Extracting connectomes from EEG signals during a visual attention task

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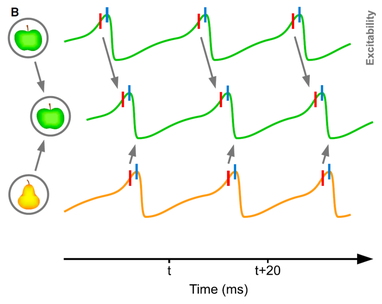
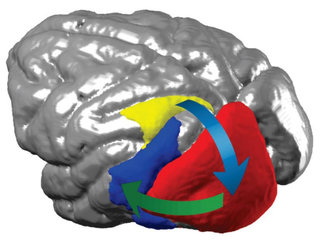
QUESTION AND HYPOTHESES

What parts of the cortex enter in communication when we pay attention to a visual scene and remember it ?

Coherence model : synchronized oscillations provide a coordination mechanism facilitating information flow via a rhythmic enhancement of excitability of local neurons. [1]



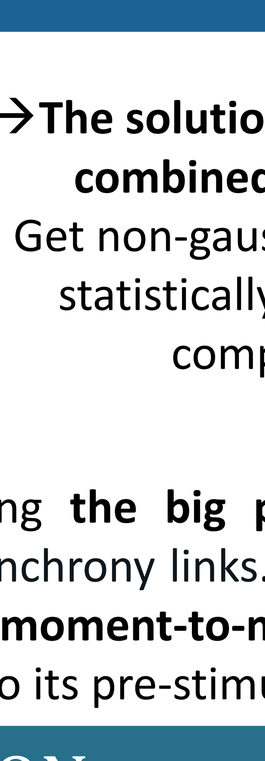
Phase synchrony : γ has been measured in visual attention on macaques (iEEG) & humans (MEG) within visual areas in **γ band** for feedforward and **β band** for feedback communication. [2]



TASK

Report if oddballs appear in one of the hemifields:

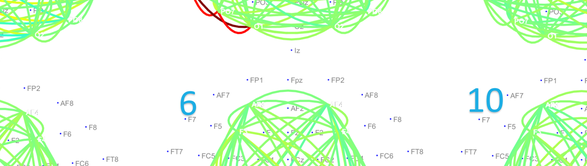
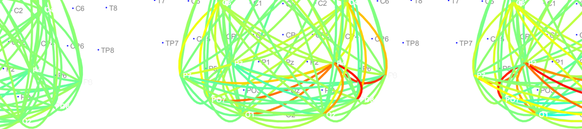
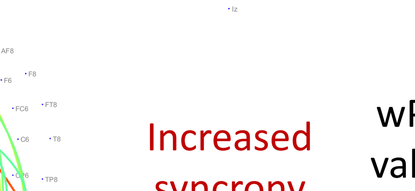
- Upper (block 1)
- Lower (block 2)

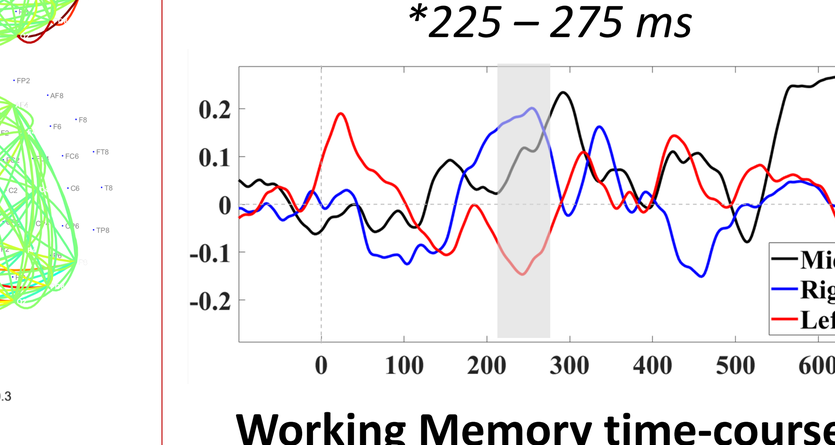


Hillyard Principle

GOAL: measure the same phenomenon but with EEG technique in humans at a larger brain scale during an attentional task.

PHASE SYNCHRONY

1. EEG and SCD 14 selected channels **= 91 pairs of channels**	
2. Band Pass Filters β Beta 19-27 Hz γ Gamma 40-50 Hz	
3. Spectral Analysis Instantaneous phase (ϕ) of each channel	
4. wPLI: Statistical Stability of Ψ the phase difference [3]	



→**The solution : ICA applied to combined β and ɤ wPLI :** Get non-gaussian signals and statistically independent components.

ICA extracted 10 components capturing **the big picture** from the temporal modulation of a hundred of synchrony links. The **time course** of one component characterizes the **moment-to-moment level of activation** of a specific network relative to its pre-stimulus state.

UNSUPERVISED BLIND SOURCE SEPARATION

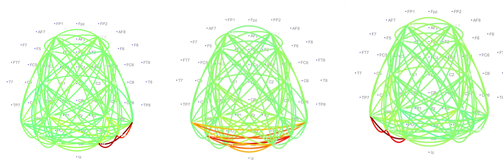
Exploring time courses of components power for the contrast of condition : "Attended minus Ignored"

Spatial attention time-course

**225 – 275 ms*

Oddballs position

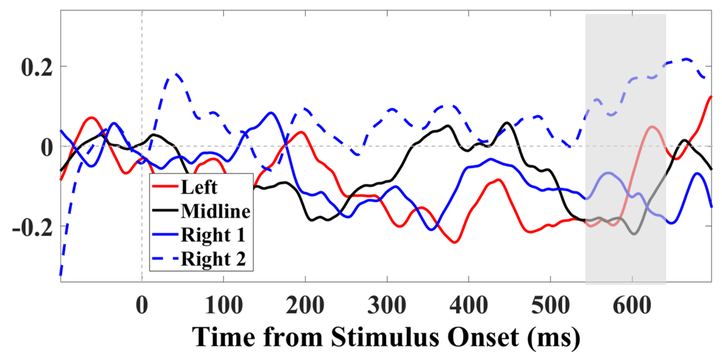
Left *Midline* *Right*



Visual areas networks

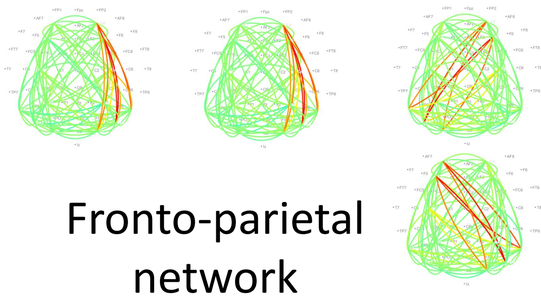
Working Memory time-course

**550 – 650 ms*



Oddballs position

Left *Midline* *Right*



Fronto-parietal network

DISCUSSION

When oddballs were attended, visual areas synchronized during attention and fronto-parietal network synchronized during working memory deployment. **The next step will consider each component time course as feature weight, input to a two-state classifier** (attended vs ignored). The performance of the classifier will provide a multivariate analysis showing in what time periods the features support classification and which contribute more.

References: [1] *Fries, P. (2015). Rhythms for Cognition:* ***Communication*** *through Coherence. Neuron, 88(1), 220-235.;* [2] *Michalareas, et al. (2016) Alpha-beta and Gamma Rhythms Subserve* ***Feedback and Feedforward Influences*** *among Human Visual Cortical Areas. Neuron. Richter CG, Thompson WH, Bosman CA, Fries P. Top-Down Beta Enhances Bottom-Up Gamma. J Neurosci. 2017;* [3] ***Phase synchronization*** *and large-scale integration. Nat Rev Neurosci, 2(4), 229-39; Thiebaut de Schotten, M., et al (2011).*