# The social code in cingulate-hippocampal circuits: The role of memory in social contests

## ABSTRACT:

**Background**
Dominance relationships among social animals have been proposed to increase survival, by reducing violence and by promoting an efficient sharing of resources. Social rank is dictated by a combination of intrinsic and extrinsic factors, including the outcomes of previous confrontations against specific individuals. This observation suggests that dominance behavior could be directly influenced by social memory. However, the circuit basis of social memory remains poorly understood. Previous studies suggested that ventral hippocampus, most specifically CA2 and ventral CA1, are necessary for social memory, but the mechanisms whereby social memory is used to guide social behavior remained elusive. Despite the diversity of ventral CA1 targets, prefrontal circuits are a strong candidate to integrate social memory with task-relevant information during dyadic encounters. In this sense, we hypothesized that CA2 social mnemonic information is routed through ventral CA1 and drives prefrontal ensembles, producing social related prefrontal patterns necessary to support social memory during dyadic social interactions.

**Aims**
We aimed to characterize the dynamics of prefrontal-hippocampal circuits during dyadic social encounters. For that, one part of our project aimed at discovering correlative evidence of social-related prefrontal patterns during social interactions. The second part of the project focused on dissecting the mechanisms whereby such social correlates are generated in prefrontal circuits.

**Method**
To address circuit dynamics during social encounters, we performed in vivo electrophysiological recordings in C57BL6 mice, while they interacted with conspecifics with different social ranks and with different degrees of familiarity. To further dissect the mechanisms whereby social correlates are generated in prefrontal circuits, we recorded a genetically engineered mouse model known to display hippocampal dysfunction and deficits of social memory – the conditional GPRASP2 mouse. For both approaches, we combined standard behavior analysis with classical metrics of in vivo electrophysiological activity.

**Results**
This work sheds light on the circuit mechanisms supporting social memory and social behaviors in prefrontal hippocampal circuits. Specifically, we found both social-sensitive and rank-sensitive cells in prefrontal circuits, suggesting that prefrontal/cingulate cortex is engaged by the social and dominance variables of the task. We also found that, during social contacts, prefrontal circuits are entrained by high theta rhythms, which were absent in an animal model suffering from hippocampal and social memory dysfunction, suggesting that these high theta oscillations

might be the communication channel whereby social-related hippocampal patterns shape PFC/CG circuits.

**Conclusions**
Our work identified two novel activity biomarkers of social and dominance behavior in prefrontal circuits in the mouse.

**Keywords**
Cingulate-hippocampal circuits, Social cognition, In vivo electrophysiology, Optogenetics

## Published Work:

Ferreira-Fernandes, E. & Peça, J. (2022). The neural circuit architecture of social hierarchy in rodents and primates. *Frontiers in Cellular Neuroscience*, *16*. doi:10.3389/fncel.2022.874310

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