Is the homeostatic reset an artefact or a good feature of synaptic plasticity rules for **sleep-dependent memory consolidation?**

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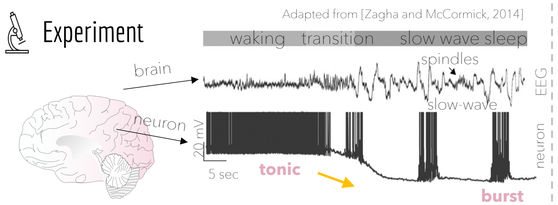
Network rhythms during sleep and wakefulness

Experiment

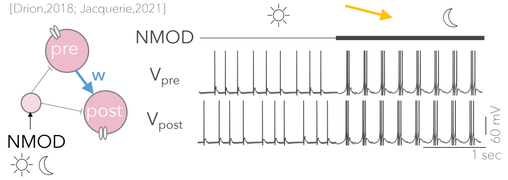


Ach, NE, 5-HT, HA, Glu ..

Neuromodulators = NMOD

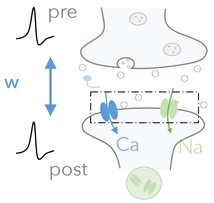
Model

[Drion,2018; Jacquerie,2021]



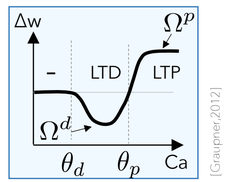
Conductance-based model

Synaptic plasticity



NMDA AMPA

Calcium-based models



Other models: STDP, triplet

✓ Fitted on experimental data

Synaptic plasticity tested during switches from tonic to burst

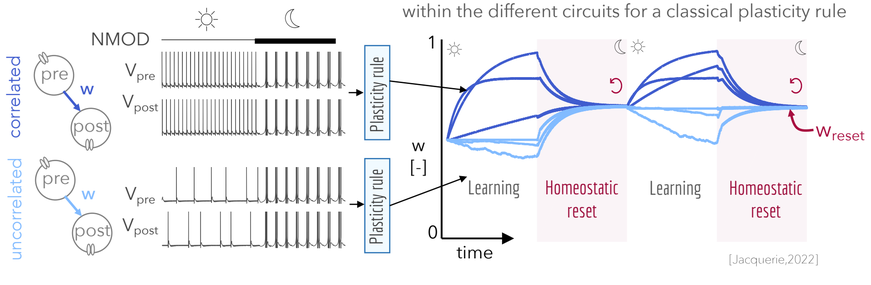
Model

Simulation of wake-sleep cycles in 6 circuits with correlated & uncorrelated activity during tonic, while letting the plasticity rule run its course.
The correlation translates the activity level of the pre and post synaptic neurons.

Conclusion

Whatever we have learned, the connection is restored to a given value each night. This phenomenon is called the homeostatic reset.

Evolution of the synaptic weights w within the different circuits for a classical plasticity rule



[Jacquerie,2022]

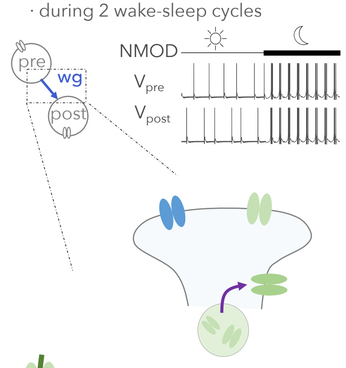
How to exploit the homeostatic reset ?

We developed a model that exploits the homeostatic reset. During learning, the synaptic weight is driven by a classical synaptic plasticity rule. During sleep, the synaptic weight is converging toward the reset value. **Learning must be transferred**. Therefore, we integrated a new variable accounting for slower, long-lasting changes, called the synaptic conductance g.

The synaptic connectivity is defined by the product of the weight and the conductance: **wg**

Model

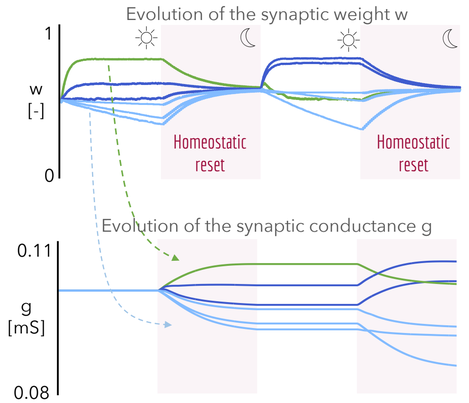
· 6 circuits
· with different activities
· during 2 wake-sleep cycles



The synaptic weight corresponds to the **efficiency** of the receptors.

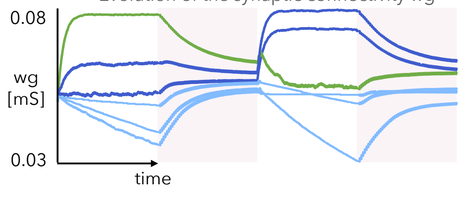
The **synaptic conductance** refers to number of AMPA receptors, the spine size or its morphology.

Evolution of the synaptic weight w



Evolution of the synaptic conductance g

Evolution of the synaptic connectivity wg



How does it work ?

✓ At the end of wake state or the learning phase:
· For w> w_{reset}, learning should be consolidated.
· For w < w_{reset}, the overall connection should be decreased.
where w_{reset} is the converging value driven by the burst rhythm [Jacquerie, 2022].

✓ During sleep, the homeostatic reset drives the change in the structural variable g.

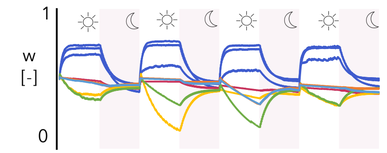
✓ At the end of sleep, learning is well transferred, and the brain is ready to learn new memory.

Application: memory engram formation

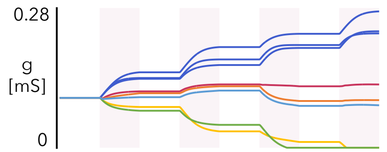
Memory engram = ensemble of neurons that stores similar information (synonym: memory trace).

Initial situation
· Neurons #1-2-3 are highly correlated
· The network is initialized with the same connectivity.

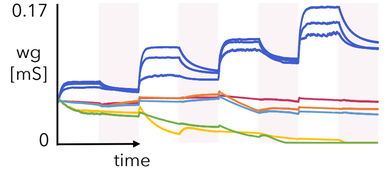
Evolution of the synaptic weights during 4 wake-sleep cycles.
Burst during sleep leads to the homeostatic reset.



Learning is transferred to the structural variable. Neurons weakly correlated are depressed.



Throughout the different wake-sleep cycles, a **memory engram** is formed.



Take-home messages

✓ Neuronal activity fluctuations are unavoidable.

✓ Switch from wake to sleep is translated by a switch from tonic to burst.

✓ Burst causes the homeostatic reset of the synaptic weights.

✓ The homeostatic reset is exploited to drive long-lasting, structural changes in synaptic connection such as the number of receptors or the spine size.