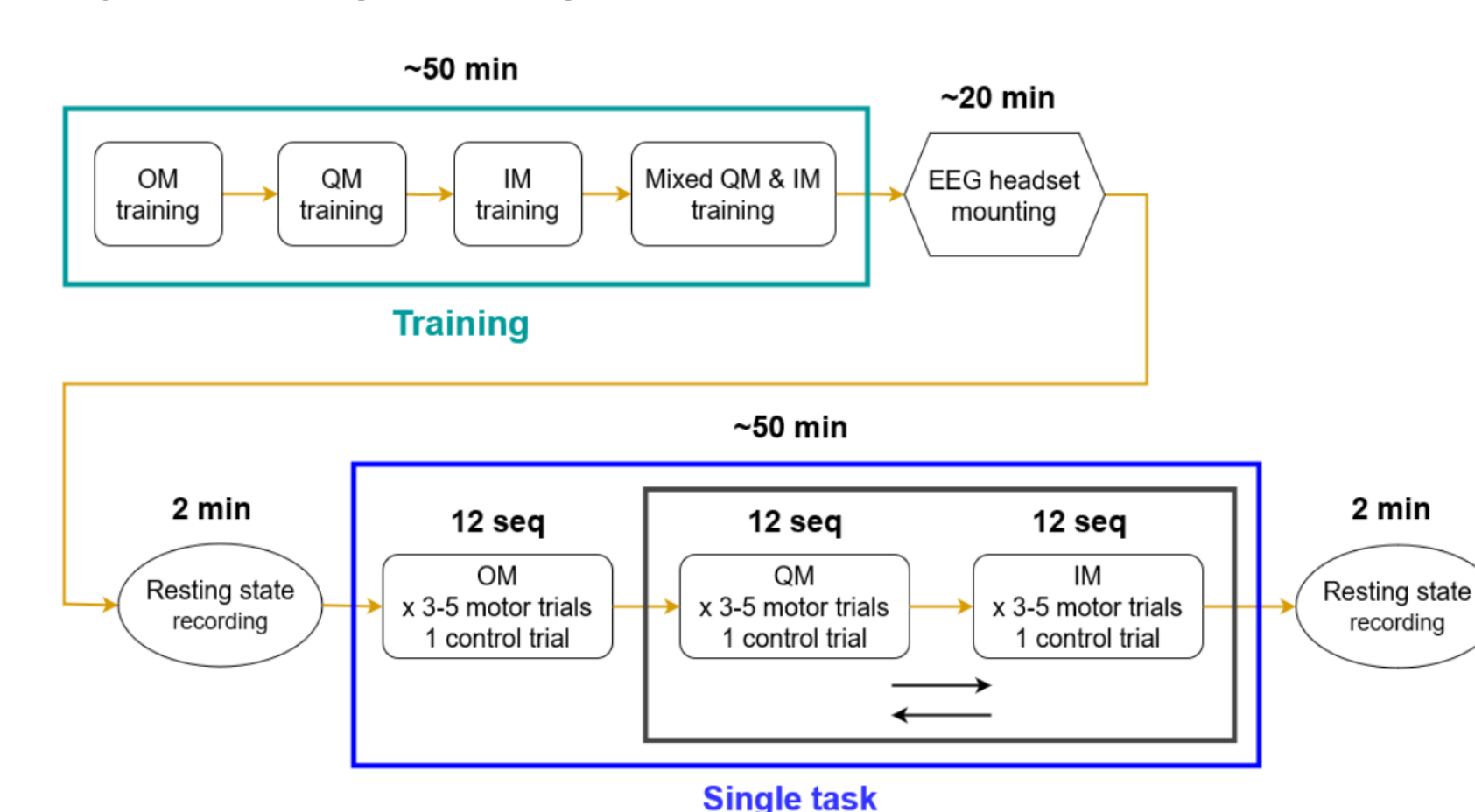


Methods

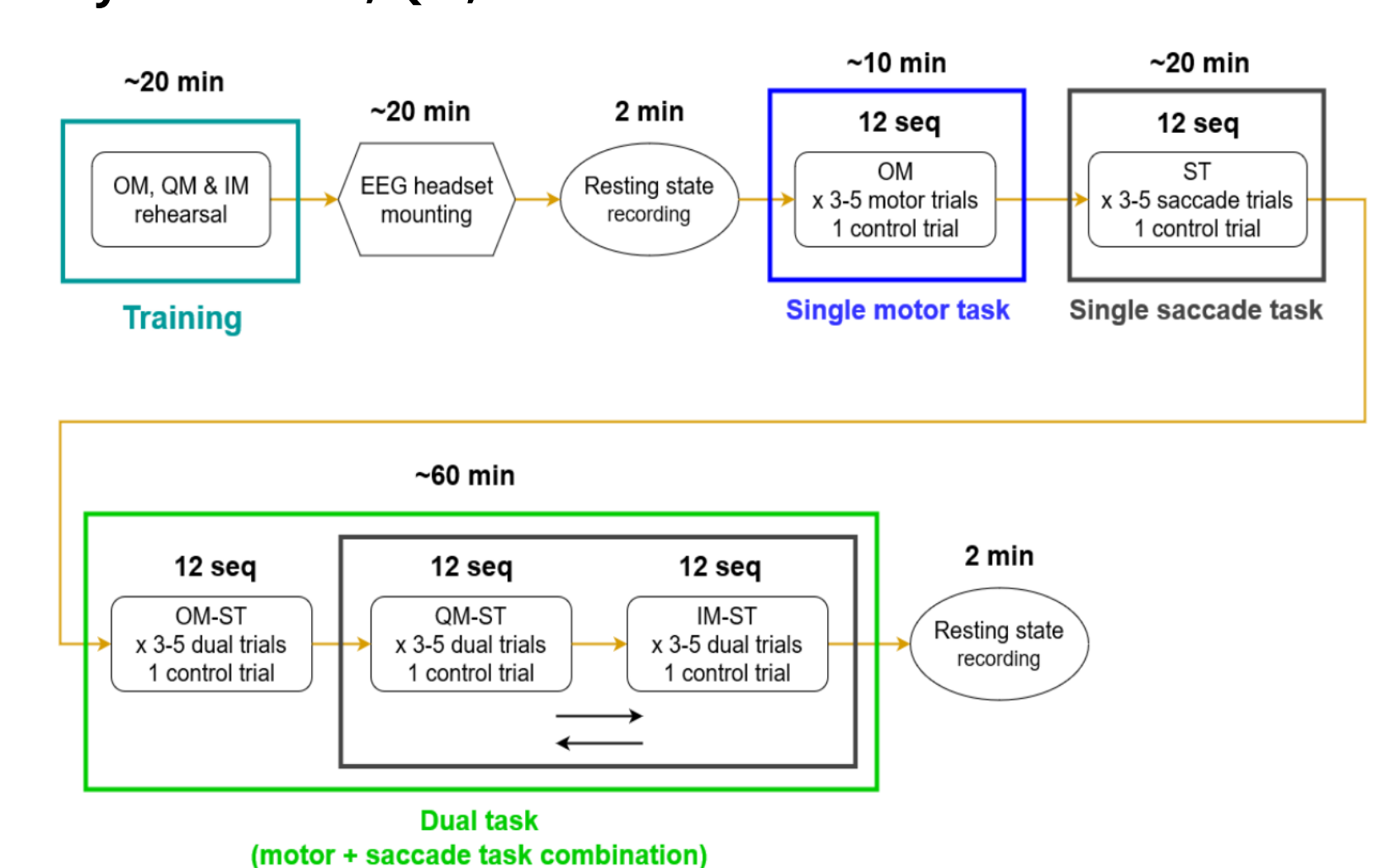
- Saccade task (ST): make a saccade to the target (square of triangle) asap when it is presented.
- Motor task trial: do a triplet of OM, QM or IM (movement: right thumb abductions under an opaque cover)
- Double task: combined instruction (without prioritizing one of the tasks)

(Based on studies of saccades + internal cogn., Walcher et al., *PLoS ONE*, 2023 and QM, Vasilyev et al., *Life*, 2023).

Day 1: training and single OM, QM, IM tasks

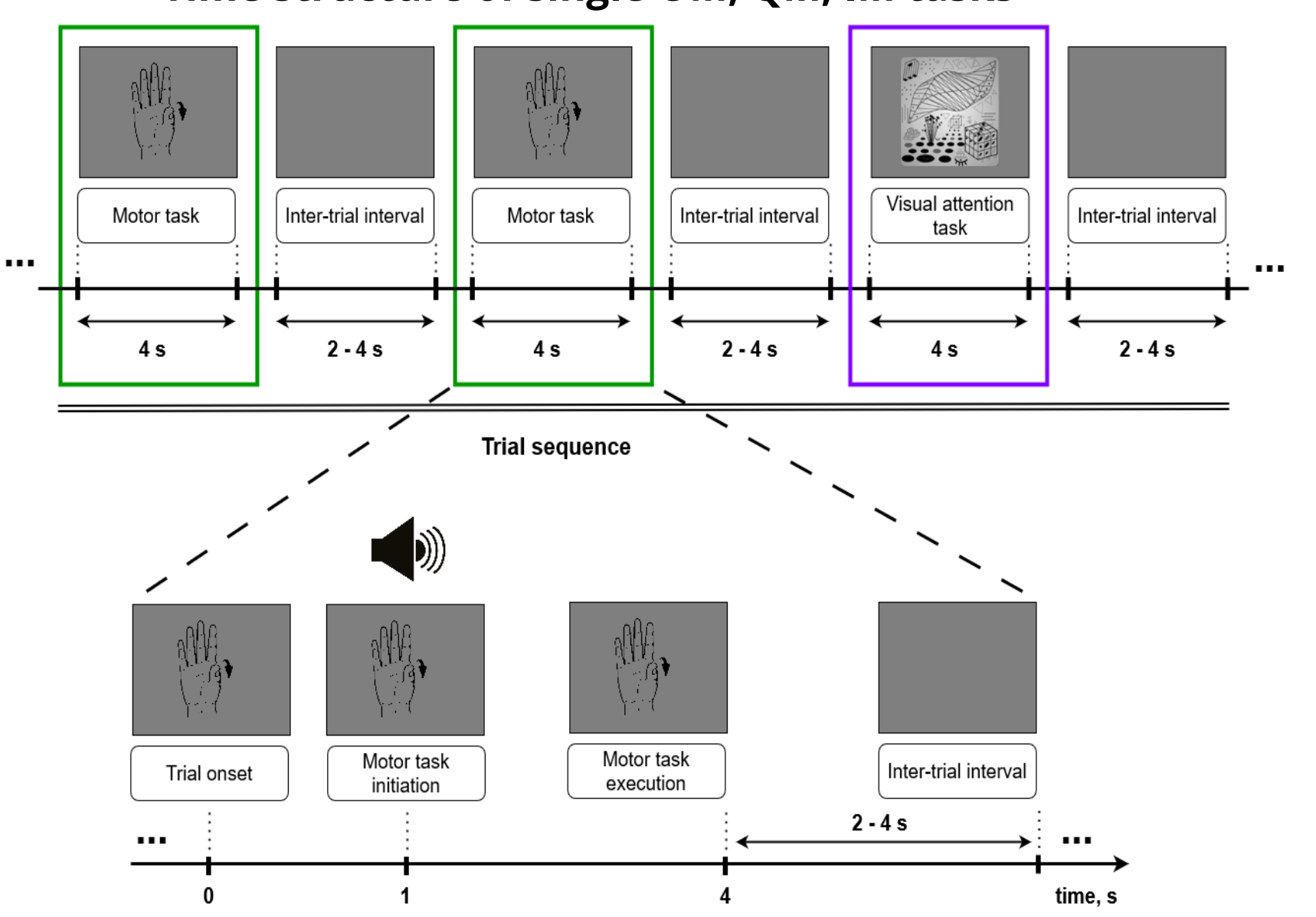


Day 2: dual OM, QM, IM tasks

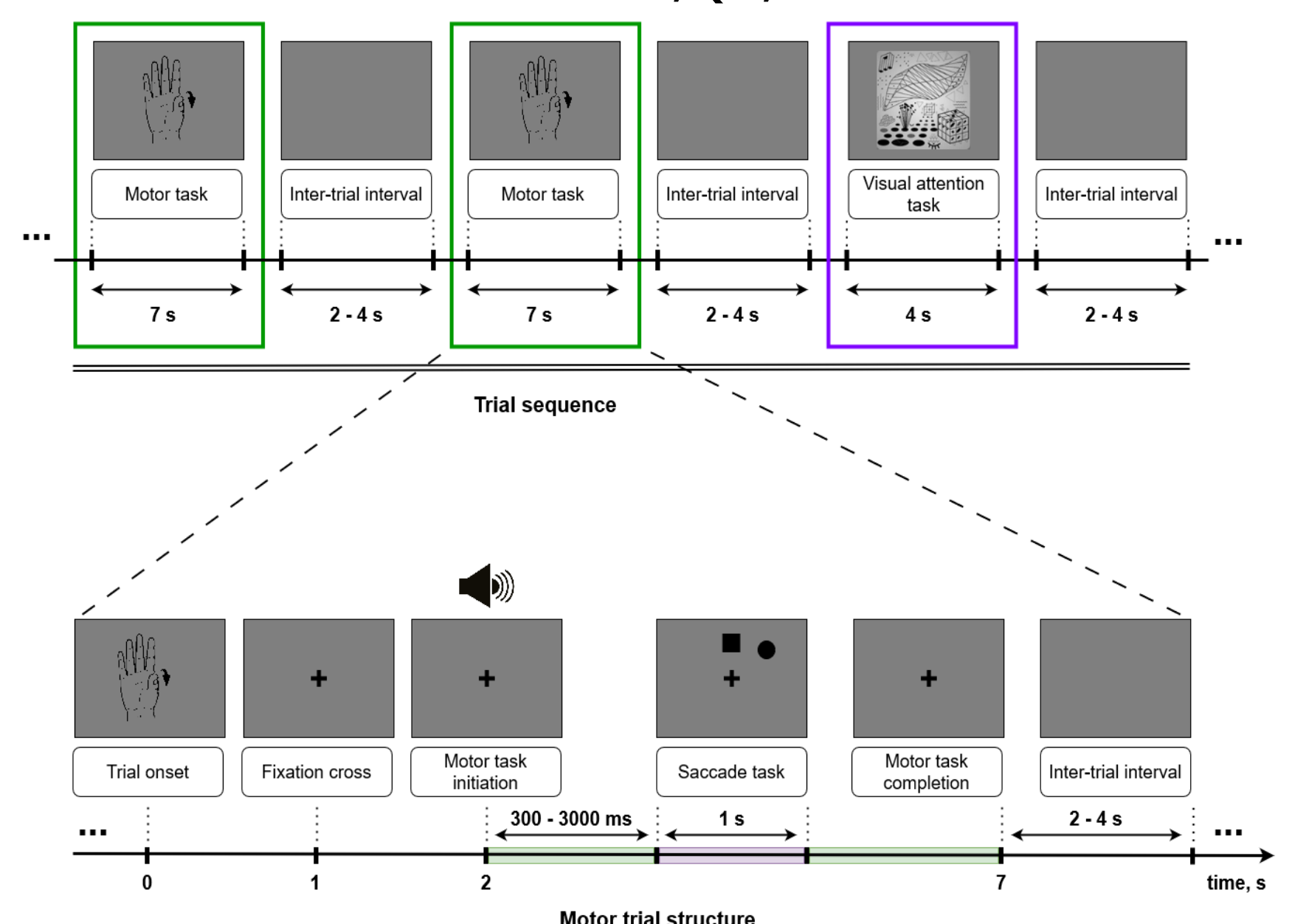


25 healthy naive volunteers, median age 23.
EMG: from *m. abductor pollicis brevis*
EEG: NVX136, 128 channels
Eye tracking: EyeLink1000 Plus, 1000 Hz

Time structure of single OM, QM, IM tasks



Time structure of dual OM, QM, IM tasks



Conclusion

- In a double task including a motor task (IM, QM, OM) and a saccade task (ST), sensorimotor rhythm ERD was deeper in QM+ST than in IM+ST.
- However, the hypothesis of **better compatibility of attempted movements (AM; here, modeled as QM) than motor imagery (IM)** with intentional gaze behavior was not clearly confirmed.
- For more clear conclusions, **online** BCI experiments, deeper gaze analysis, improved **instructing** and training of participants will be needed.

Acknowledgement

The authors thank Vadim V. Nikulin for helping to dive into the quasi-movements.