



Exploiting brain critical dynamics to inform Brain-Computer Interfaces performance

Marie-Constance Corsi, Pierpaolo Sorrentino, Denis P Schwartz, Nathalie George, Laurent Hugueville, Ari E Kahn, Sophie Dupont, Danielle S Bassett, Viktor K Jirsa, Fabrizio de Vico Fallani

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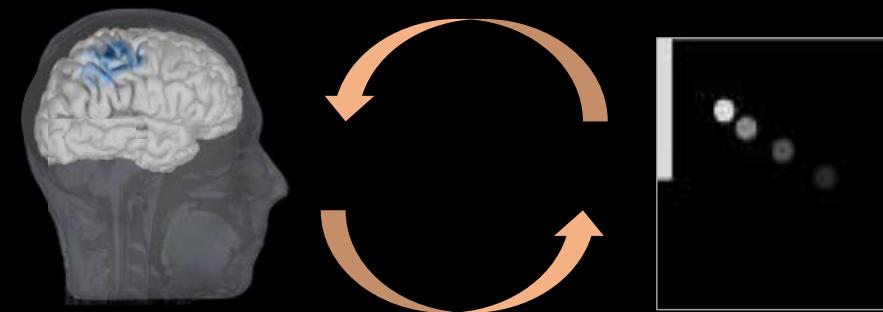
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Exploiting brain critical dynamics to inform Brain-Computer Interfaces performance

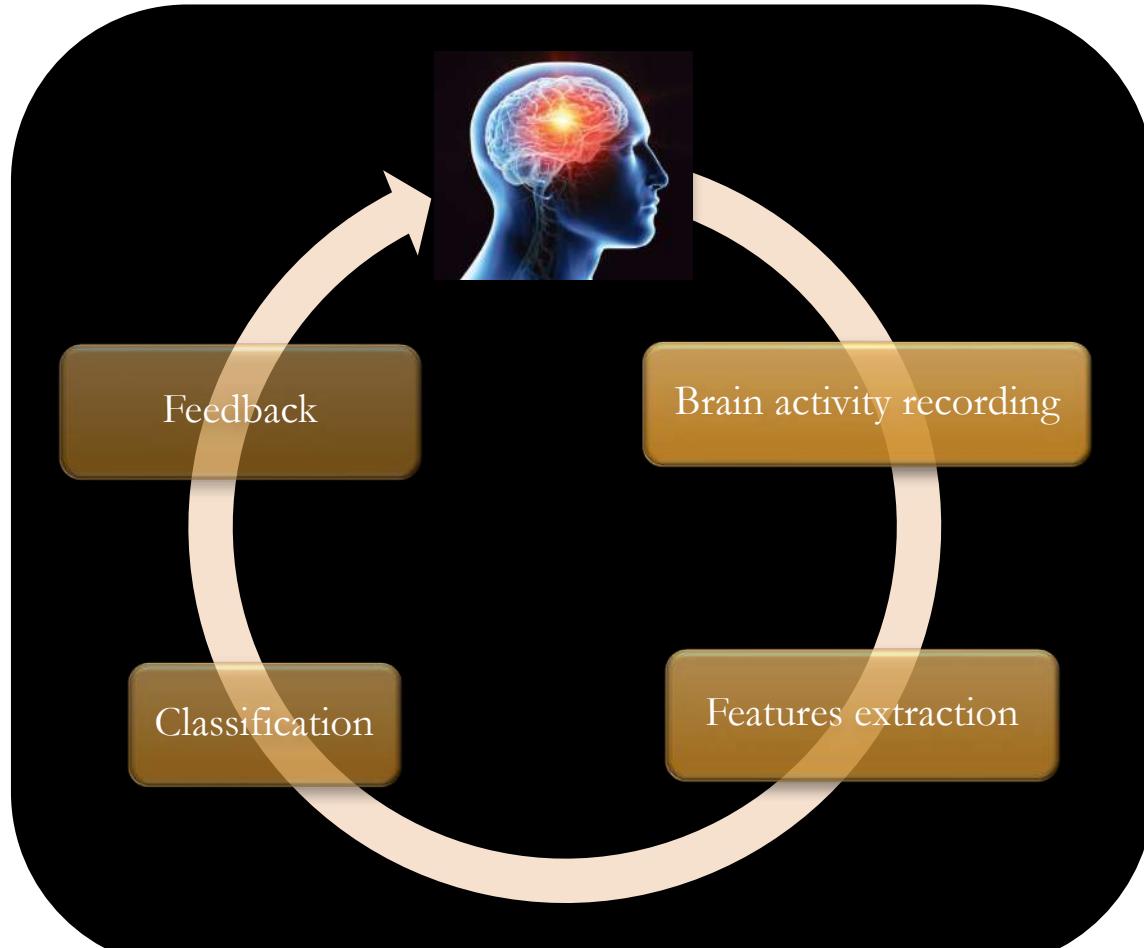


MC Corsi*, P Sorrentino*, D Schwartz, N George, L Hugueville, A E. Kahn, S Dupont, D S. Bassett,

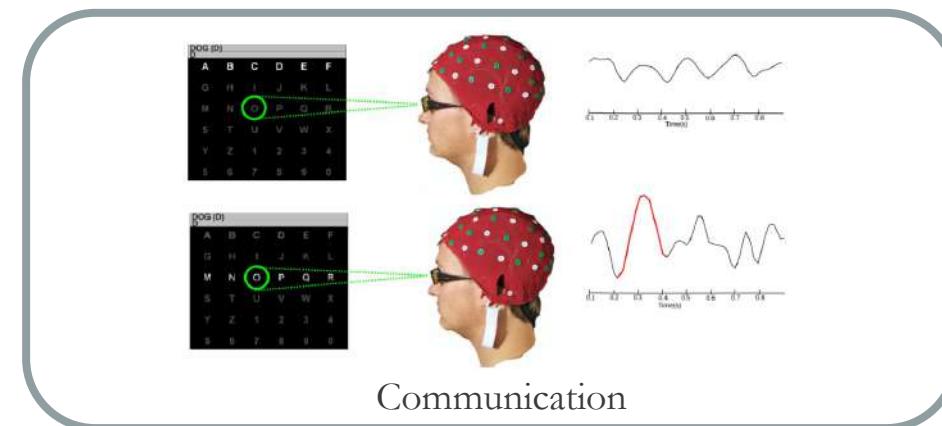
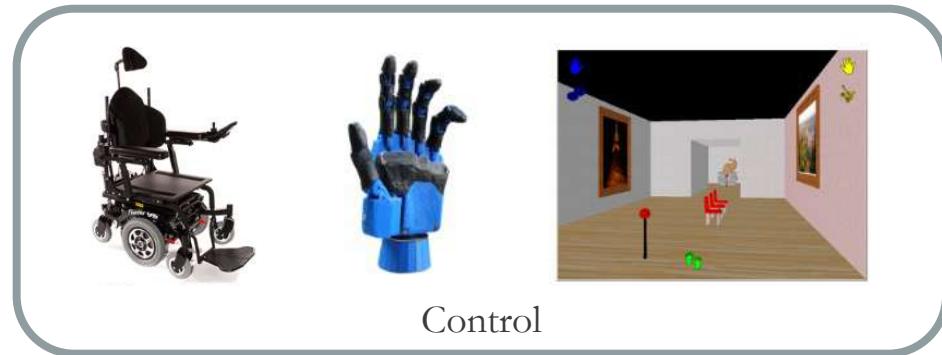
V Jirsa**, F De Vico Fallani**

Brain-Computer Interface (BCI) – behind the magic...

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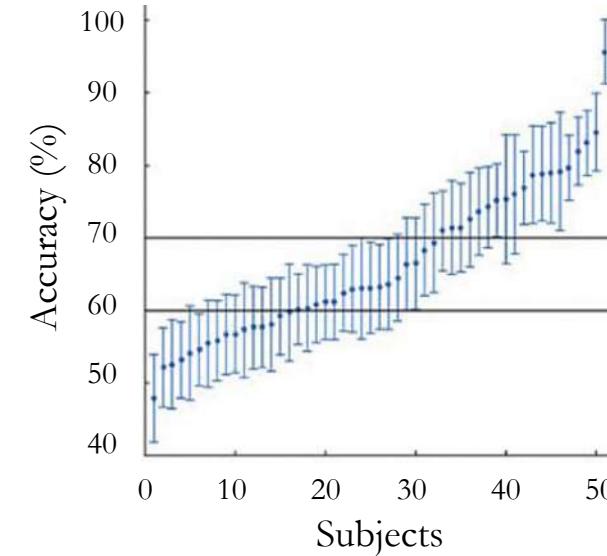
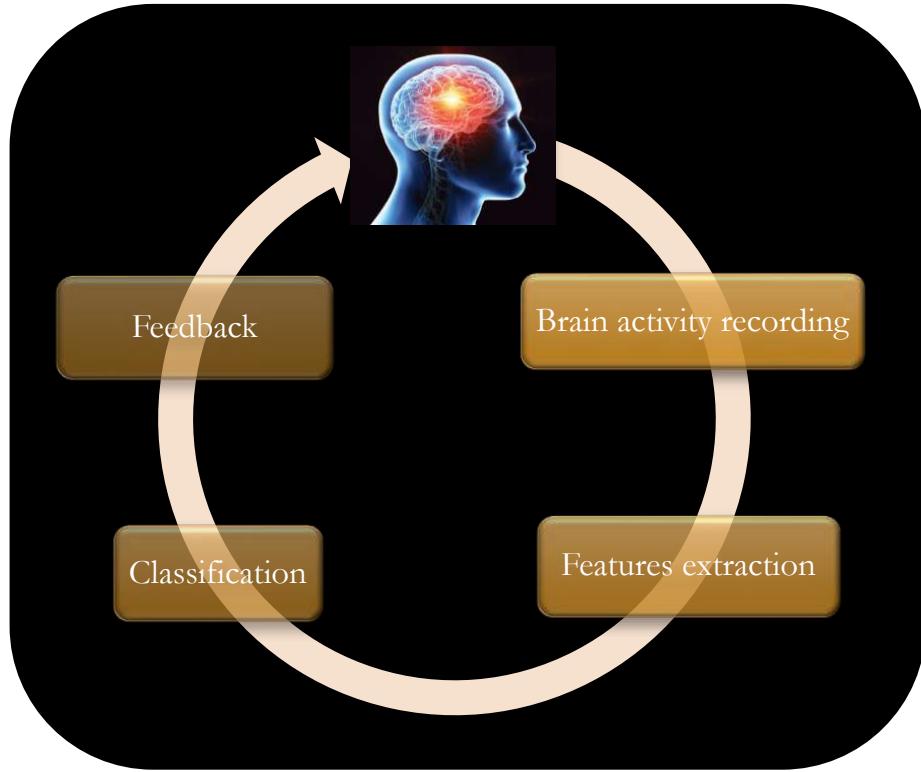
BCI framework



Adapted from (Lotte et al, 2015)

Brain-Computer Interface (BCI) – current challenges

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Adapted from (Ahn & Jun, 2015)

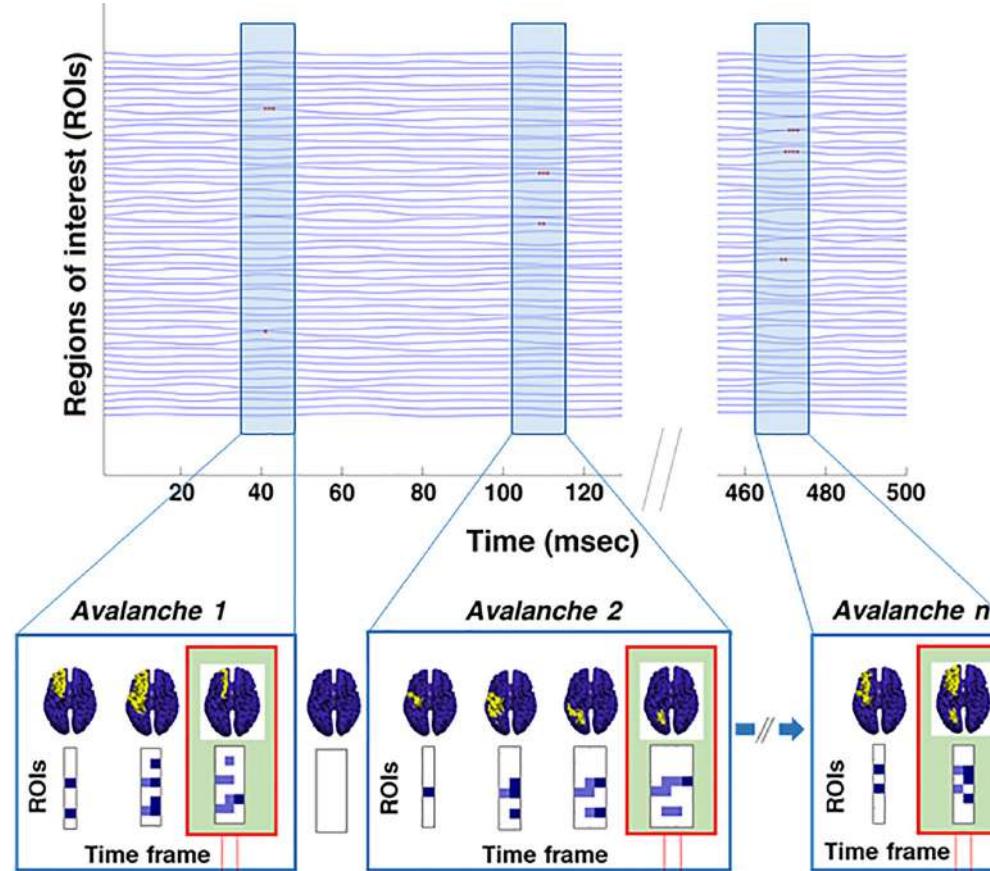
Problem:

Current BCIs fail to detect the mental intentions in ~30% of users – **BCI inefficiency** (Thompson, 2018)
⇒ Rely on local measurements of the brain activity

Capturing fast, non-linear brain dynamics

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Neuronal avalanches: bursts of enhanced activity observed across neuroimaging modalities



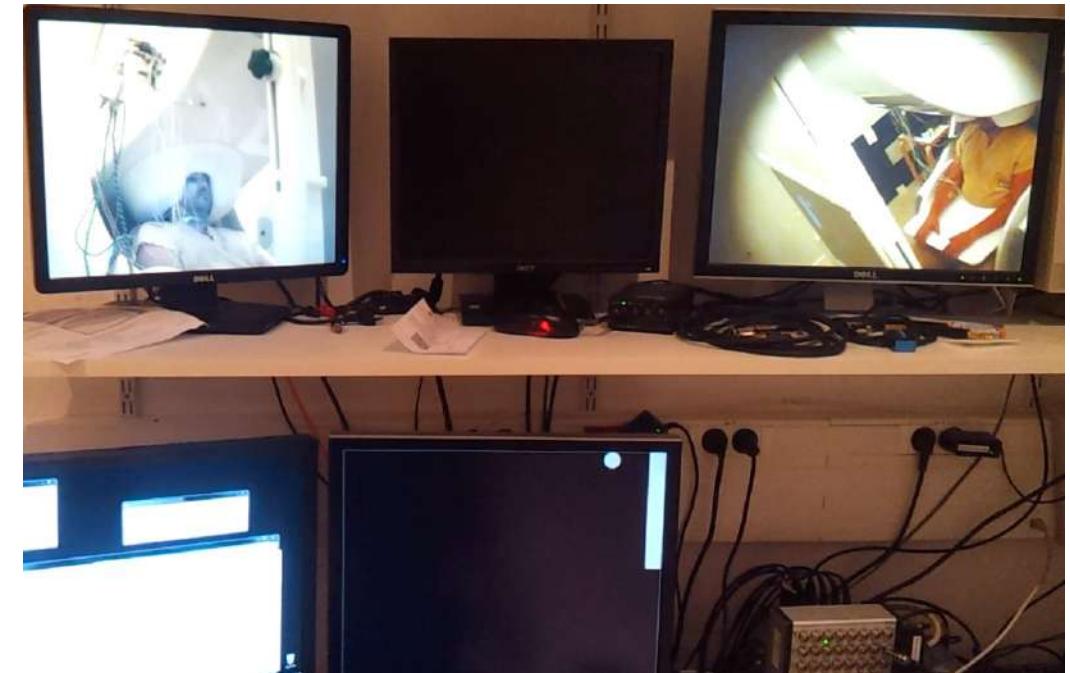
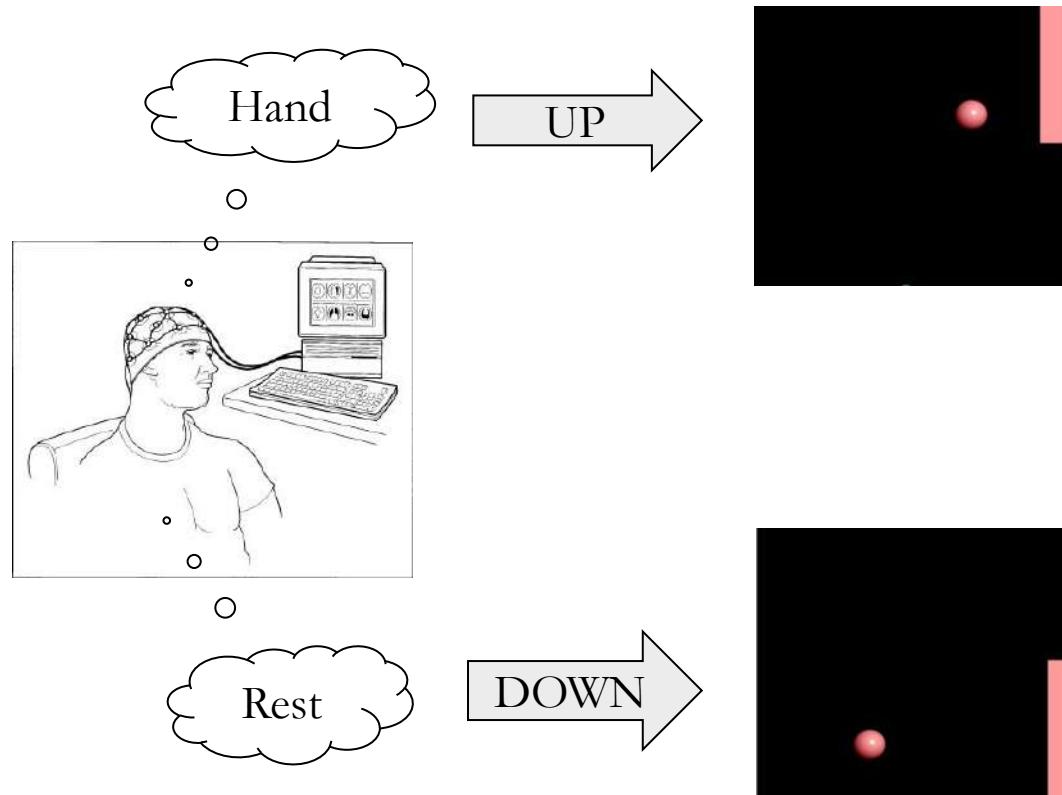
Adapted from [Polverino et al, Neurology, 2022]

Hypothesis:

The neuronal avalanches could spread differently according to the task & provide original markers of BCI performance.

BCI experiment

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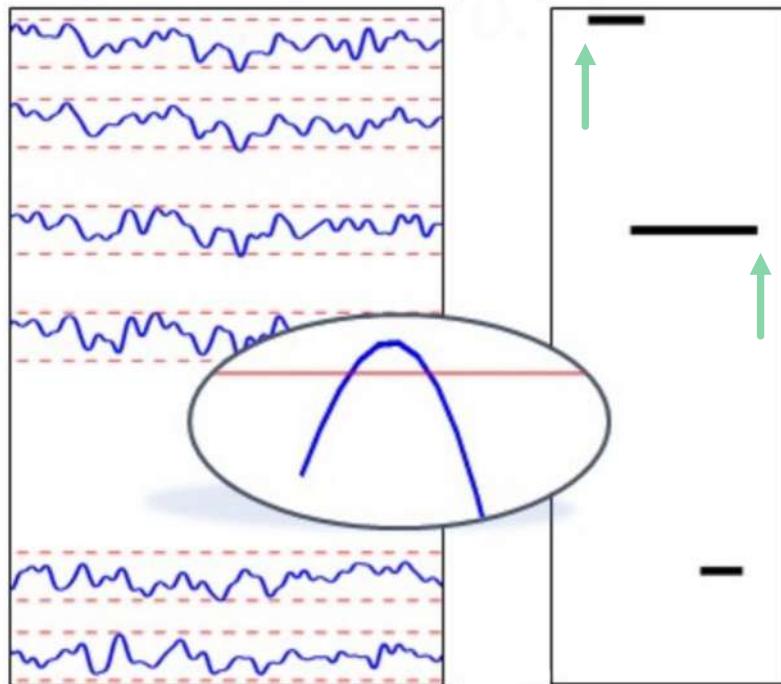
For a complete description of the protocol and the dataset, please refer to [Corsi et al, NeuroImage, 2020]

Objective:

Tracking the dynamical features related to motor imagery as compared to rest

Differences in transition probabilities discriminate mental states

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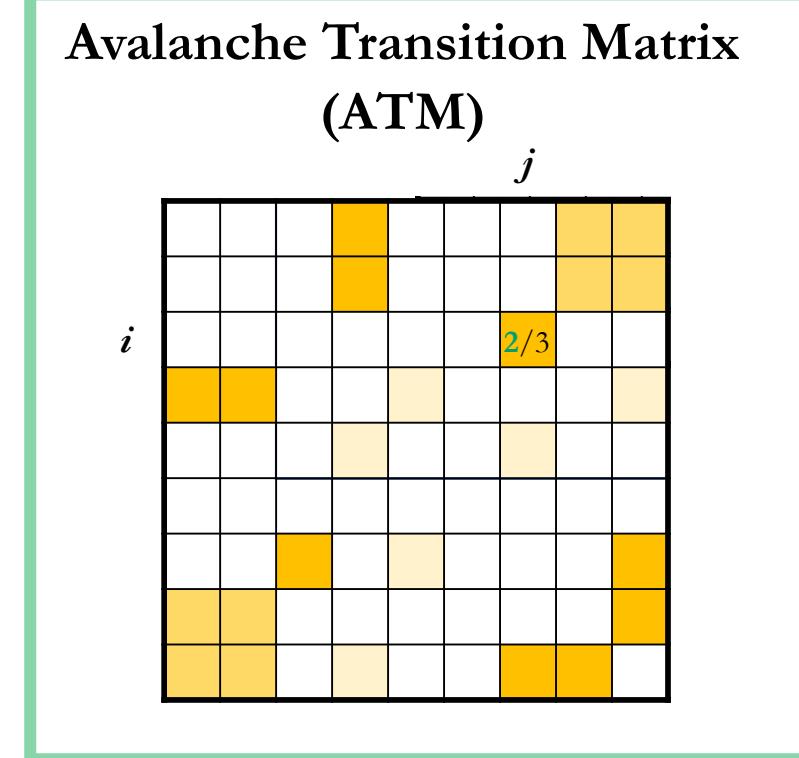
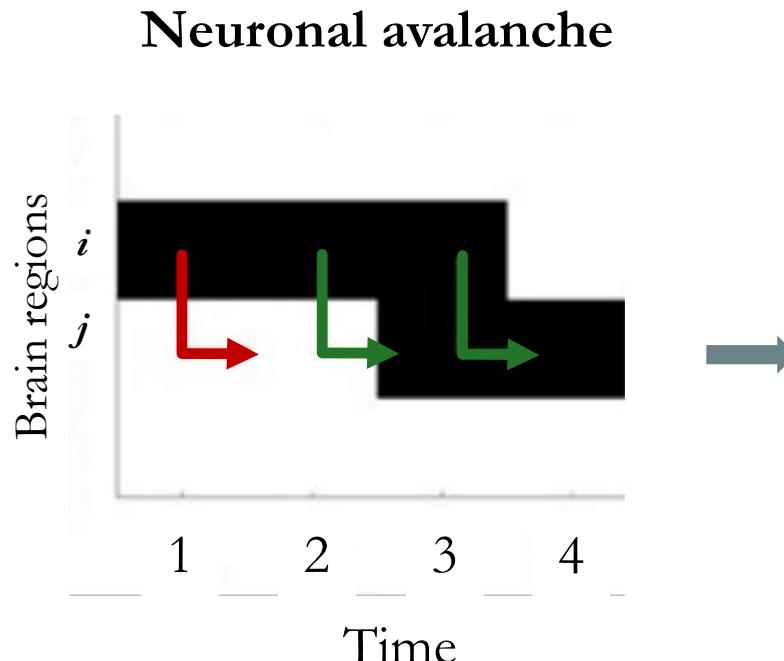
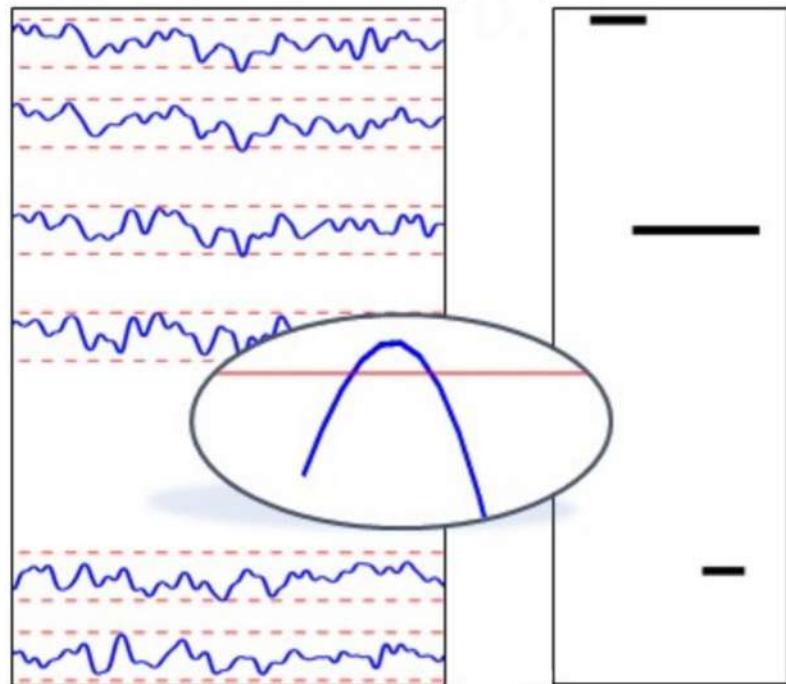


Adapted from [Sorrentino et al, eLife, 2021]



Differences in transition probabilities discriminate mental states

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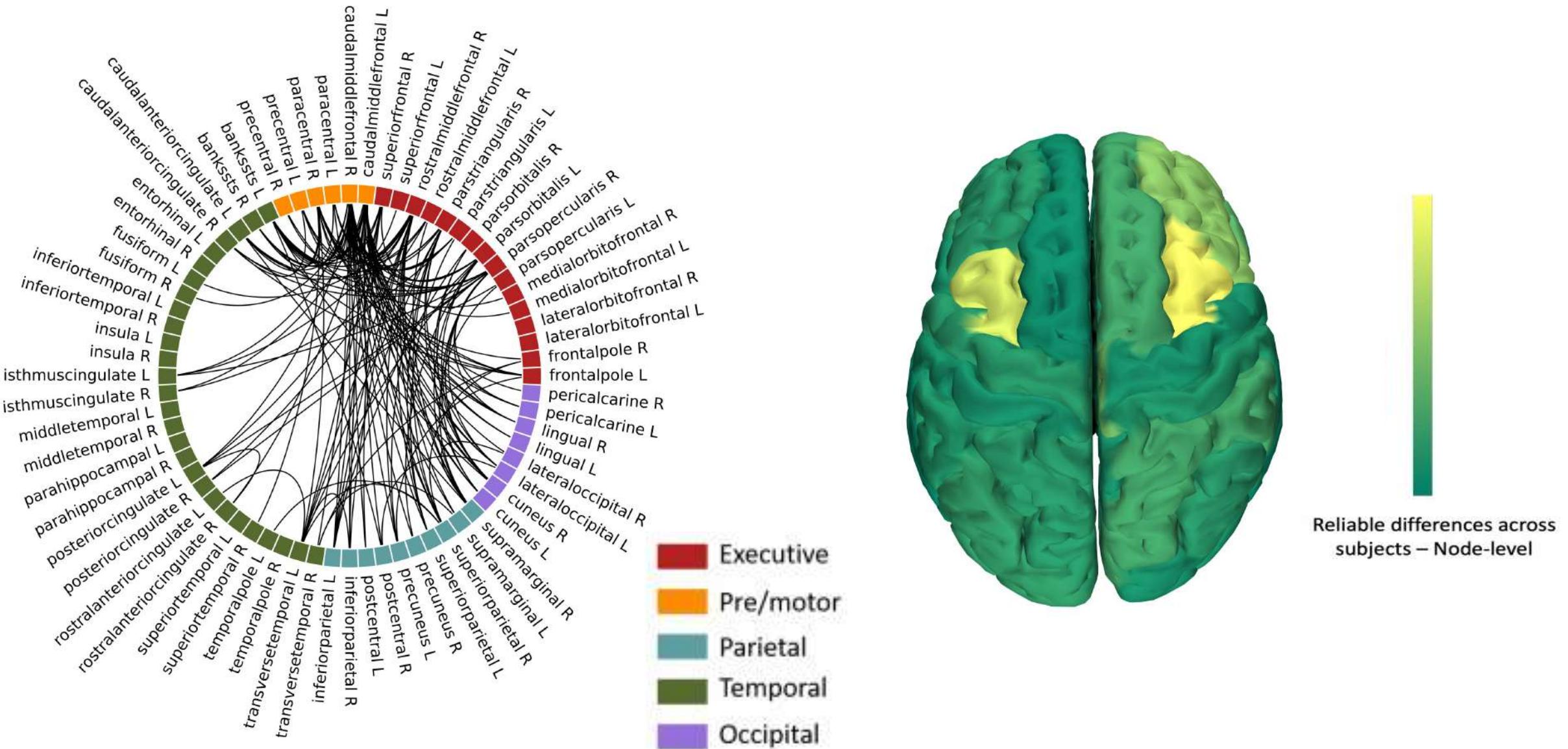


Adapted from [Sorrentino et al, eLife, 2021]

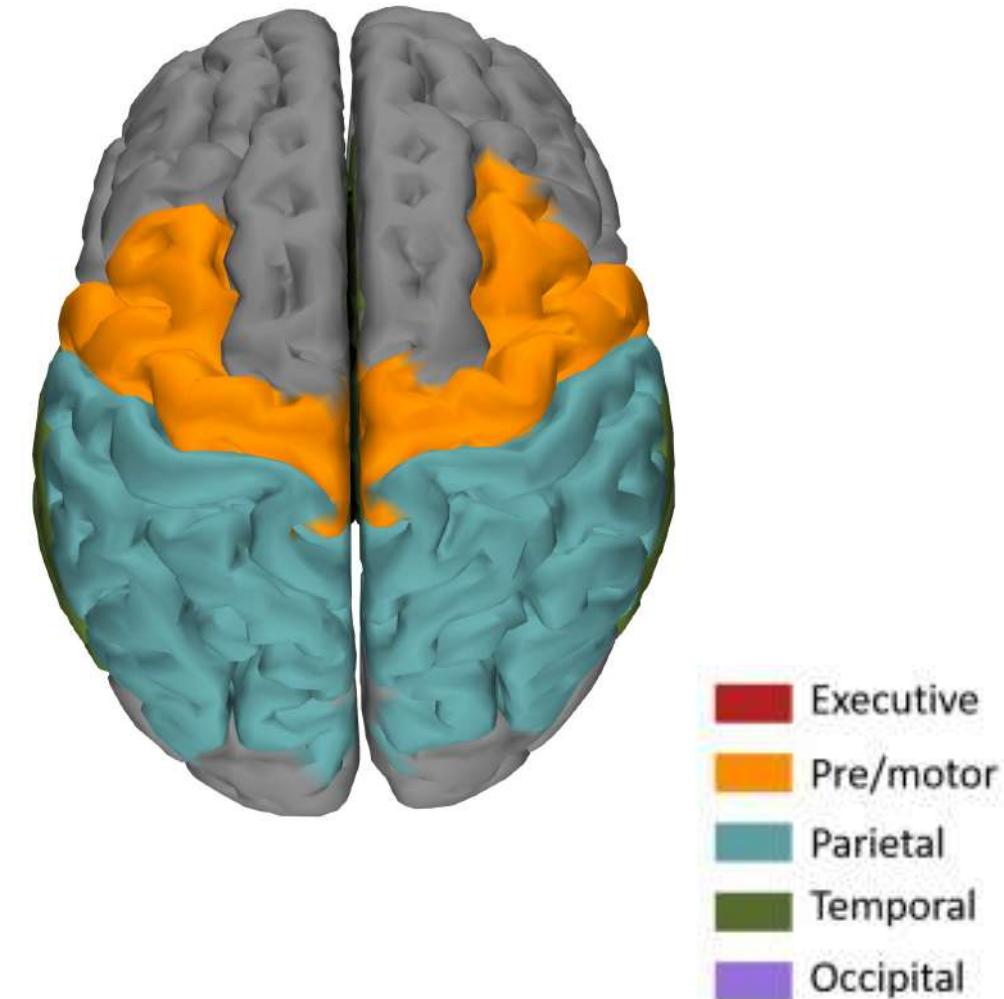
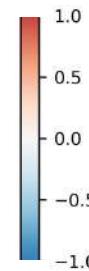
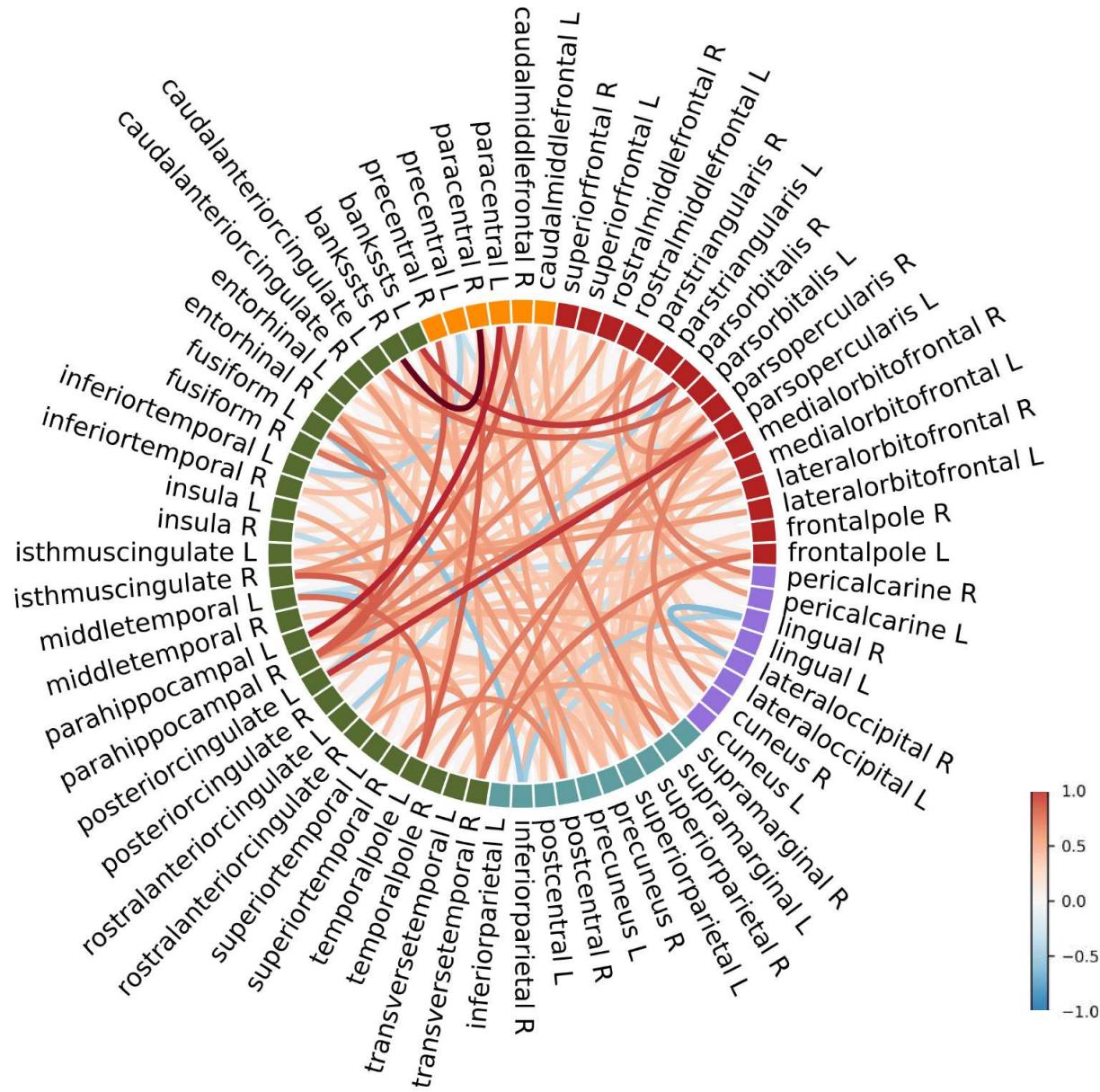


Differences in transition probabilities discriminate mental states

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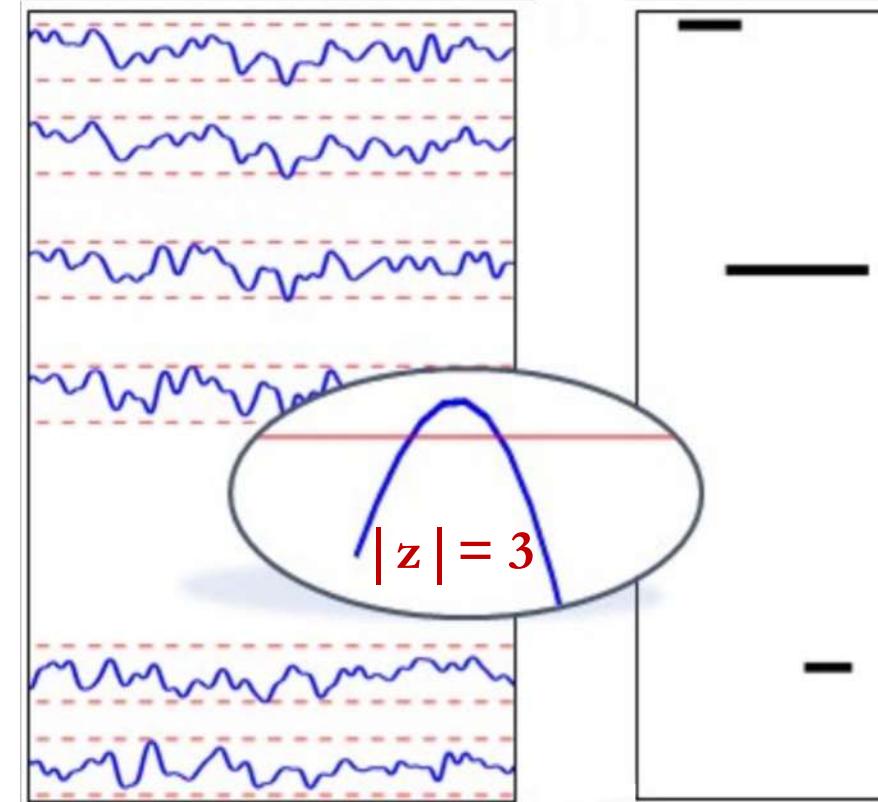


Differences in transition probabilities relate to BCI scores



Reliable functional information of task performance retrieval

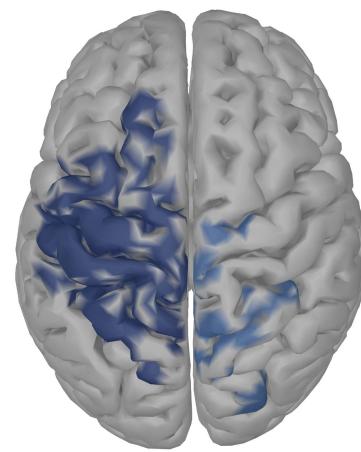
- Meaningful information communication among regions on the large-scale & aperiodic and scale-free perturbation



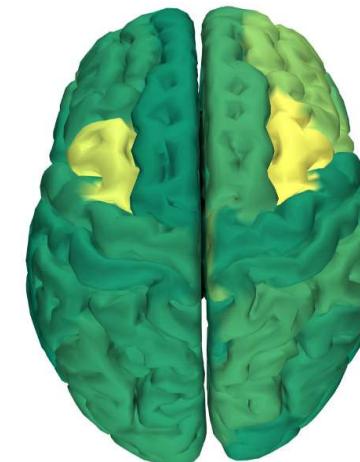
⇒ Focusing on higher-order perturbations to capture functionally-relevant processes & reliable information

Reliable functional information of task performance retrieval

- Meaningful information communication among regions on the large-scale & aperiodic and scale-free perturbation
- Building innovative BCI protocols



Power spectra
significant at **group** level



Neuronal avalanches
significant at **individual** level



⇒ Tracking changes in perturbation spreading while performing different tasks via the avalanches transition matrices

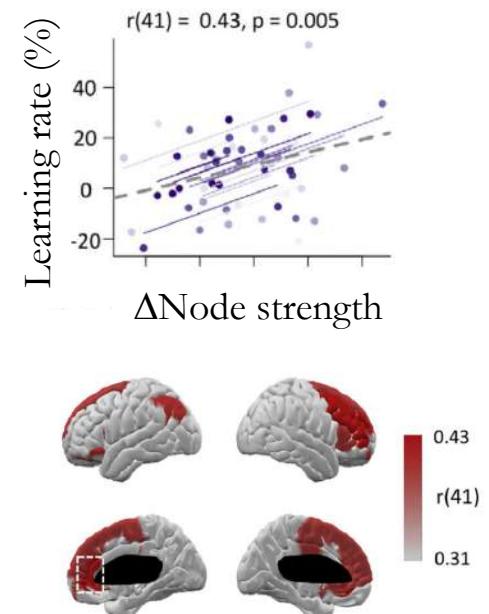
Reliable functional information of task performance retrieval

- Meaningful information communication among regions on the large-scale & aperiodic and scale-free perturbation
- Building innovative BCI protocols

Markers of BCI performance

- Current predictors of BCI
 - Local measurements – power spectra (Ahn et al, 2015)
 - Time-averaged interactions (Sugata et al, 2014)
 - Brain networks metrics [Corsi et al, NeuroImage 2020; Corsi et al, JNE 2021]
- Spreading of neuronal avalanches
 - Patterns behaviorally meaningful (Chialvo et al, 2010)
 - Computational fast marker

} Replicability?
} Online implementation?



Acknowledgements

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Interested in this study?

Scan the QR code to get access to the associated preprint!



[mccorsi/NeuronalAvalanches4BCI](https://github.com/mccorsi/NeuronalAvalanches4BCI)

Thank you for your attention!



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