TECHNISCHE UNIVERSITÄT BERLIN

Effects of Long-Term Meditation Practices on Sensorimotor Rythm-Based Brain-Computer Interface Learning

Jiang et al., Frontiers in Neuroscience, 2021

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Brain-Computer Interfacing Seminar
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Outline

1. Motivation
2. Study Design
3. Methods
4. Results
5. Conclusion
6. References

Limitations of SMR-based BCI:

- Long training times
- BCI inefficiency [Blankertz et al. 2010]
- Subject variability

→ Approaching the problem from the „brain“ side

Meditation

- Changes brain plasticity

  [Luders et al. 2009, 2013, Debarnot et al. 2014]

- Increases attention control

  [van den Hurk et al. 2010, Jha et al. 2007]

- Modulates brain rhythms

  [Halsband et al. 2009, Kerr et al. 2011a]



https://www.uclahealth.org/u-magazine/images/FallWinter11/FallWinter11-Meditation.jpg

Research Goals

Verifying that meditators perform better in SMR BCI

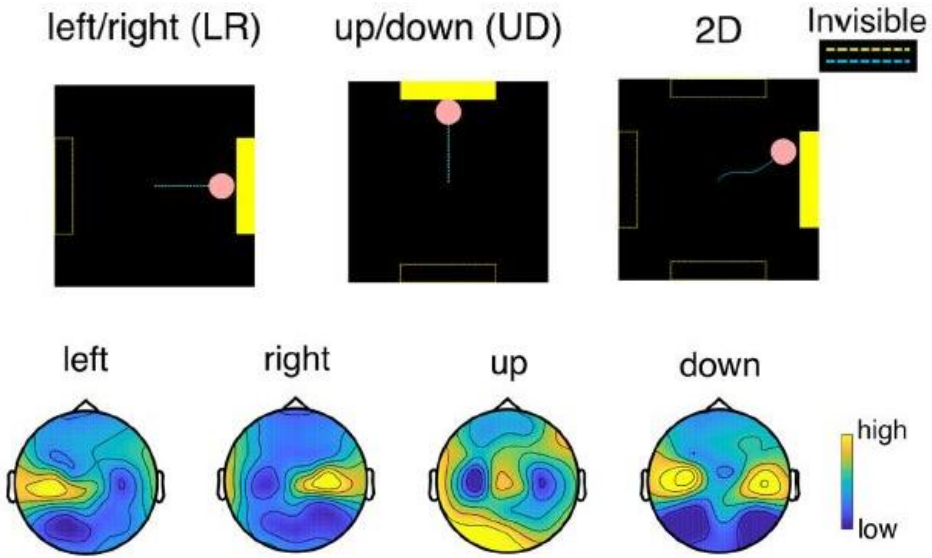
Studying the behavior in more complex 2D tasks

Examining the neurophysiological differences

Single-Blind Two Group Experiment

Meditation Group

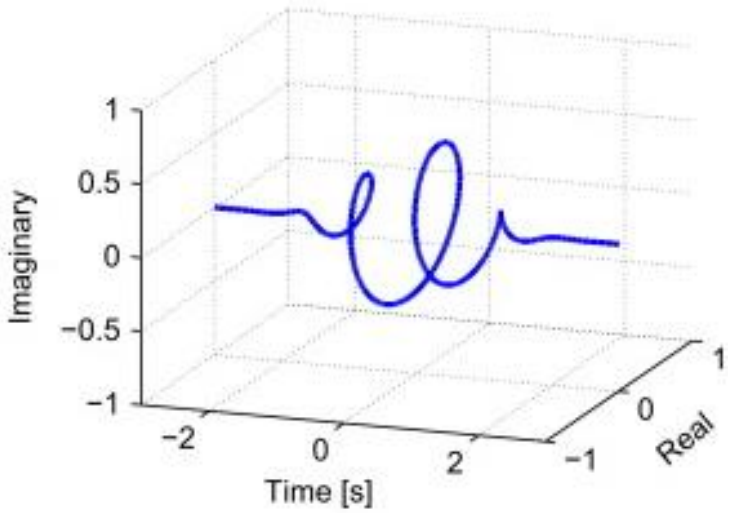
Control Group



Methods

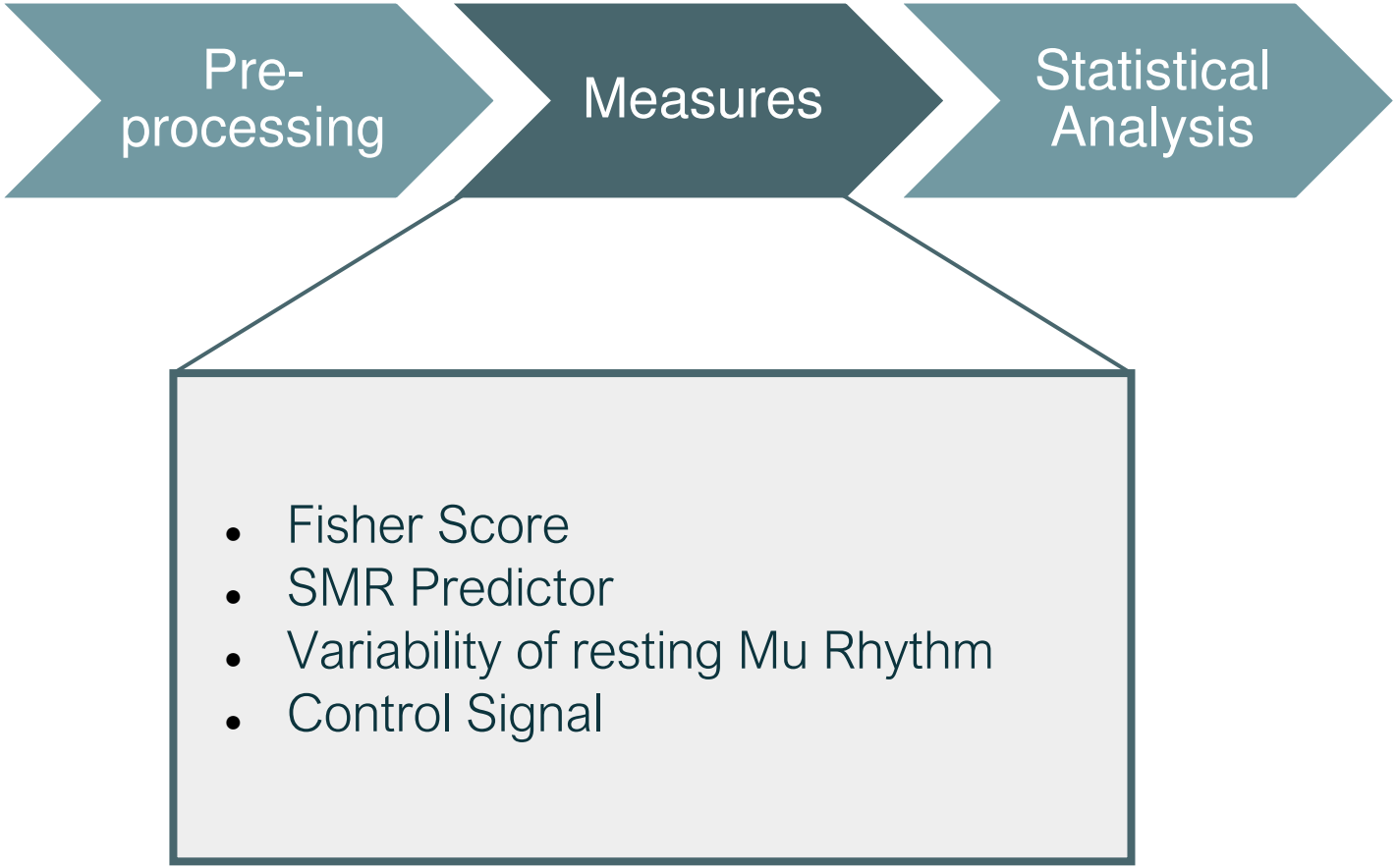
Pre-processing | Measures | Statistical Analysis

- Bandpass filtering with Hamming Window
- Downsampling to 250 Hz
- Common Average Referencing
- ICA
- Complex Morlet Wavelet Convolution



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Methods


Pre-
processing
Measures
Statistical
Analysis
Fisher Score
SMR Predictor
Variability of resting Mu Rhythm
Control Signal

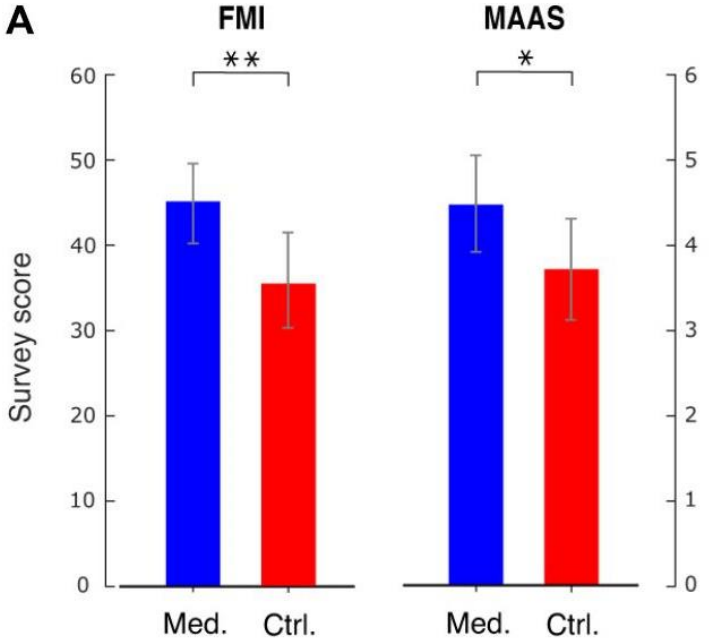
Methods

Pre-processing → Measures → Statistical Analysis

Linear mixed-effects model

- Session effect
- Group effect
- Group-session interaction effect

Performance

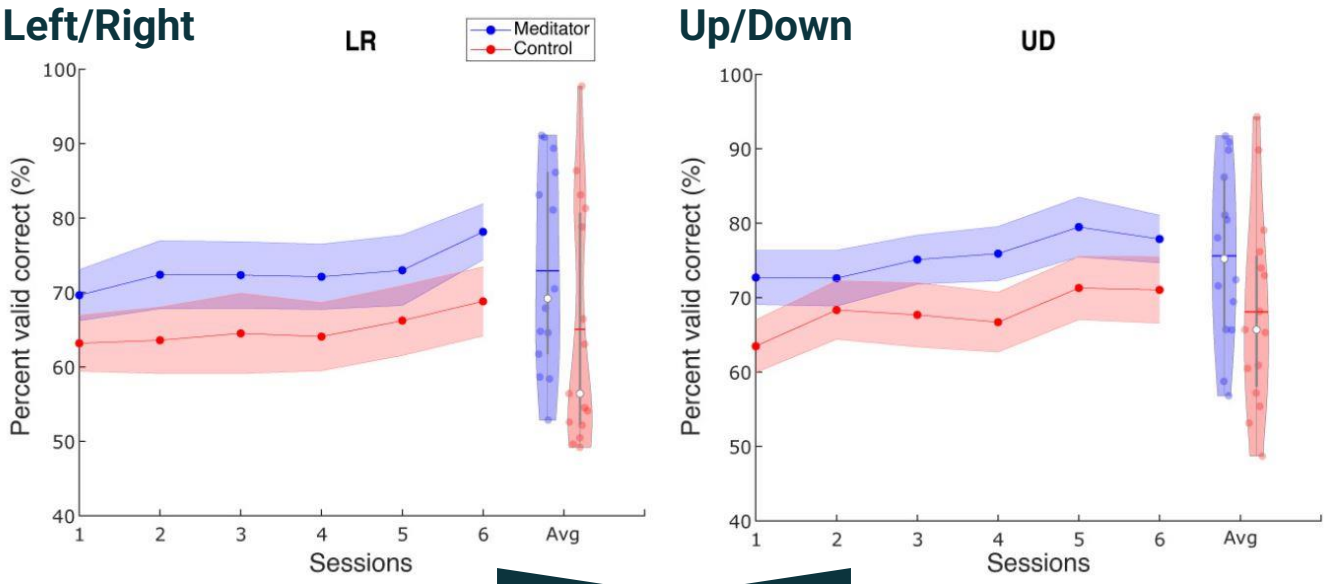


Percent Valid Correct

$$PVC = \frac{\#hit\ trials}{\#hit\ trials + \#missed\ trials}$$

Significant correlation between scores and PVC in UD task

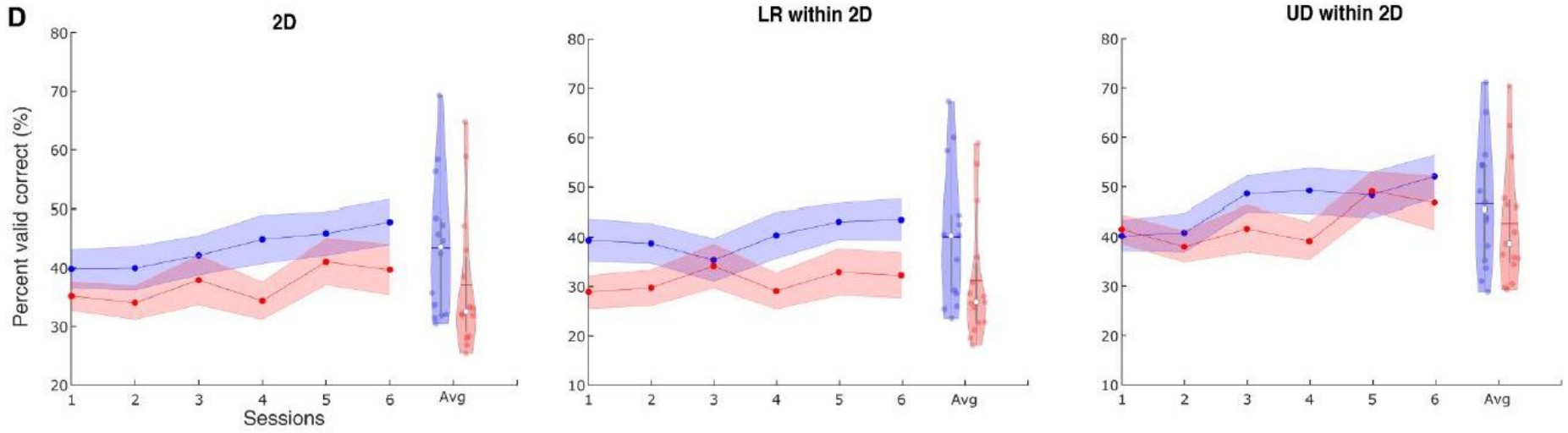
Performance



Numerically better performance

Session effect

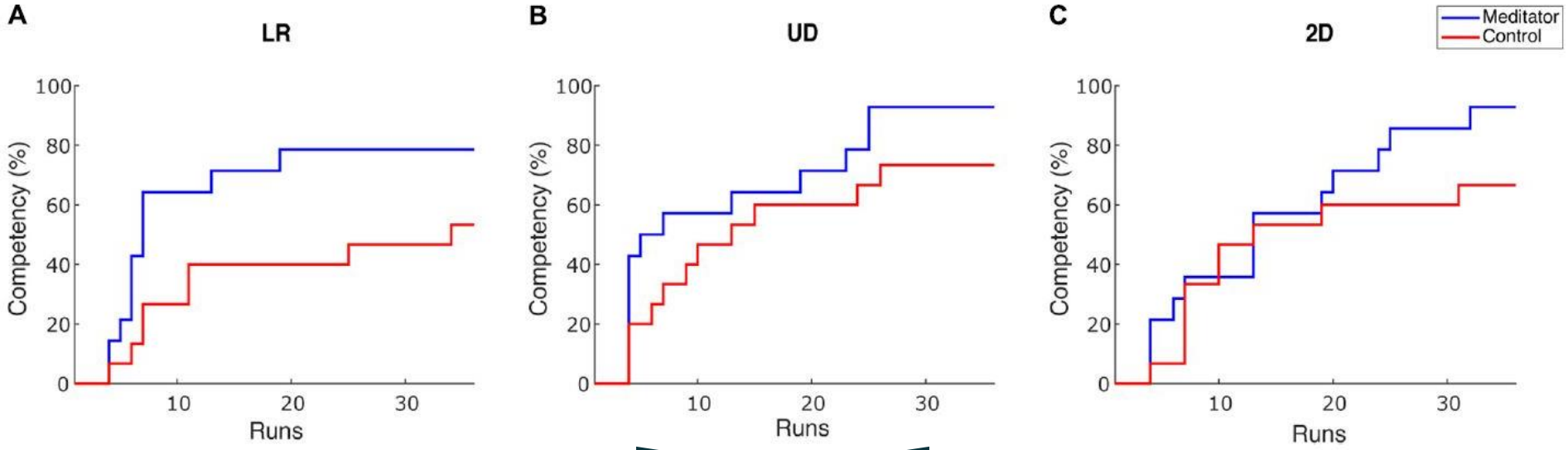
Performance



Numerically better performance

Session effect

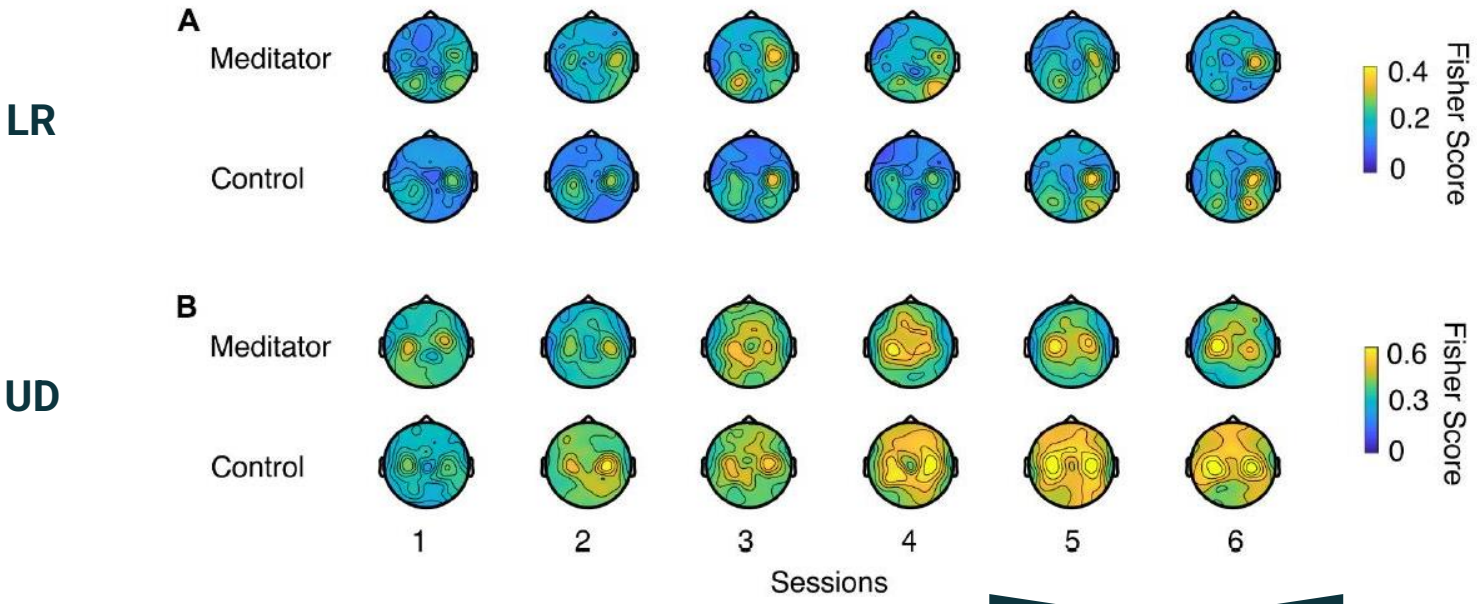
Competency



Fewer BCI inefficient subjects after 6 sessions

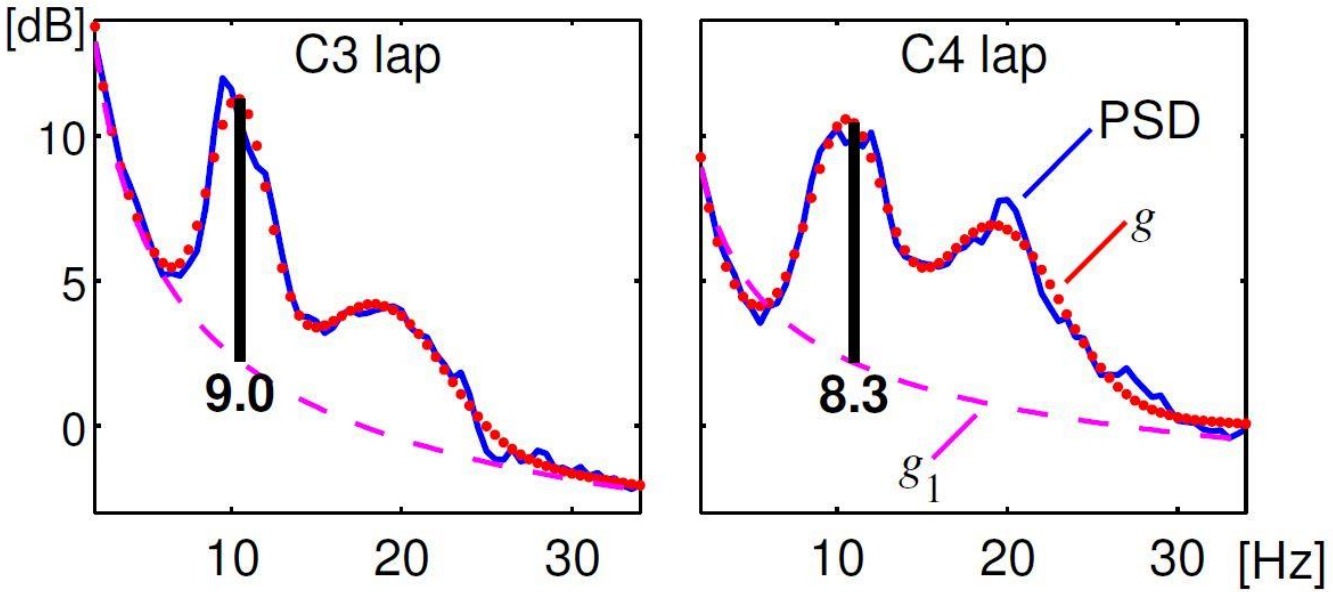
Fisher Score

$$FS = \frac{|\mu_1 - \mu_2|}{\sqrt{s_1^2 + s_2^2}}$$



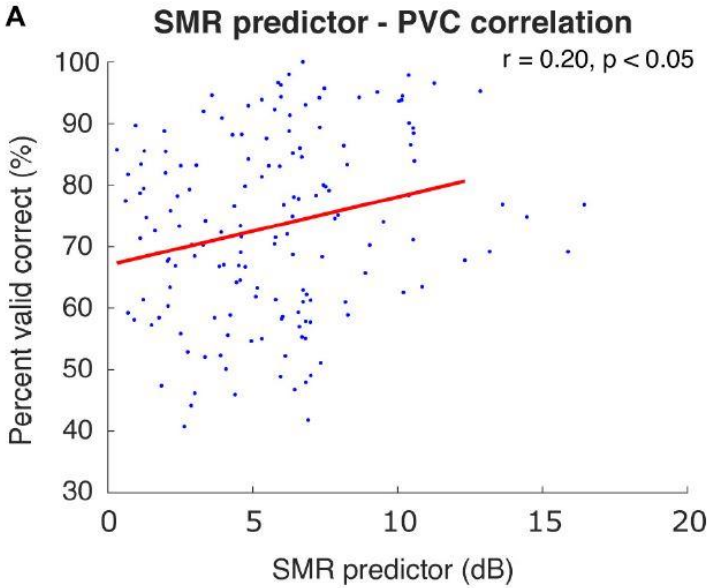
Increased contrast

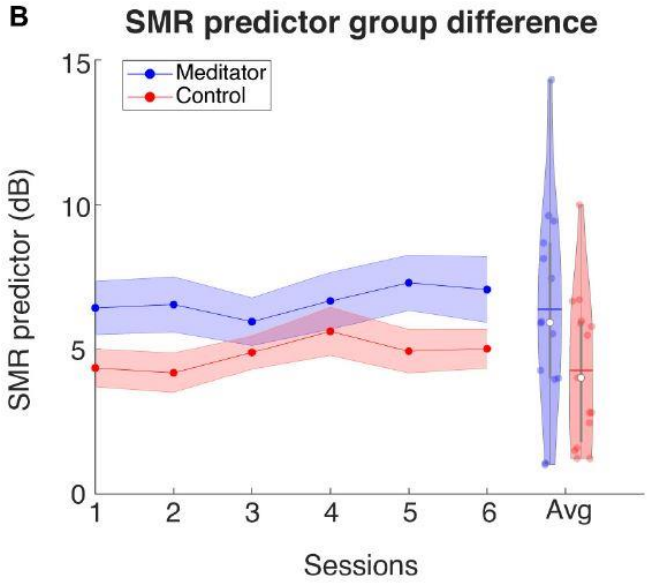
SMR Predictor [Blankertz et al. 2010]



Source: Blankertz et al. 2010

SMR Predictor [Blankertz et al. 2010]



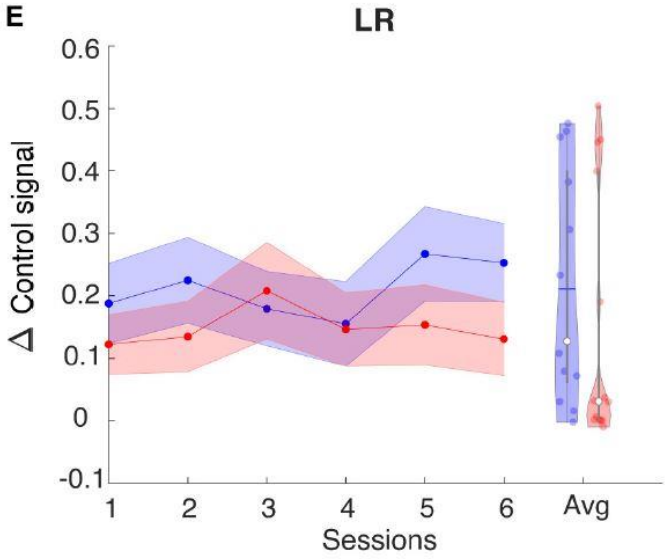


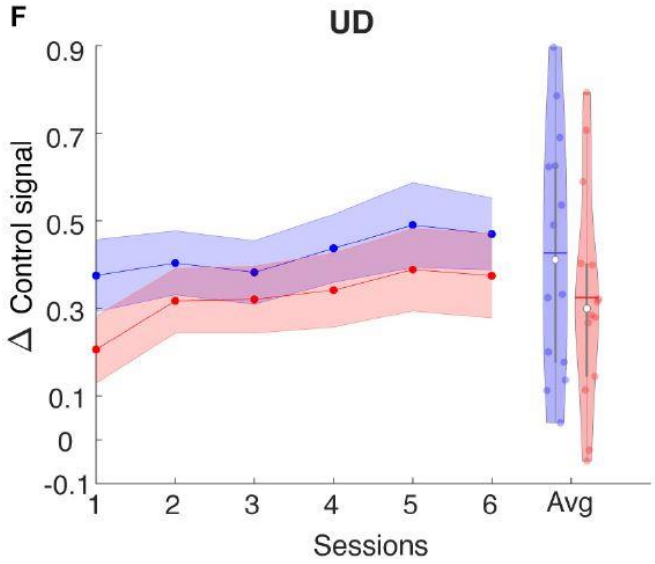
Smaller correlation

Session effect

Control Signal

$CS_{LR} = C4 - C3$ $CS_{UD} = C4 + C3$





Session effect

Conclusion

- Long-term meditation experience could influence SMR BCI in terms of the CS during task execution, SMR predictor and performance
- Meditators outperformed control group on average by 5 – 10%

→ Statistical significance mainly in learning

- Potential influences

→ Order of the tasks

→ Effect of age and sex

Further Research Questions

Investigate ability of neurotypical people to improve control

Study extent of better performance in 2D tasks

More studies & show replicability of results

References

Figures are taken from Jiang et al. 2021

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Questions?