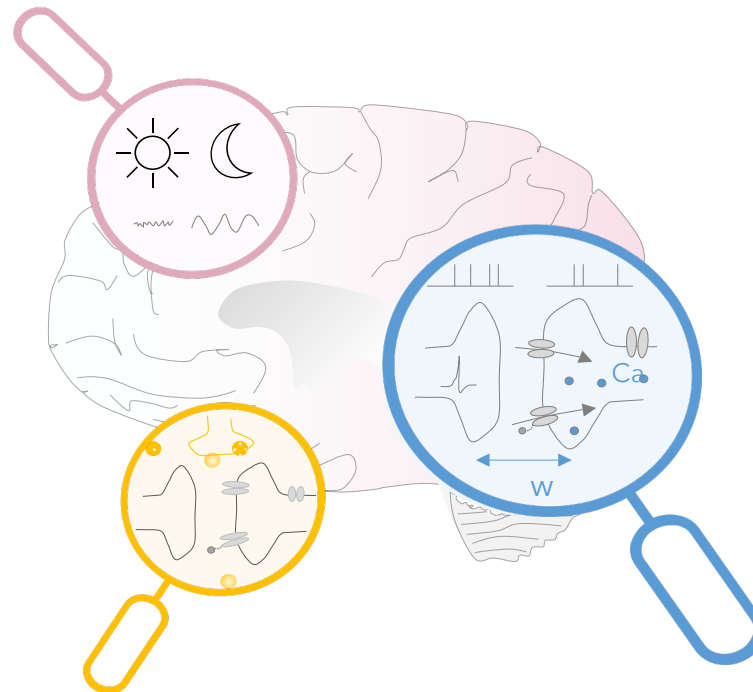
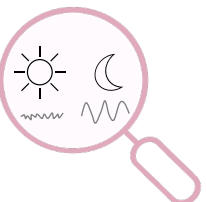


Neuromodulation of excitability and synaptic plasticity: an underestimated challenge for computational models

Kathleen Jacquerie, Caroline Minne and Guillaume Drion

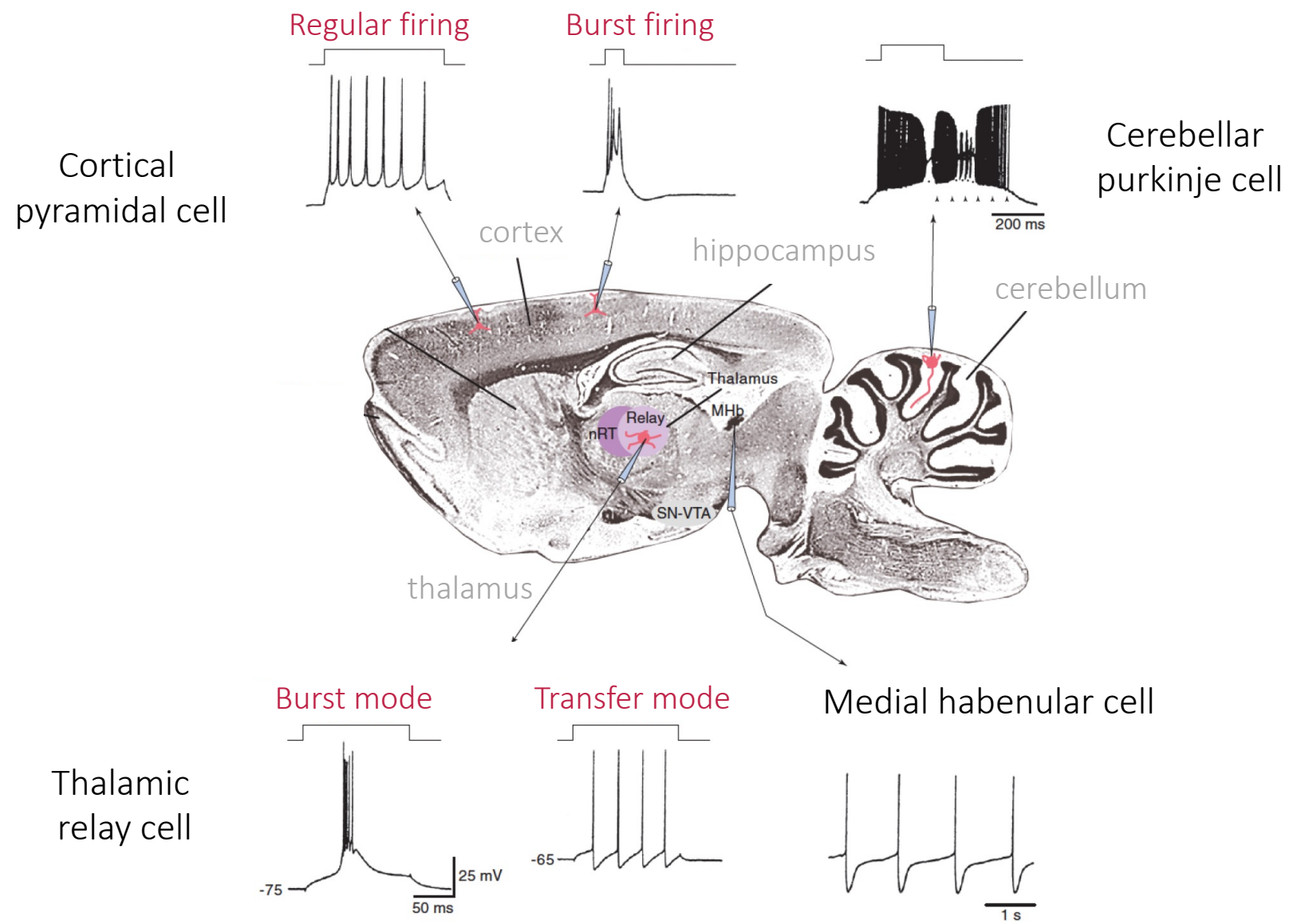
University of Liege, Belgium

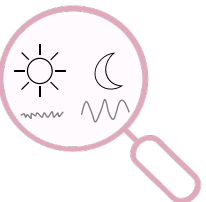




Excitability

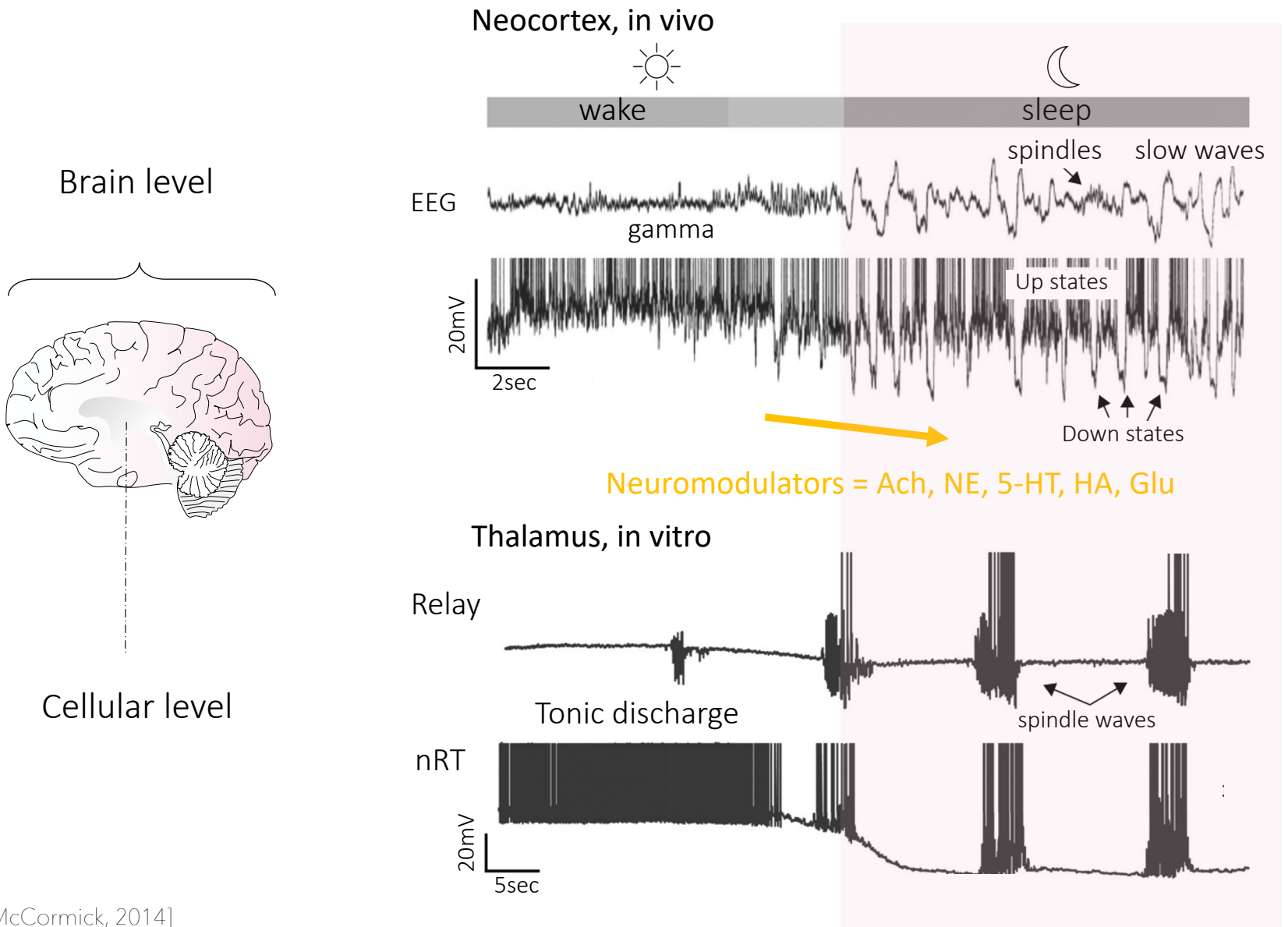
Neurons exhibit various electrophysiological properties





Excitability

Network rhythms during sleep and wakefulness





Excitability

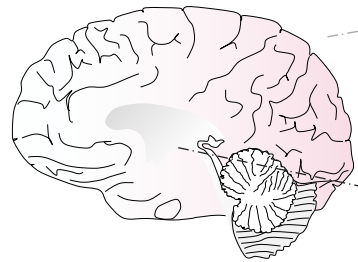
Network rhythms during sleep and wakefulness



Switch in firing activity from tonic to burst



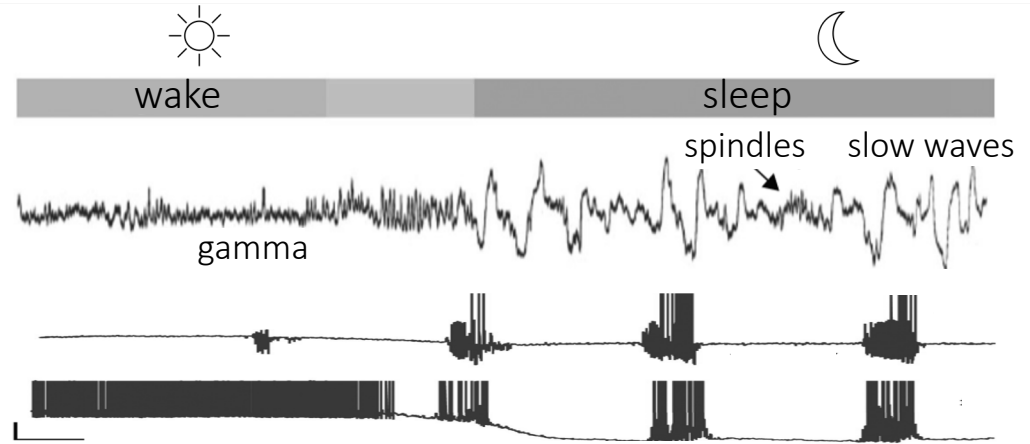
Experiment



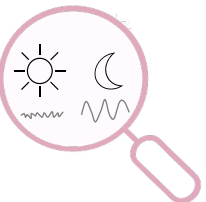
Brain level

Cellular level

Adapted from [Zagha and McCormick, 2014]



Model



Excitability

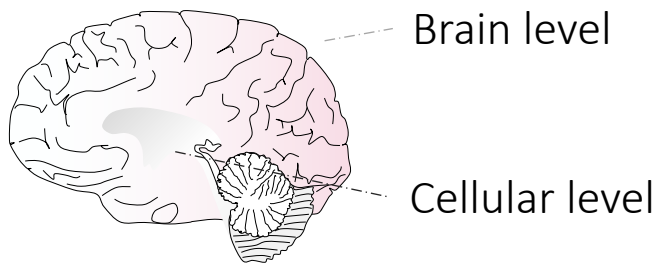
Network rhythms during sleep and wakefulness



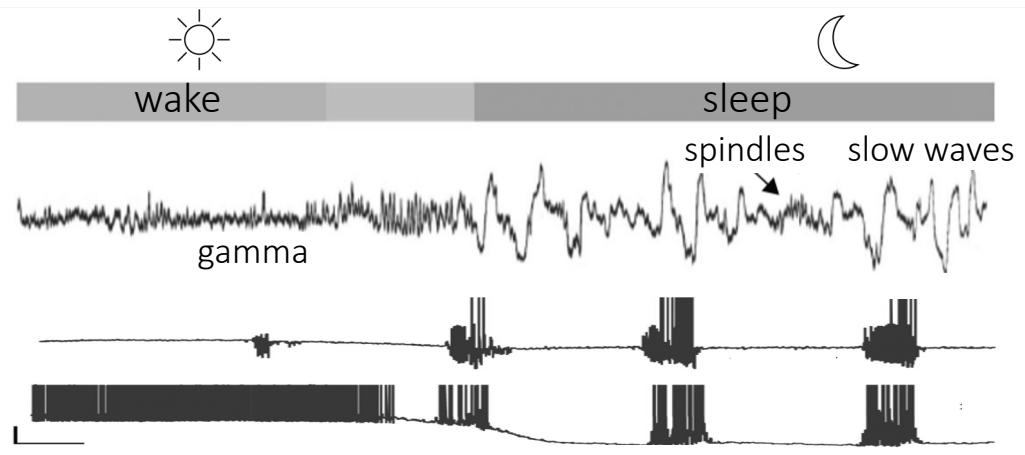
Switch in firing activity from tonic to burst



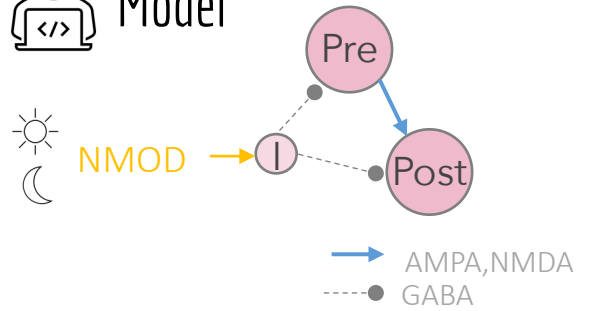
Experiment



Adapted from [Zagha and McCormick, 2014]

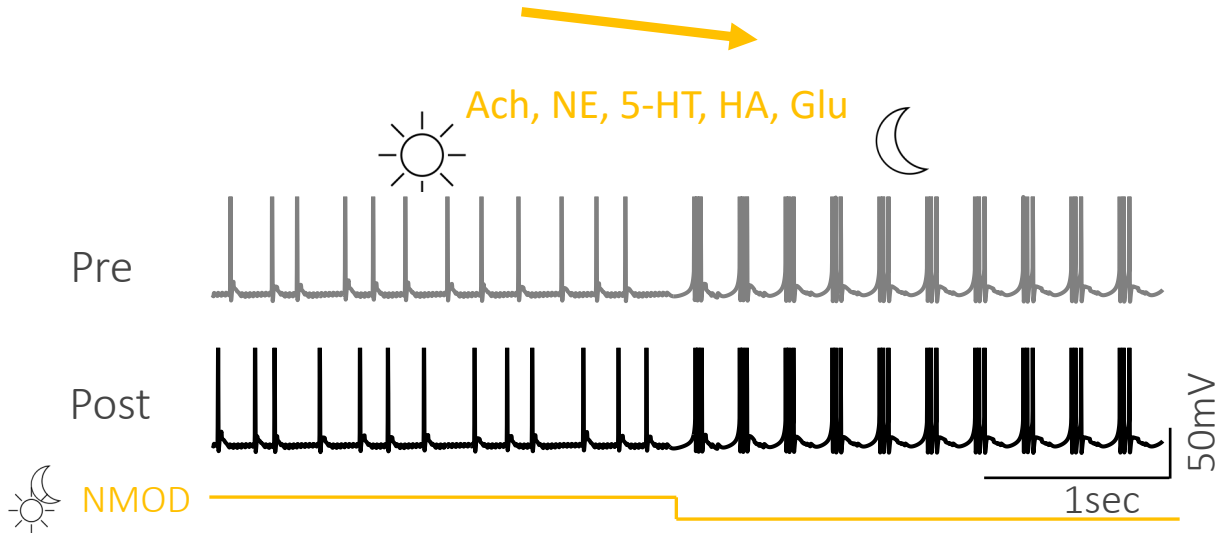


Model

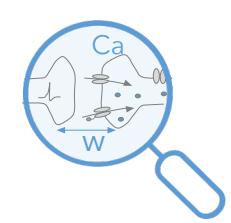


Conductance-based model

✓ Robust to variability

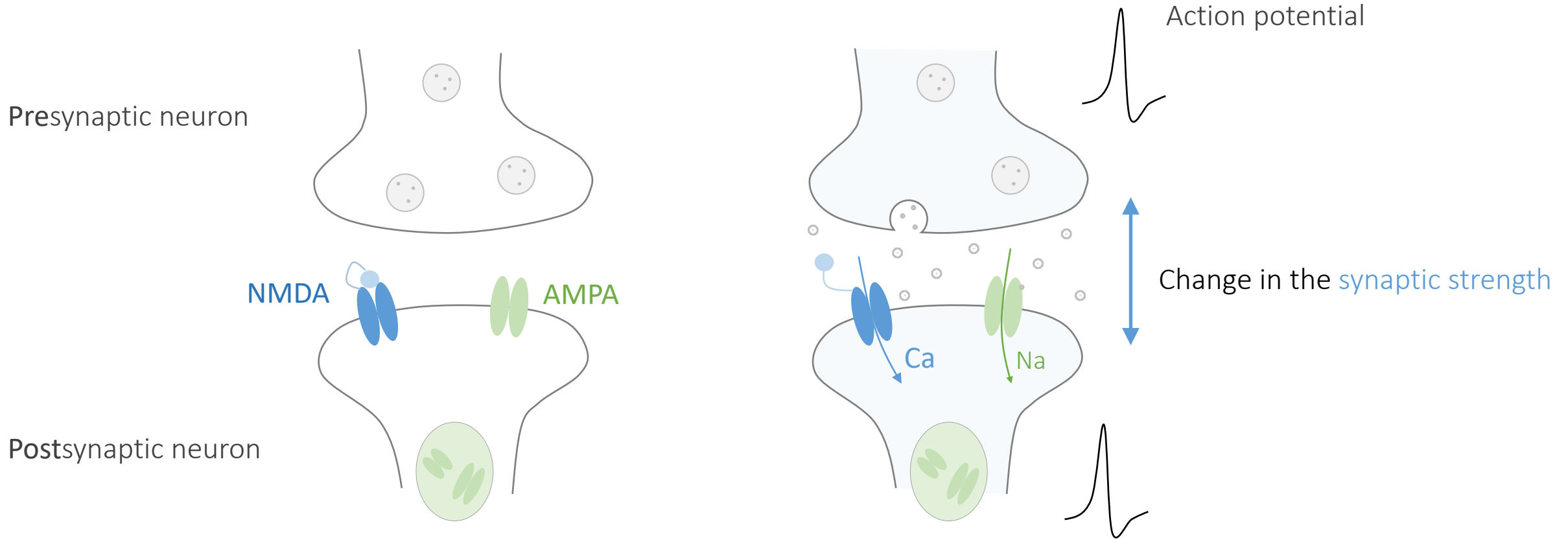


[Drion,2018; Jacquerie,2021]

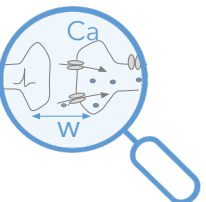


Synaptic plasticity

Ability of neurons to modify their connections with other cells



[Hebb, 1949] "Fire together, wire together"

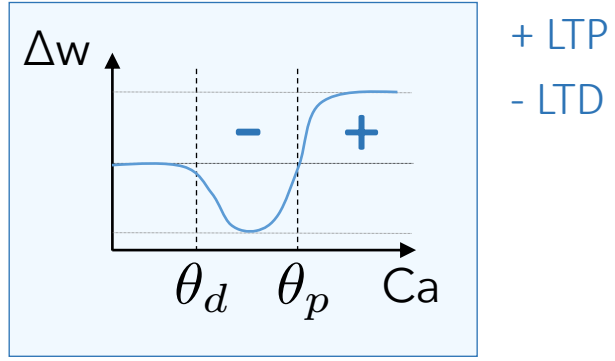
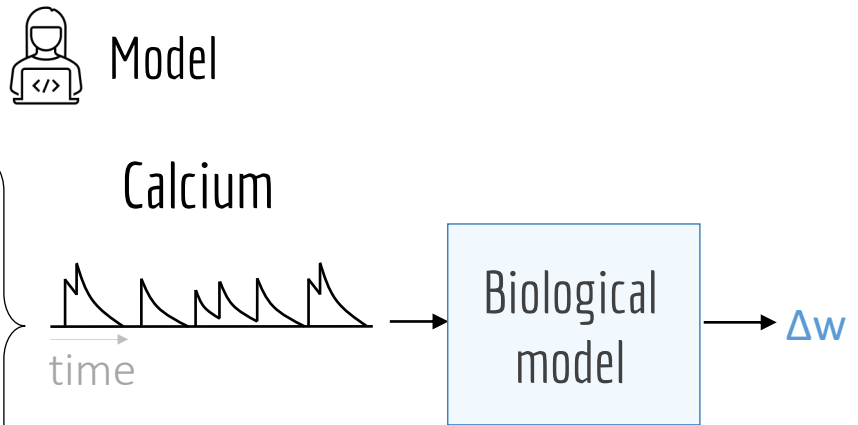
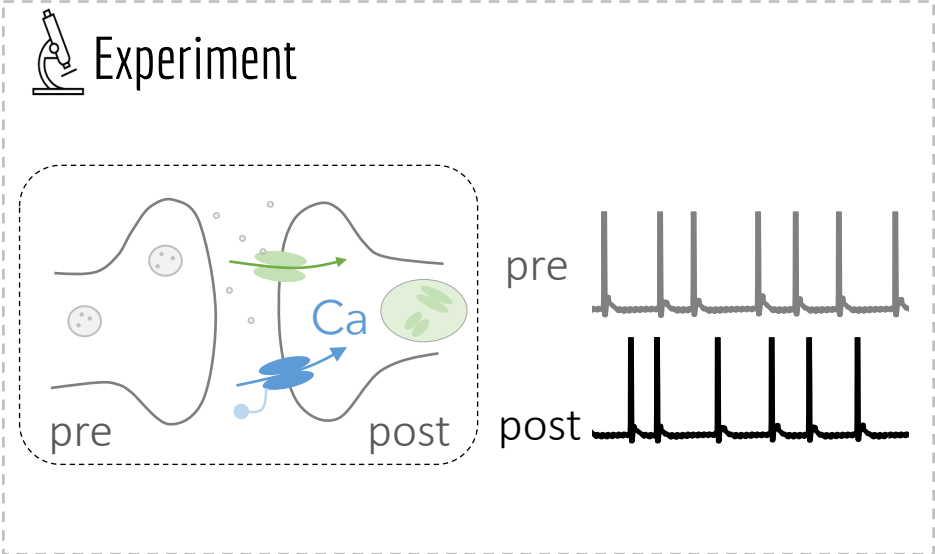


Synaptic plasticity

Implementation of synaptic plasticity in computational models



Two categories of synaptic plasticity models



$$\tau_w(Ca) \frac{dw}{dt} = f(Ca) - w$$



Synaptic plasticity

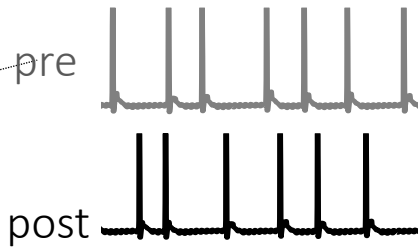
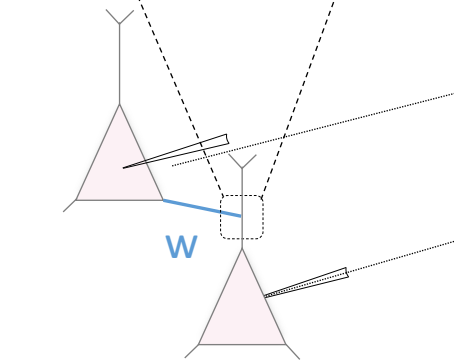
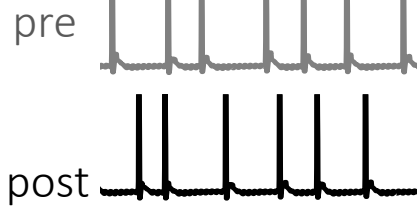
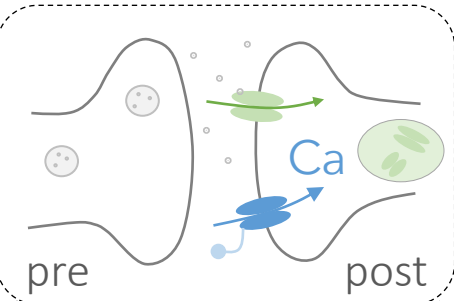
Implementation of synaptic plasticity in computational models



Two categories of synaptic plasticity models

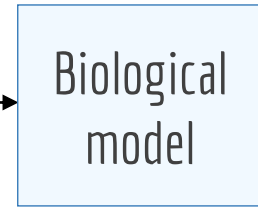
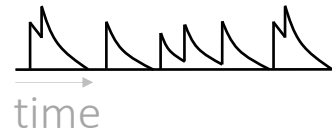


Experiment



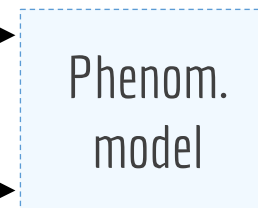
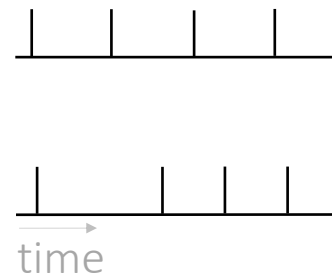
Model

Calcium

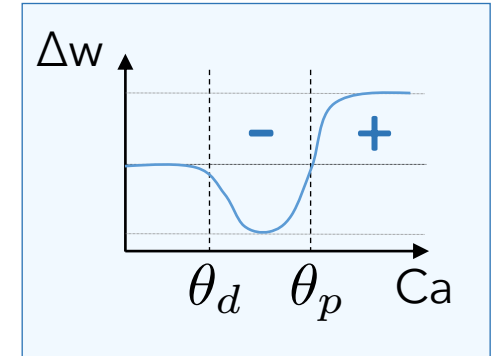


Δw

Spike times

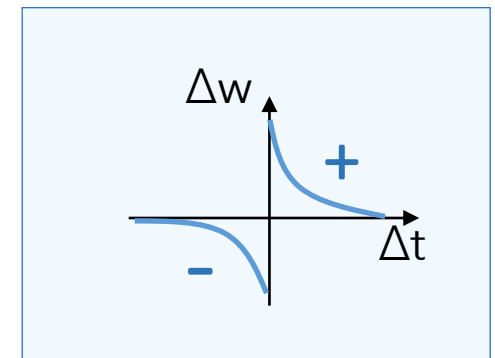


Δw



+ LTP
- LTD

$$\tau_w(Ca) \frac{dw}{dt} = f(Ca) - w$$

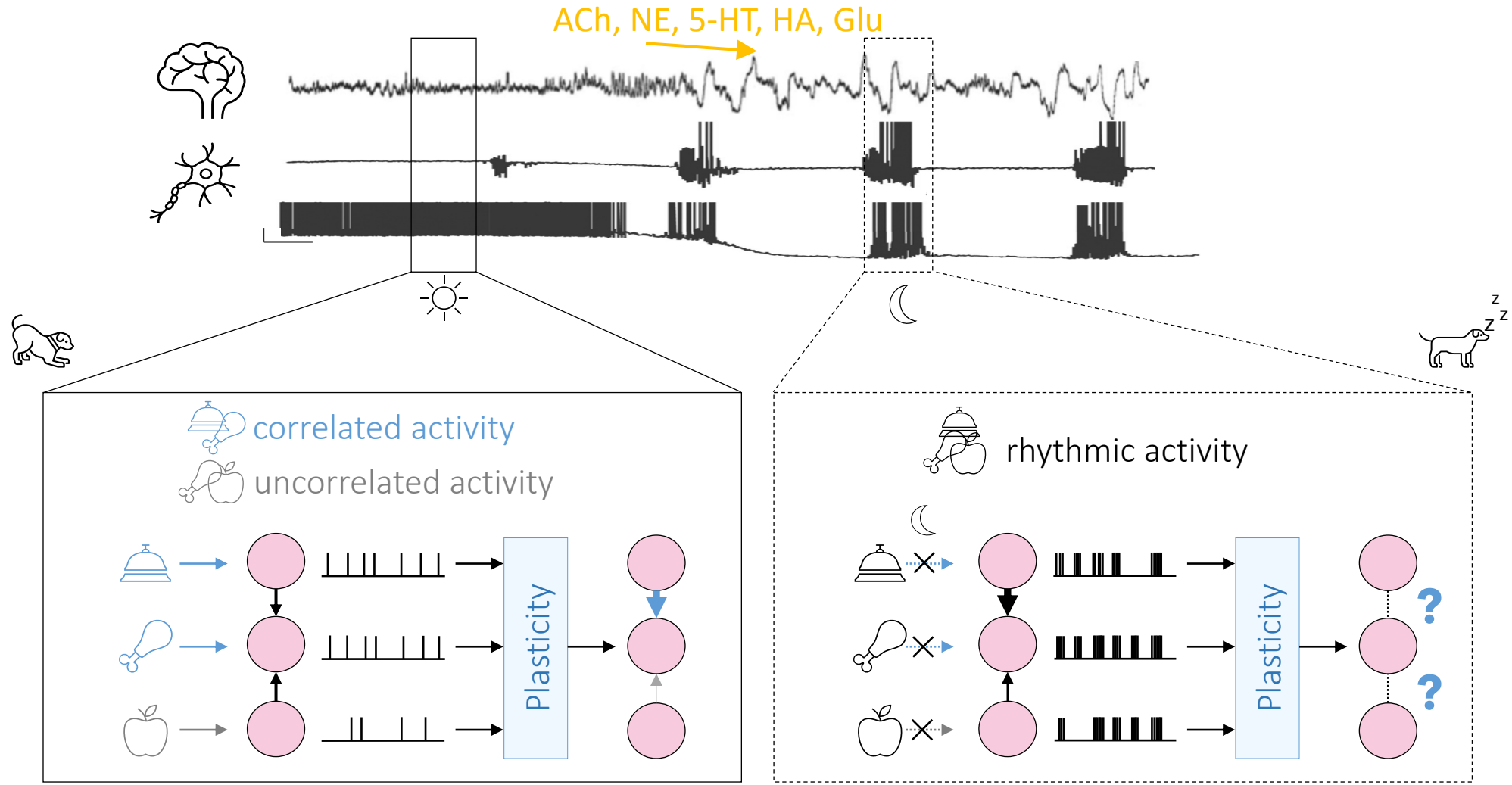


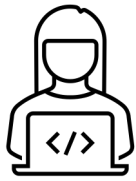
$$\Delta w = \text{sign}(\Delta t) e^{-|\Delta t|/\tau}$$



Neuromodulation of excitability and synaptic plasticity

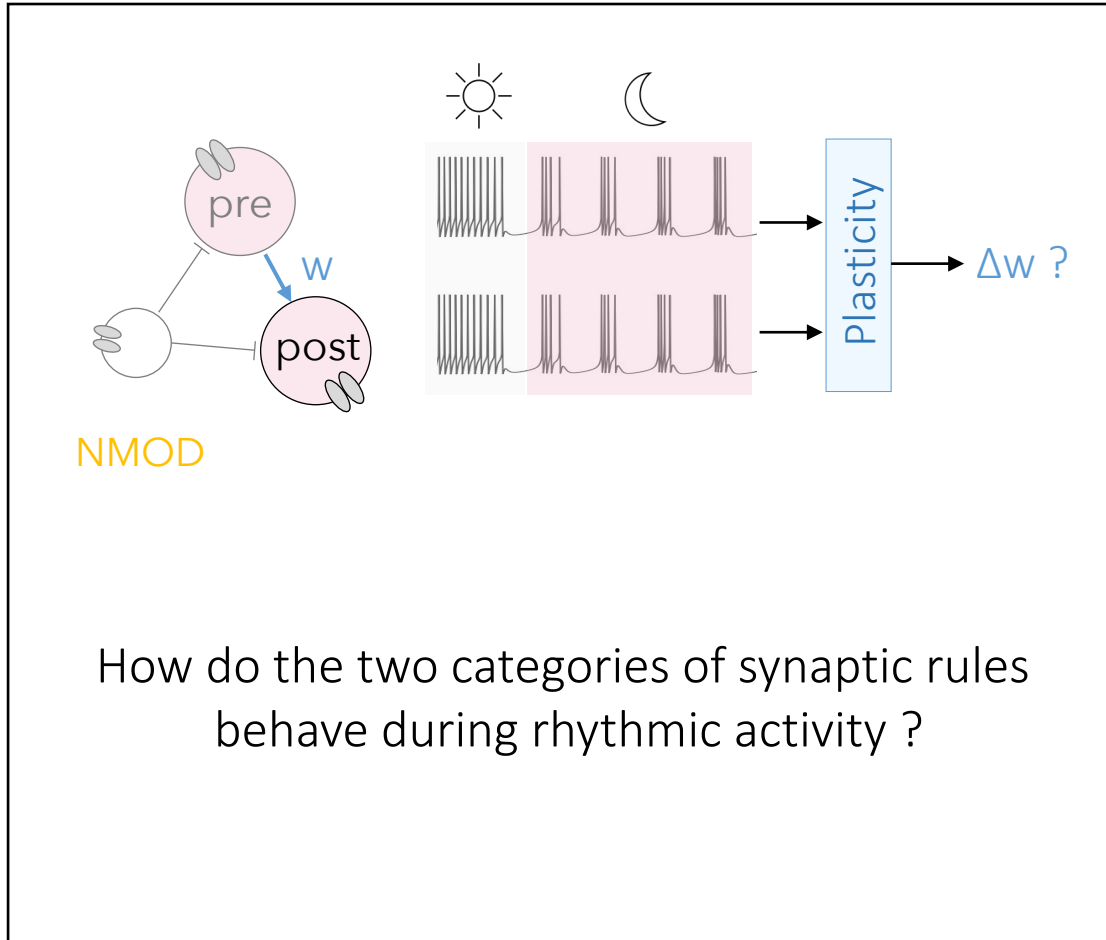
How do models of neuron activity and synaptic plasticity interact ?

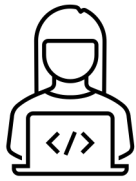




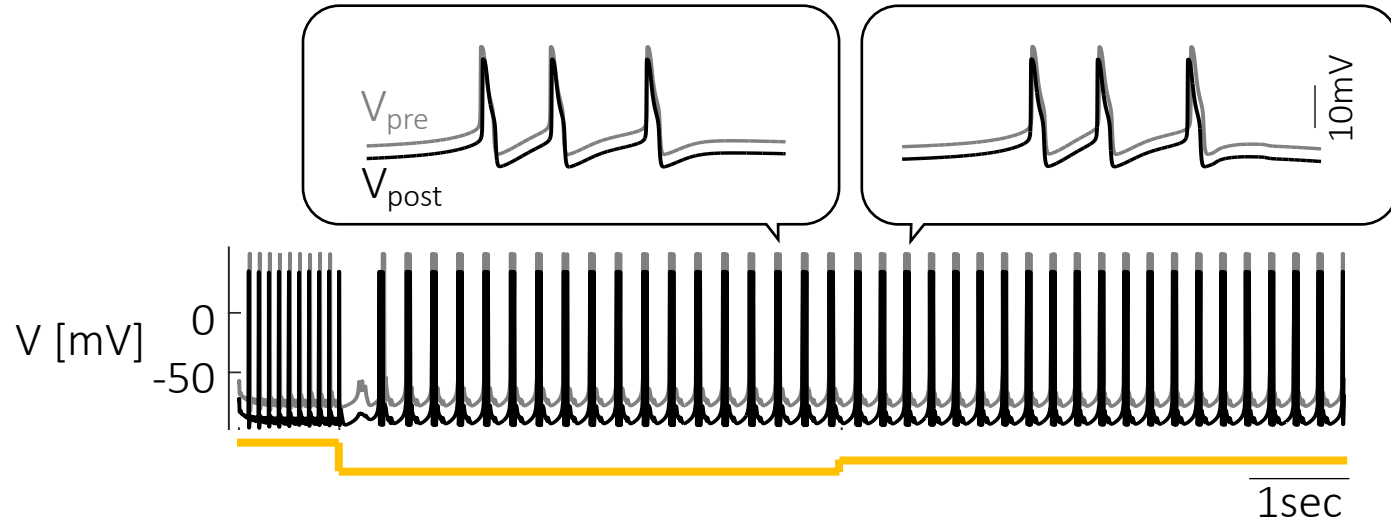
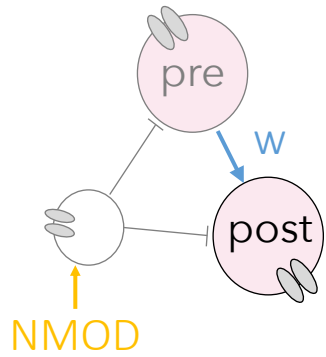
Modeling the interaction between modulation and synaptic plasticity

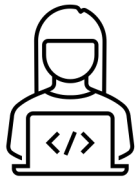
In the context of sleep- dependent memory consolidation



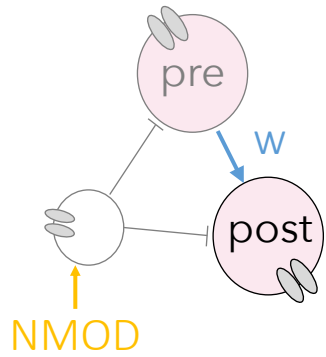


How do the two categories of synaptic rules behave during rhythmic activity?

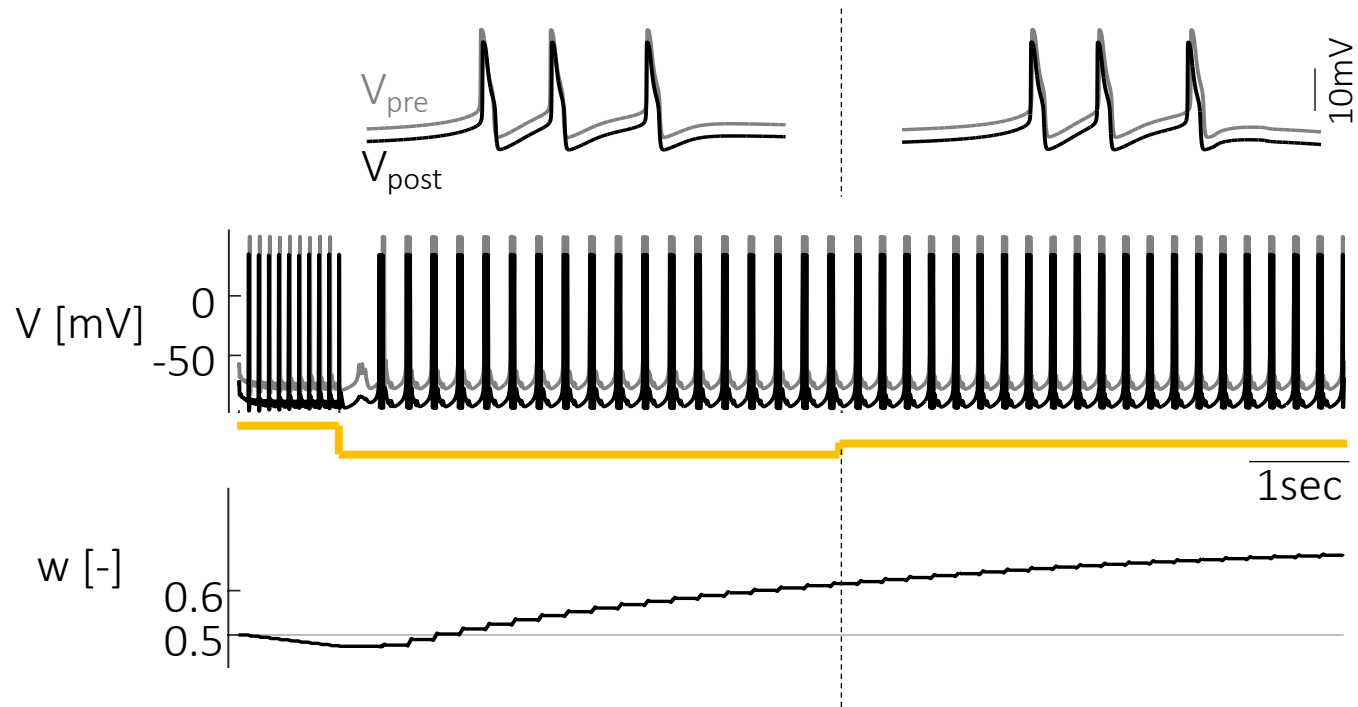


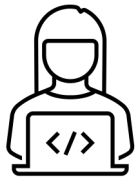


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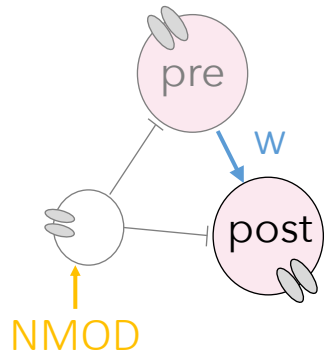
Bio.





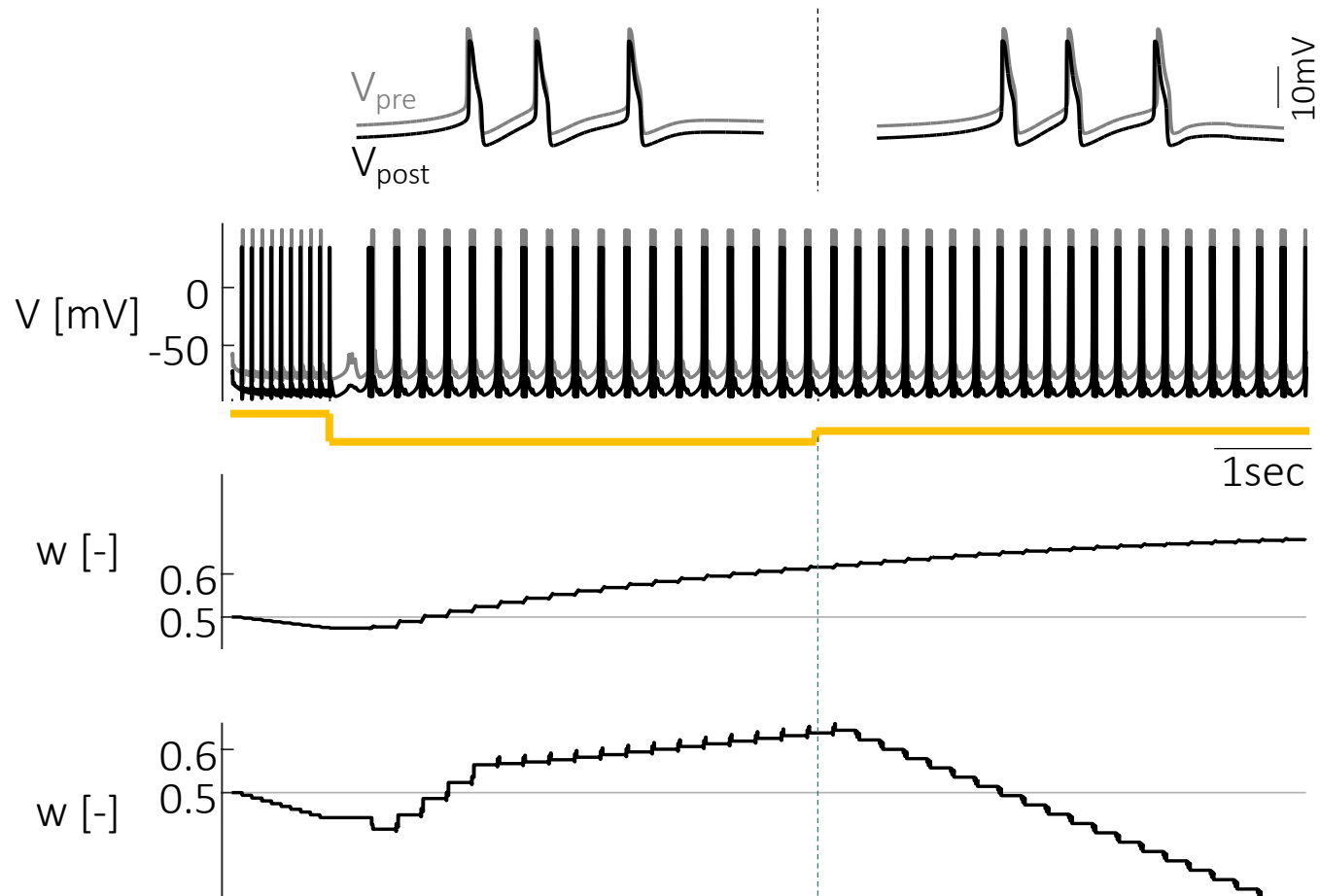
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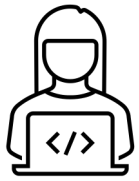
Phenomenological models are fragile to a small alteration of the spike timing in a burst mode



Bio.

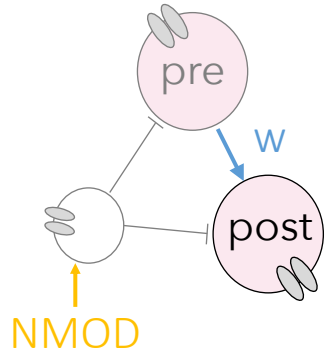
Phenom.





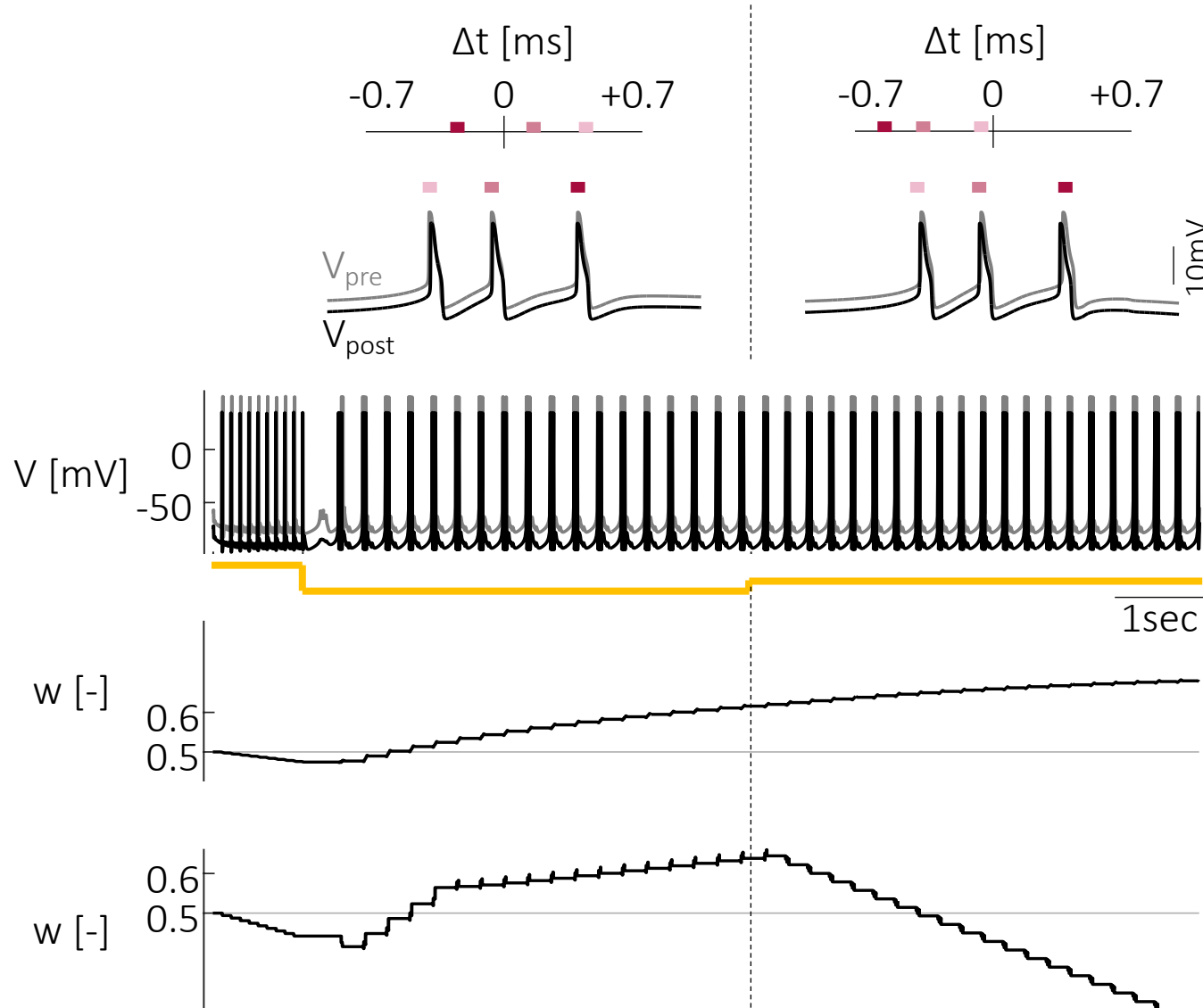
How do the two categories of synaptic rules behave during rhythmic activity ?

Phenomenological models are fragile to a small alteration of the spike timing in a burst mode

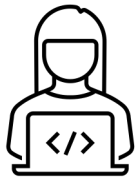


Bio.

Phenom.

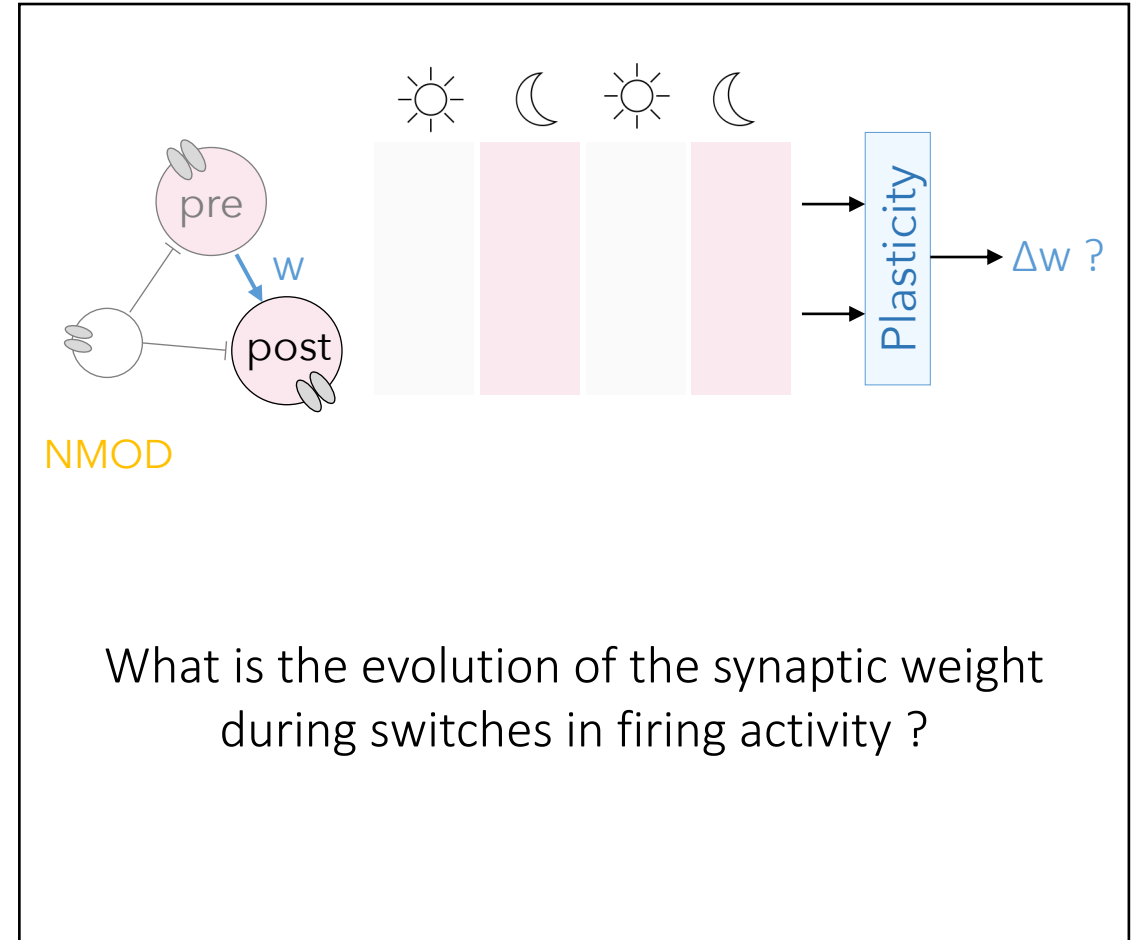
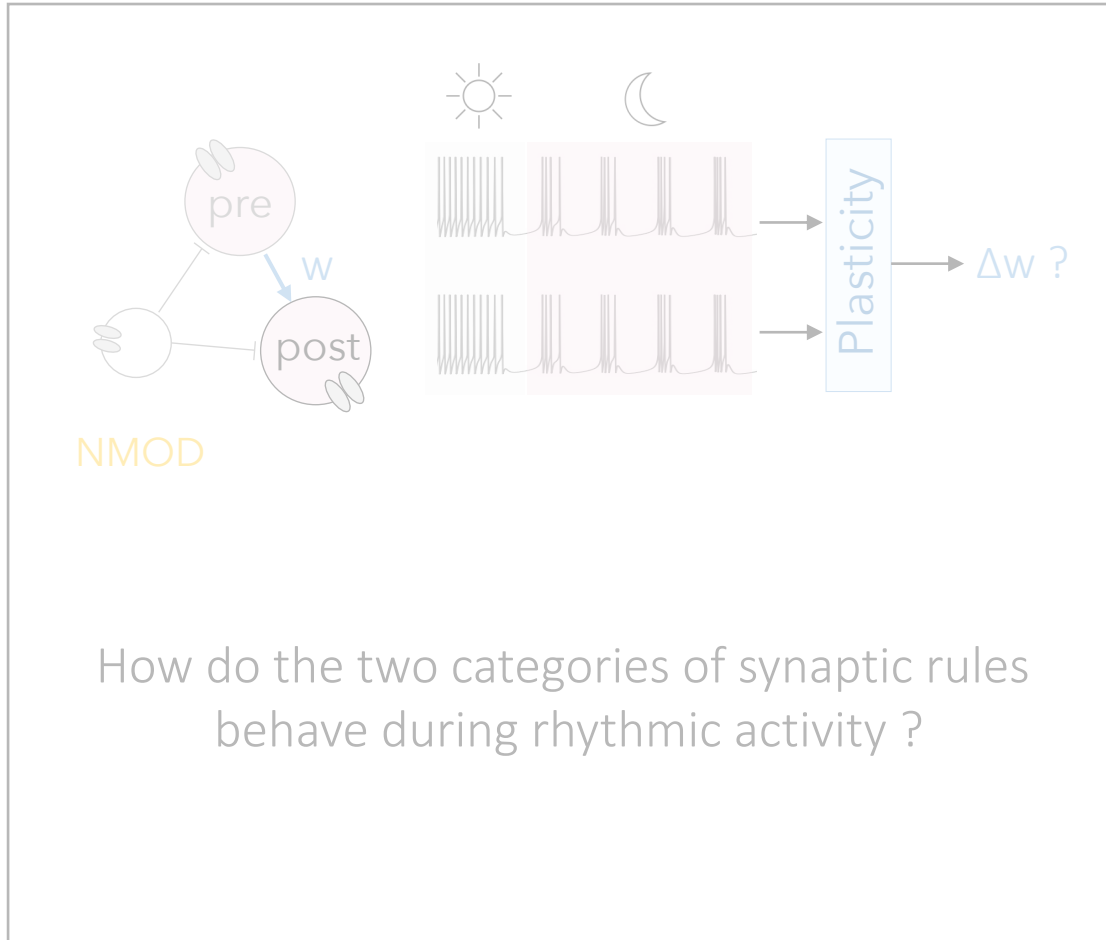


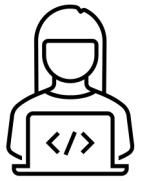
Synchronous burst is not synchronous tonic



Modeling the interaction between modulation and synaptic plasticity

In the context of sleep- dependent memory consolidation

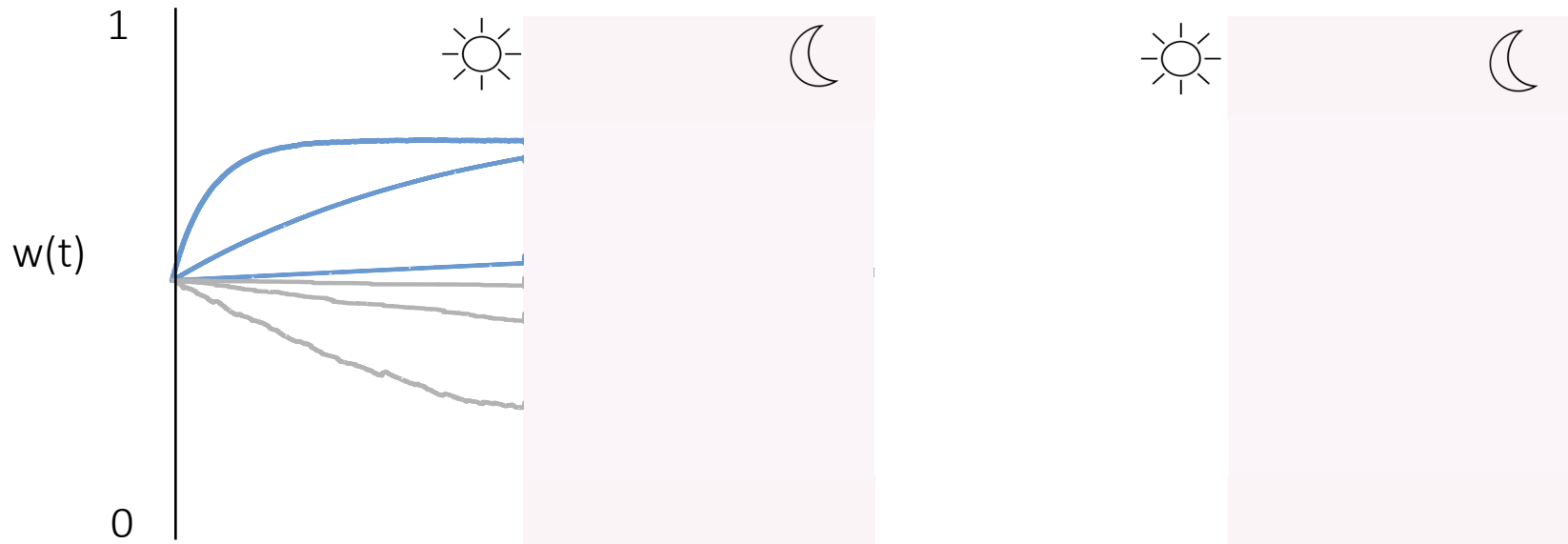
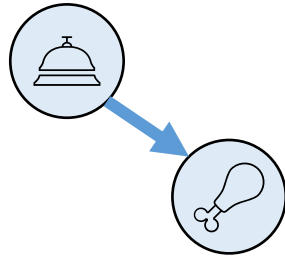




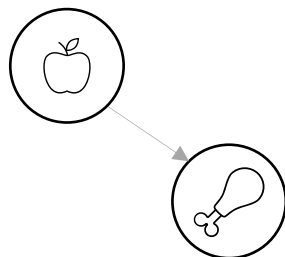
What is the evolution of the synaptic weight during switches in firing activity?

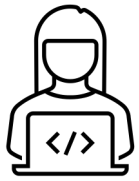
Comparison of the weight between correlated neurons and uncorrelated neurons

correlated neurons



uncorrelated neurons

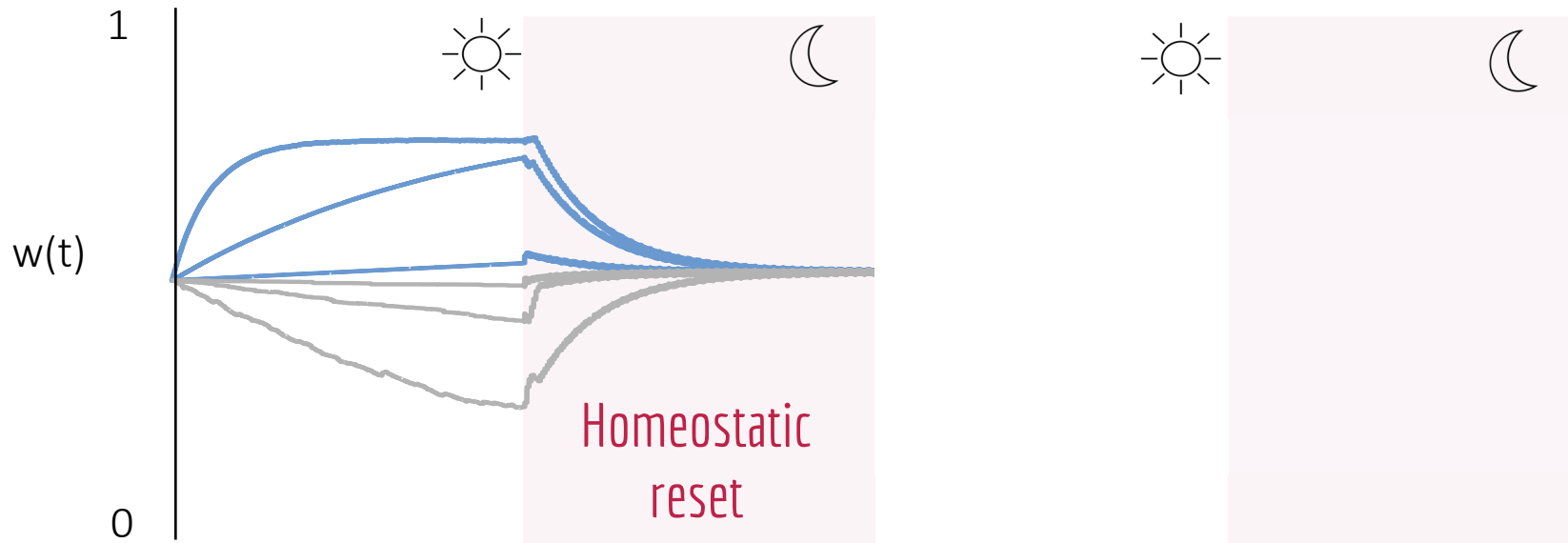
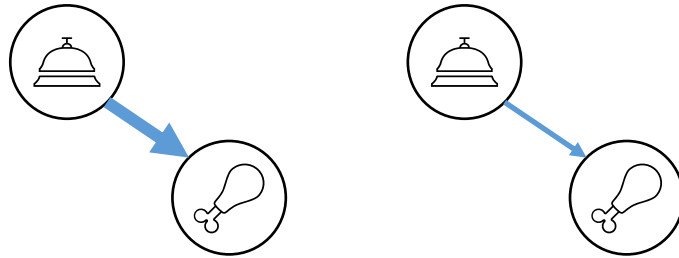




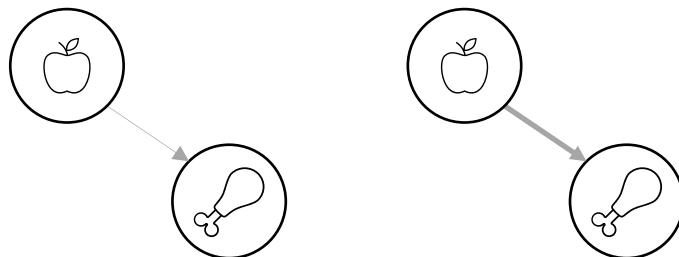
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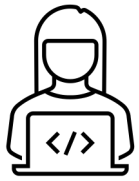
Comparison of the weight between correlated neurons and uncorrelated neurons

correlated neurons



uncorrelated neurons

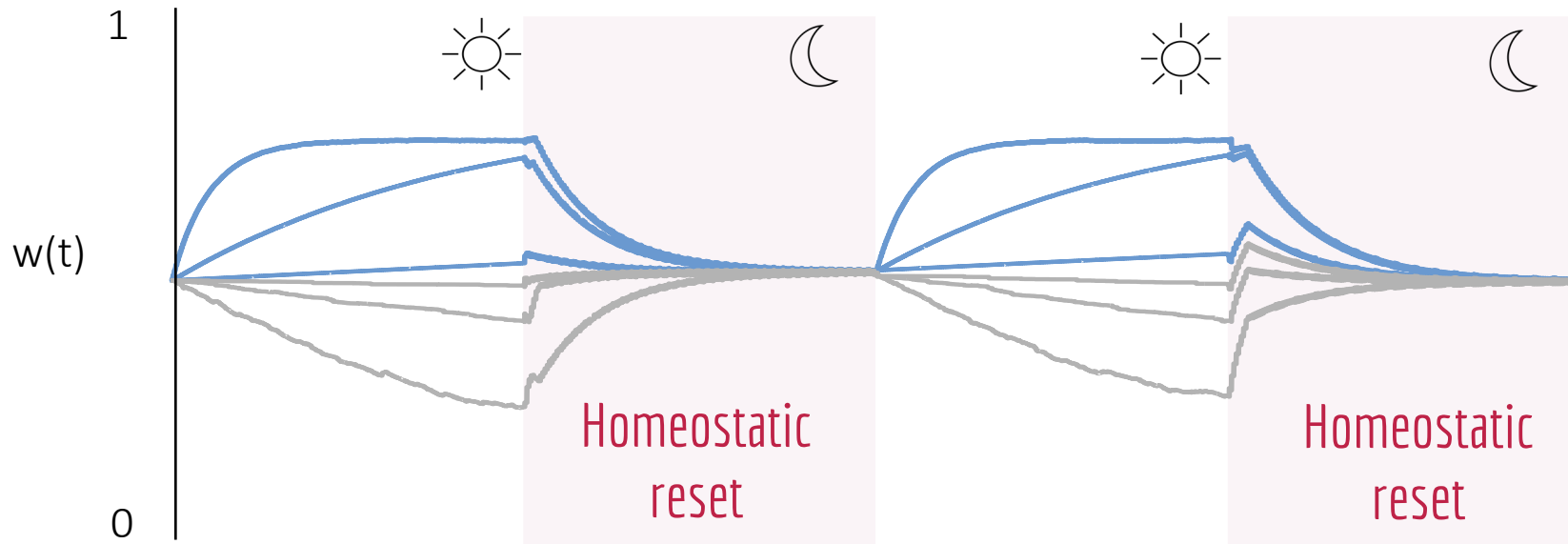
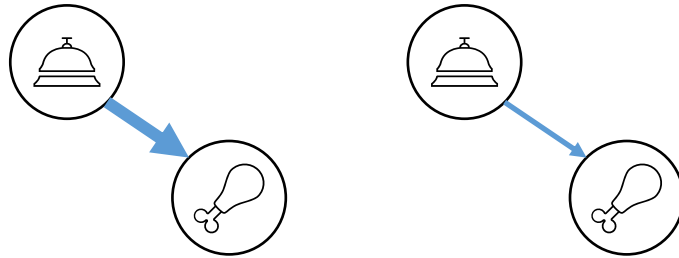




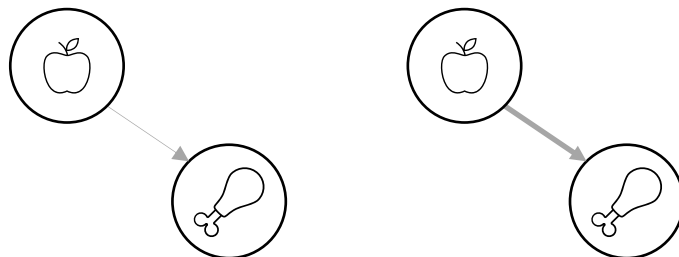
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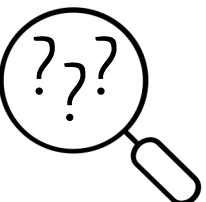
Comparison of the weight between correlated neurons and uncorrelated neurons

correlated neurons



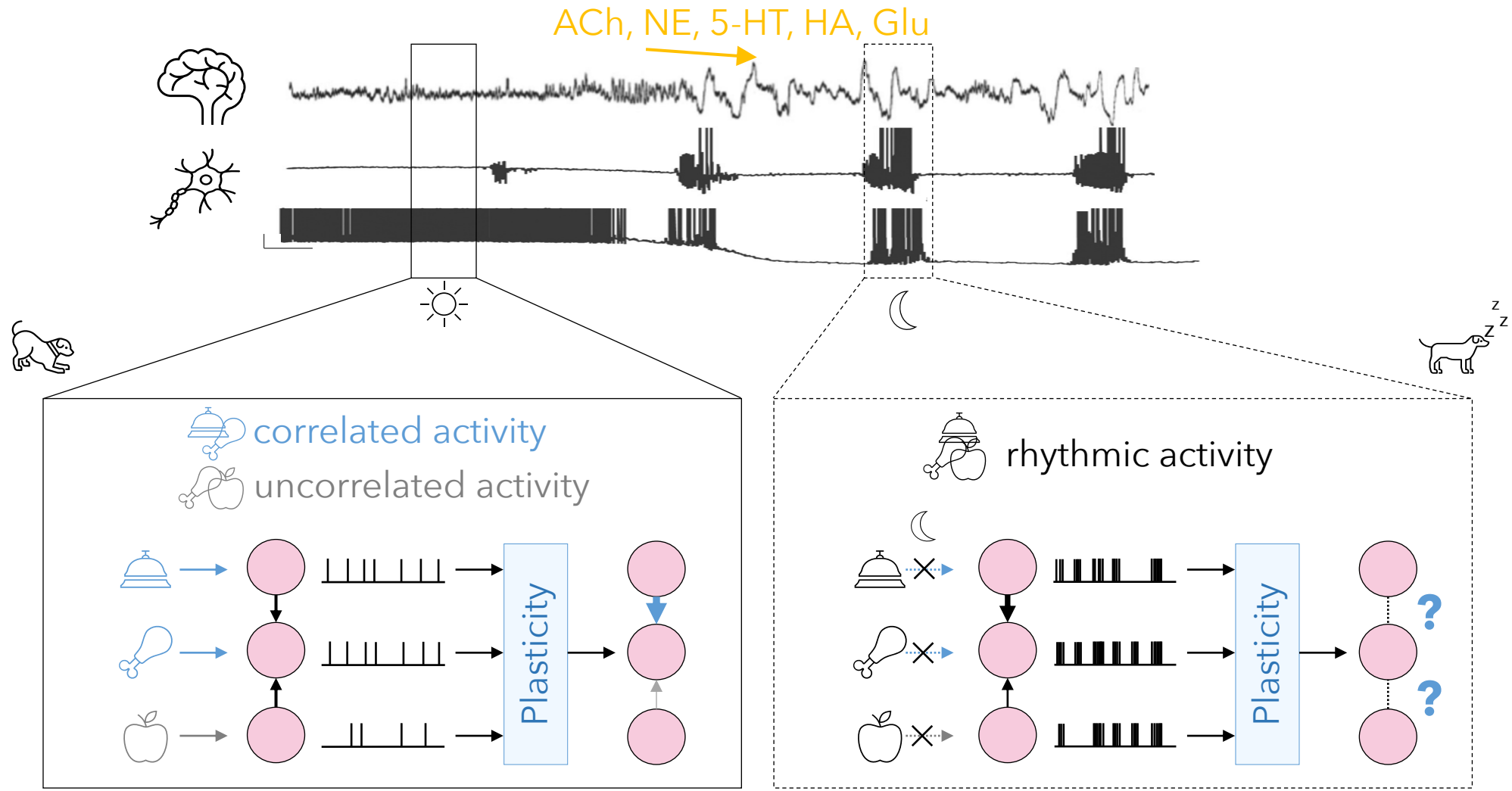
uncorrelated neurons



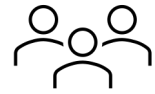
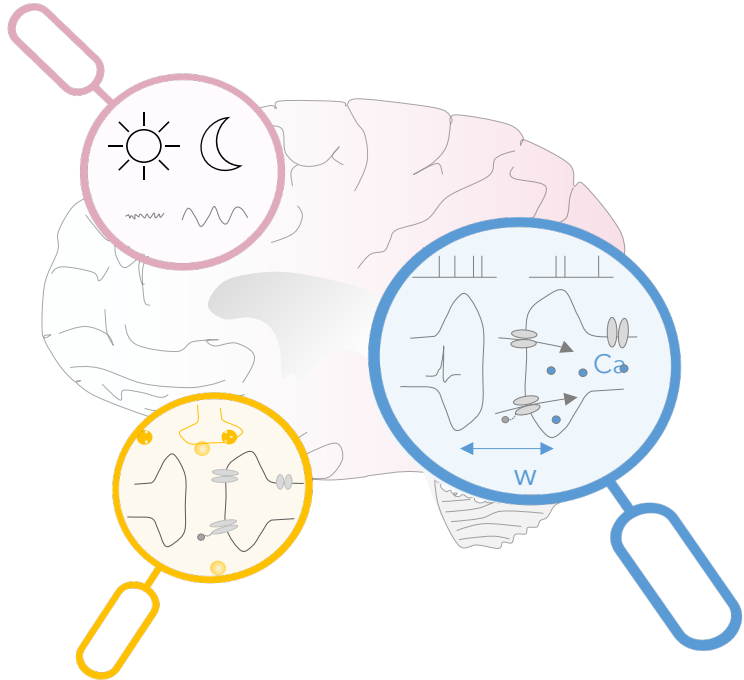


Neuromodulation of excitability and synaptic plasticity

Incompatibility between existing synaptic plasticity rules and switches in firing activity



What to know more about my project ?



FENS Forum 2022 | Paris, 9-13 July: poster presentation



kathleen.jacquerie@uliege.be

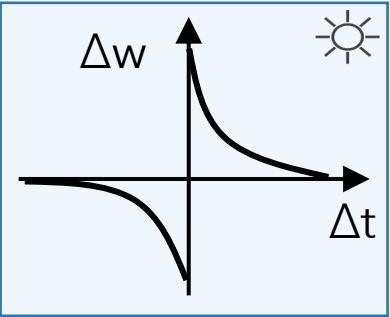


[@KJacquerie](https://twitter.com/KJacquerie)

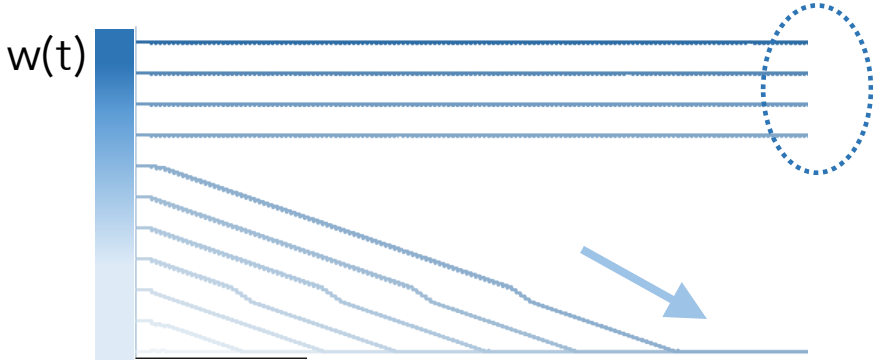
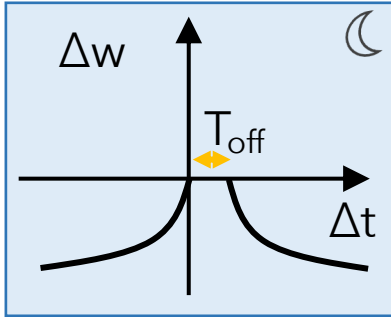


[Kathleen-jacquerie](https://www.linkedin.com/in/Kathleen-jacquerie)

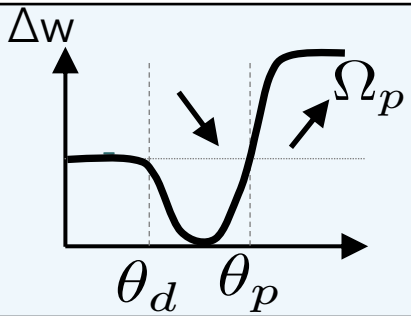
How to overcome the homeostatic reset ?



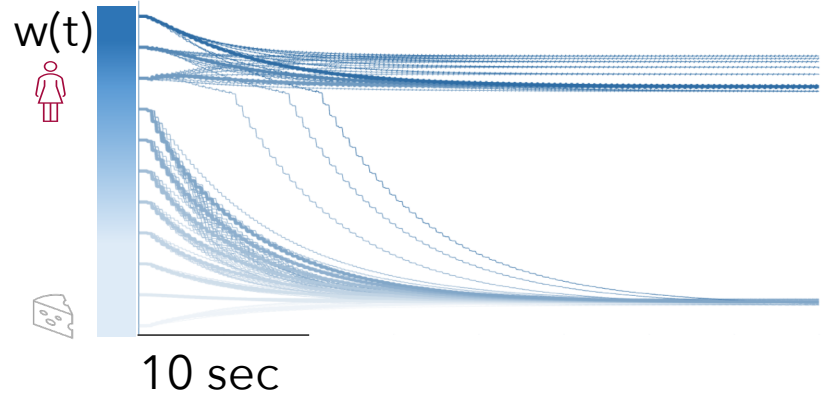
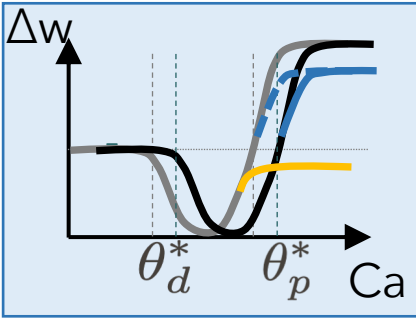
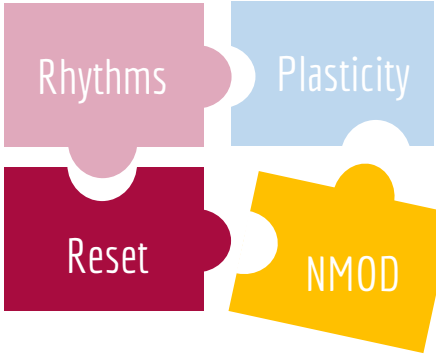
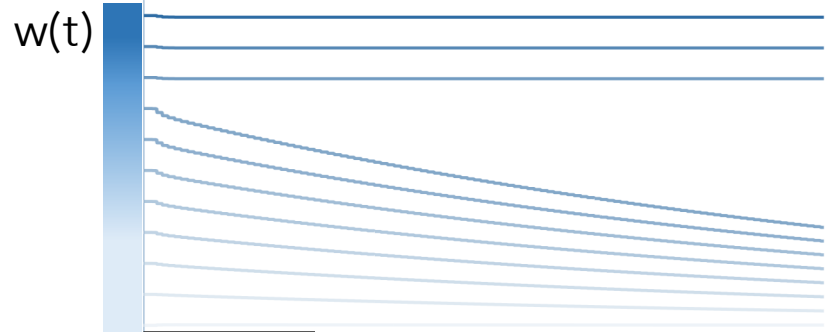
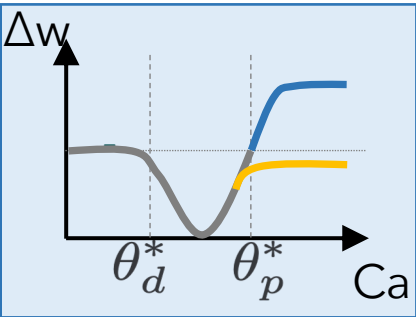
NMOD



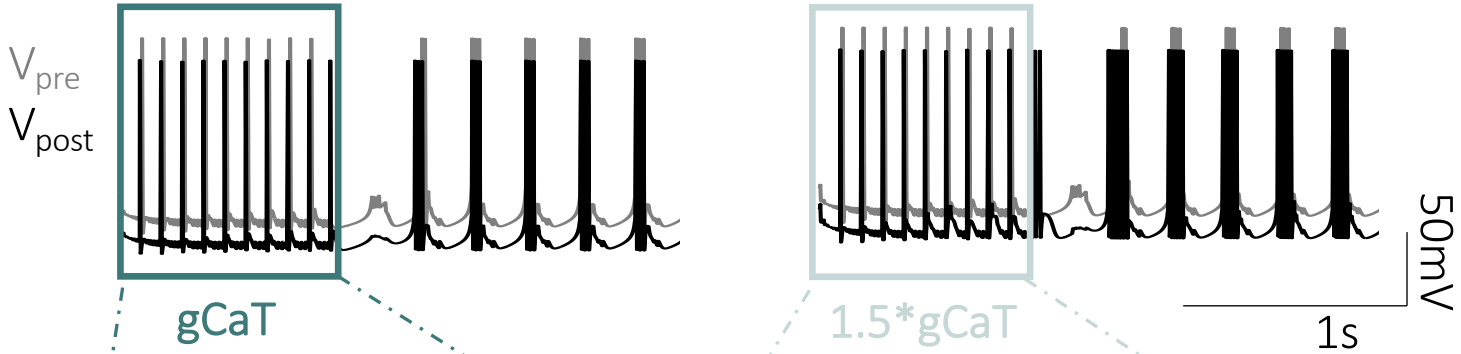
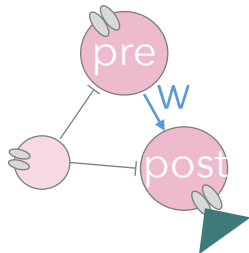
weak weights are depressed



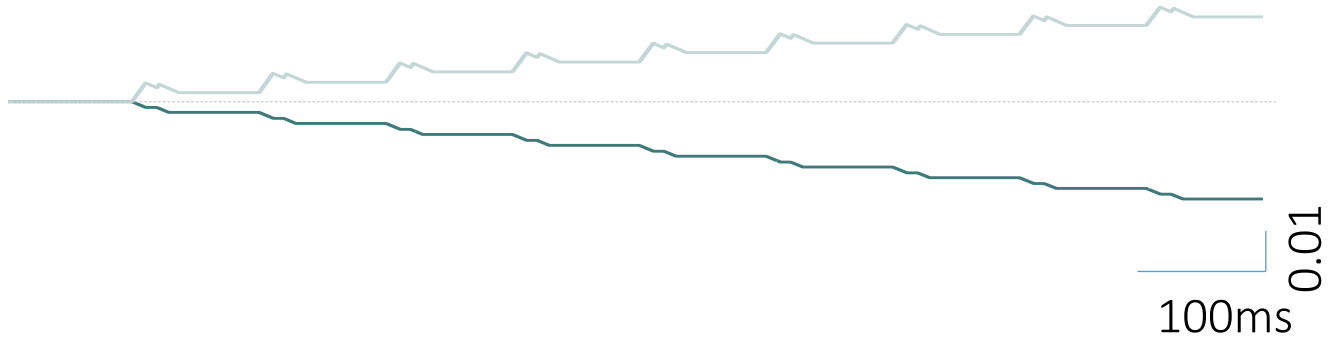
NMOD



Lack of robustness against intrinsic variability



Bio·



Phenom·

