ESPCI PARIS
ÉCOLE SUPÉRIEURE DE PHYSIQUE ET DE CHIMIE INDUSTRIELLES DE LA VILLE DE PARIS

PSL RESEARCH UNIVERSITY

cnrs advancing the frontiers

European Research Council
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"The ethical challenges of Artificial Intelligence"

Karim Benchenane

ERC Consolidator
PROJECT: **MNEMOSYNE**

Brain computer interface to study and manipulate memories of aversive experience during sleep

Karim Benchenane - **MNEMOSYNE project**

Brain-computer interface during sleep to reverse post-traumatic stress disorder

European Research Council

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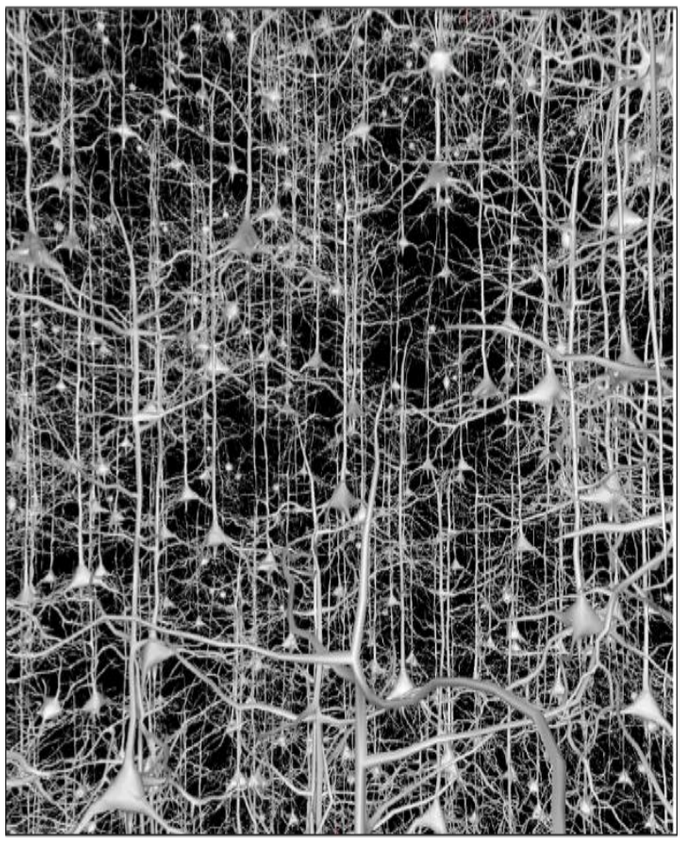
Main topic of research : Sleep and memory



Neuronal network

Understand memory and its pathologies

=

Understand how neurons communicate together and how experience modifies this communication

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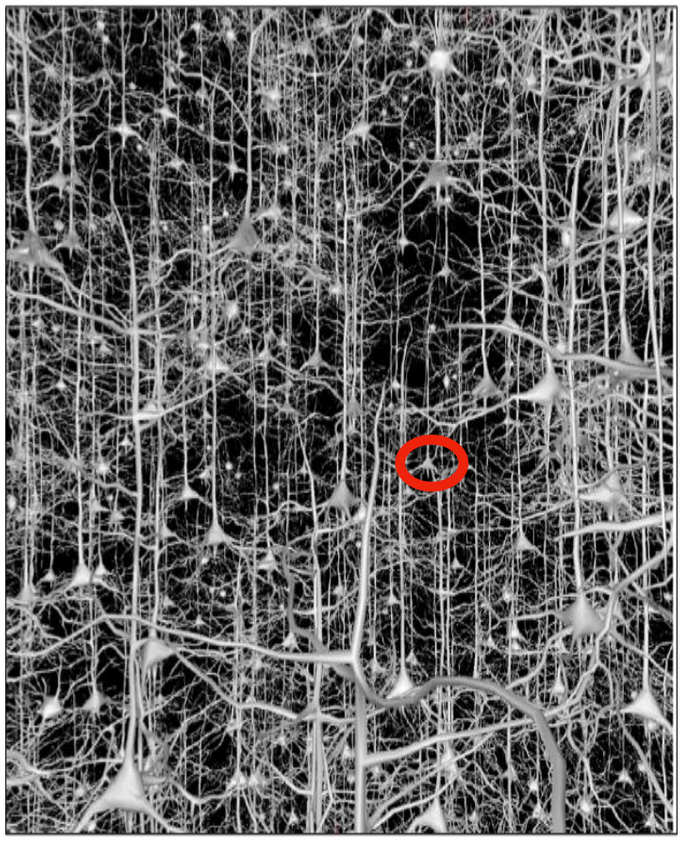
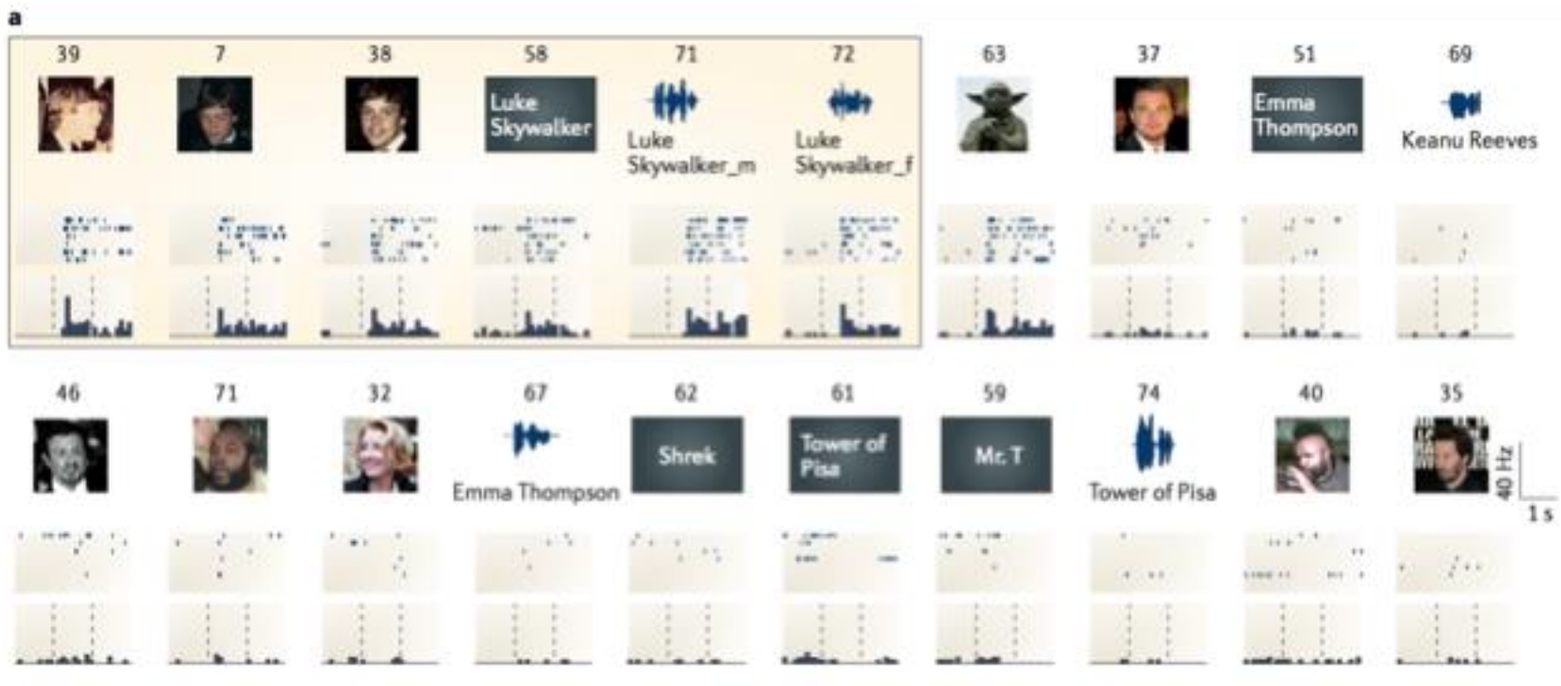


Neuronal network

The « Luke Skywalker » neuron



(Quian Quiroga, 2012)

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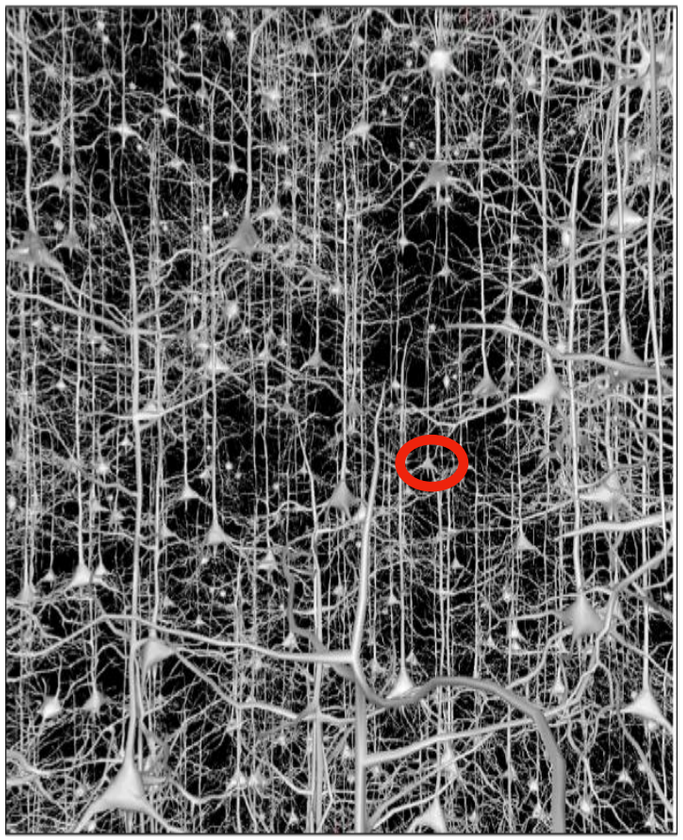
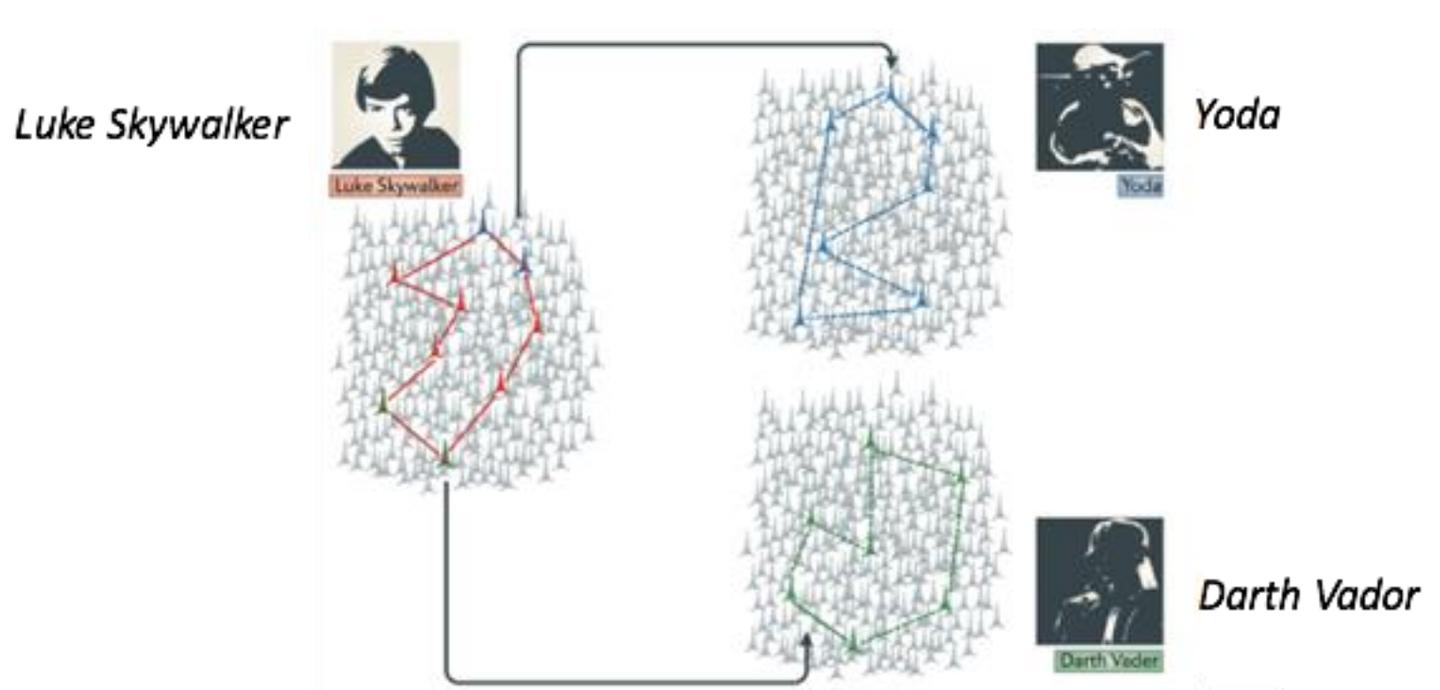


Neuronal network



(Quian Quiroga, 2012)

Population coding in the brain

Need to record a lot of neurons simultaneously

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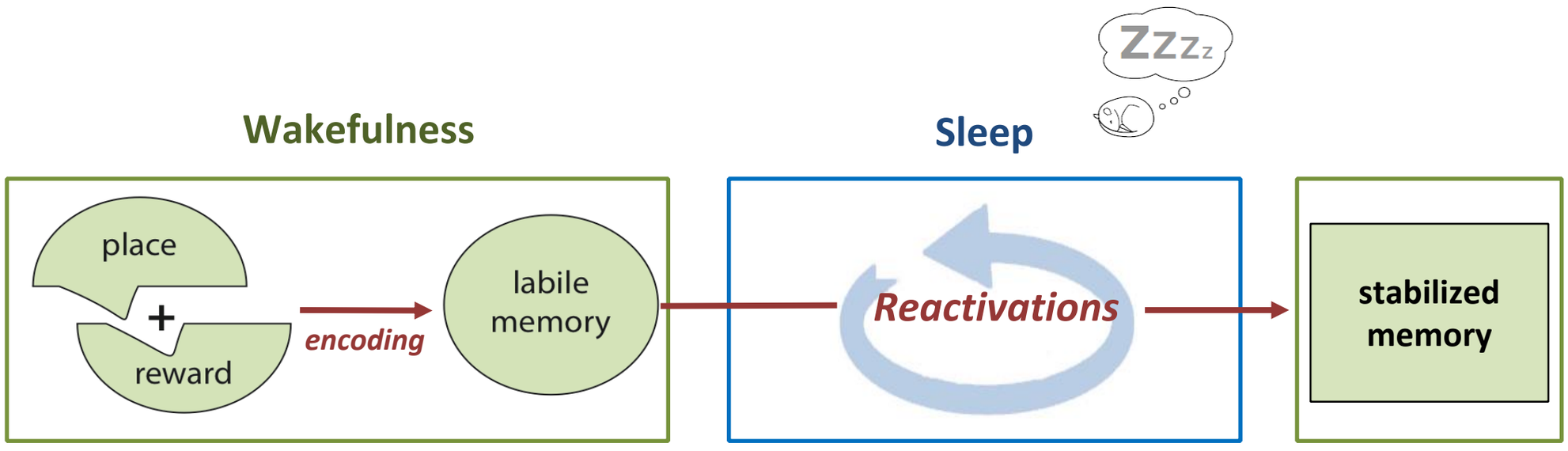

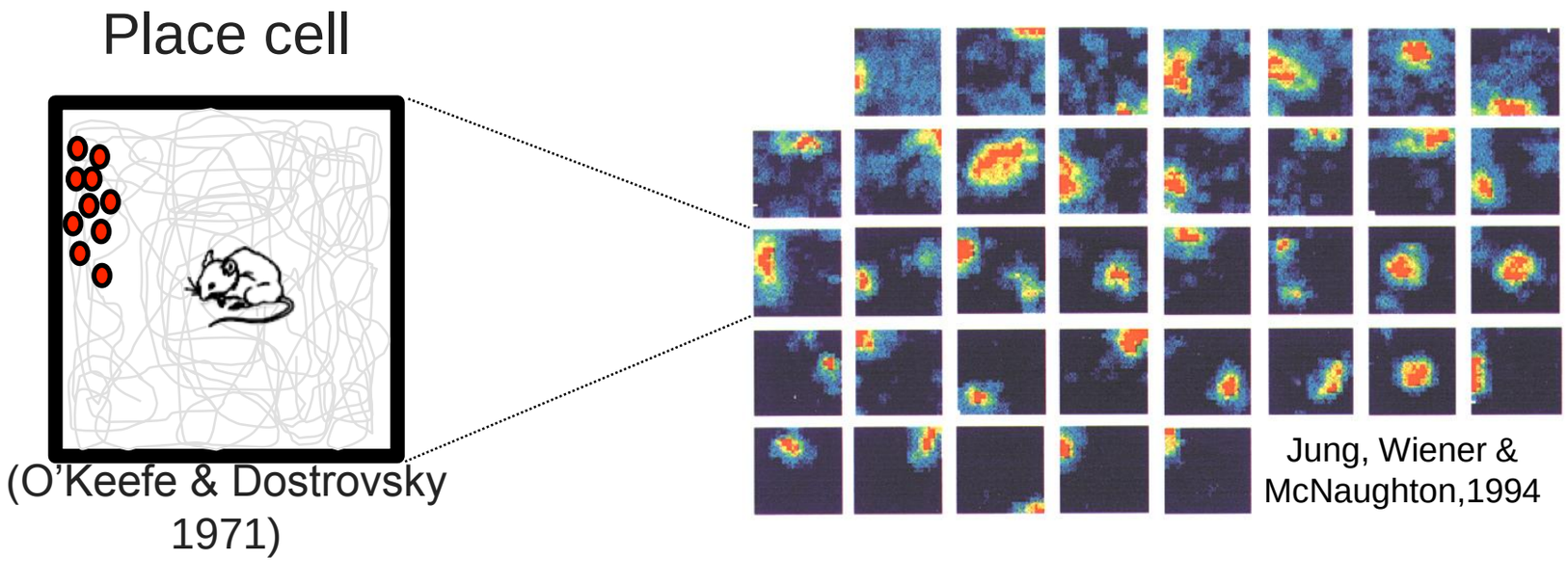

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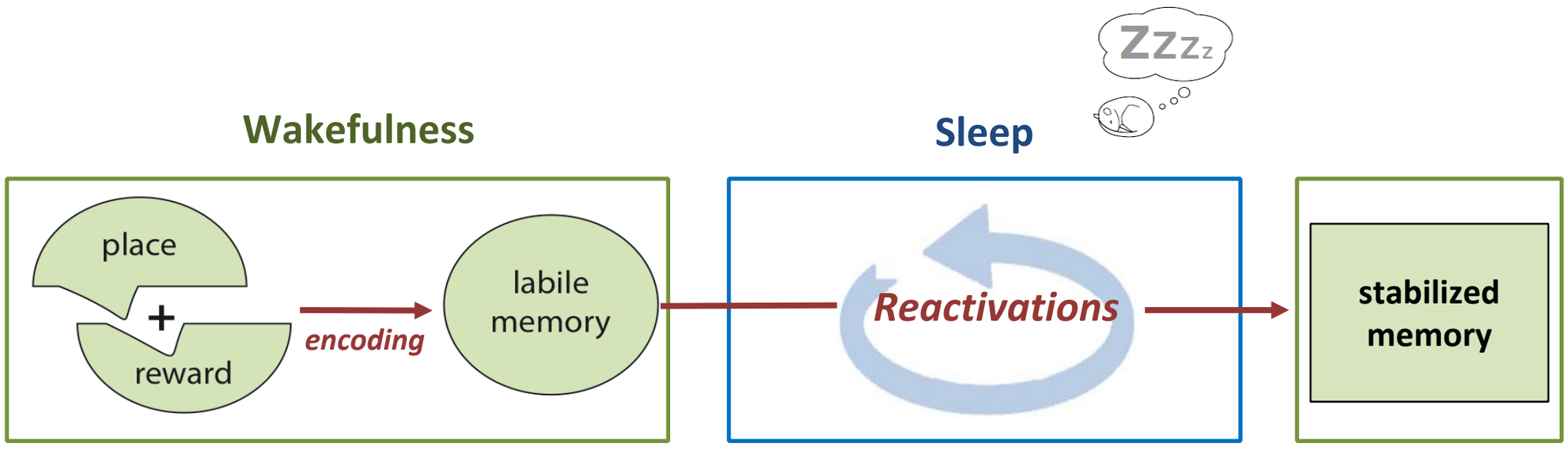

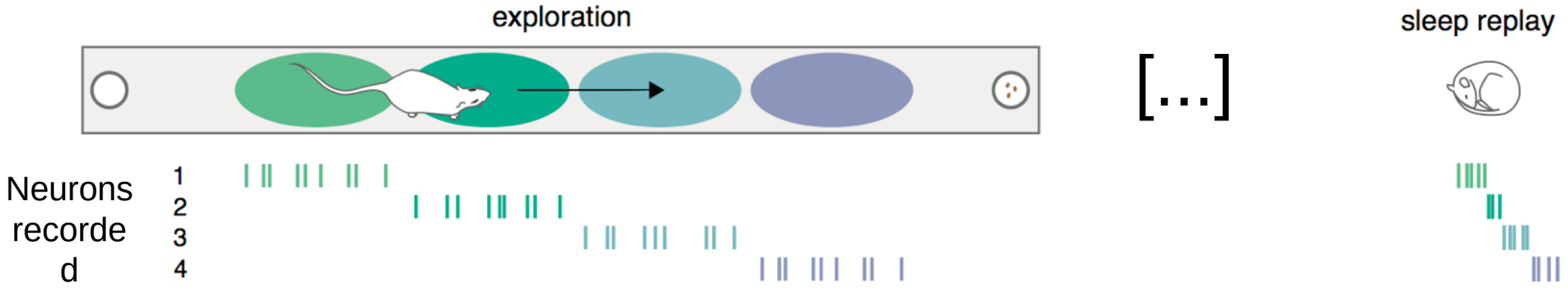

Wakefulness
Encoding

Sleep
Reactivation - Consolidation

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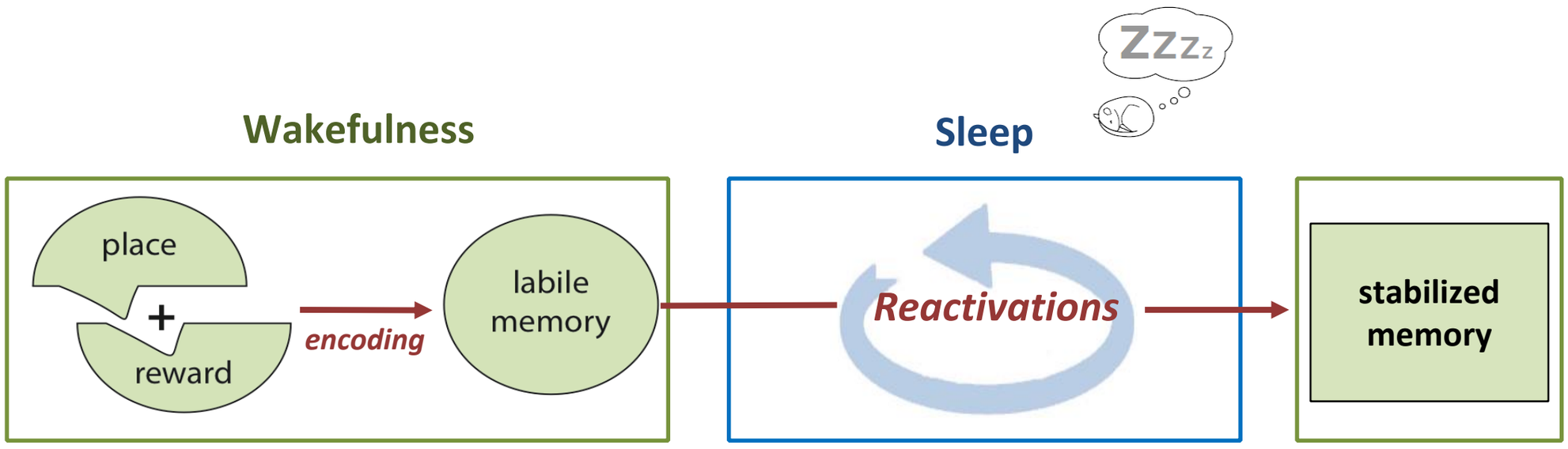

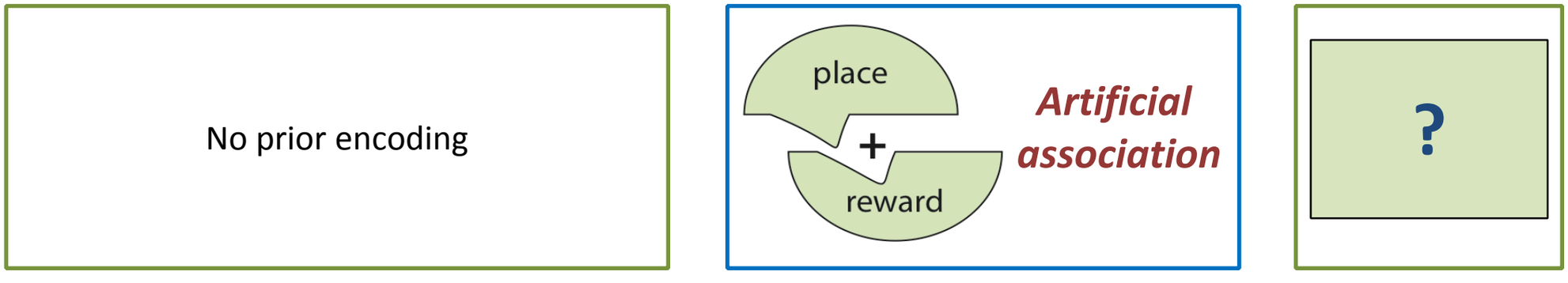

ARTIFICIAL LEARNING

during sleep

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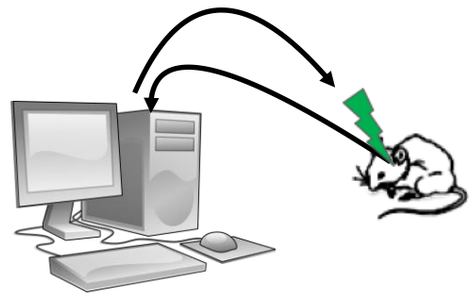
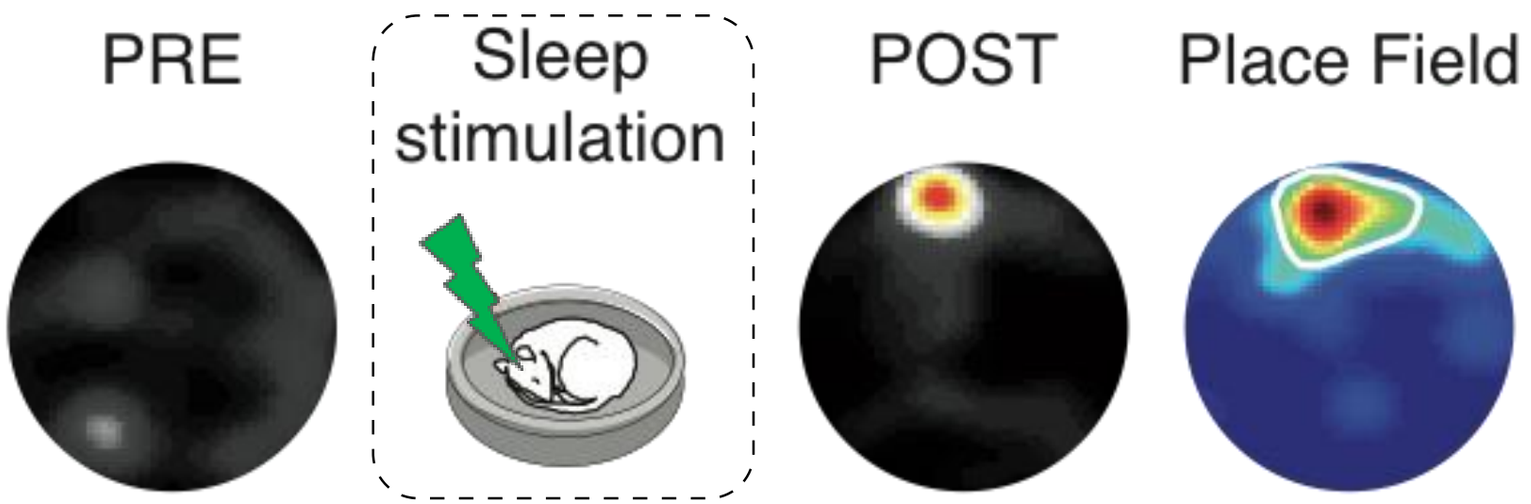
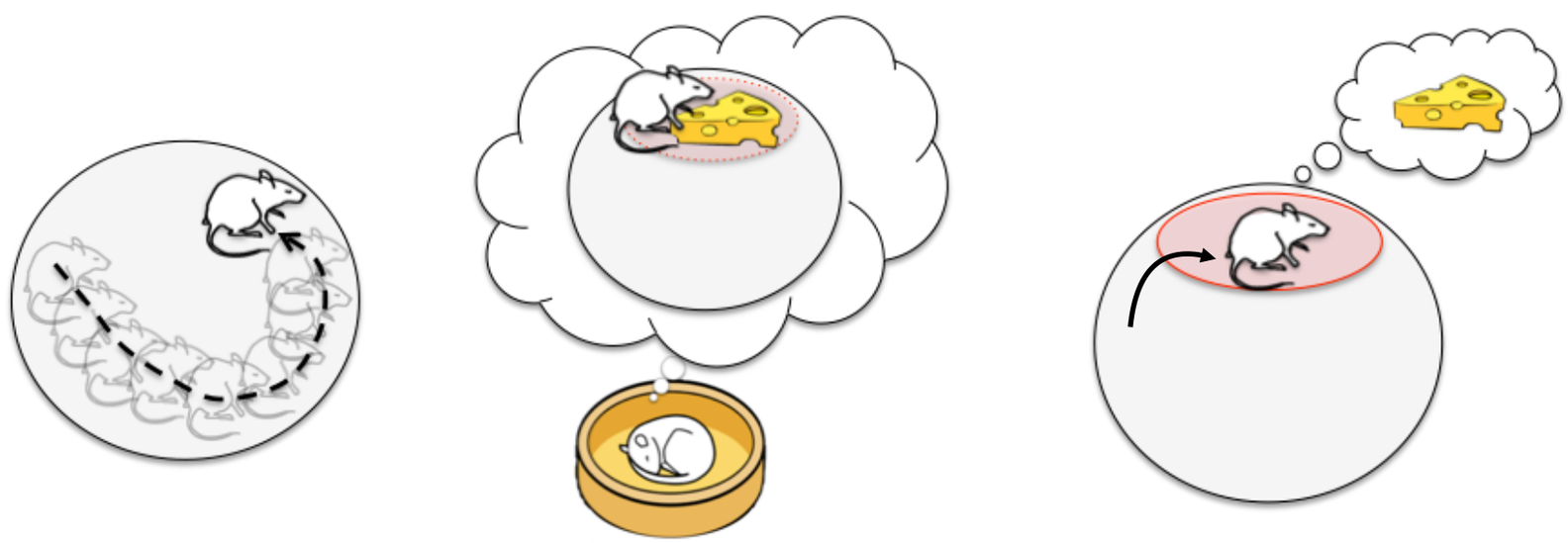
Brain computer interface







de Lavilléon G, Lacroix M, Rondi-Reig L, Benchenane K. *Nature Neuroscience* 2015

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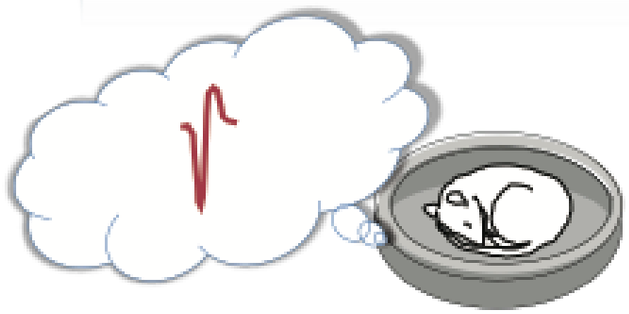
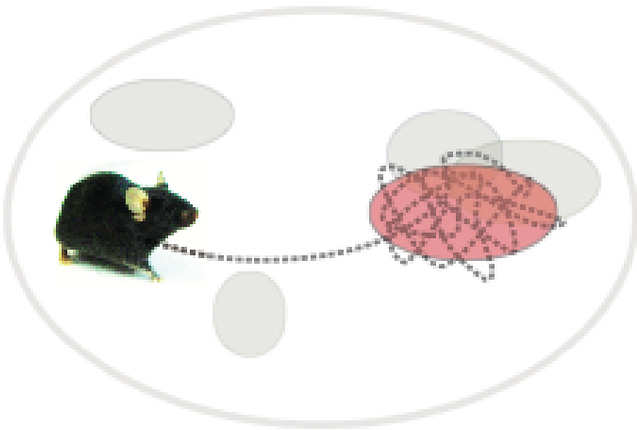


Spikes of a place cell

Place Field



Reward

Reward

CHANGE THE EMOTIONAL VALENCE OF A KNOWN ITEM

de Lavilléon G, Lacroix M, Rondi-Reig L, Benchenane K. *Nature Neuroscience* 2015

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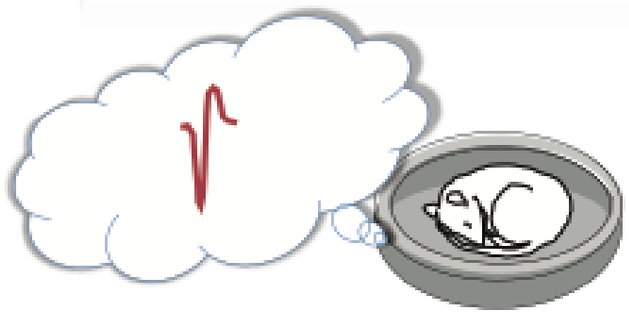

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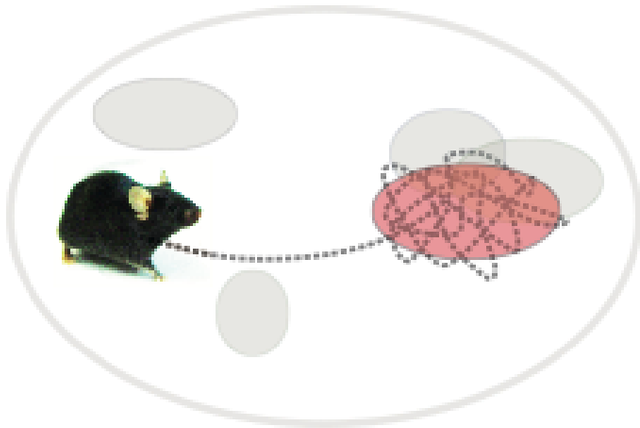

Reward

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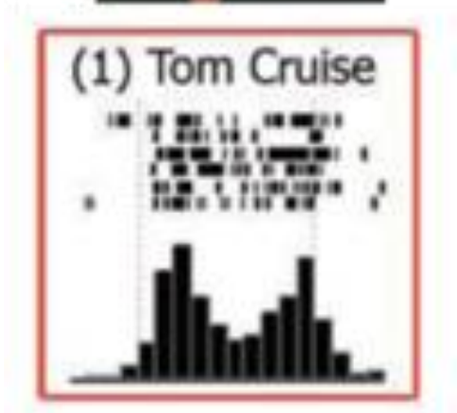

(Gelbard et al. 2008)

de Lavilléon G, Lacroix M, Rondi-Reig L, Benchenane K. *Nature Neuroscience* 2015

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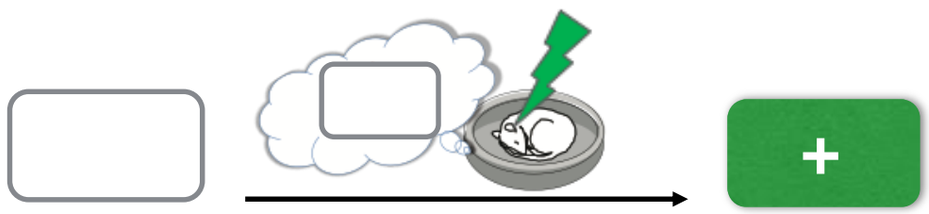
Rewarding-learning during sleep



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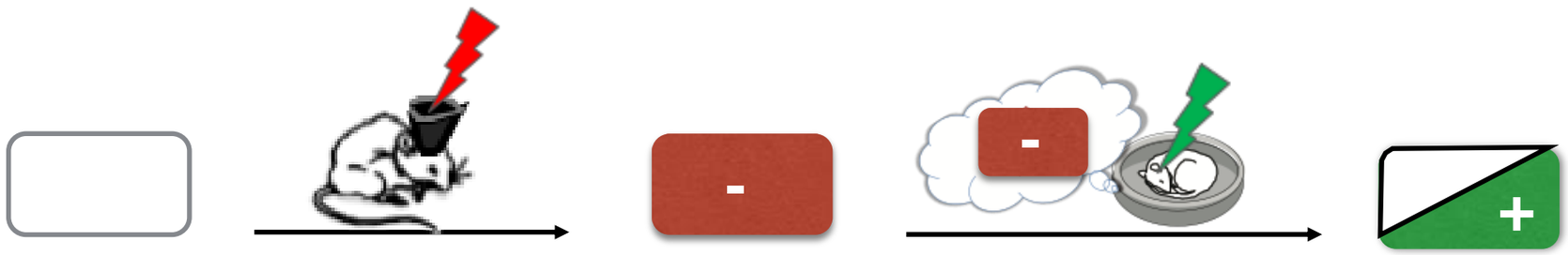
Reverse an aversive experience during wakefulness (trauma) by a rewarding-learning during sleep



Learning during wake

Learning during sleep

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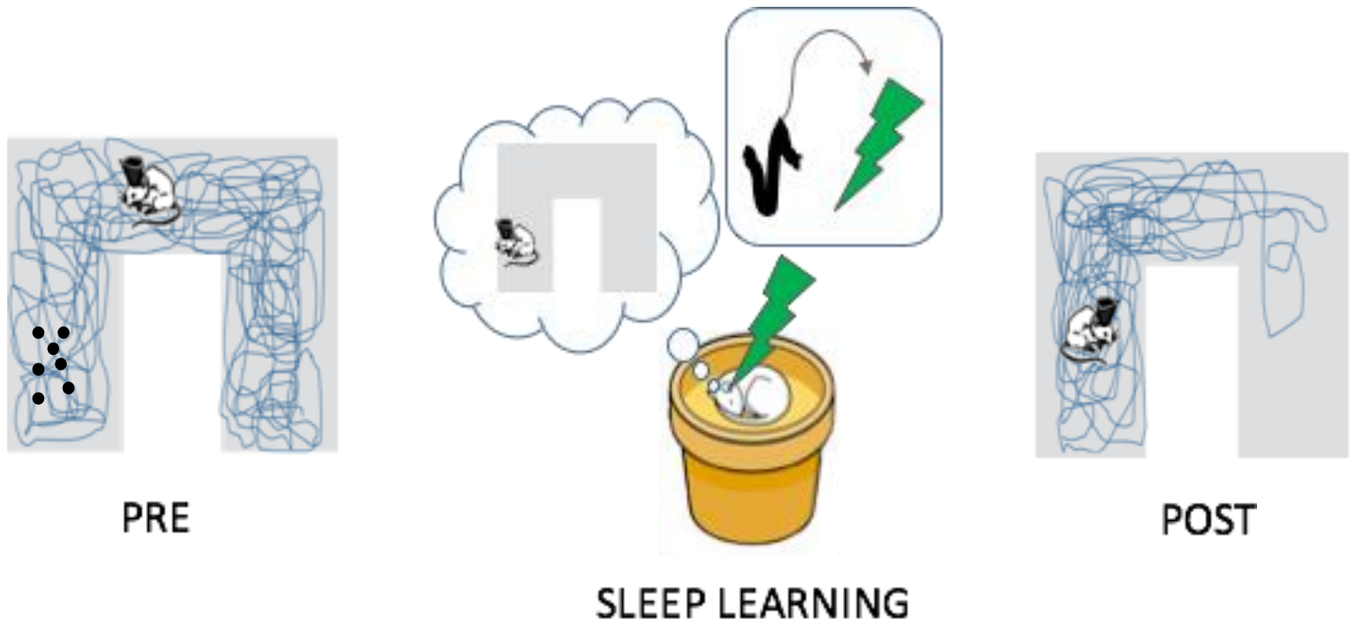
Reverse an aversive experience during wakefulness (trauma) by a rewarding-learning during sleep

Rewarding learning during sleep



PAG aversive stimulations

MFB rewarding stimulations

Brain-computer interface

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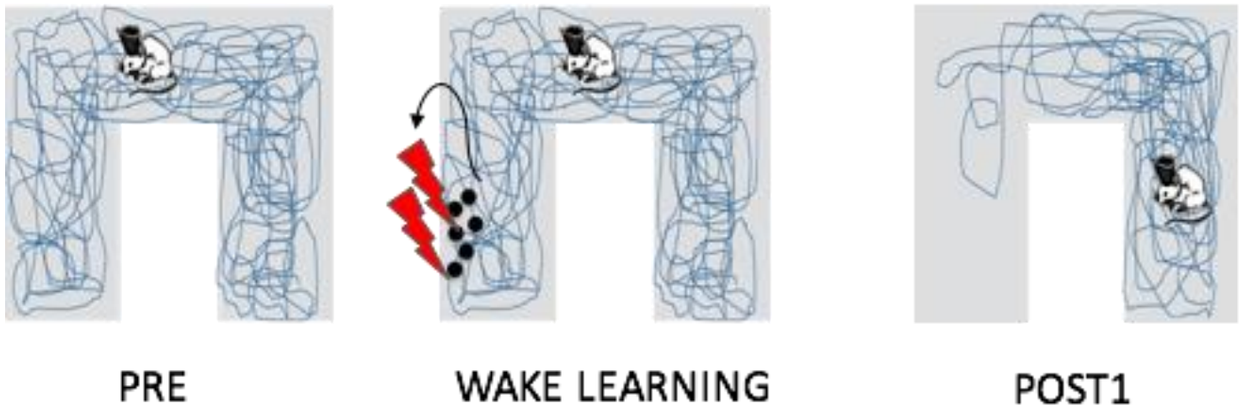
Reverse an aversive experience during wakefulness (trauma) by a rewarding-learning during sleep

Awake aversive learning



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MFB rewarding stimulations

Brain-computer interface

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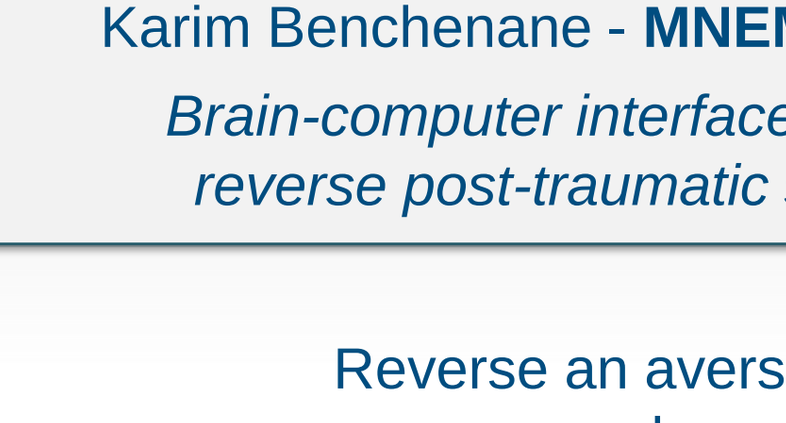
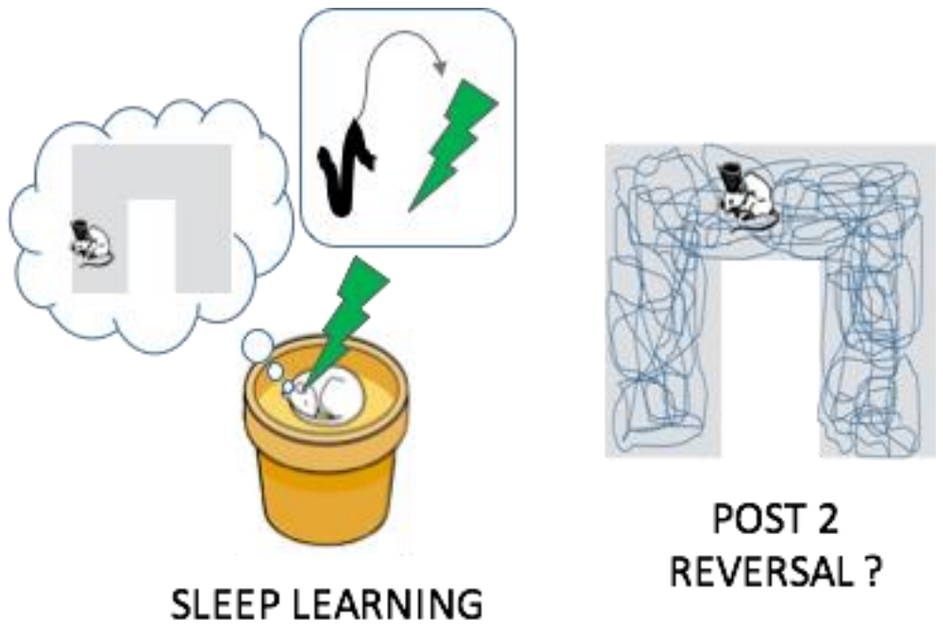


Rewarding learning during sleep



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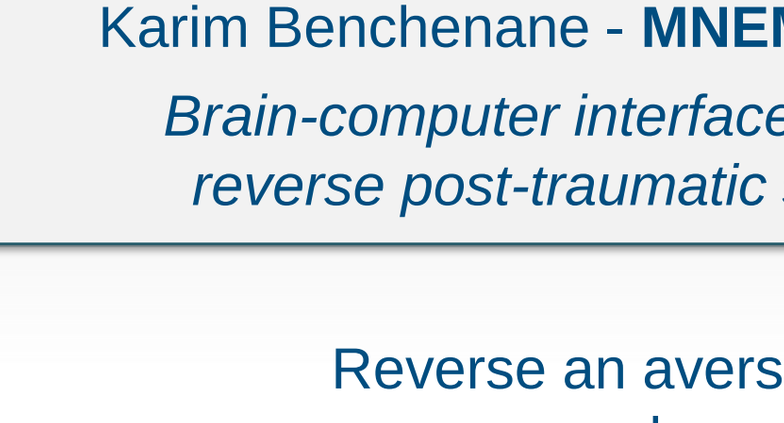

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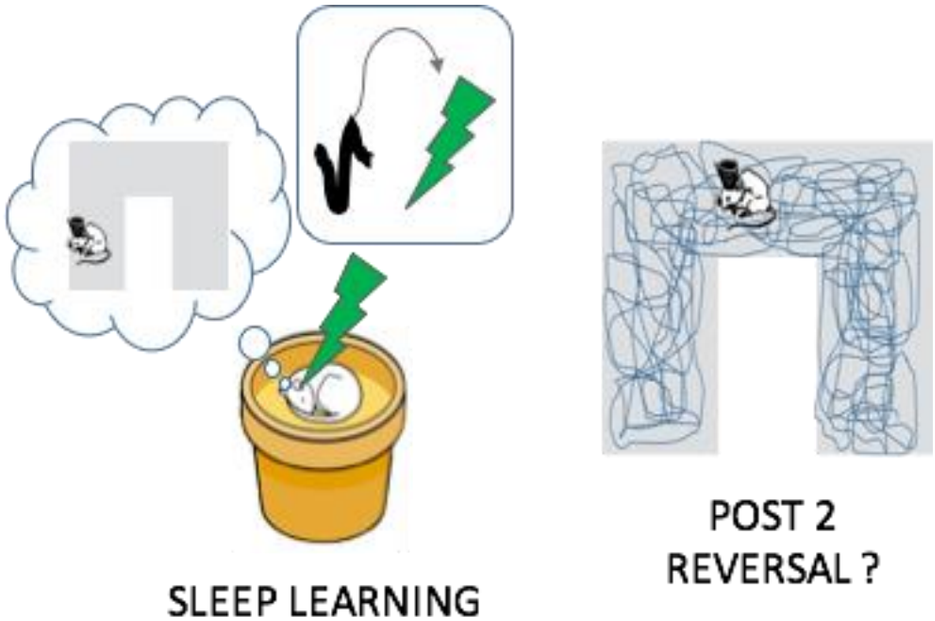

PAG aversive stimulations

MFB rewarding stimulations

Brain-computer interface

Artificial intelligence

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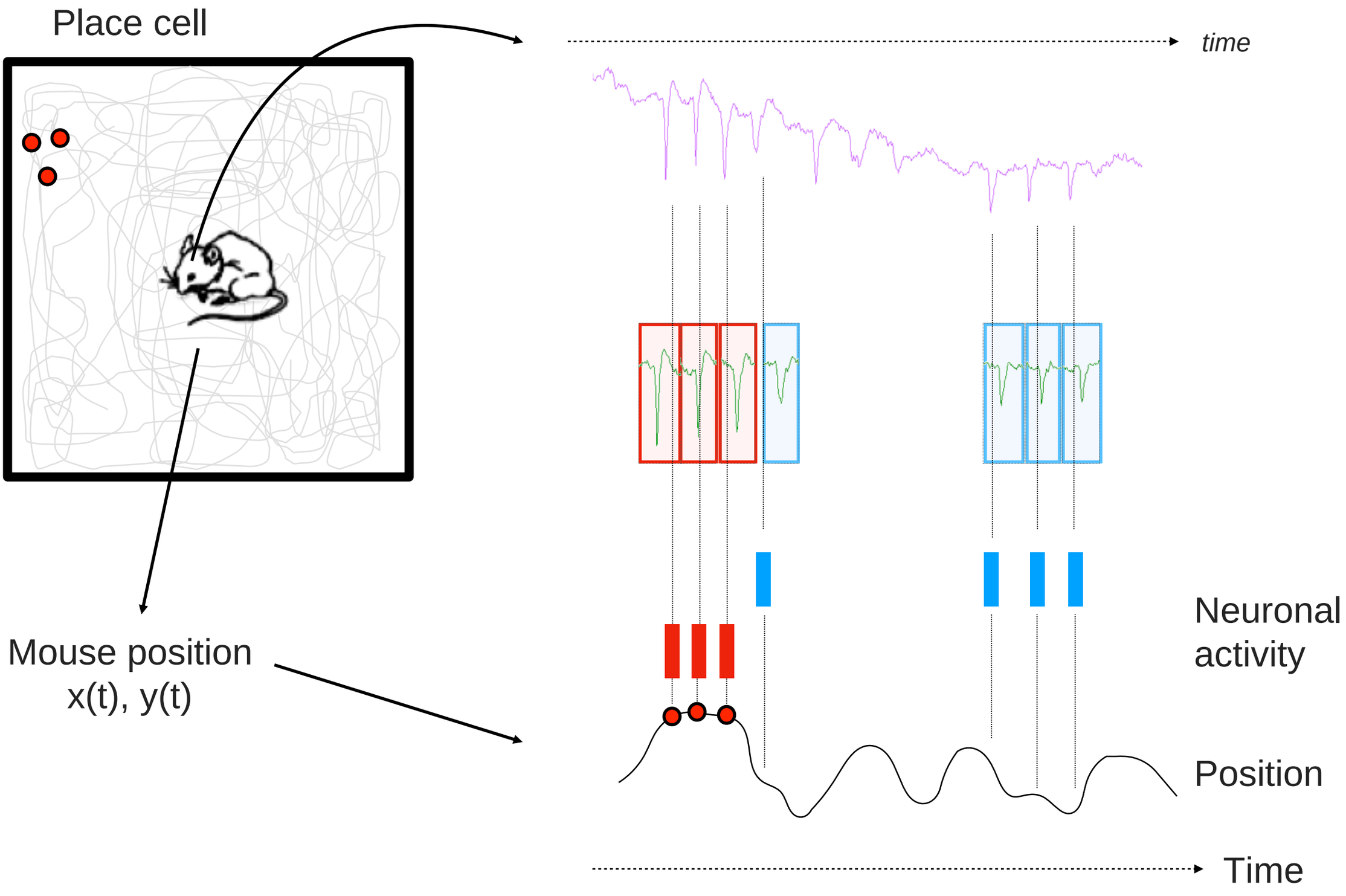

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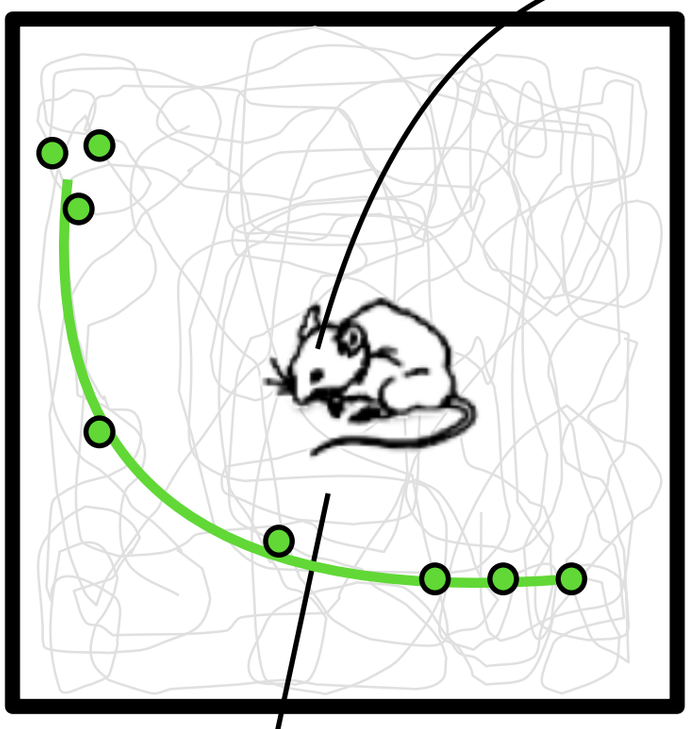
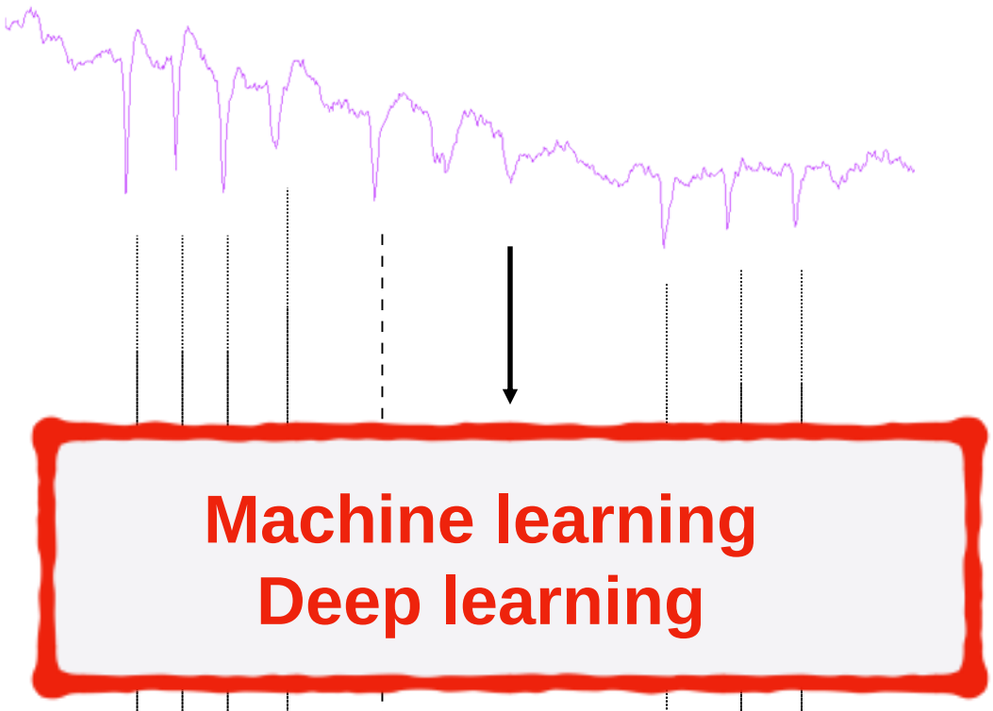
Place cell



Mouse position
x(t), y(t)

time



Neuronal activity

Position

Time

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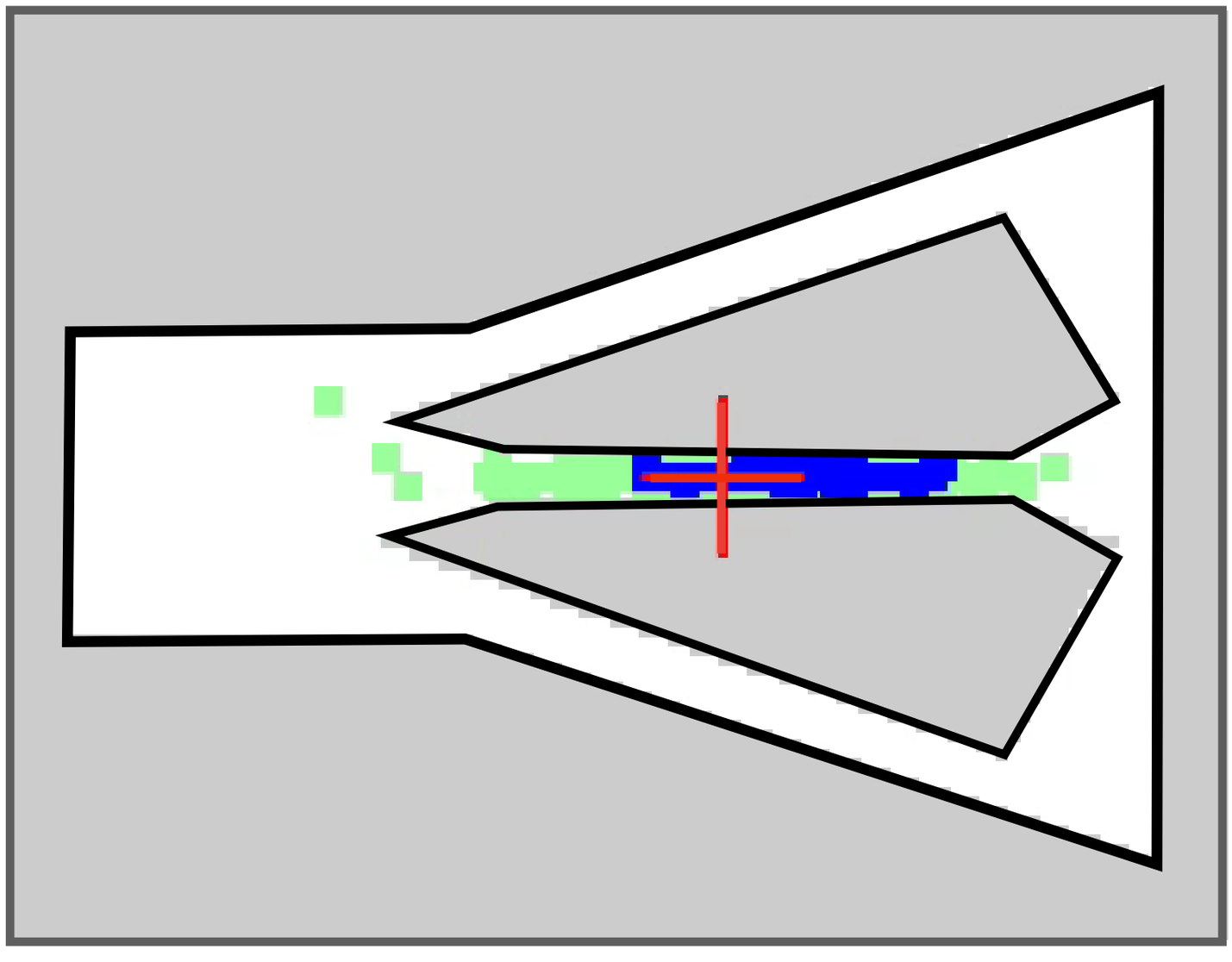
Machine learning : Decode position in the entire environment in real time



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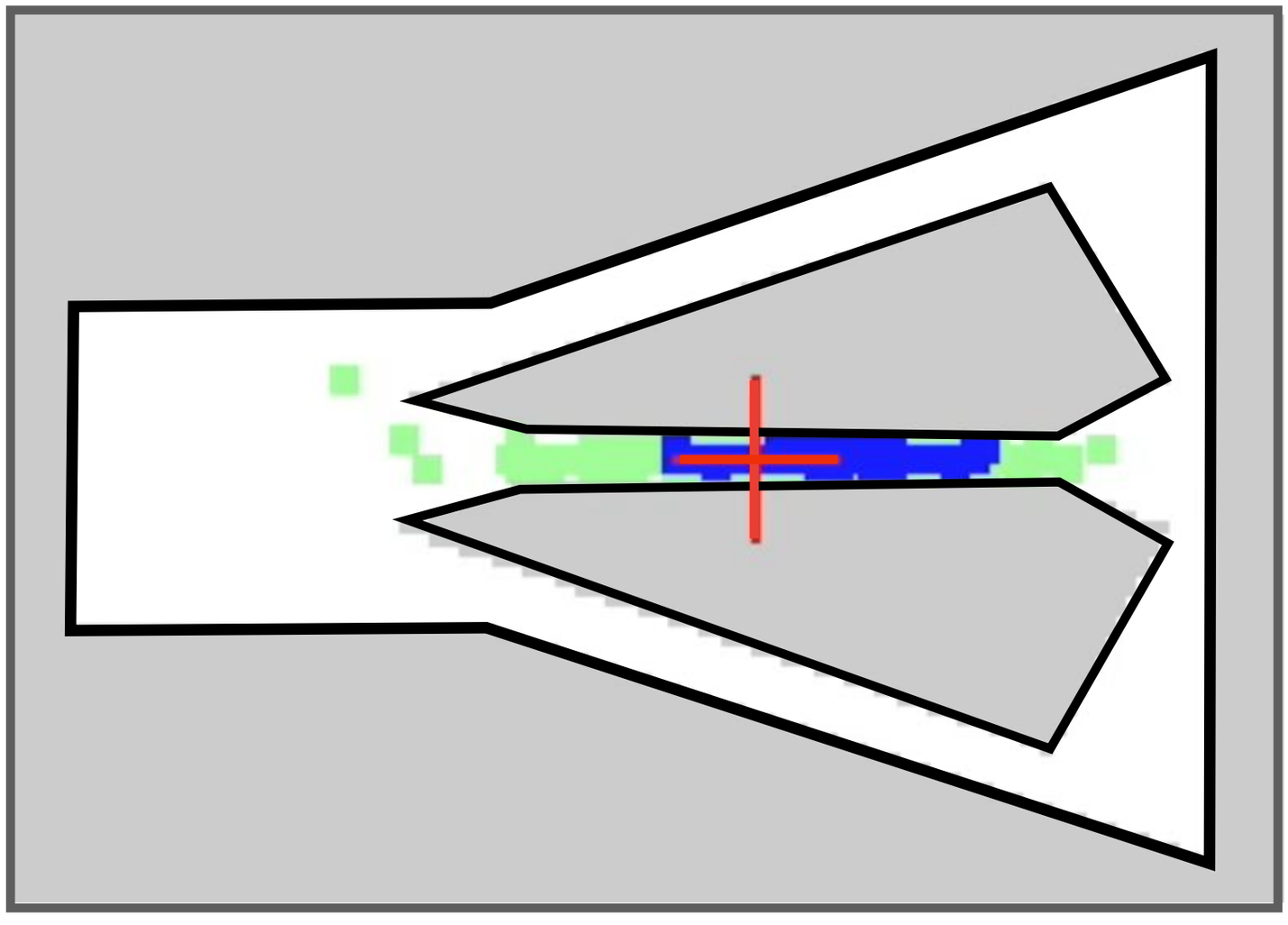
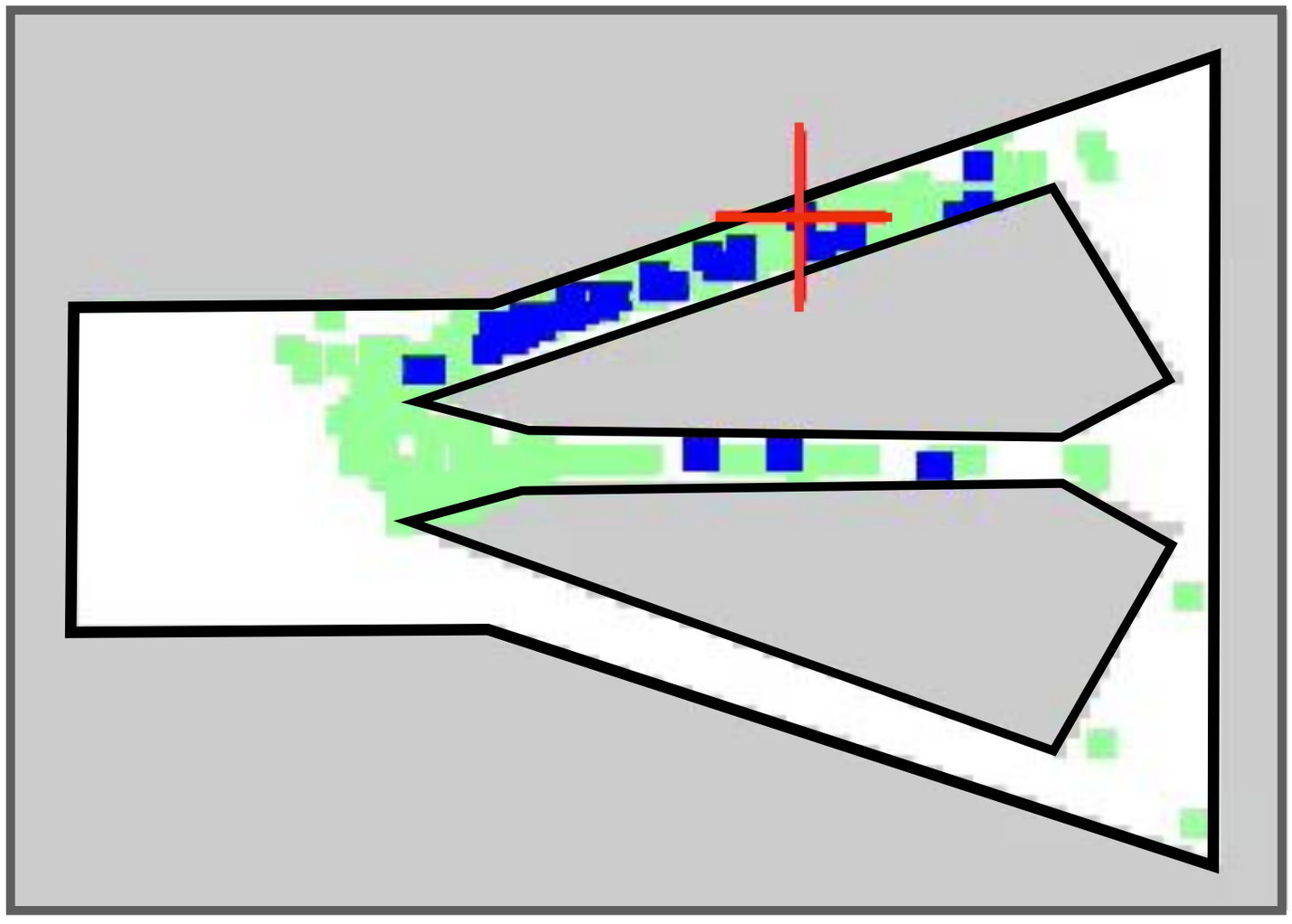


Machine learning : Decode position in the entire environment in real time



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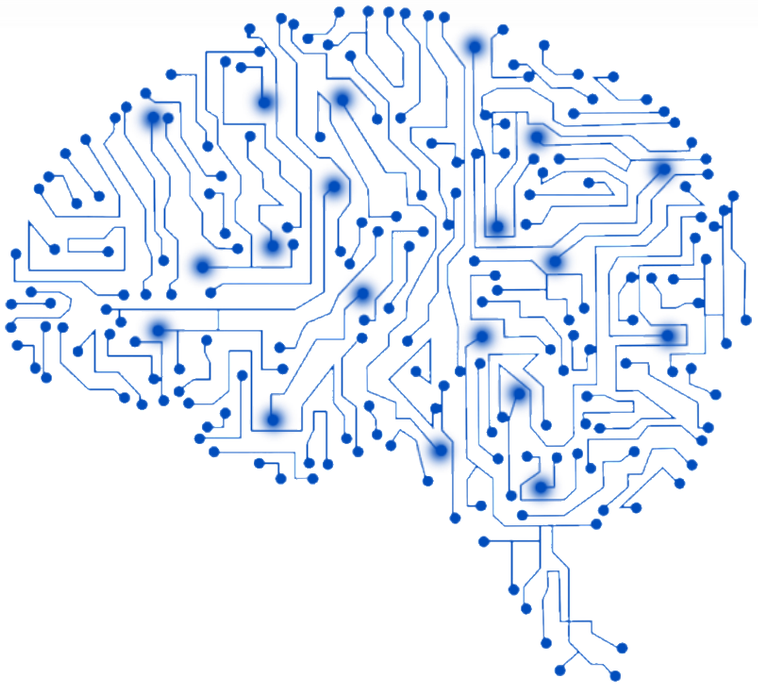
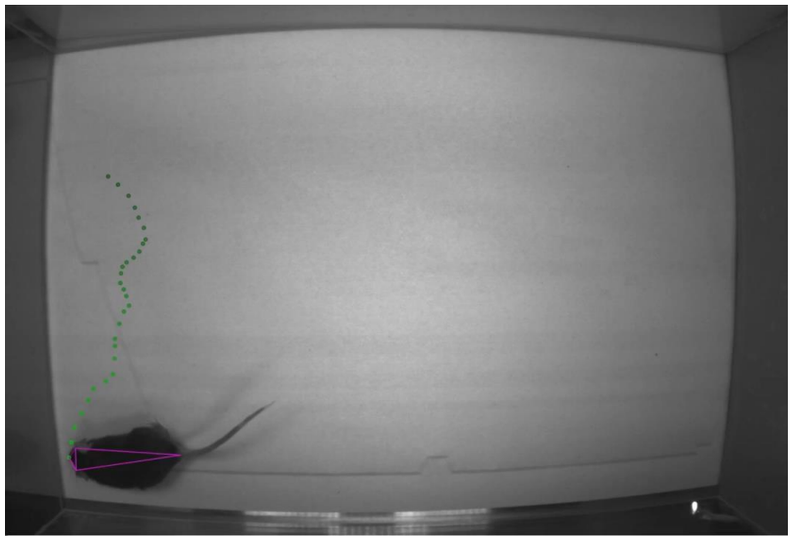
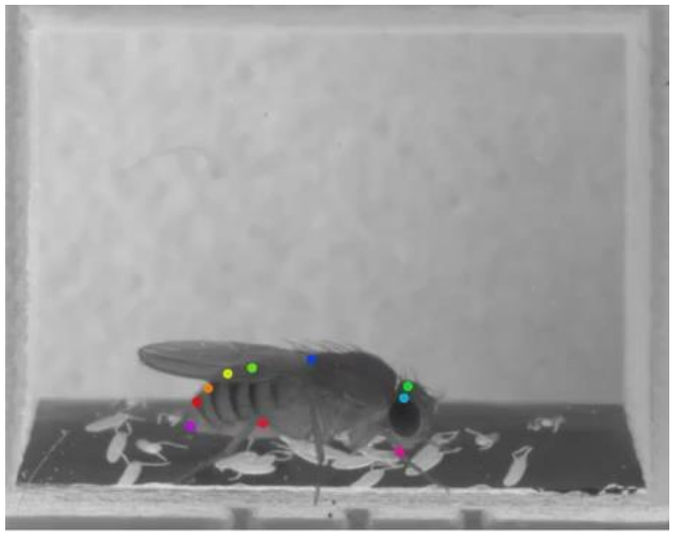


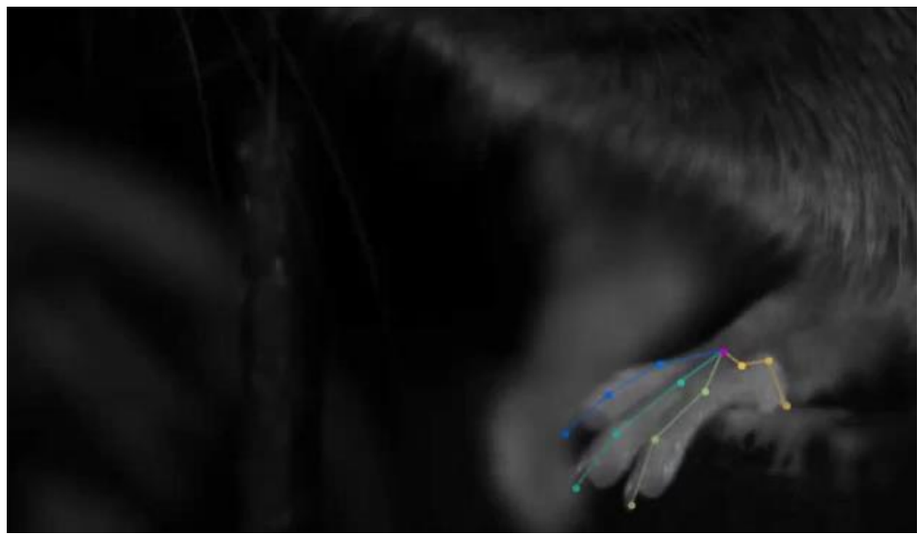
Supervised machine learning

If you can see it …

Deep learning will detect it faster and better than you …







DeepLabCut - Mathis et al. *Nat Neurosci* 2018

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IF YOU CAN SEE IT

	Precision	Invasive	Long term monitoring	Freely moving
Intracranial neuronal recordings	✓✓✓	✗	✓	✓
fMRI	✓	✓✓✓	✓✓	✗

Presented clip

Clip reconstructed from brain activity

Nishimoto et al 2011

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IF YOU CAN SEE IT

	Precision	Invasive	Long term monitoring	Freely moving
Intracranial neuronal recordings	✓✓✓	✗	✓	✓
fMRI	✓	✓✓✓	✓✓	✗
New technique	✓✓✓	✓✓✓	✓✓✓	✓✓✓

Nishimoto et al 2011

Ethical question : Do we want to be able to detect thoughts in your brain ?

To have a fruitful discussion about this question, it is important that experts explain exactly to non-specialists what is feasible or not

Science « Easy »	**Science** Difficult	**Science** Fiction
- Decode some thoughts	- Decode in real time - Motor control (exoskeleton) - Repair sensory modality - Choice prediction	- Download your brain into a computer - Upload new knowledge - Decoding without you noticing it

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Ethical question : Do we want to be able to detect thoughts in your brain ?

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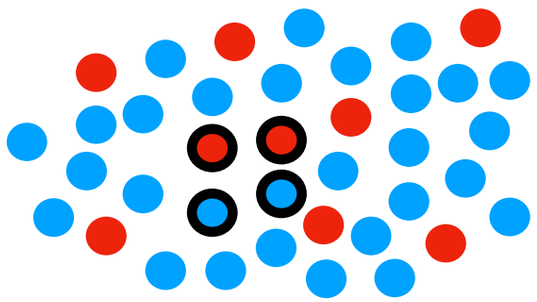
Science
« Easy »

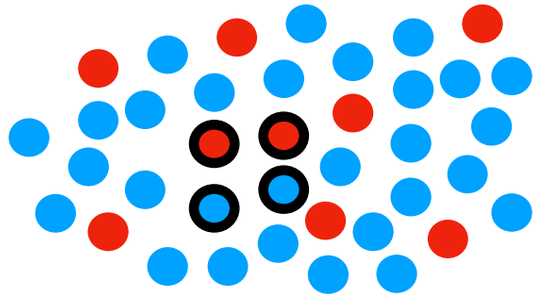
- Decode some thoughts



Enough to decode

Science
Difficult

- Decode in real time
- Motor control (exoskeleton)
- Repair sensory modality
- Choice prediction



Not enough to induce

Science
Fiction

- Download your brain into a computer
- Upload new knowledge
- Decoding without you noticing it

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Ethical question : Do we want to be able to detect thoughts in your brain ?

To have a fruitful discussion about this question, it is important that experts explain exactly to non-specialists what is feasible or not

fMRI

Science ✓

Medical ✓

Advertising ✗

Political communication ✗

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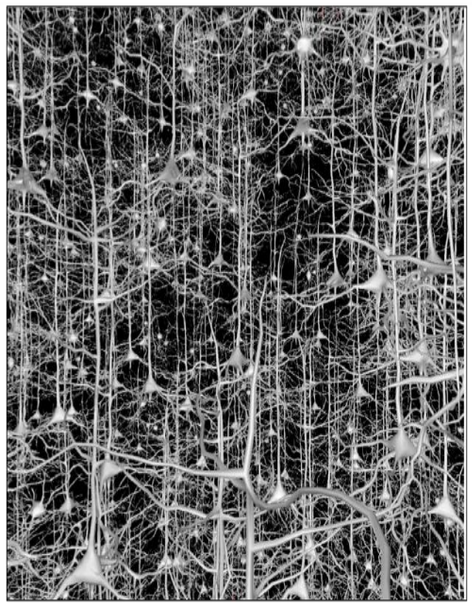
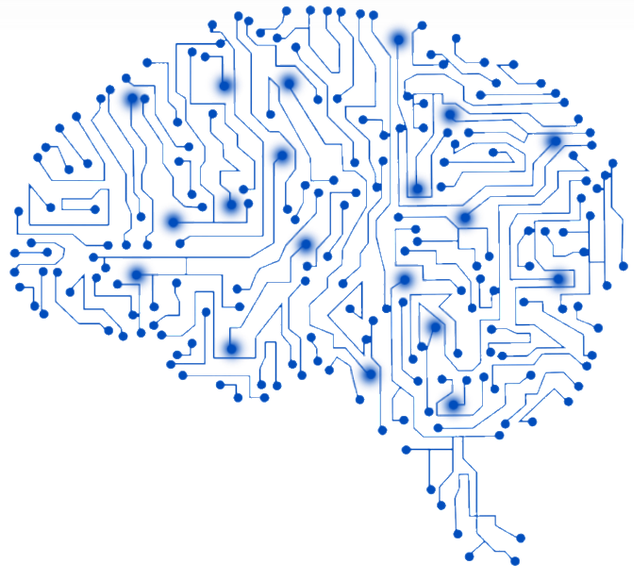
FUTURE



Neuronal network



Artificial
neuronal network

If you can see it …

Deep learning will detect it faster and better than you …

Is there anything to see ?

Supervised machine learning

Unsupervised machine learning

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Thank you !

karim.benchenane@espci.fr

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