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Physiological Relevance and Temporal Stability of Common Spatial Patterns in Motor Imagery Neurofeedback

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► **To cite this version:**

Cassandra Dumas, Claire Dussard, Nathalie George, Marie-Constance Corsi. Physiological Relevance and Temporal Stability of Common Spatial Patterns in Motor Imagery Neurofeedback. 2026 - 1st EBRAINS Student Conference on Interdisciplinary Brain Research, Mar 2026, Nice, France. ⟨hal-05567808⟩

HAL Id: hal-05567808

<https://hal.science/hal-05567808v1>

Submitted on 26 Mar 2026

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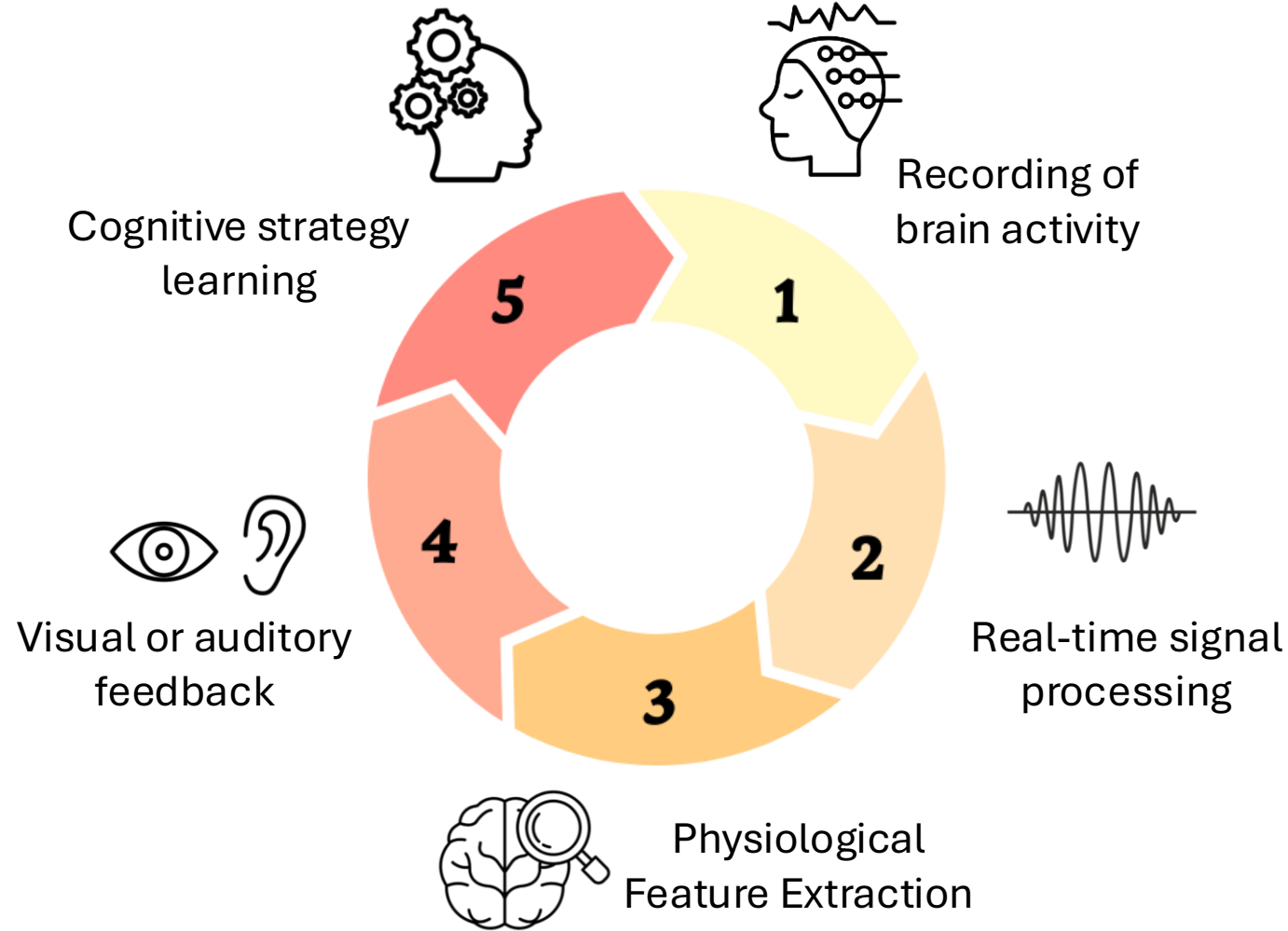
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Physiological Relevance and Temporal Stability of Common Spatial Patterns in Motor Imagery Neurofeedback

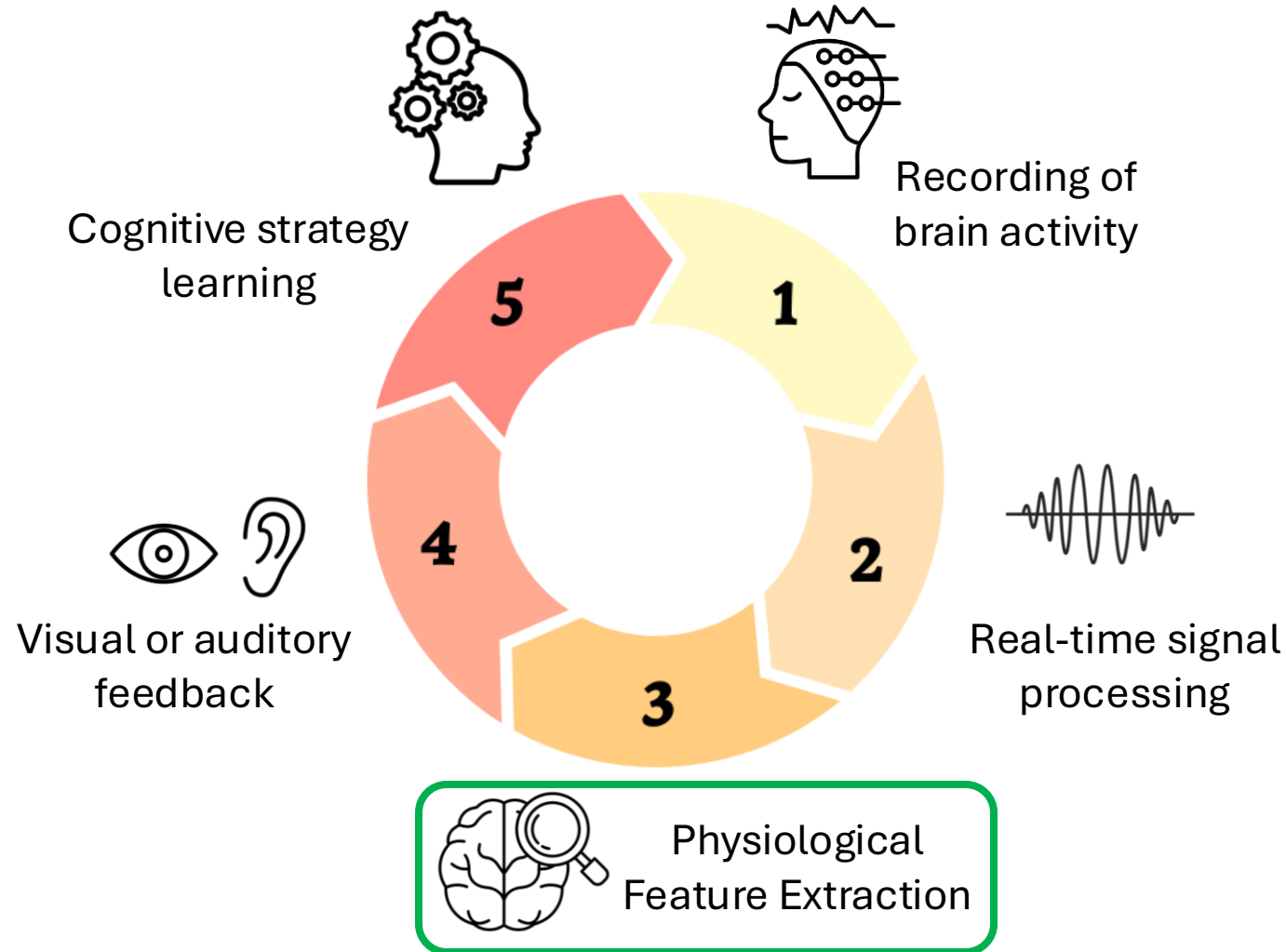
(C. Dumas, C. Dussard, N. George, M.-C. Corsi*)*

CASSANDRA DUMAS – cassandra.dumas@icm-institute.org

Neurofeedback: Principles & Limitations



Neurofeedback: Principles & Limitations



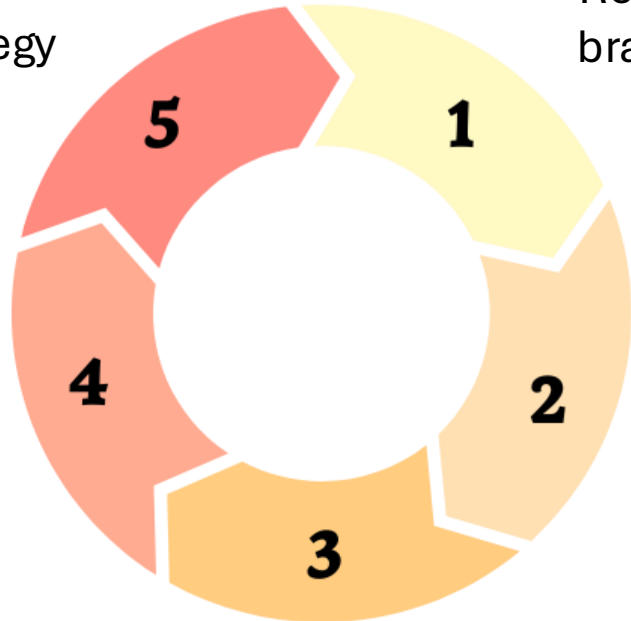
Neurofeedback: Principles & Limitations



Cognitive strategy learning



Recording of brain activity



Real-time signal processing

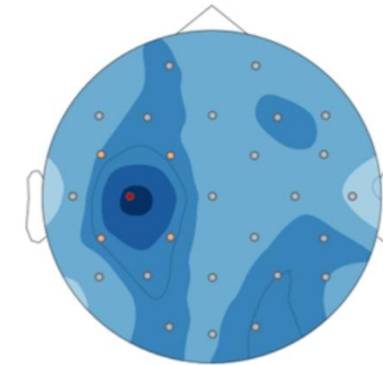


Visual or auditory feedback

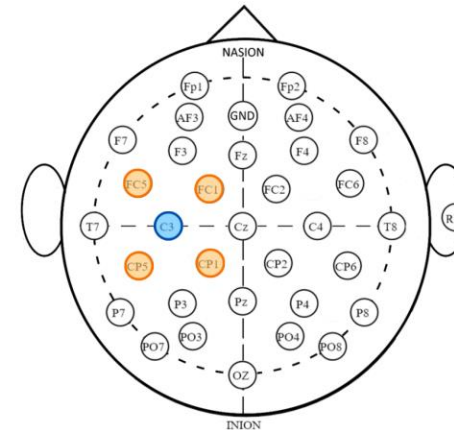
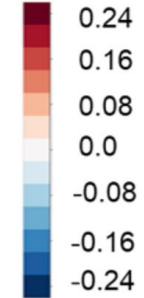


Physiological Feature Extraction

Right Hand Motor Imagery (8-30Hz)

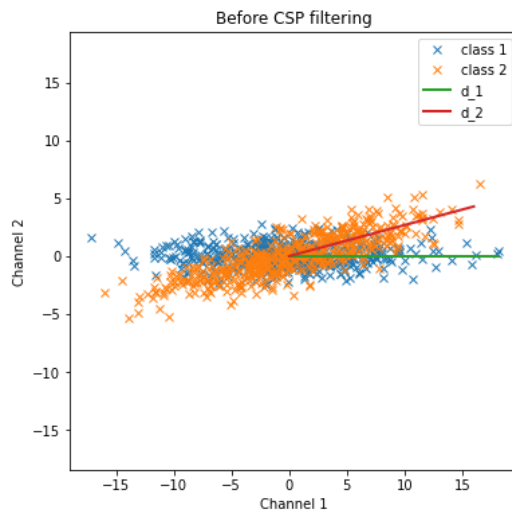
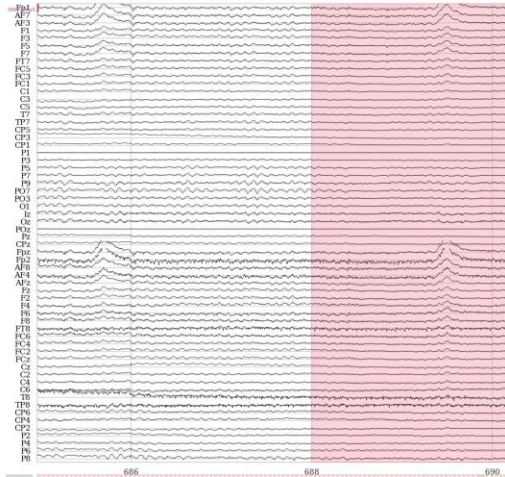


ERD/ERS (dB)

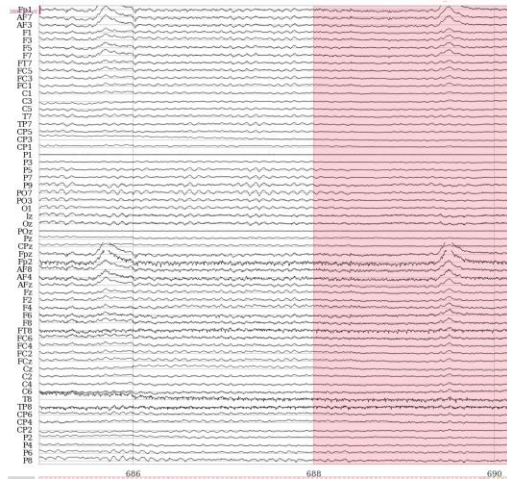


Surface Laplacian

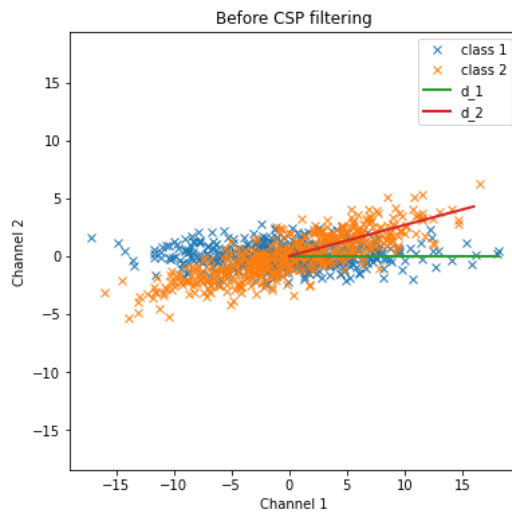
CSPs: Spatial Filters for Classification



CSPs: Spatial Filters for Classification



Find a set of spatial filters that effectively differentiate between two classes of signals



CSP in neurofeedback



How Are CSPs Used in Neurofeedback?

- A **single CSP** is selected to extract subject-specific motor-related activity and drive the feedback signal
- This filter acts as an **informed Laplacian**

CSP in neurofeedback



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Known Limitations of CSPs

- CSP reliability is affected by **noise, artifacts**, and the **inherent variability of EEG data** [Yong *et al*, 2008]
- Difficulties in identifying a physiologically relevant pattern
 - *Lioi et al*, 2020: fallback to **standard Laplacian** when CSP fails to capture expected motor activity (based on expert inspection)

CSP in neurofeedback



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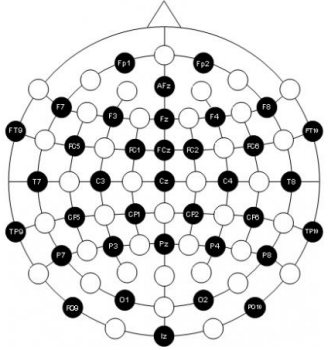
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How can we ensure a CSP selection that is both reliable and physiologically meaningful?

Study Design: Pre-recorded Neurofeedback EEG

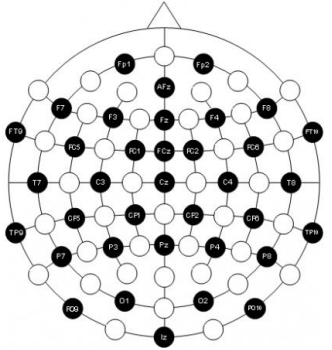


Participants : 20 (10 ♀)
Age (mean ± sd) : 28.5 ± 6.8
Channels (10-20) : 32
Sampling rate : 1kHz



Virtual hand (**HAND**)

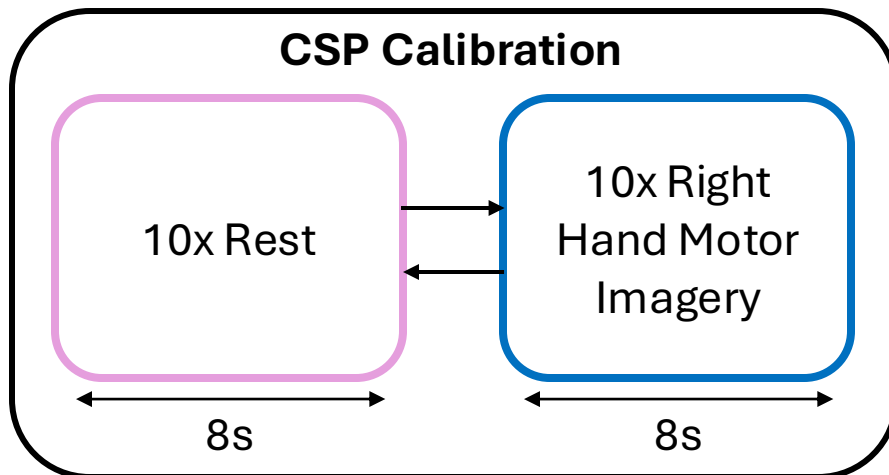
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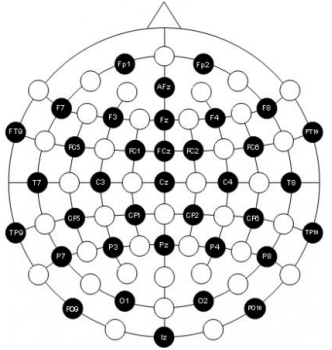
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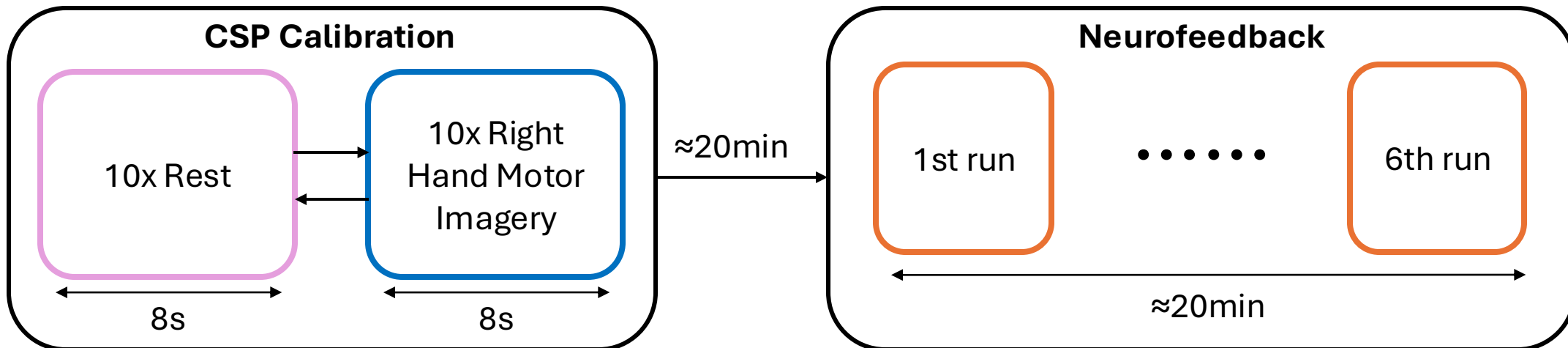
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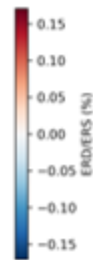
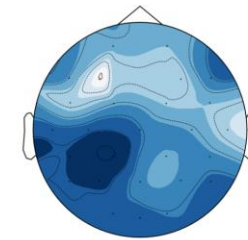
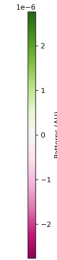


Neurofeedback Performance:
Median power in 8-30Hz band on a
Laplacian C3 relative to reference level

CSP Selection & Analysis



Question: *Which CSP best reflects motor imagery-related activity?*



Standard CSP Selection



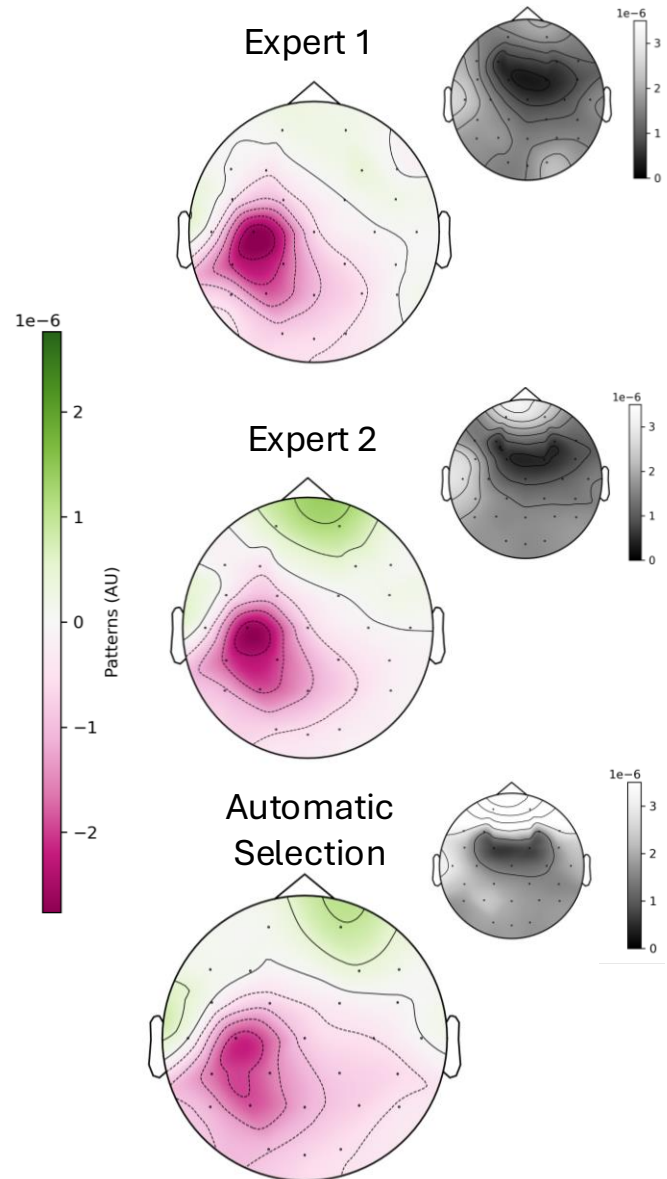
Maximize Contrast
between Conditions



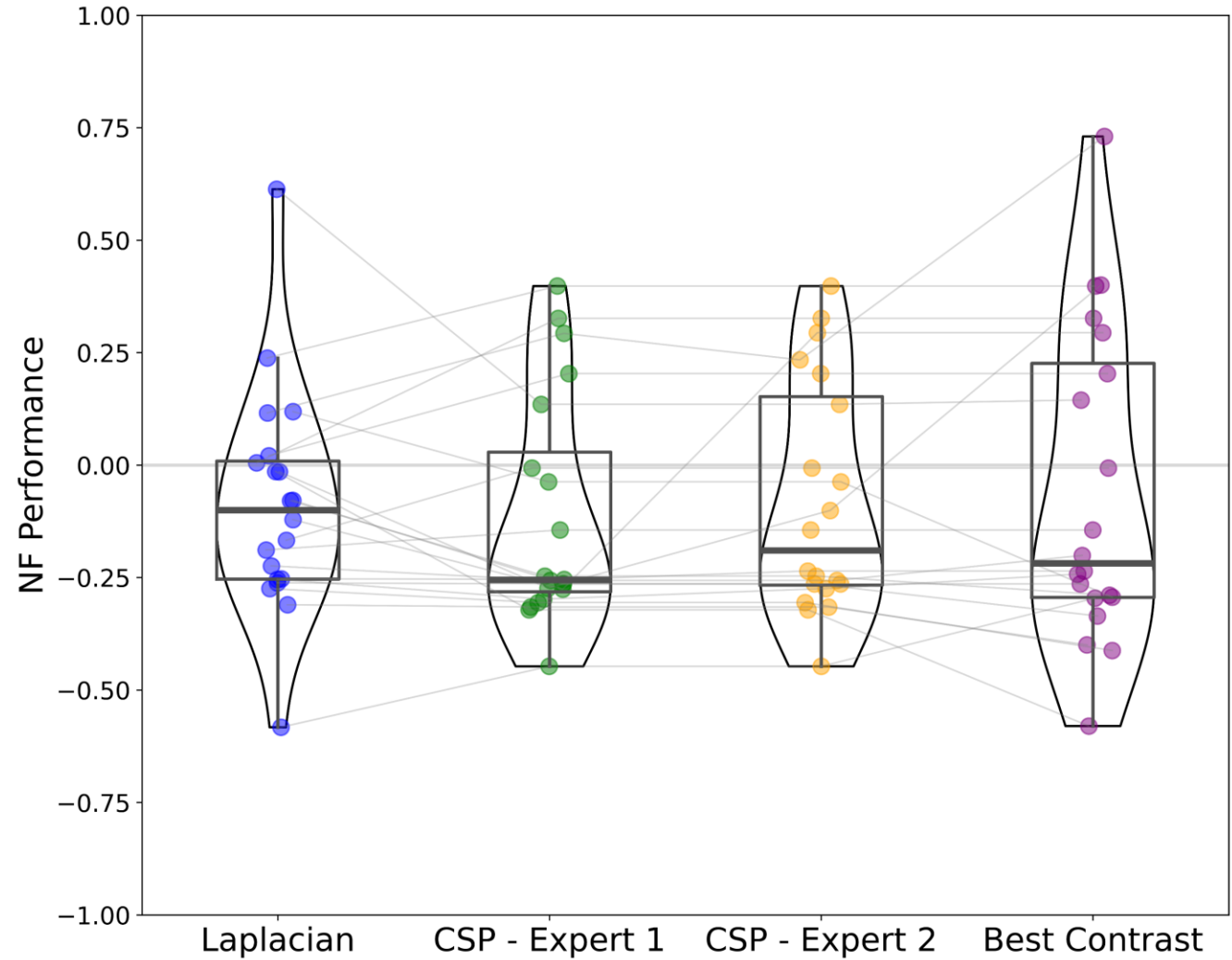
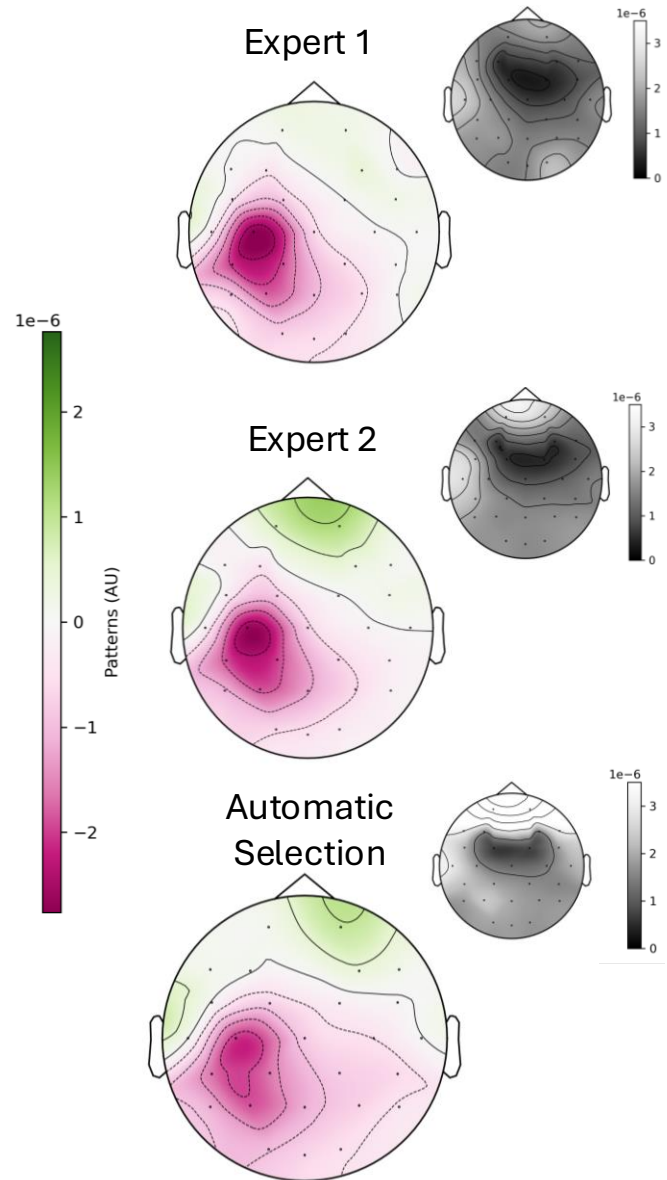
Analysis

- Grand average of selected CSPs
- NF Performance

CSP Selection & Neurofeedback Performance



CSP Selection & Neurofeedback Performance



Take-Home Messages

- Theoretically CSPs appear promising for **physiologically personalized neurofeedback**
- A **real-time validation** is still required
- CSP selection remains variable → need to assess **inter-expert variability**

Thank you!

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Nathalie George



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