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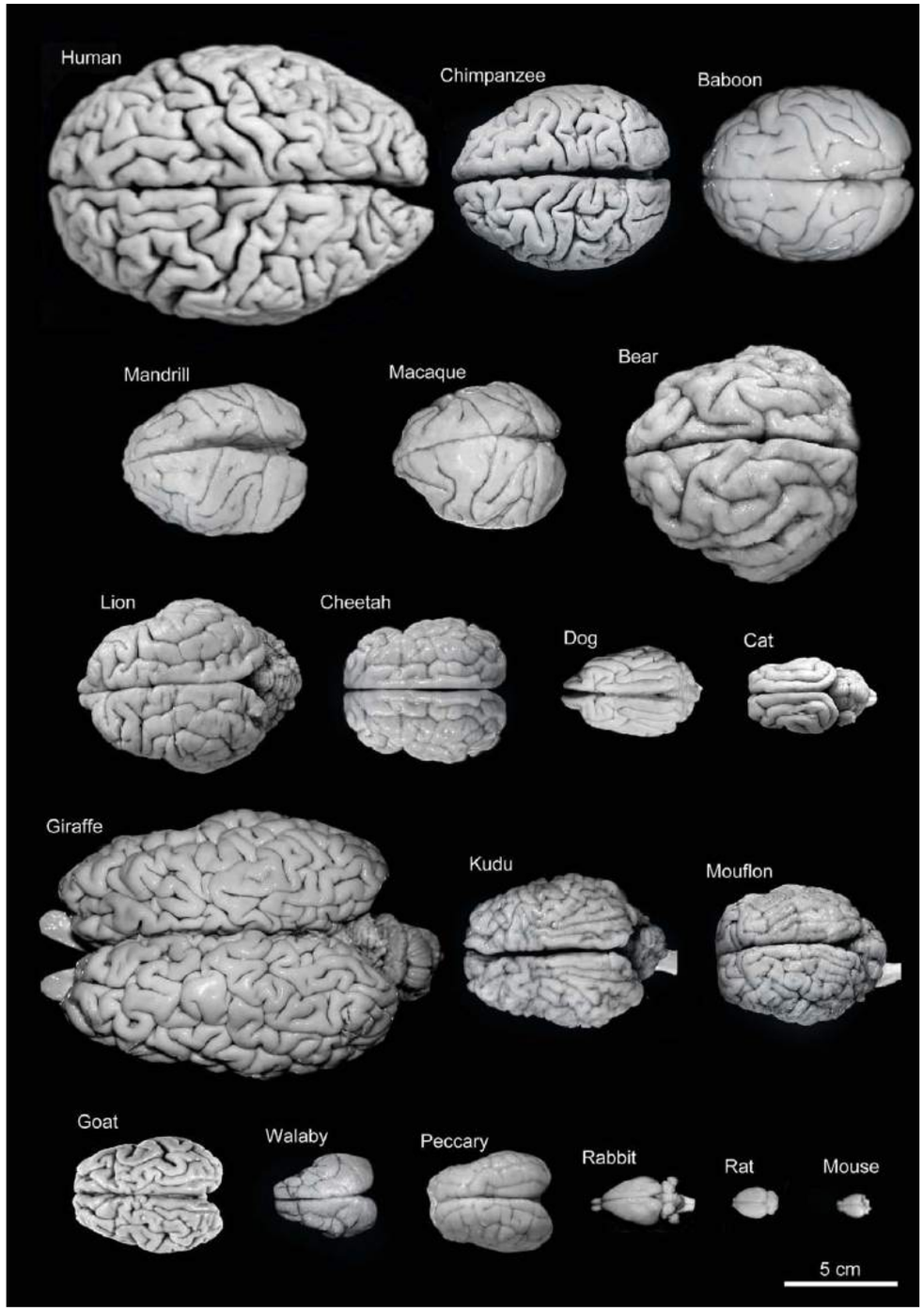
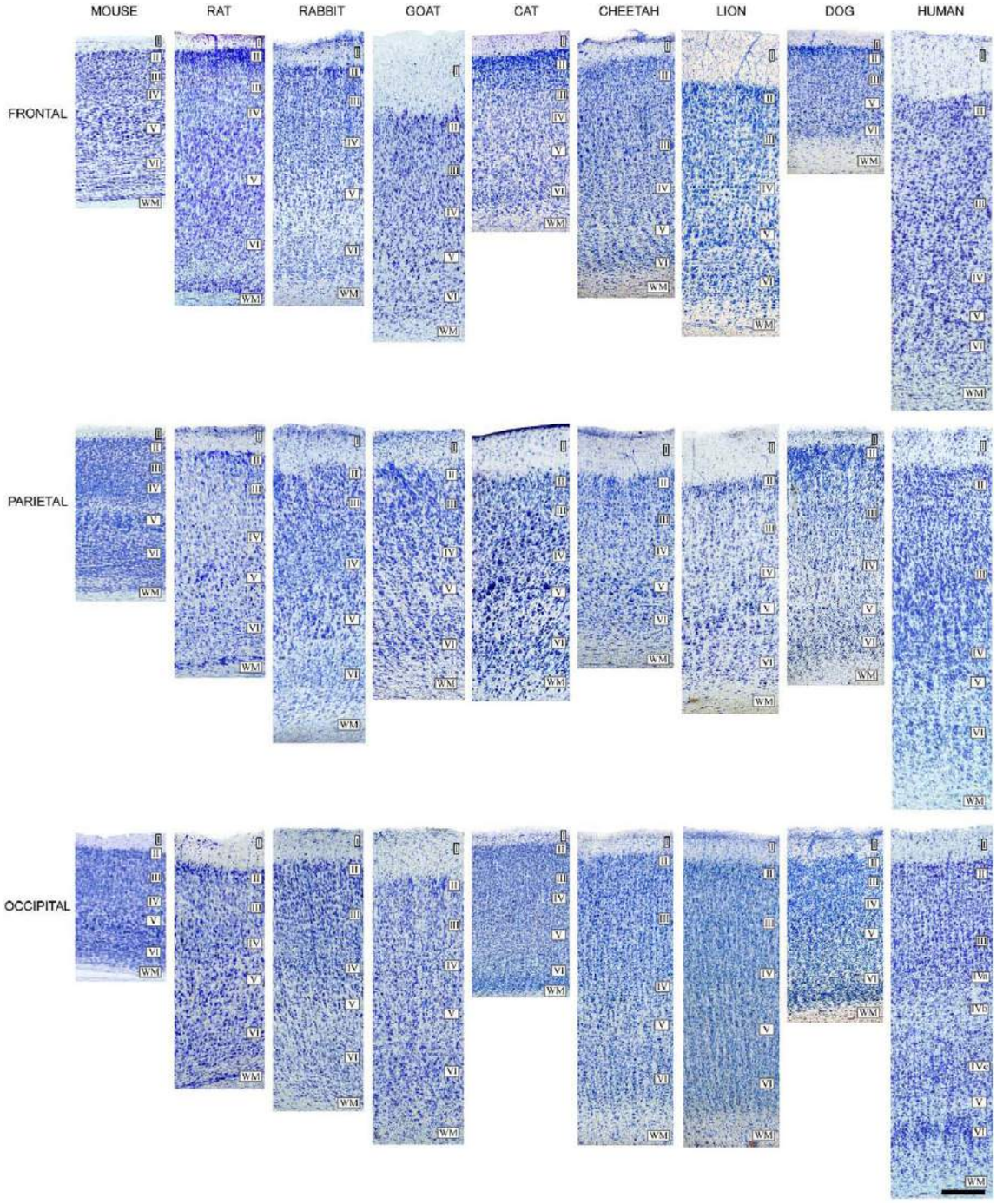
Investigating the canonical organization of neocortical circuits for sensory integration

Collaborators:

CA Bosman, U Olcese, L Gentet, Z Somogyvári, L Négyessy

The organizational principles of the brain





DeFelipe, J (2011) *Frontiers Neuroanat* 5:29

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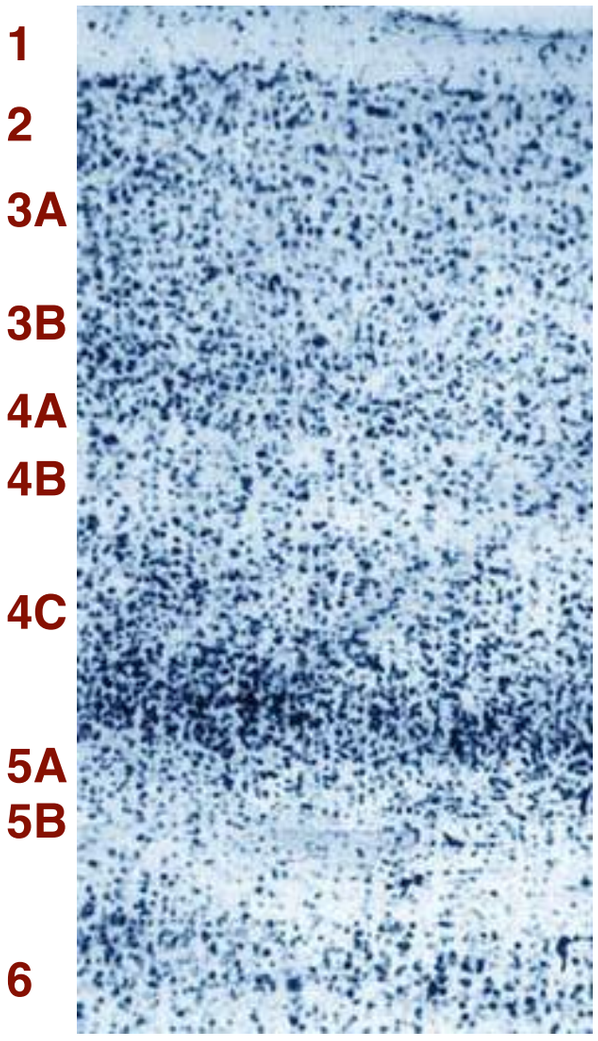
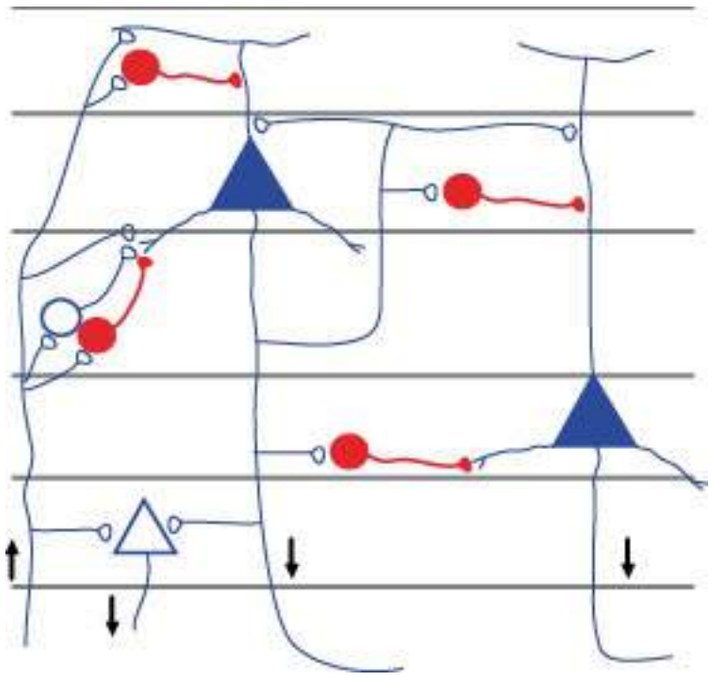
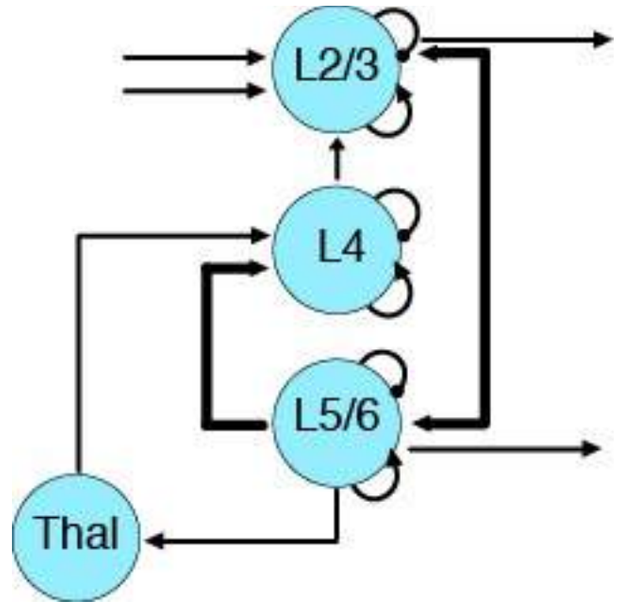
Circuit organization across the cortical column





Cortical Microcircuit



Canonical Microcircuit

Columnar microcircuits convey adaptive advantages to perform several neuronal computations

Bosman, CA & Aboitiz, F (2015) *Frontiers Neurosci 9*:303
Douglas, R & Martin, KAC (2004) *Annu Rev Neurosci* 27: 419

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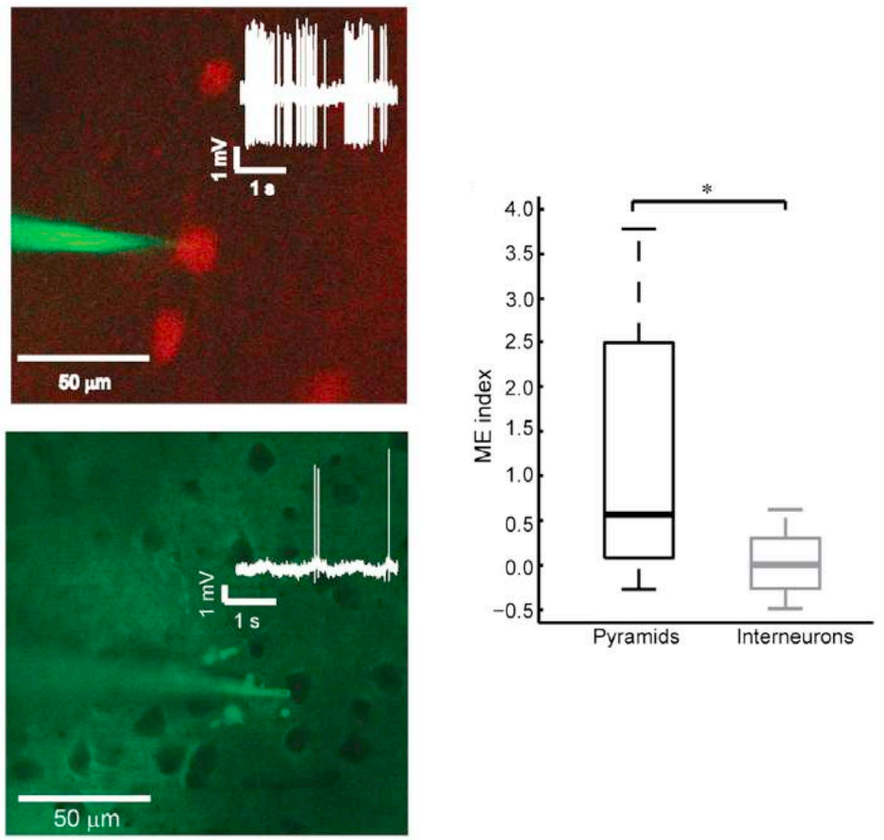
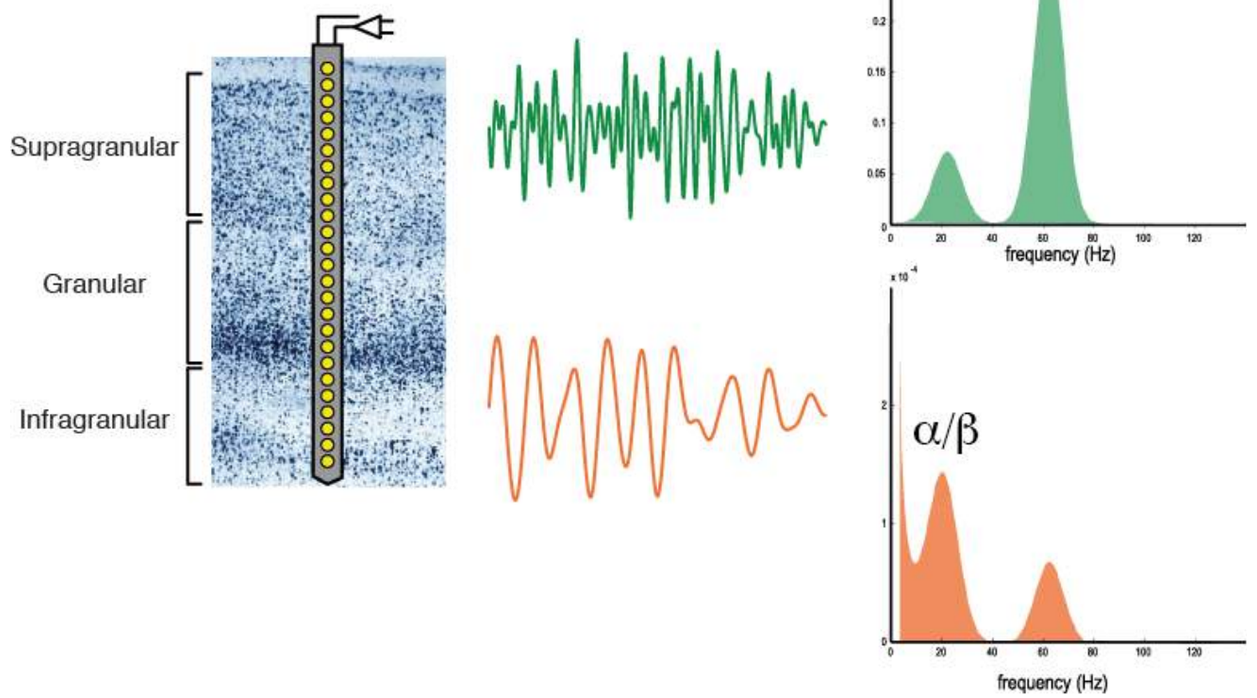
This circuit organization increases the efficiency of cortical computations



Neuronal subtypes are functionally organized across layers and specific neuronal subtypes exert specific computations



Circuit microarchitecture promotes oscillatory compartmentalization

The mechanisms underlying cortical microcircuits functionality are not yet fully understood

Olcese et al. (2013) *Neuron* 79: 593
van Kekoerle et al. (2014) *PNAS* 111: 14332

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CANON aims to reveal the functional micro-architecture governing cortico-cortical integration

Questions to answer:

1. How are the different forms of cortical communication (e.g feedforward, feedback) performed at the level of distinct layers and neuronal subtypes?

2. How do the feedforward and feedback forms of cortical oscillatory activity relate to the function of individual neurons and to specific computations?

3. Do different mammals share the same micro-architecture for cortical integration? Can we observe traces of a similar architecture in intracranial recordings in humans?

CANON Circuit architectures for multisensory integration

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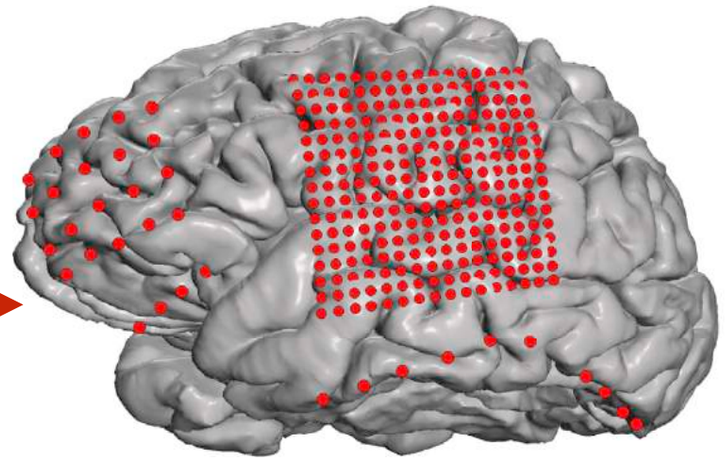
1. Multi-species approach

Mice

Ferrets



Humans

Data Model

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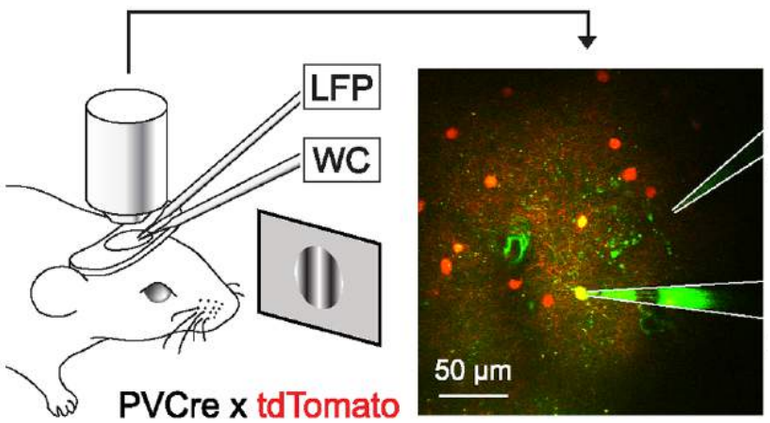
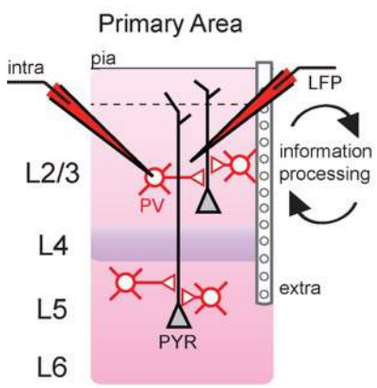
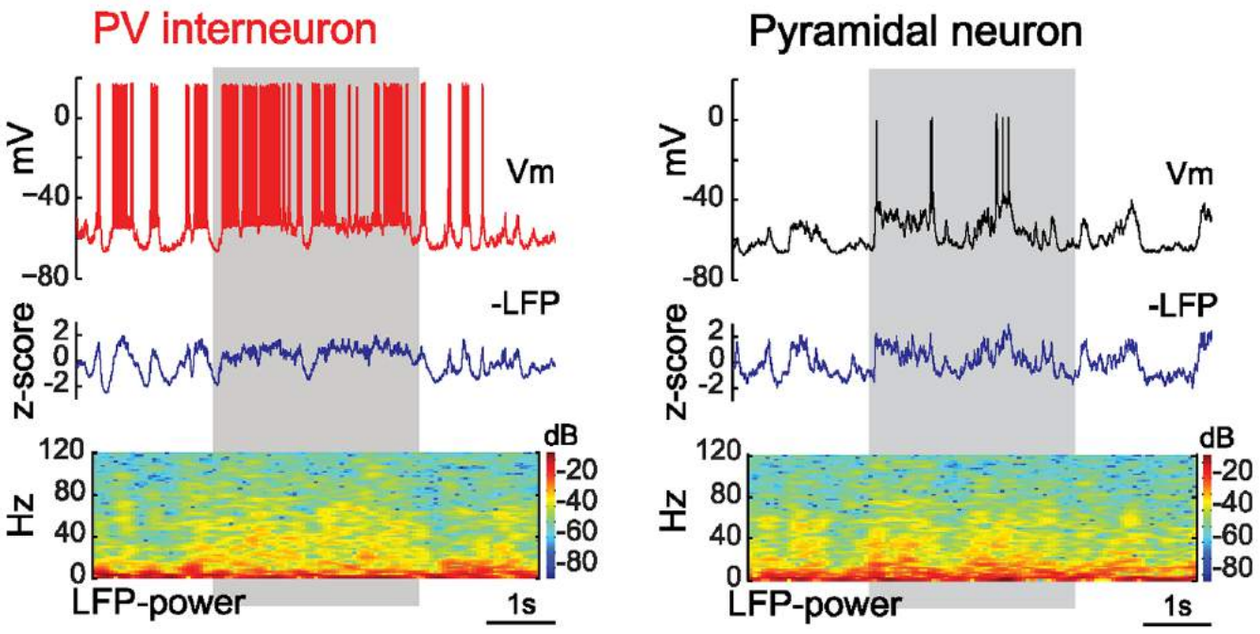
2. Multi-level approach

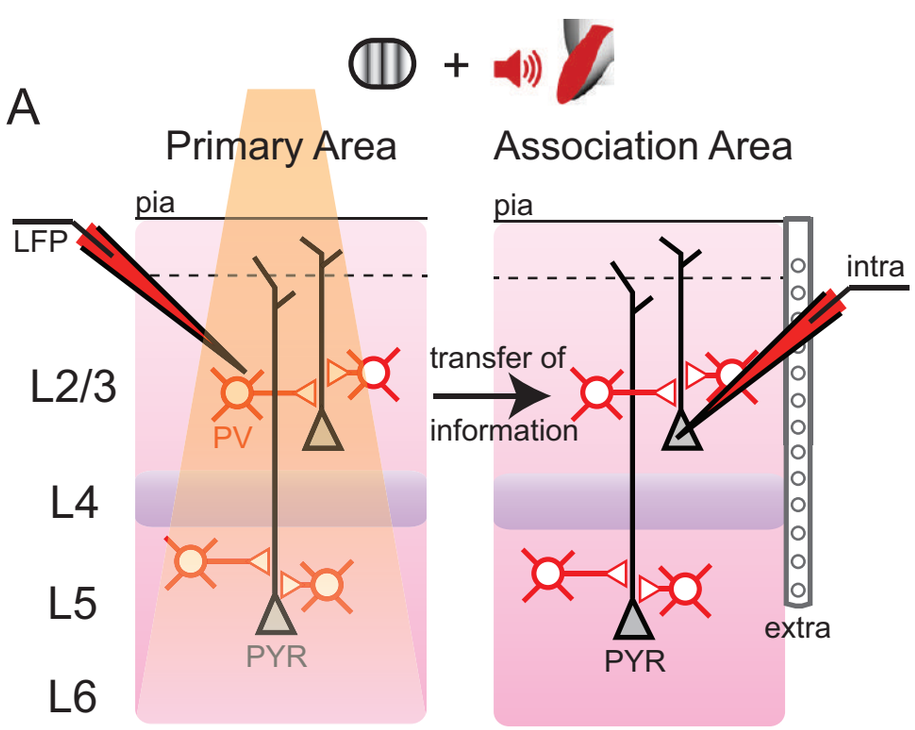
Two-photon targeted patch clamp recordings of pyramidal cells and parvalbumin-expressing interneurons, combined with Local Field Potentials (LFPs)





Contribution of different neuronal subtypes



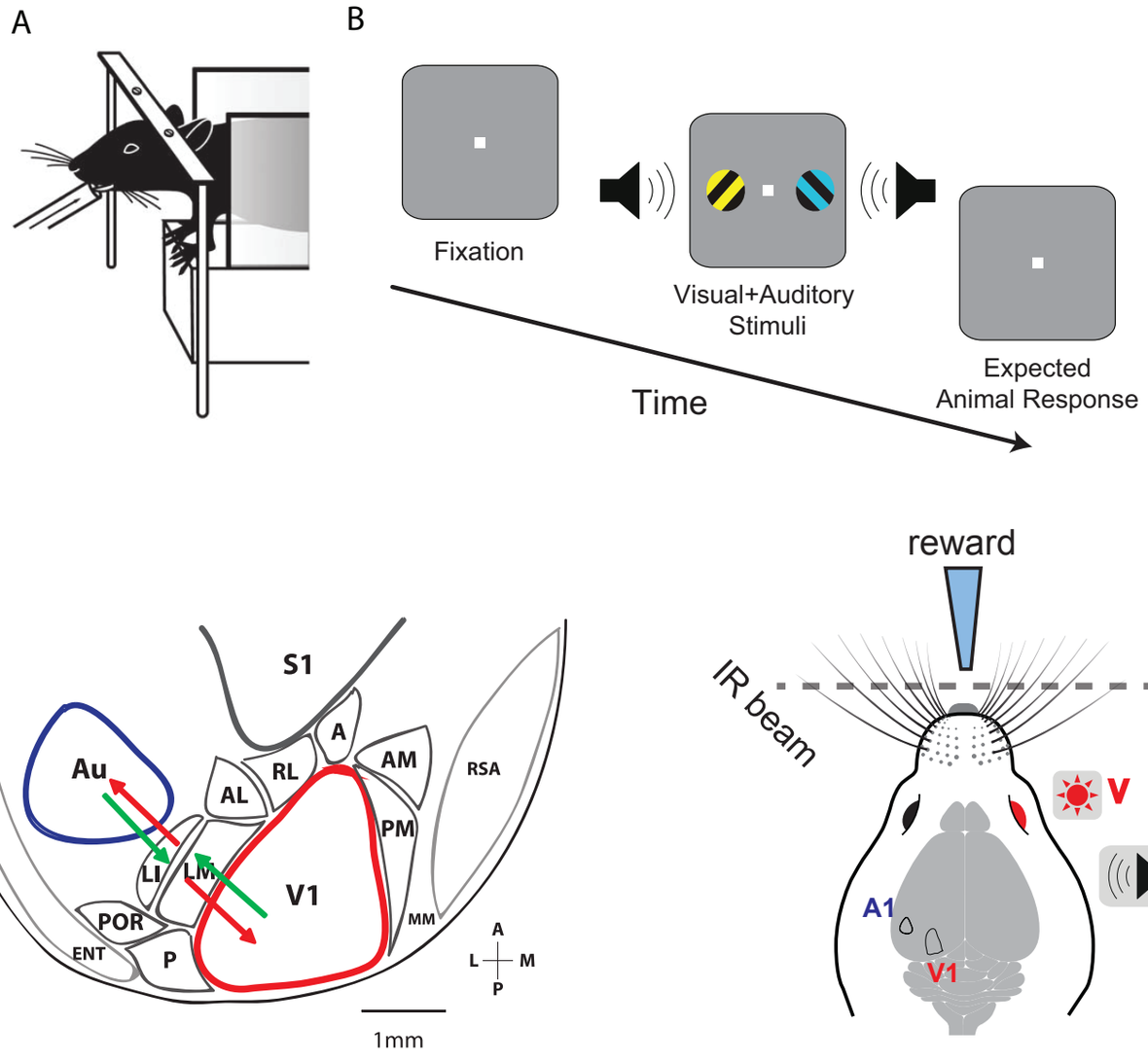


Perrenoud et al. (2016) *PLOS Biol* e1002383

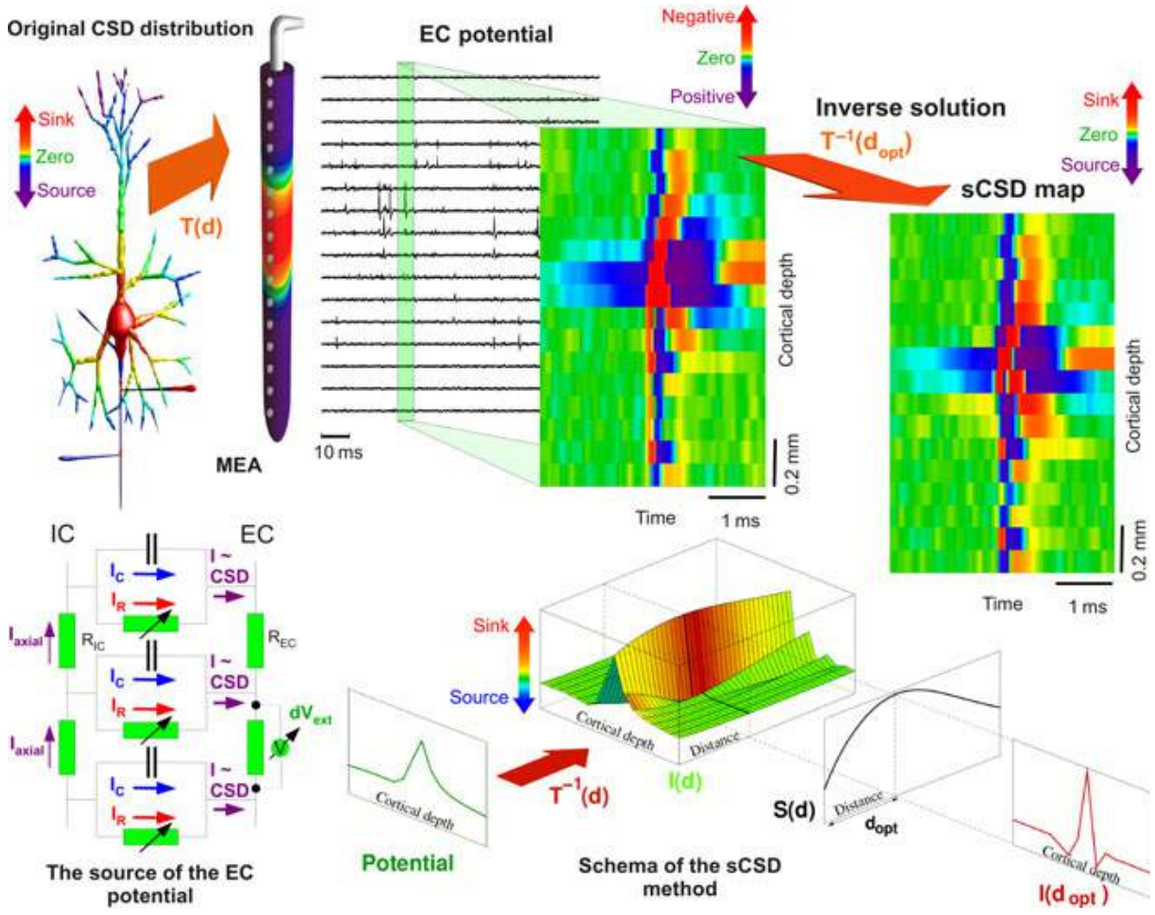
2. Multi-level approach

Laminar recordings in awake mice and ferrets using the same experimental paradigm

Neuronal population features in cortical computations.
Species comparison

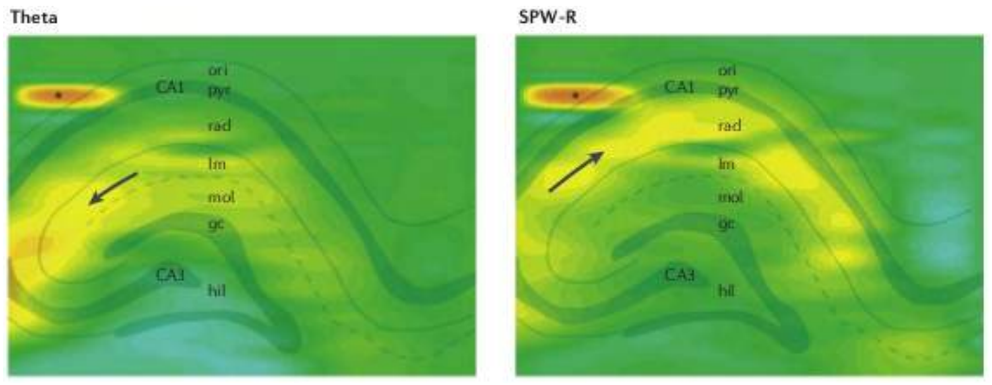


3. Model of Cortical Computations



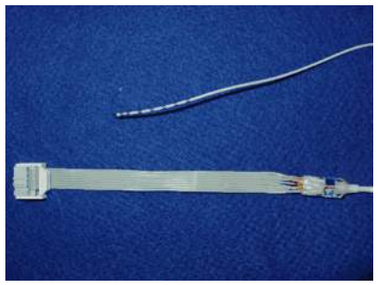
spike Current Source Density, (sCSD) is a method able to reconstruct full spatio-temporal CSD dynamics of single neurons

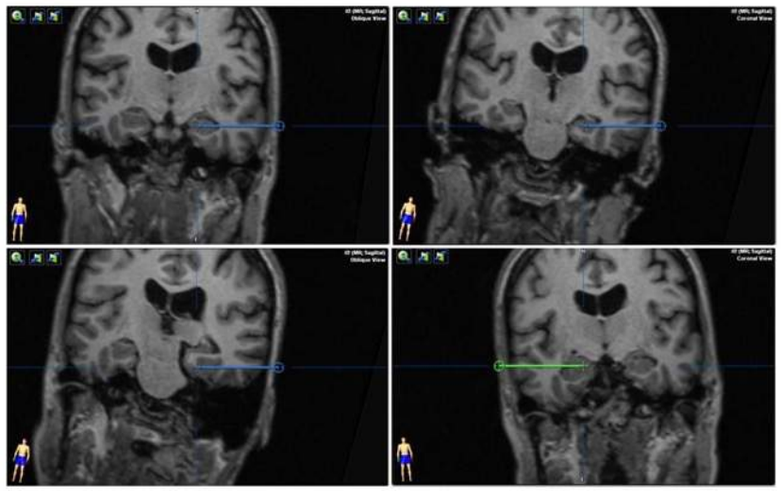
Cell type specific laminar distribution of synaptic currents

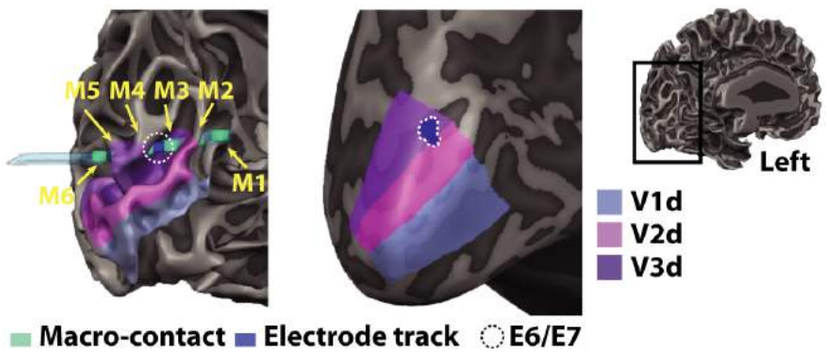


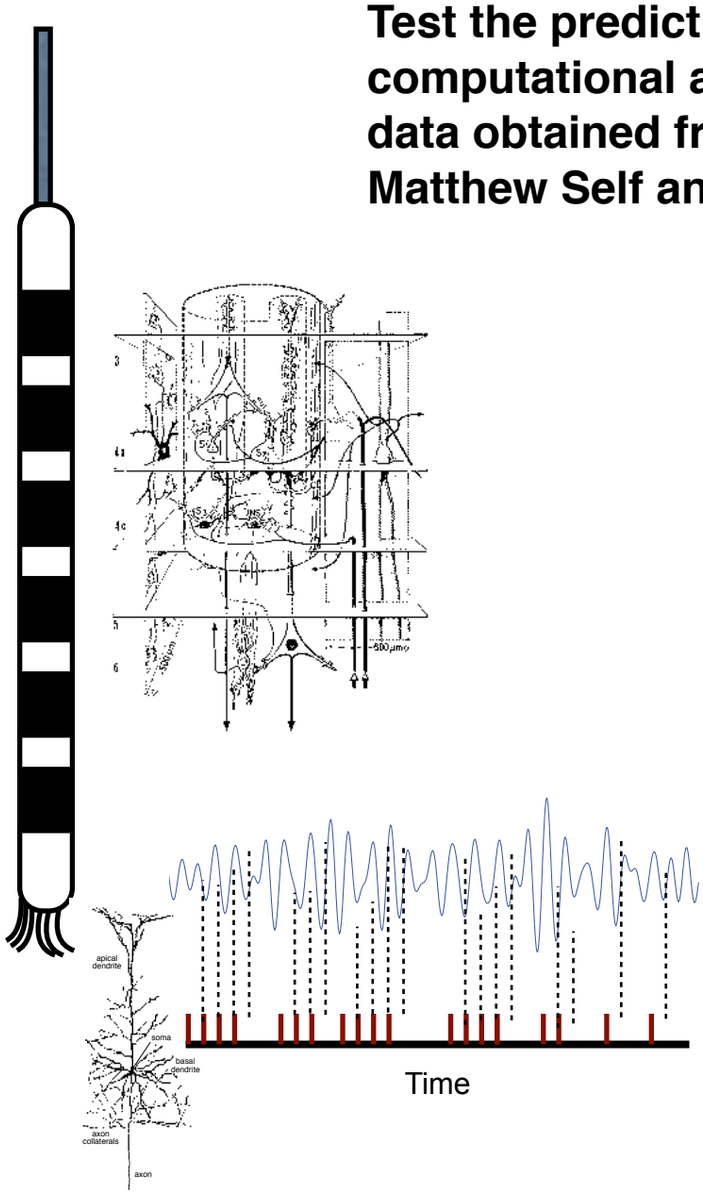
Somogyvári et al. (2012) *Eur J Neurosci,* 36: 3299

4. Comparative functional architectures in mice, ferrets and humans









Test the predictions derived from the model about computational architecture in electrophysiological data obtained from humans (collaboration with Matthew Self and Pieter Roelfsema from NIN, NL).

Self et al. (2016) *PLOS Biol* e1002420

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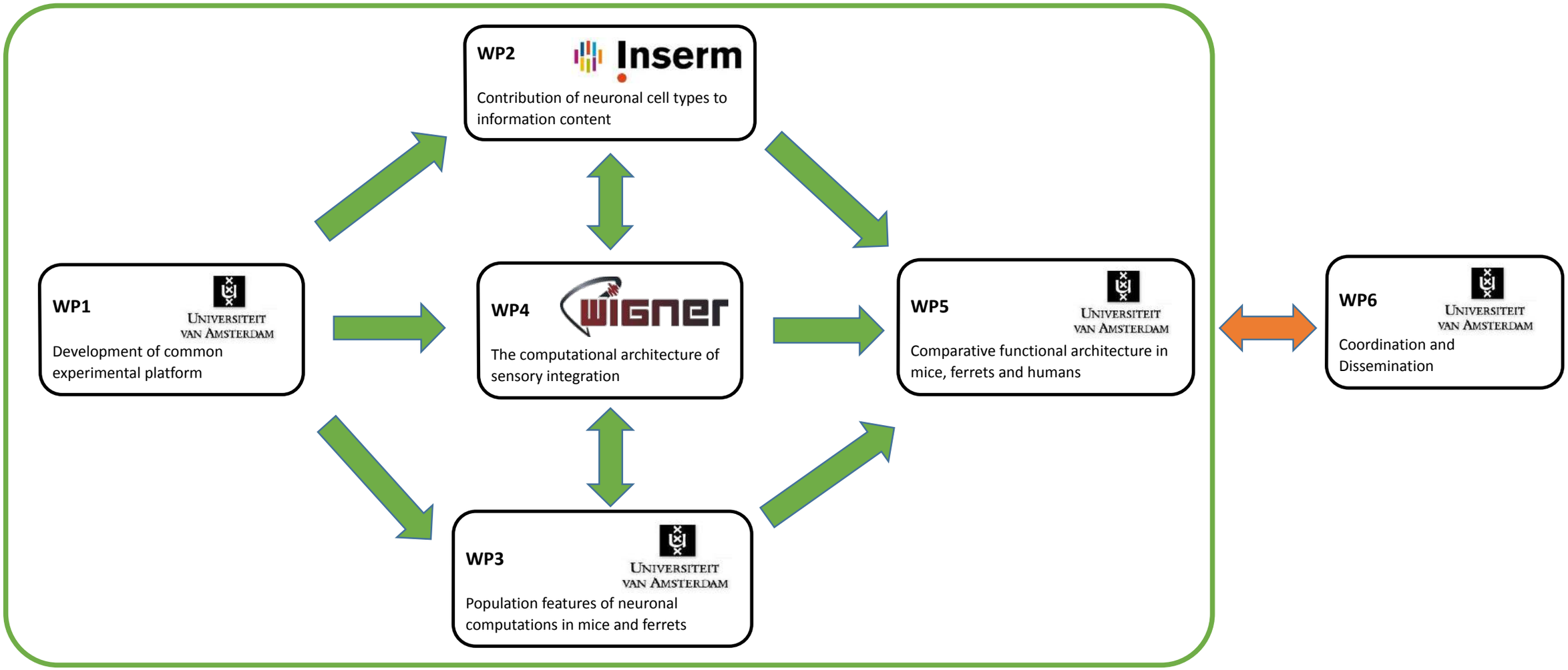
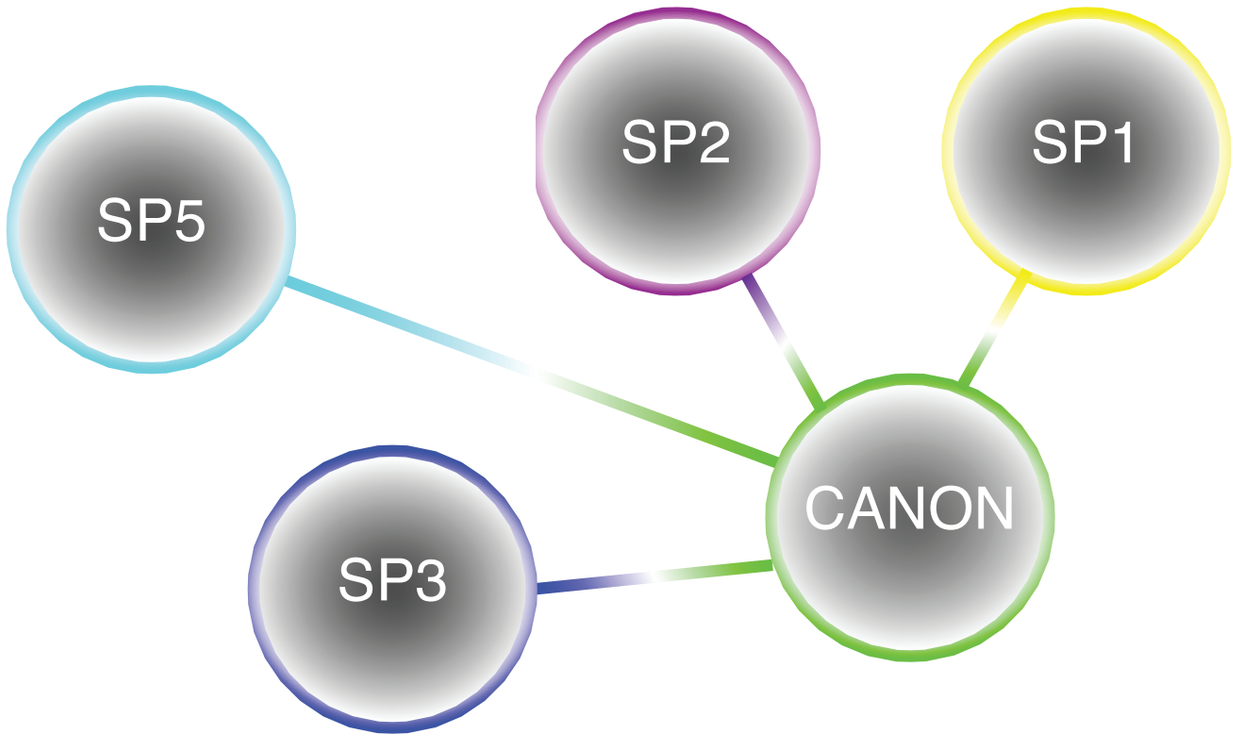
Work Plan



Expected Synergies with HBP



- **SP1-SP2:** Comparison between species
- **SP3:** Unveiling Neuronal Circuits for Cognitive Architectures
- **SP5:** New Neuroinformatics tools
- Other FLAG-ERA projects:
  - FIIND
  - SloW-Dyn
  - CHAMP-Mouse

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Human Brain Project

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Thanks!!

Universiteit van Amsterdam

Wigner

Instituts thématiques

Inserm

Institut national de la santé et de la recherche médicale