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What brain patterns should we reinforce during BCI training procedures targeting motor imagery abilities?

An experimental study on athletes

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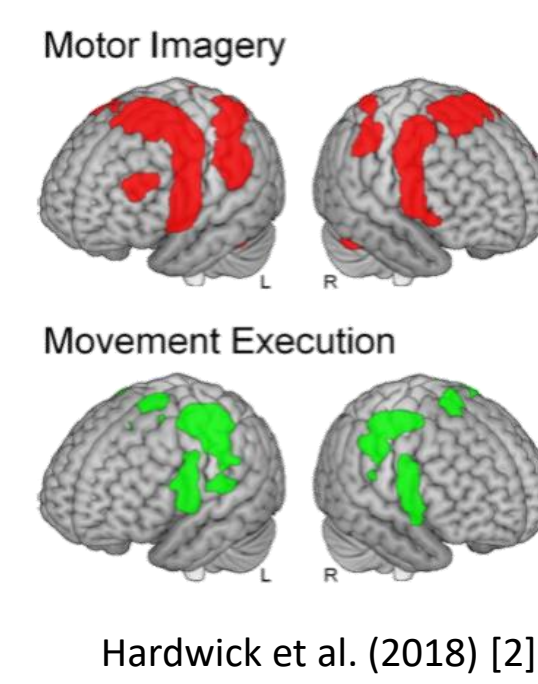
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Introduction

Motor imagery (MI)

Mental simulation of an action without movement

- ↑ motor learning (e.g. technique) [1]
- Solicitates similar regions as movement execution [2]
- Is associated with an event-related desynchronisation (ERD) of sensorimotor rhythms (SMR) [3]



Research question

BCI training can enhance MI performance, but what brain activity patterns should we reward?

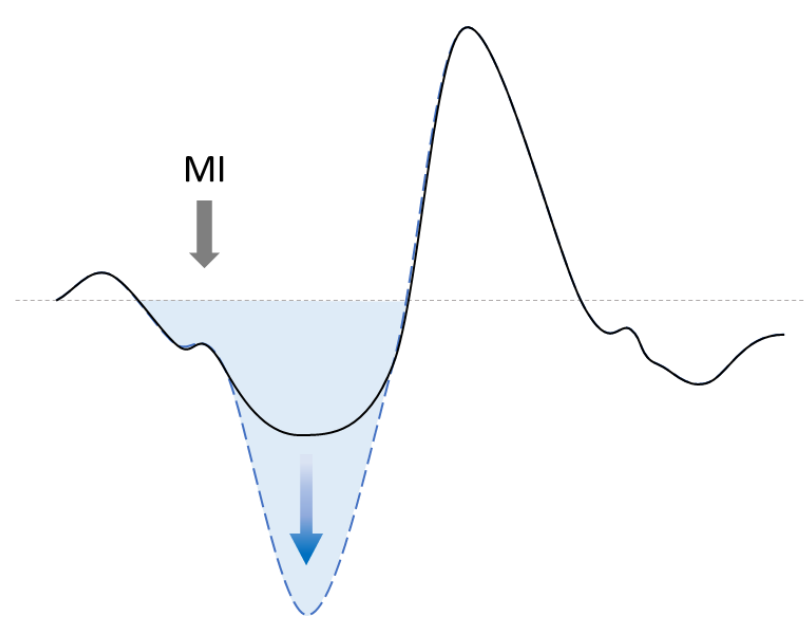
MI performance variations

≠ brain activities are observed depending on :

- MI type (visual or kinesthetic) [4]
- ability (vividness, control...) [5]
- practice (frequency, context...)
- Mastery of the task that is imagined [6]

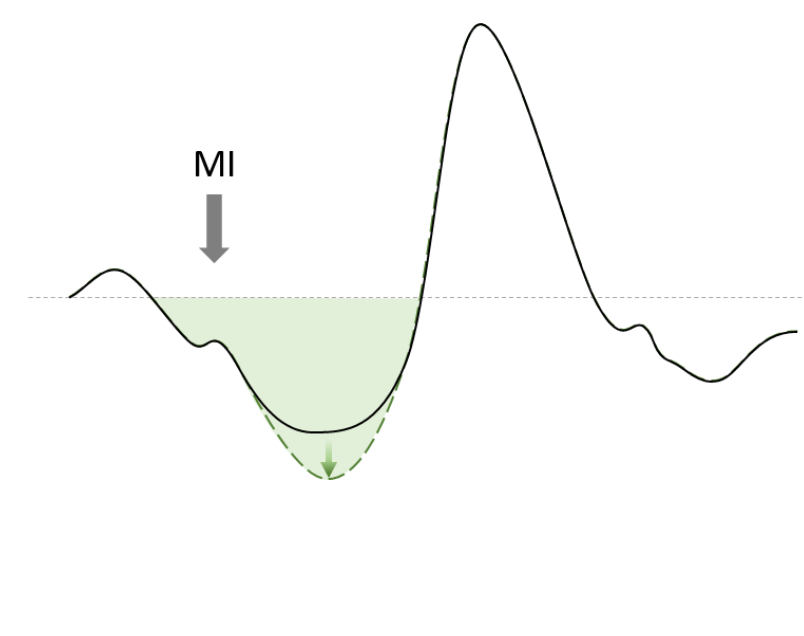
An "expert" can be a specialist in MI, in the imagined task or both. Athletes, musicians & gamers are often both as their activities require MI use in learning processes or anxiety management.

Max ERD%
 ↑ information processing capacity
 ↑ sensorimotor area activation
 ↑ recruited cortical neurons & excitability

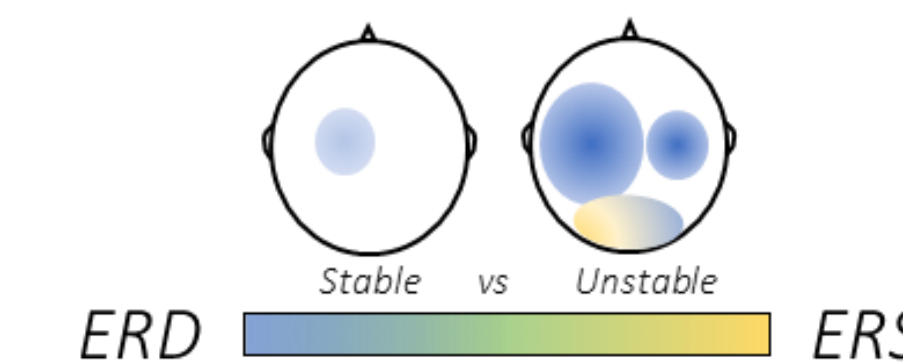


Historically based [3]

Min ERD%, spatial & temporal stability
 ↑ cortical & energetic efficiency
 ↓ activation of task related areas
 ↓ deactivation of irrelevant regions

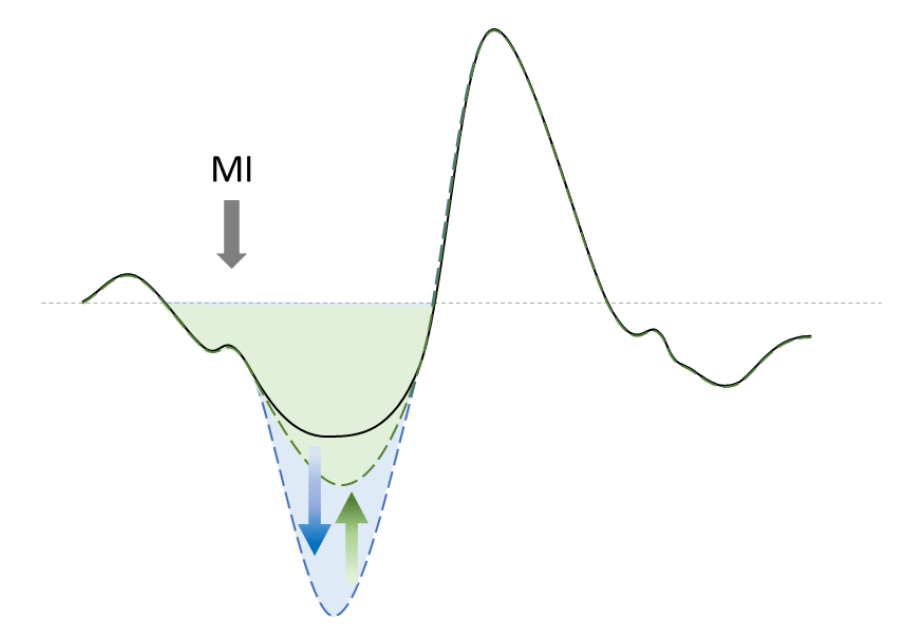


Neural efficiency hypothesis (NEH) based [7, 8]



Patterns that vary with the expertise

Efficiency comes with expertise/learning



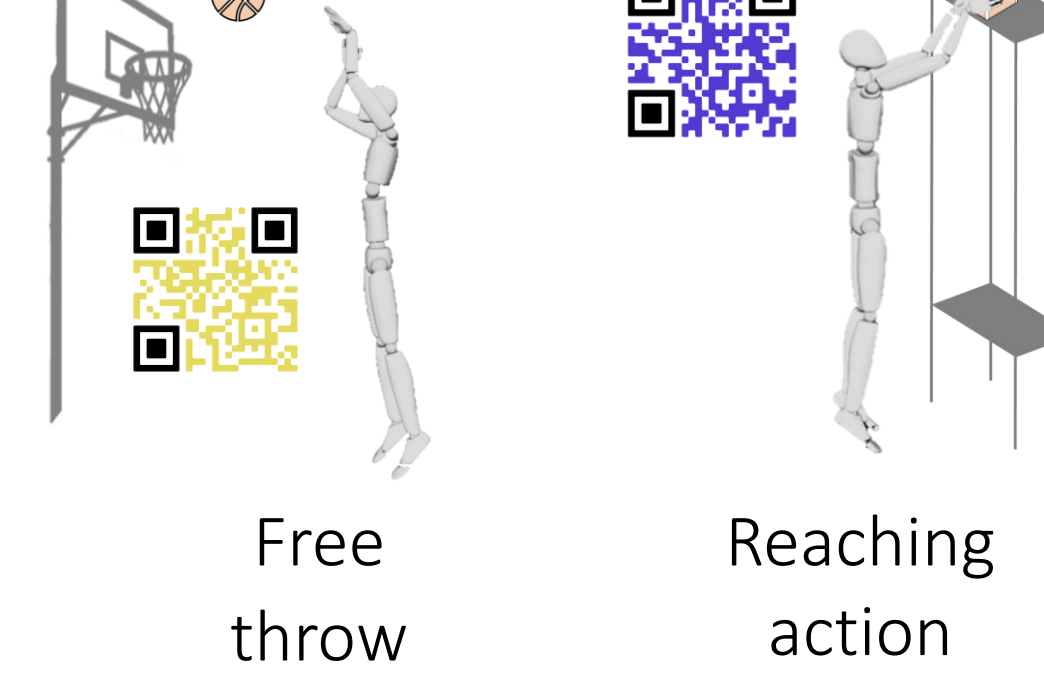
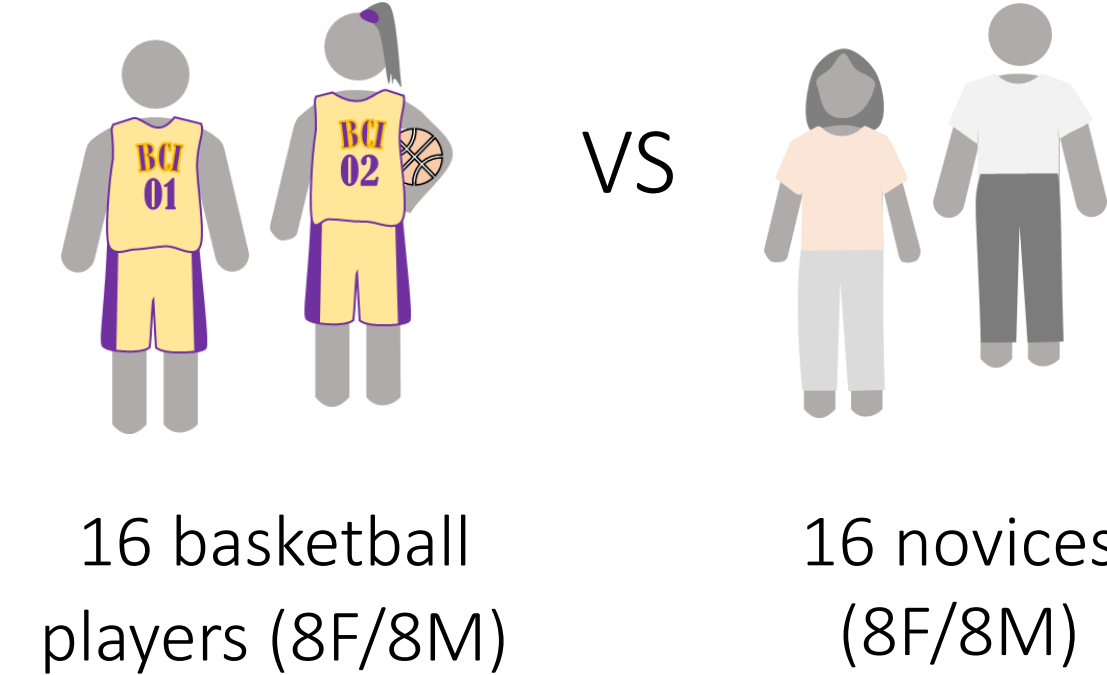
Expertise stage based [9]

Methods

Mixed experimental design

Factor 1 (between) : Expertise

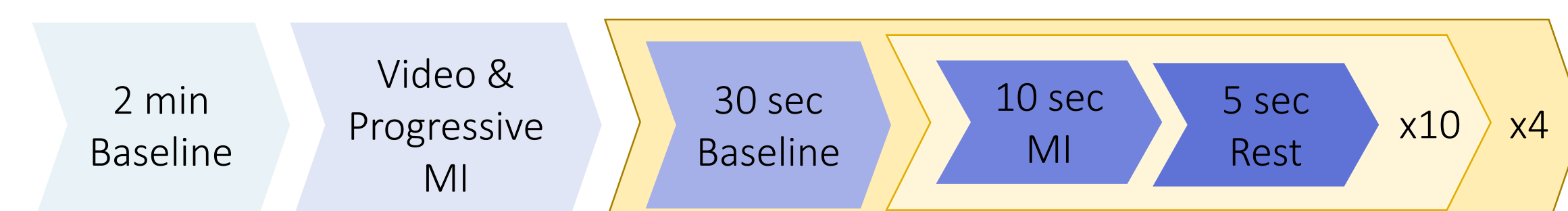
Factor 2 (within) : MI task



2 dependent variables :

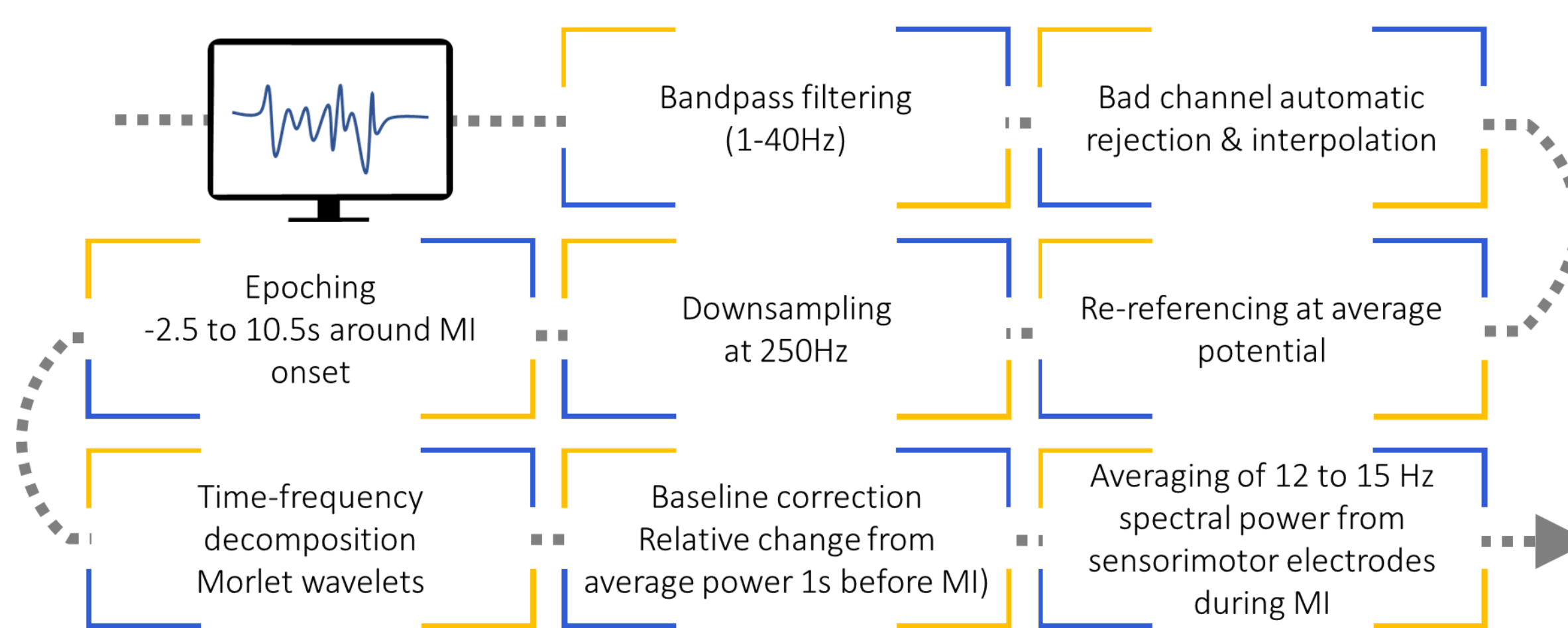
- SMR-ERD | % of desynchronisation compared to pre-trial baseline
- Perceived MI ability | MIQ-3f [10] items measuring MI abilities for each task

Experimental procedure



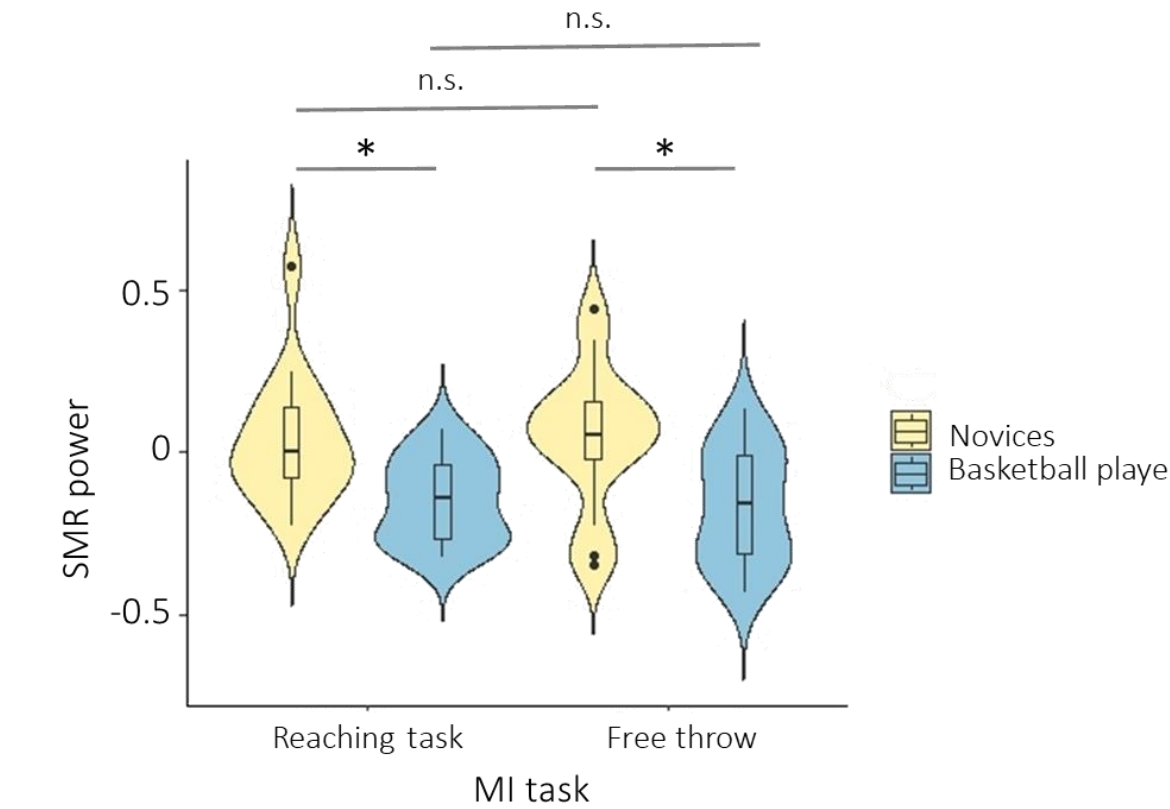
Repeated for each MI task – The order was counterbalanced between participants

Pre-processing



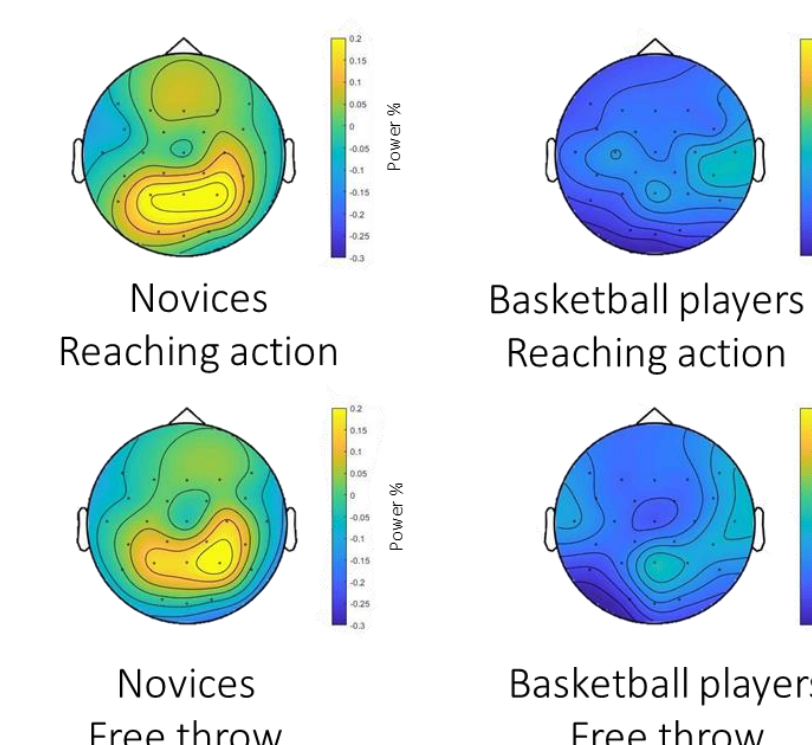
Preliminary results

Effects of the MI task & expertise on SMR-ERD

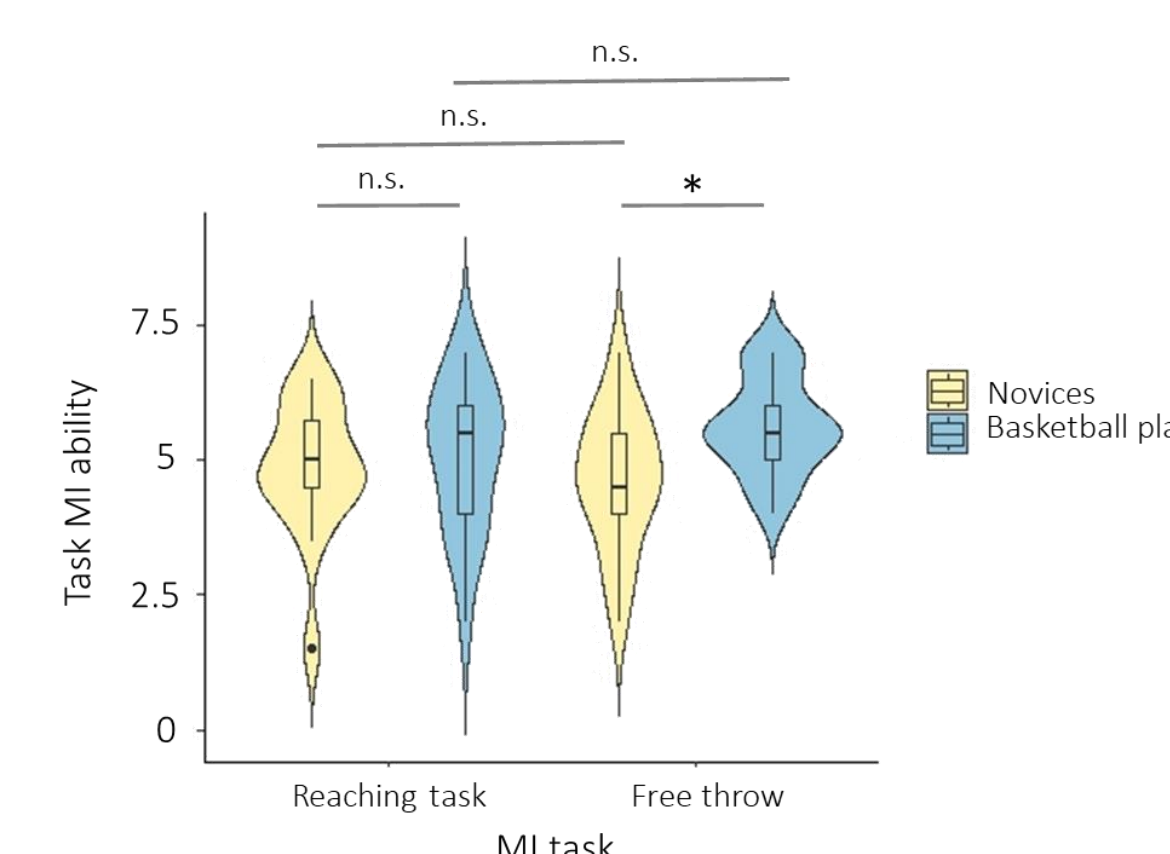


Analysis: 2-way ANOVA for repeated measures | Results: main effect of the group [F(1,29) = 11.1, p = 0.002, η²p = 0.28]

Conclusion: basketball players significantly decrease their SMR power around sensorimotor regions to a greater extent than novices; basketball players show a stronger SMR-ERD during the free-throw MI task than during the reaching action.



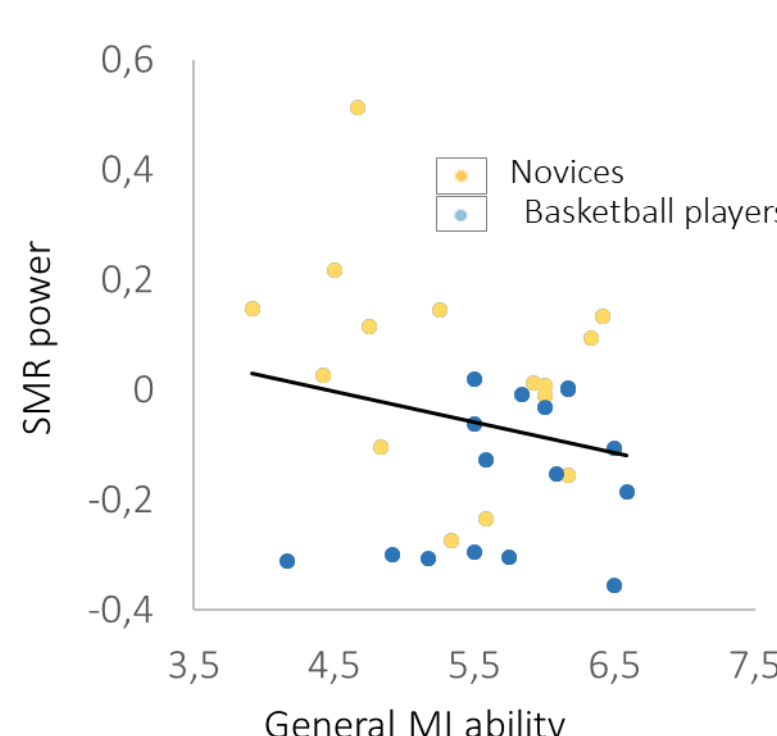
Effects of the MI task & expertise on perceived MI abilities



Analysis: 2-way ANOVA for repeated measures | Results: trend towards a main effect of the group [F(1,30) = 3.58, p = 0.068, η²p = 0.11]

Conclusion: while both groups show similar perceived general MI abilities (MIQ-3f scores; t(30)=1.477, p=0.15), the basketball players tend to report better perceived MI abilities. Post-hoc analyses reveal a significant difference between the groups for the free-throw task only.

Correlations between SMR-ERD & perceived MI abilities



Analysis: Pearson's correlation | Results: significant correlation [r=-0.16, p=0.385]

Conclusion: Perceived general MI abilities do not significantly impact SMR-ERD.

Summary

- Athletes show greater SMR-ERD than novices during MI whatever the imagined task, which suggests acquisition of "non task-specific" skills.

Discussion

- MI ability may need to be decomposed into ≠ dimensions that could correlate with SMR-ERD.
 - Further analysis will consider MI frequency of practice as responses to the Imagery Use Questionnaire [11] were recorded.
- Results go in the "historical based" or "expertise stage based" approaches direction.
 - As MI ability might only be significantly ≠ for high level athletes, further inclusion will be needed to see if SMR-ERD fluctuates according to expertise stage.

Opinions

- How do you think ERD% evolves with expertise?
- Should we be using other target metrics for BCI/NF training?
- If so, which ones and how?

References

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