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Incremental Awake-NREM-REM Learning Cycles: Cognitive and Energetic Effects in a Multi-area Thalamo-Cortical Spiking Model

Thursday 23 June 2022 14:10 (3 minutes)

INTRODUCTION/MOTIVATION
This work leverages Apical Isolation (AI) and Apical Drive (AD)[1][2] principles to induce in a model some of the favourable energetic and cognitive effects associated to NREM and REM sleep. Also, we follow the Apical Amplification (AA)[3] concept during awake learning. This way, we added REM to the brain states accessible to the thalamo-cortical spiking model[4][5] already capable of expressing realistic AWAKE and NREM brain dynamics.

METHODS
We developed a multi-area thalamo-cortical spiking model made of integrate-and-fire neurons: the thalamic layer provides perceptual input through contralateral feedforward connections to cortical areas, which gather and process such information by means of Spike-Timing-Dependent-Plasticity and Winner-Take-All Cell-Assemblies (CA) circuitry (Fig 1A).

RESULTS-AND-DISCUSSION
We found the optimal sleep stages duration is at 40s of NREM and 10s of REM (Fig. 1D), corresponding to a reduction of 22% in the network power consumption and an improvement of 1% in classification accuracy, in agreement with experimental data[8,11]; moreover sleep rhythms were found comparable with biological recordings[9] (Fig. 1B).
Cell-Assemblies trained over different examples of the same digit are grouped together in each area during NREM whereas those belonging to different cortical areas are associated through REM-stage (Fig. 1C).
Figure 1D demonstrates after-sleep cortico-cortical synapses homeostasis.

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Topic area

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Awake-NREM-REM cycles, Spiking Models, Classification task, Thalamo-cortical network, Apical Amplification-Drive-Isolation

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