



Investigating the cognitive functions of sleep and its spatio-temporal features: data analysis and simulations

HBP Summit 2021, Chiara De Luca

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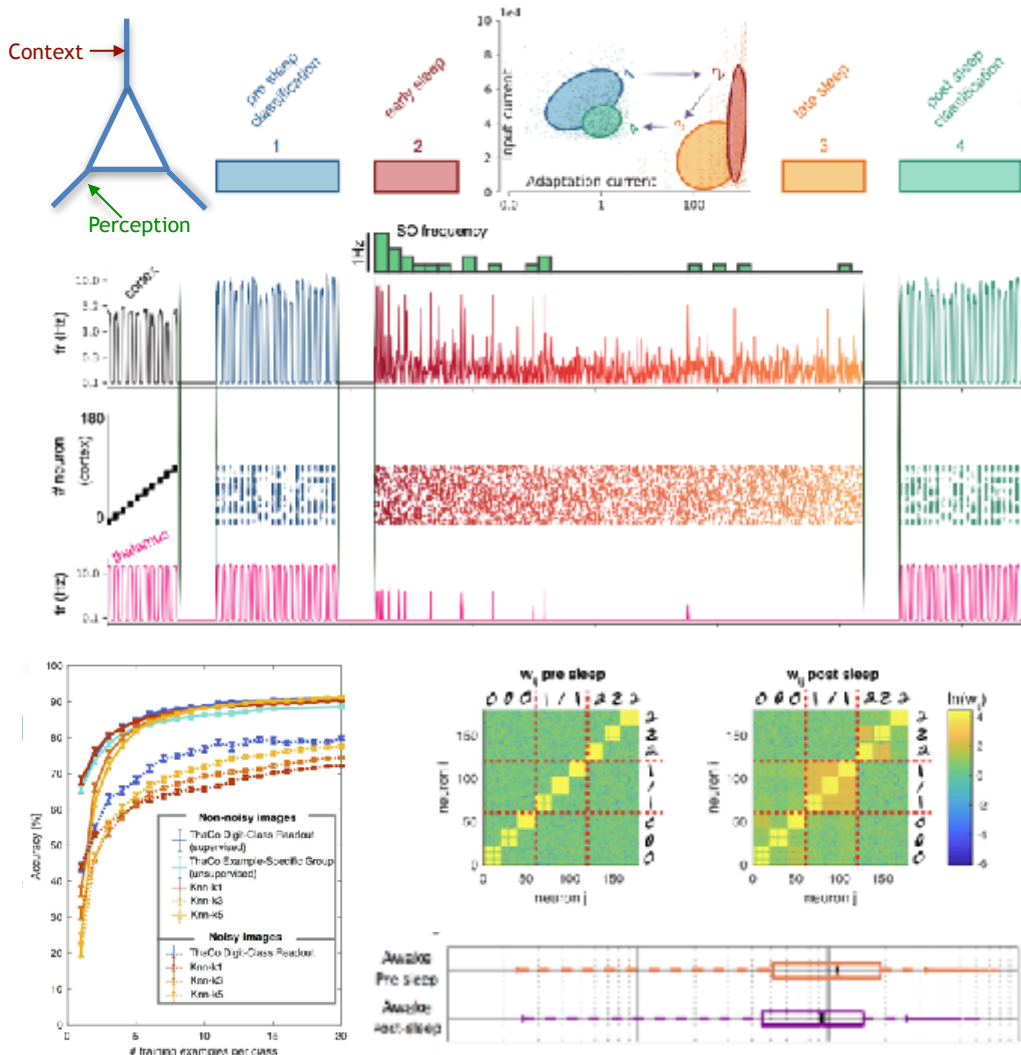
On behalf of: Cristiano Capone, Bruno Golosio, Giulia De Bonis, Elena Pastorelli, Francesco Simula, Irene Bernava, Cosimo Lupo, Leonardo Tonielli, Robin Gutzen, Arnau Manasanch Berengué, Giovanni Stegel, Gianmarco Tiddia, Francesco Resta, Anna Letizia Allegra Mascaro, Maria V Sanchez-Vives, Francesco Saverio Pavone, Michael Denker, Pier Stanislao Paolucci.

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Take-home message

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- Aim: understanding brain states and their cognitive features.
- Improvement of experimental techniques and of new neural network simulation tools towards a coherent understanding of high-level cognitive functions during wakefulness and sleep.
- Two complementary approaches: **data-inspired** and **data-driven** models carrying out cognitive tasks while expressing realistic brain dynamics in different states:
 - Implementation of **data-inspired spiking network simulations** starting from a theoretical framework.
 - Thalamo-cortical spiking model capable of incremental learning and deep sleep.
 - Implementation of **data-constrained mean field model**.
 - Parameters **inferred** from experimental data through an inner (**likelihood** maximization) and outer (*a posteriori* experimental/simulated data comparison) loop.
 - Fast mean field model of the whole hemisphere of mouse.



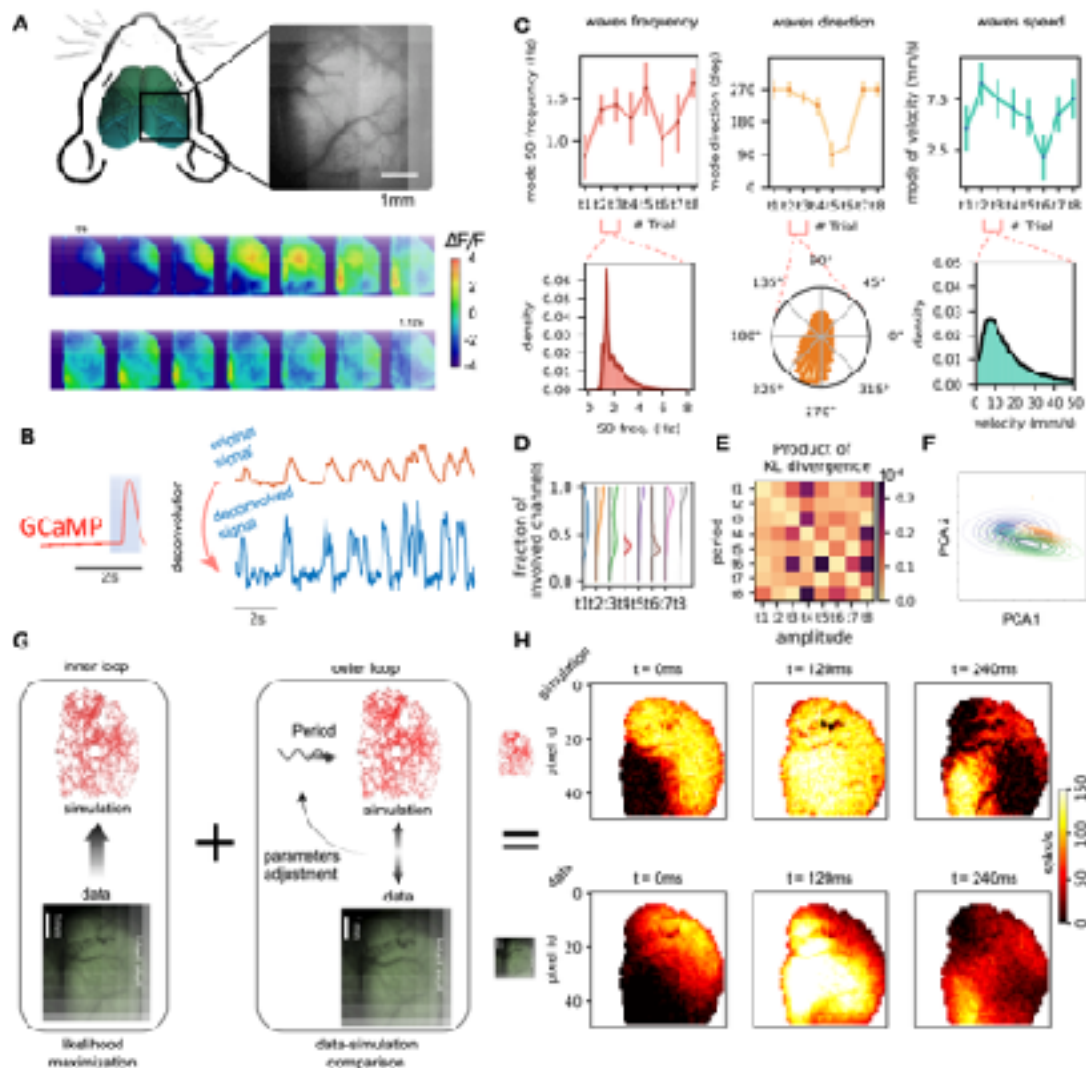
Thalamo-cortical spiking model capable of incremental learning and sleep.

- Combination of context and perception with a soft winner-take-all circuit of excitatory and inhibitory spiking neurons.
- Features of awake and deep-sleep states comparable with biological measures.
- Capability of fast noise-resilient **incremental learning**.
- Visual classification **improvement** after sleep.
- Sleep **homeostatic** and **associative** effects.

Capone et al. SciRep 2019 <https://doi.org/10.1038/s41598-019-45525-0>
Goloso et al., Plos Comp Bio 2021 <https://doi.org/10.1371/journal.pcbi.1009045>

Data-constrained model

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Mean-field model capable to reproduce the slow wave spatio-temporal dynamics observed in experimental recordings of the cortical hemisphere of a mouse under anesthesia.

Inference procedure for parameter optimization through an **inner** and an **outer** loop.

Most of the features of the **non-stationary** and **non-linear** dynamics displayed by the biological network are reproduced.

Usage and develop of a **versatile analysis tool** to compare experimental and simulated behavior.

Capone et al. [arXiv:2104.07445](https://arxiv.org/abs/2104.07445)

Link to the dataset in the knowledge graph: <https://search.kg.ebrains.eu/instances/Dataset/>

Mean field interactive model <https://wiki.ebrains.eu/bin/view/Collabs/interactive-exploration-of-brain-states>

De Bonis et al 2019, <https://doi.org/10.3389/fnsys.2019.00070>

Celotto et al 2020, [10.3390/mps3010014](https://doi.org/10.3390/mps3010014)

Thank You!



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