The connectivity of minimal neuronal motifs could explain gamma-leading theta interactions in recordings of synchronous neural activity

Dimitrios Chalkiadakis[1,2], Jaime Sánchez-Claros[1], Santiago Canals[2] and Claudio R. Mirasso[1]

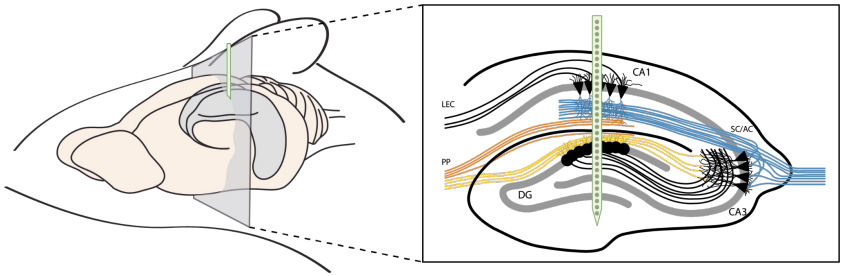
[1] IFISC (CSIC-UIB) Palma de Mallorca – Spain.

[2] Instituto de Neurociencias (CSIC – UMH) Alicante – Spain

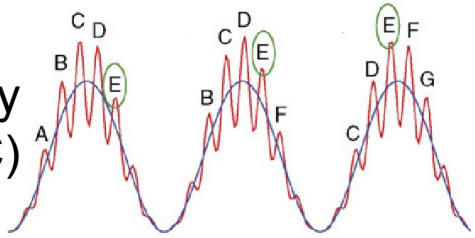
Contact: claudio@ifisc.uib-csic.es

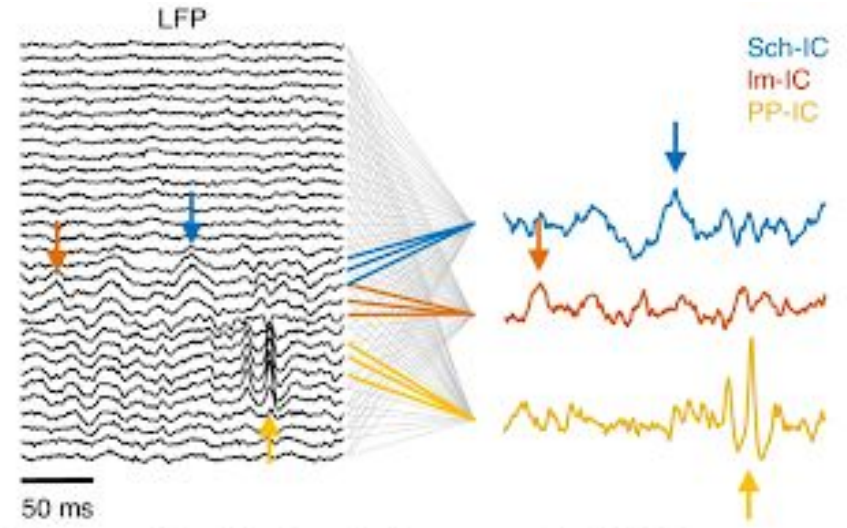
Introduction: Cross frequency coupling in electrophysiological data

Experimental results

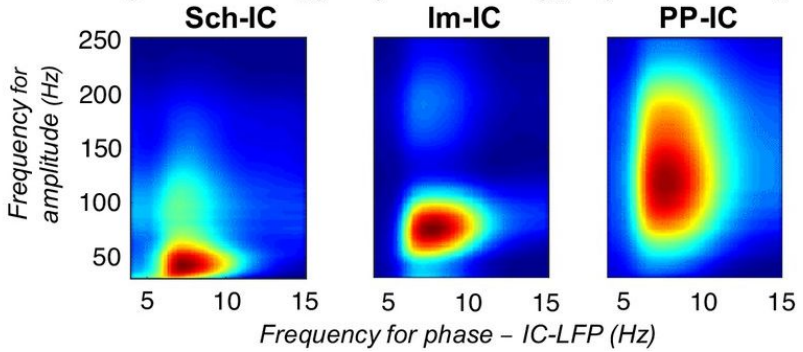


Cross Frequency Coupling (CFC)





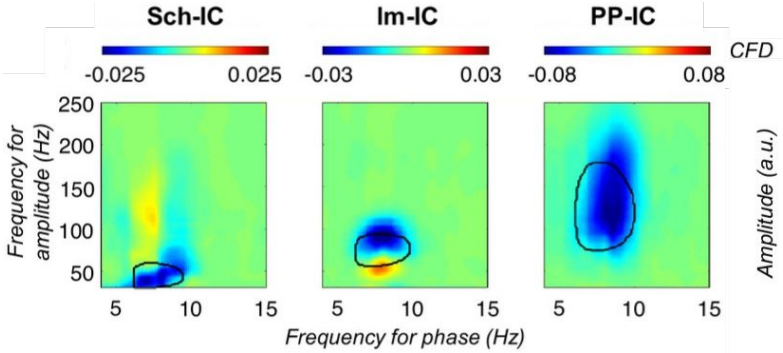
Decomposition of independent components with ICA



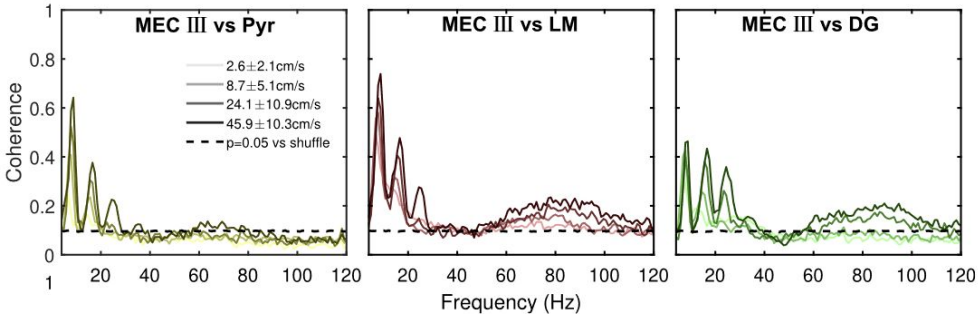
V. J. López-Madrona *et al.*, *eLife*, 2020

Introduction: is theta (slow) leading gamma (fast) or the opposite?

CFD



vs



Cross Frequency Directionality (CFD): fast->slow

Traditional view (e.g. from coherence): slow->fast

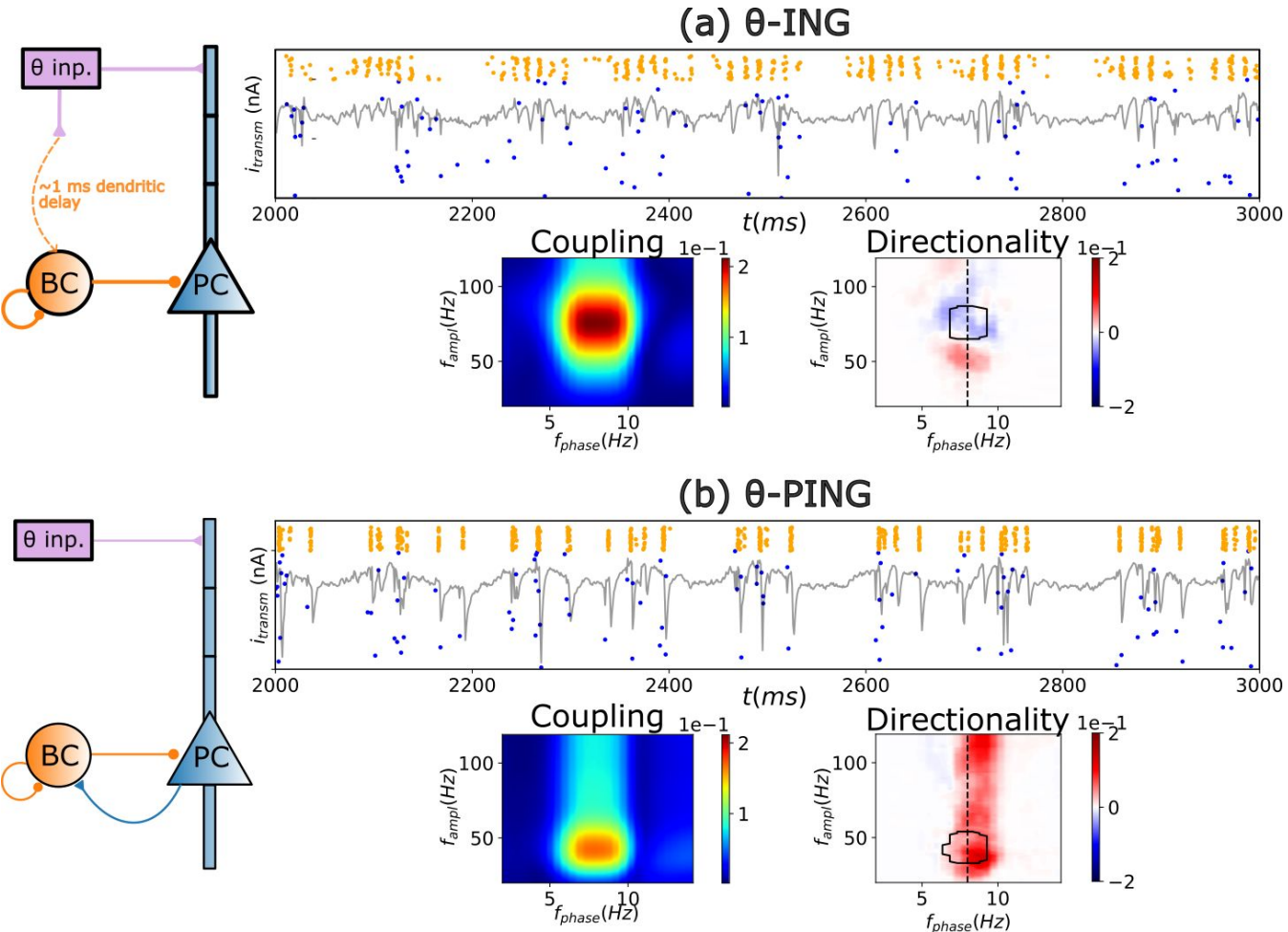
(Negative CFD values are denoted with blue color)

H. Jiang, *NeuroImage,* 2015

V. J. López-Madrona *et al.*, *eLife*, 2020

Y. Zhou et al., iScience, 2022

Results: Motifs of opposite Cross Frequency Directionality



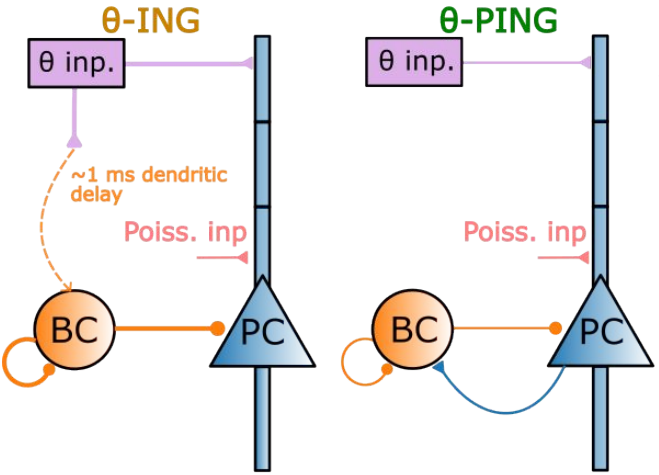
θ-inp: external drive
BC: basket cells
PC: pyramidal cells

- θ imposed externally

Yet, locally:

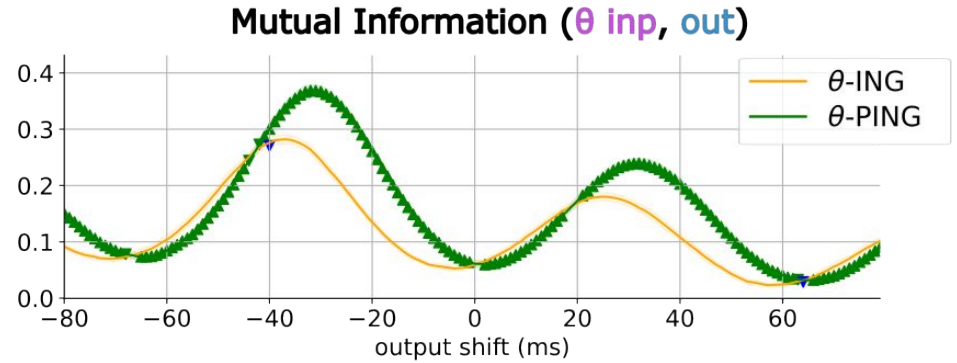
- θ-ING: fast->slow
- θ-PING: slow->fast

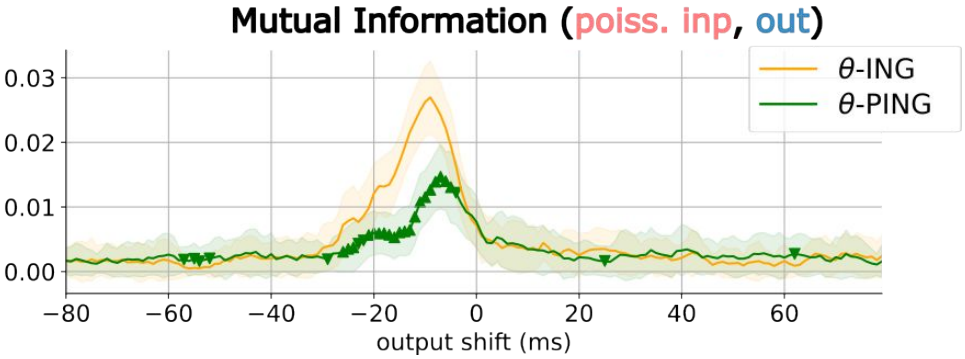
Results: Functional differences of θ-ING and θ-PING



θ-PING (slow to fast) better at integrating the theta driver.

θ-ING (fast to slow) better at integrating parallel drivers





Conclusions

Simple neuronal circuits exhibit different cross frequency directionality depending on connectivity:

1. Fast to slow for feedforward inhibition (θ-ING)

2. Slow to fast for feedback inhibition (θ-PING)

Depending on the circuits computational needs one of the modes could be chosen:

1. θ-ING: Integration of parallel pathways

2. θ-PING: Attending the slow driver