Oscillations continued

Mads Jensen, PhD

mads@cas.au.dk

AARHUS UNIVERSITY

IMC
INTERACTING MINDS CENTRE

CFIN

Contents

1. Oscillations & phases
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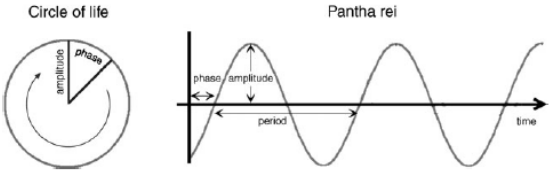
    - Intertrial phase coherence
    - Baseline correction
2. Communication through coherence
3. Frequency tagging
4. Summary so far...

THERE ARE NO STUPID QUESTIONS!

Oscillations & phases

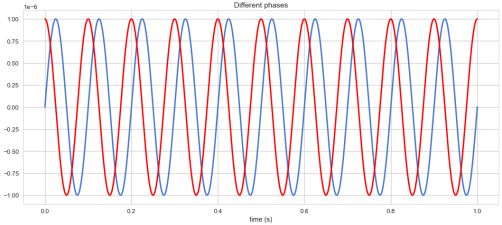
Phase data



(Figure from Buzsáki, 2006)

Phase data

Same amplitude, different phase



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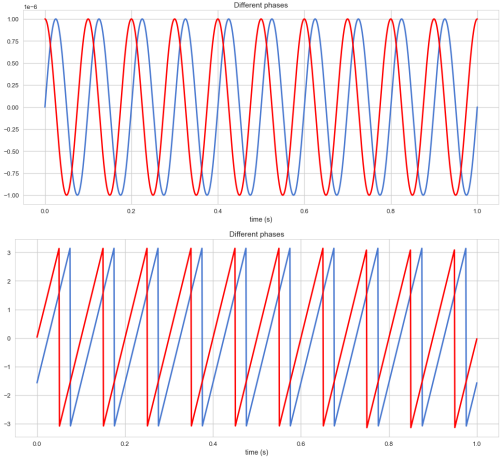

Phase data

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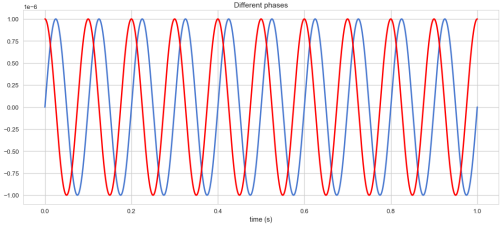
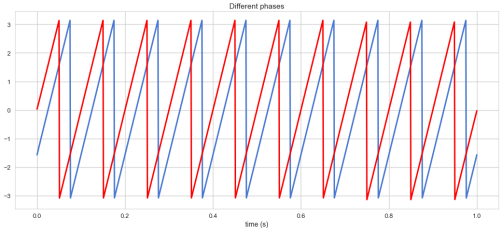
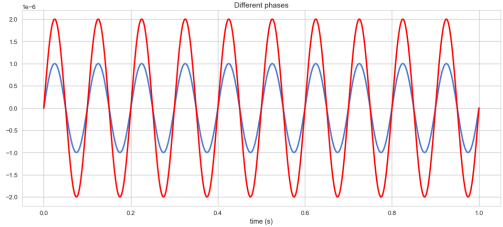




Different amplitude, same phase



Phase data

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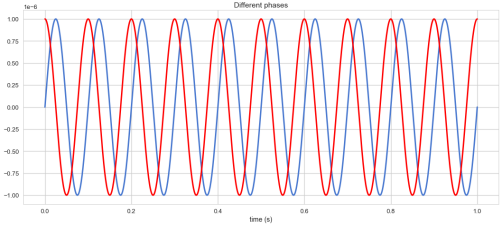

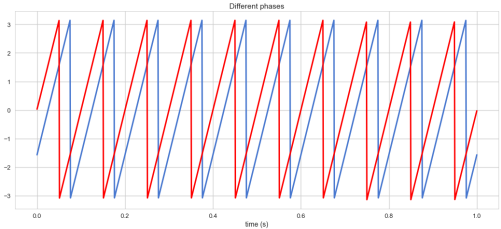

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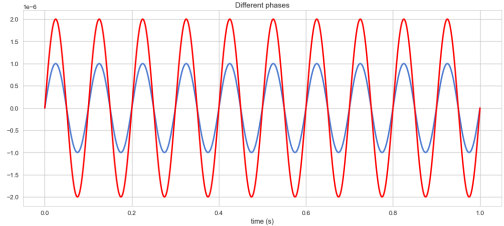

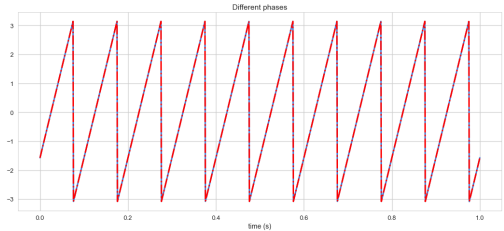

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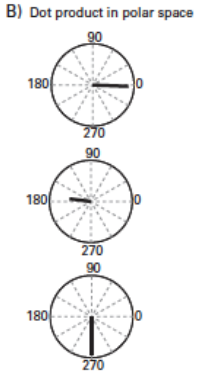
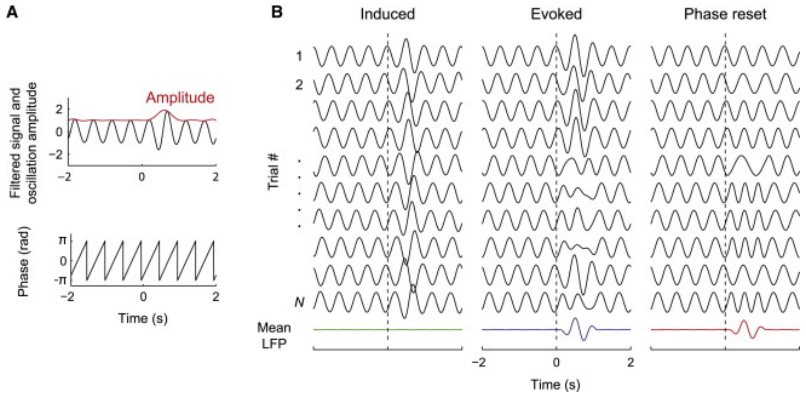


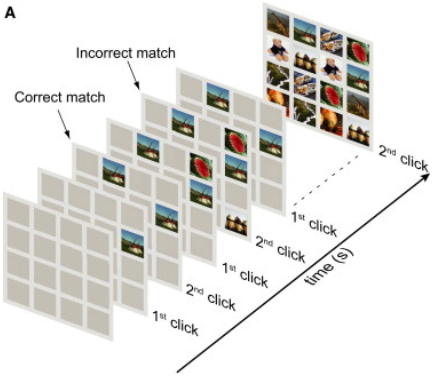
(Figure from Cohen, 2014)

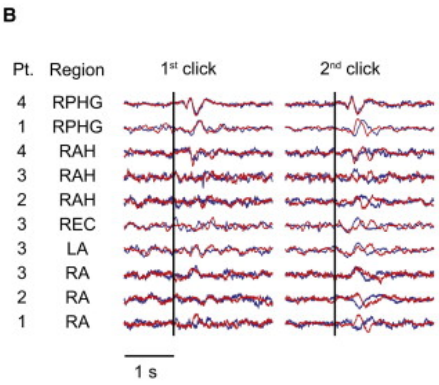
Phase reset



(Figure from Lopour et al., 2013)

Phase reset





correct (blue) and incorrect (red)
RPHG, right parahippocampal gyrus; RAH, right anterior hippocampus; REC, right entorhinal cortex; LA, left amygdala; and RA, right amygdala

Coherence

Correlation in time domain
Coherence in the spectral domain

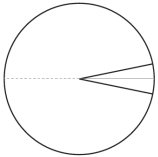
Coherence

Correlation in time domain
Coherence in the spectral domain

Options in MNE-python:

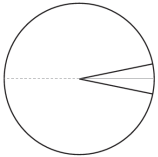
- Coherence
- Coherency
- Imaginary coherence
- Phase-Locking Value (PLV)
- Corrected imaginary PLV (icPLV)
- Pairwise Phase Consistency (PPC)
- Phase Lag Index (PLI)
- Unbiased estimator of squared PLI
- Weighted Phase Lag Index (WPLI)
- Debiased estimator of squared WPLI

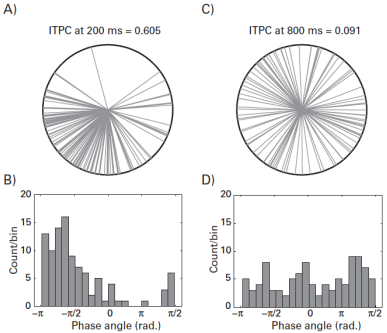
Intertrial phase coherence



(Figure from Cohen, 2014)

Intertrial phase coherence





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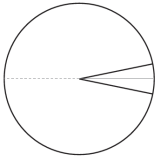
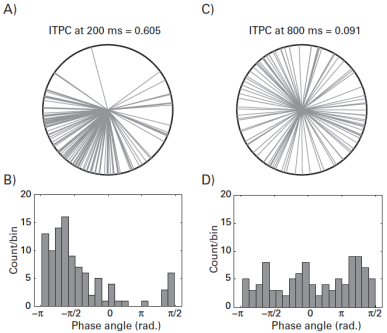
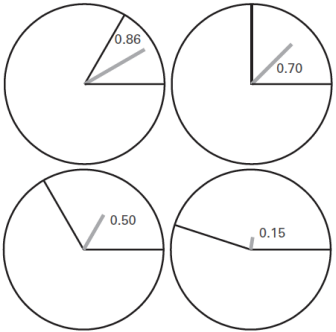






(Figure from Cohen, 2014)

Intertrial phase coherence: equation

Intertrial phase coherence (ITPC) over trials (From Cohen, 2014, chap. 19):

$$ITPC_{tf} = \left| n^{-1} \sum_{r=1}^{n} e^{ik_{tfr}} \right|$$

Intertrial phase coherence: equation

Intertrial phase coherence (ITPC) over trials (From Cohen, 2014, chap. 19):

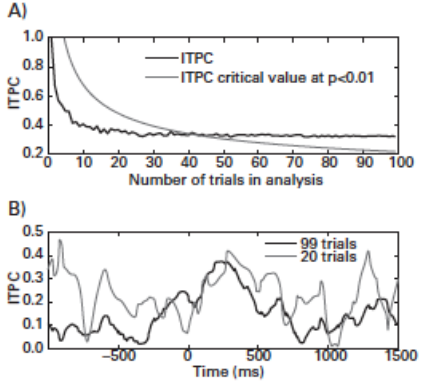
$$ITPC_{tf} = \left| n^{-1} \sum_{r=1}^{n} e^{ik_{tfr}} \right|$$

- n is the number of trials
- n^{-1} is shorthand for $1/n$ and combined with the summation operator indicates an average;
- e^{ik} is from Euler's formula and provide complex polar representation of phase angle k on trial r at time-frequency point tf.

Intertrial phase coherence: code

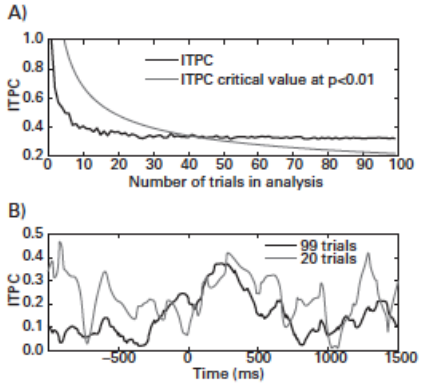
```
tmp = np.zeros(stcs[0].data.shape, dtype=np.complex)
for stc in stcs:
    # divide by amplitude and sum angles
    tmp += stc.data / abs(stc.data)

# take absolute value and normalize
itpc = abs(tmp) / len(stcs)
```

Intertrial phase coherence: sensitive to the number of trials



(Figure from Cohen, 2014)

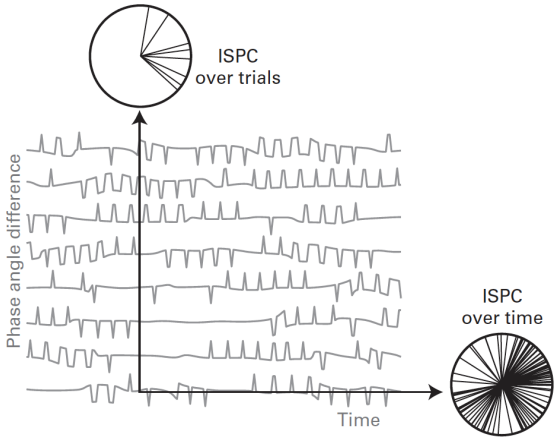
Intertrial phase coherence: sensitive to the number of trials



So keep the number of trials equal across conditions!

(Figure from Cohen, 2014)

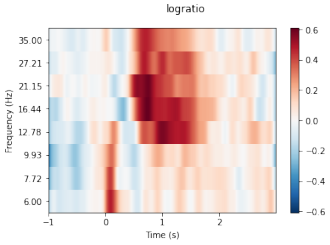
Intersite phase coherence: over trials or times?

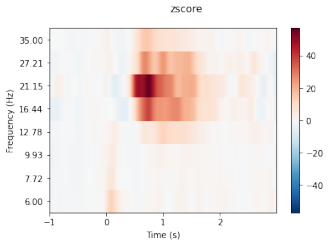


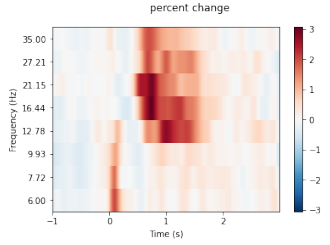
(Figure from Cohen, 2014)

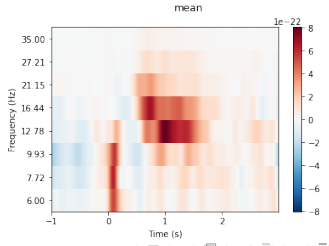
Baseline correction

Baseline correction









Communication through coherence

A mechanism for cognitive dynamics: neuronal communication through neuronal coherence

Pascal Fries[1,2]

[1]F.C. Donders Centre for Cognitive Neuroimaging, Radboud University Nijmegen, 6525 EN Nijmegen, The Netherlands
[2]Department of Biophysics, Radboud University Nijmegen, 6525 EZ Nijmegen, The Netherlands

Reading . . . Fries 2005

Reading . . . Fries 2005

- Skim abstract

Reading . . . Fries 2005

- Skim abstract
- Look at figures

Reading . . . Fries 2005

- Skim abstract
- Look at figures
- Read methods

Reading . . . Fries 2005

- Skim abstract
- Look at figures
- Read methods
- Read results

Reading . . . Fries 2005

- Skim abstract
- Look at figures
- Read methods
- Read results
- Read introduction, discussion, & conclusion.

Communication through coherence

[W]e can fixate on a central cross and press a button only when a green dot is flashed to the right while ignoring the same dot anywhere else in the visual field. And we can switch attention to do this task at any other spatial position, now ignoring the formerly relevant position. Although in both conditions, the same physical stimuli are given and the same behavioral responses are issued.

(Fries, 2005, p. 474)

Communication through coherence

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>
> *(Fries, 2005, p. 474)*

Two types of communication:

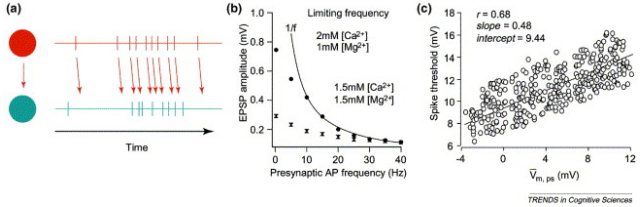
- effective communication
- anatomical communication

Hypothesis

I hypothesize that neuronal communication between two neuronal groups mechanistically depends on coherence between them and the absence of neuronal coherence prevents communication.

(Fries, 2005, p. 474)

Communication through coherence



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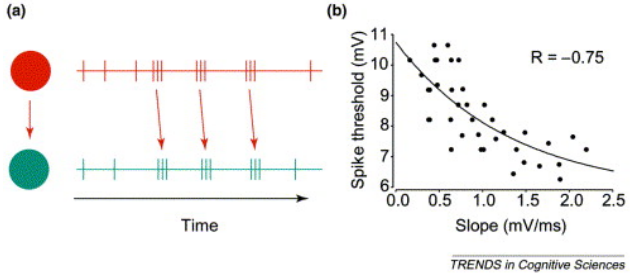
Communication through coherence



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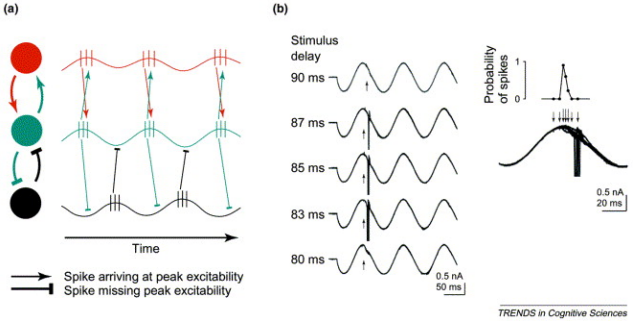

(Figure from Fries, 2005)

Taking points from Fries 2005

Taking points from Fries 2005

- functional communication

Taking points from Fries 2005

- functional communication
- phase-locking enables communication

Taking points from Fries 2005

- functional communication
- phase-locking enables communication
- strong evidence for the hypothesis

Frequency tagging

Early visual brain areas reflect the percept of an ambiguous scene

Lauri Parkkonen[a,1], Jesper Andersson[a,b], Matti Hämäläinen[c,d], and Riitta Hari[a,e,1]

[a]Brain Research Unit, Low Temperature Laboratory, Helsinki University of Technology, FIN-02015 TKK, Finland; [b]Oxford Centre for Functional Magnetic Resonance Imaging of the Brain, University of Oxford, John Radcliffe Hospital, Oxford OX3 9DU, United Kingdom; and [c]Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA 02129; [d]Harvard-MIT Division of Health Sciences and Technology, Massachusetts Institute of Technology, Cambridge, MA 02139; and [e]Department of Clinical Neurophysiology, Helsinki University Central Hospital, FIN-00290 Helsinki, Finland

Contributed by Riitta Hari, October 29, 2008 (sent for review September 2, 2008)

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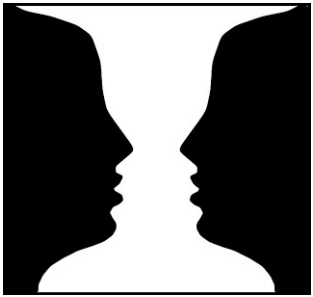
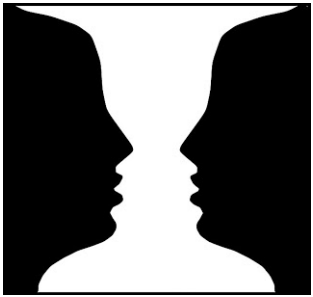


(Figure from http://www.brandstoryonline.com/see-face-vase-image/)

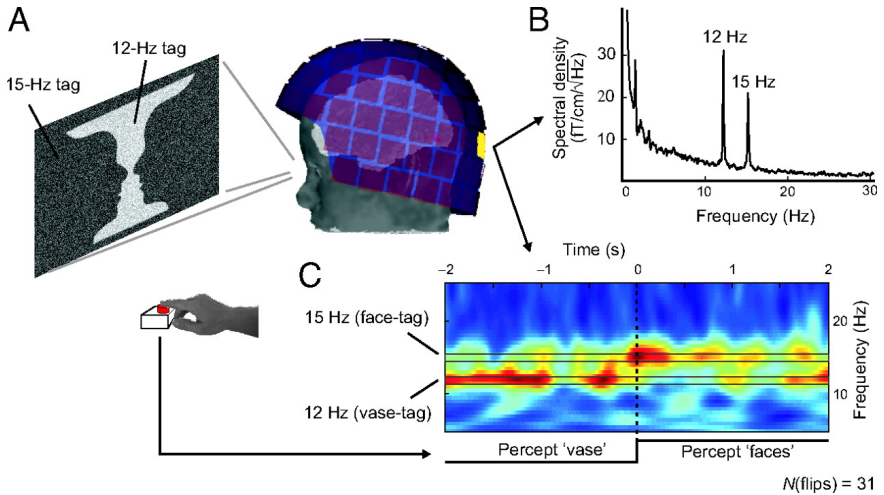
Early visual brain areas reflect the percept of an ambiguous scene



Is the difference in "vase vs face" perception an early or late cognitive process?

(Figure from http://www.brandstoryonline.com/see-face-vase-image/)

Early visual brain areas reflect the percept of an ambiguous scene



(Figure from Parkkonen et al., 2008)

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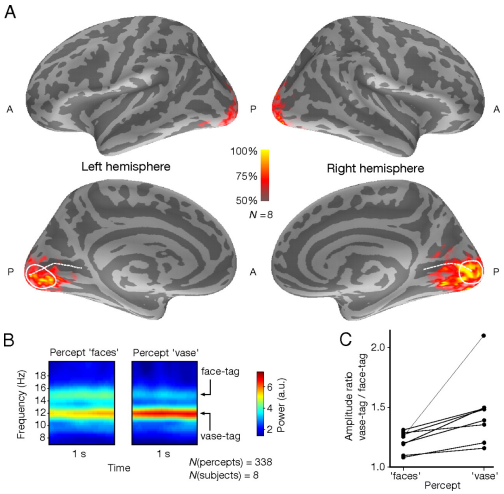
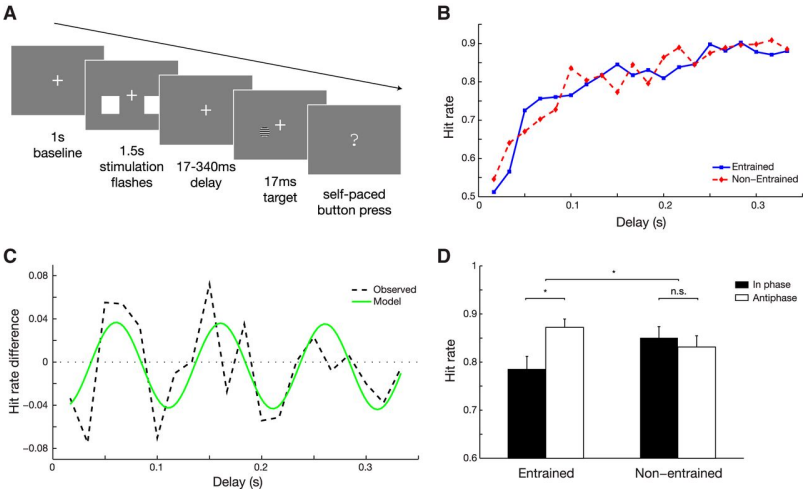


(Figure from Parkkonen et al., 2008)

Local Entrainment of Alpha Oscillations by Visual Stimuli Causes Cyclic Modulation of Perception

Eelke Spaak, Floris P. de Lange, and Ole Jensen
Donders Institute for Brain, Cognition, and Behaviour, Centre for Cognitive Neuroimaging, Radboud University Nijmegen, 6525 EN Nijmegen, The Netherlands

Entrainment of Alpha Oscillations



(Figure from Spaak et al., 2014)

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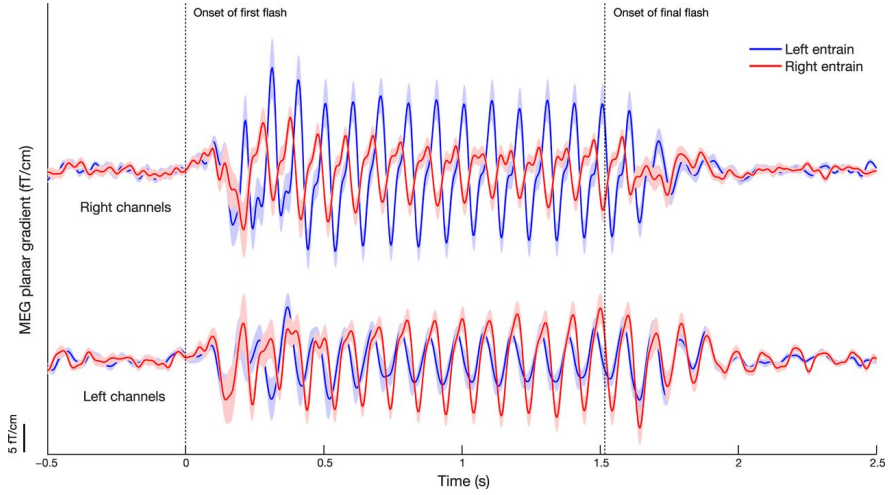

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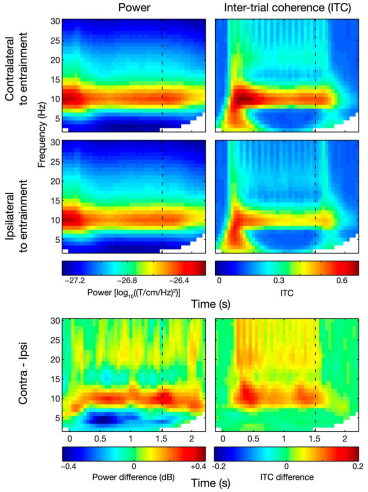

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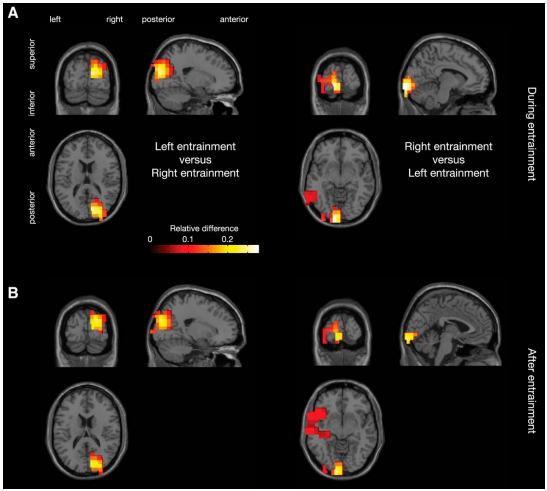

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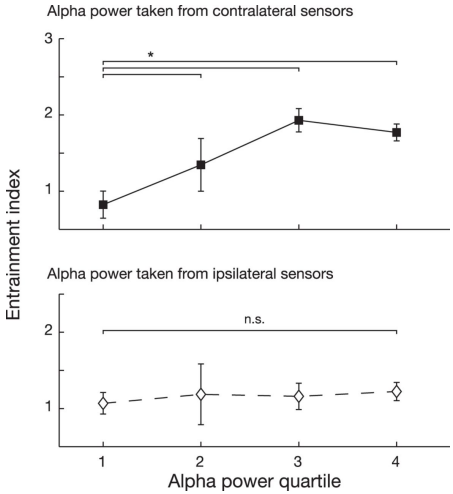

(Figure from Spaak et al., 2014)

Summary so far...

Summary

Recording brain data

Summary

Recording brain data

- spatial vs temporal resolution

Summary

Recording brain data

- spatial vs temporal resolution
- origins of the signals

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Brain data and signal properties

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- spatial vs temporal resolution
- origins of the signals

Brain data and signal properties

- dependency:
  - spatial (location) (f/MRI)
  - temporal (time) (single cell recordings)
  - spatial and temporal (EEG/MEG)

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- methods for quantifying brain rhythms

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- methods for quantifying brain rhythms
- frequency bands and functions

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Cognition as brain rhythms

- methods for quantifying brain rhythms
- frequency bands and functions
- oscillations and information processing

References I

- Buzsáki, G. (2006). *Rhythms of the Brain*. Oxford University Press. Retrieved July 25, 2020, from http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780195301069.001.0001/acprof-9780195301069
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