

Oscillations continued

Mads Jensen, PhD

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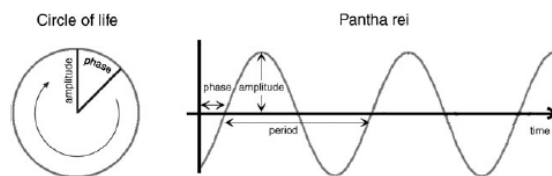
Contents

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

THERE ARE NO STUPID QUESTIONS!

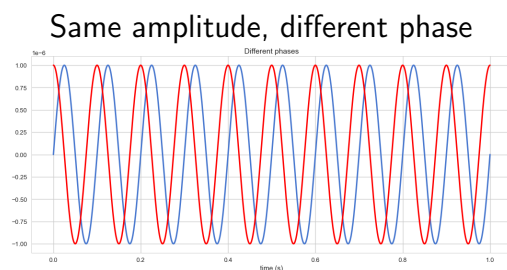
Oscillations & phases

Phase data



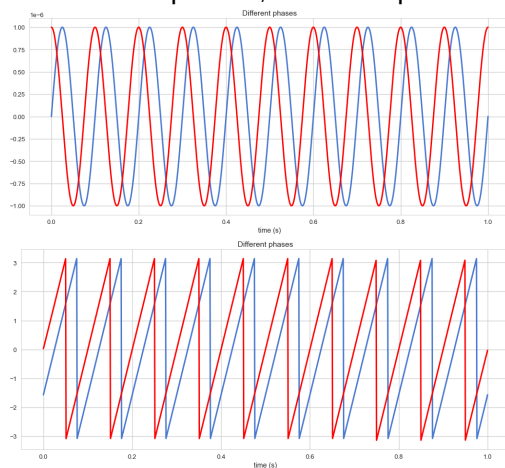
(Figure from Buzsáki, 2006)

Phase data



Phase data

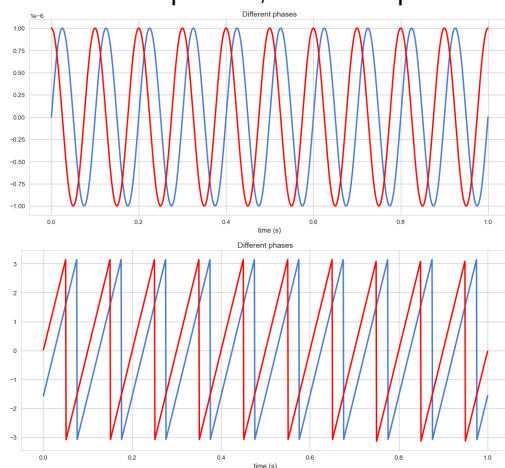
Same amplitude, different phase



Navigation icons: back, forward, search, etc.

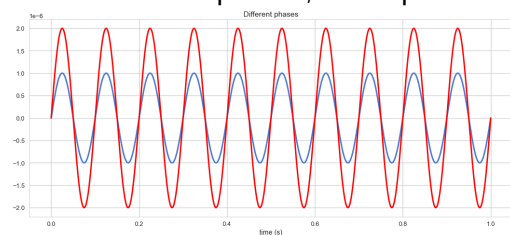
Phase data

Same amplitude, different phase



Navigation icons: back, forward, search, etc.

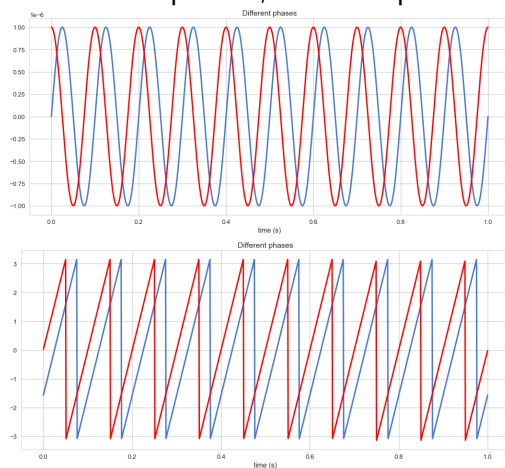
Different amplitude, same phase



Navigation icons: back, forward, search, etc.

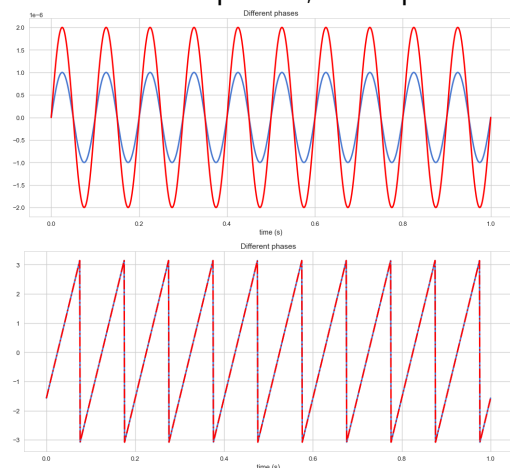
Phase data

Same amplitude, different phase



Navigation icons: back, forward, search, etc.

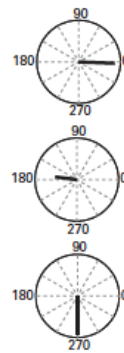
Different amplitude, same phase



Navigation icons: back, forward, search, etc.

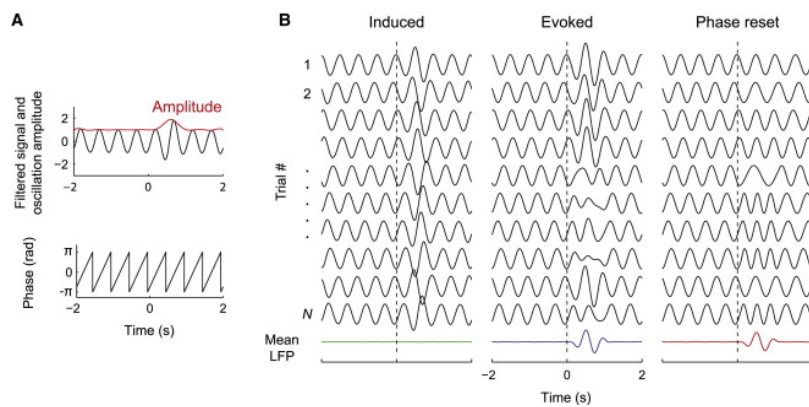
Phase data

B) Dot product in polar space



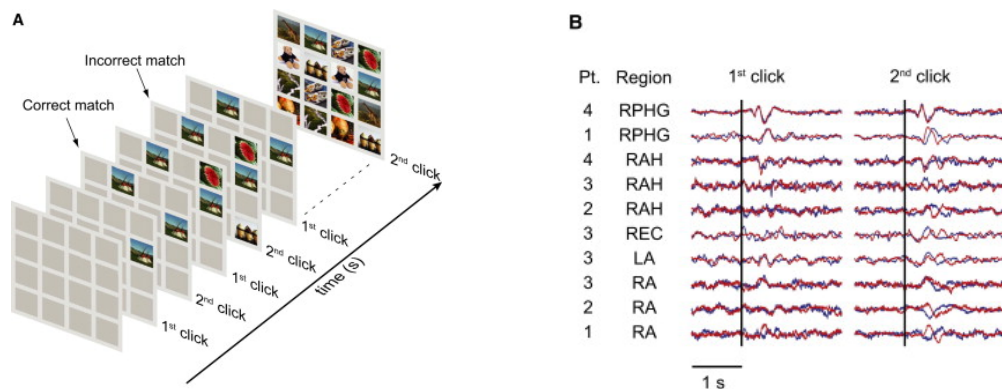
(Figure from Cohen, 2014)

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

(Figure from Jensen et al., 2013)

Coherence

Correlation in time domain

Coherence in the spectral domain

Navigation icons

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Oscillations cont.

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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

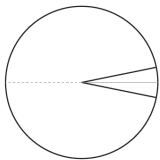
Navigation icons

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Oscillations cont.

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Intertrial phase coherence



(Figure from Cohen, 2014)

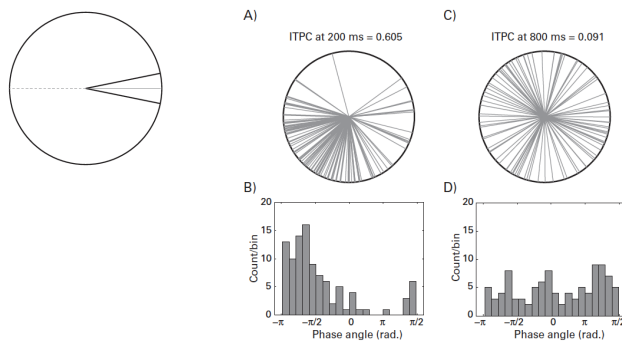
Navigation icons

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Oscillations cont.

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Intertrial phase coherence



(Figure from Cohen, 2014)

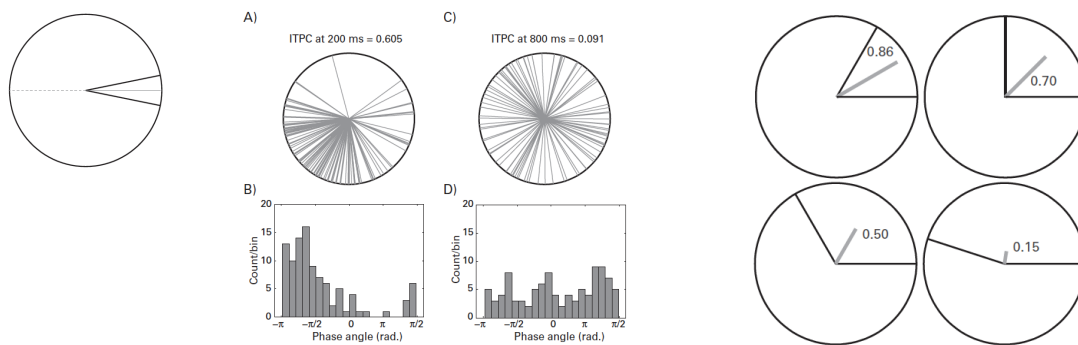
Navigation icons: back, forward, search, etc.

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Oscillations cont.

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Intertrial phase coherence



(Figure from Cohen, 2014)

Navigation icons: back, forward, search, etc.

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Oscillations cont.

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Intertrial phase coherence: equation

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

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

Navigation icons: back, forward, search, etc.

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Oscillations cont.

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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 .

Navigation icons

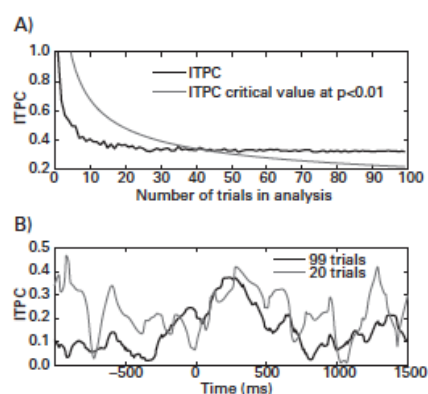
Intertrial phase coherence: code

```
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)
```

Navigation icons

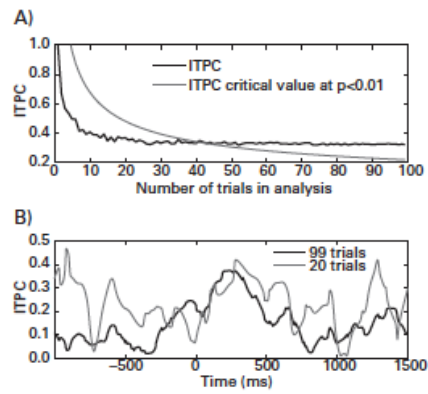
Intertrial phase coherence: sensitive to the number of trials



(Figure from Cohen, 2014)

Navigation icons

Intertrial phase coherence: sensitive to the number of trials



So keep the number of trials equal across conditions!

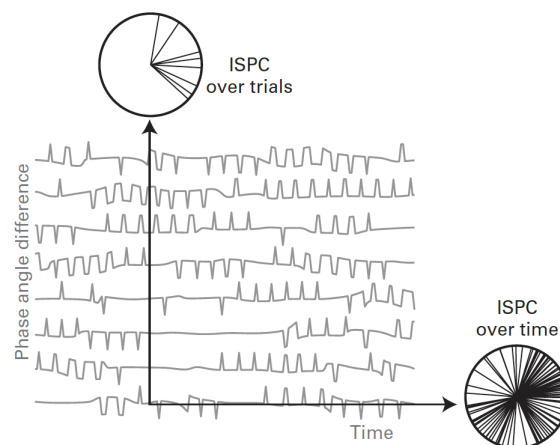
(Figure from Cohen, 2014)

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Oscillations cont.

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Intersite phase coherence: over trials or times?



(Figure from Cohen, 2014)

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Oscillations cont.

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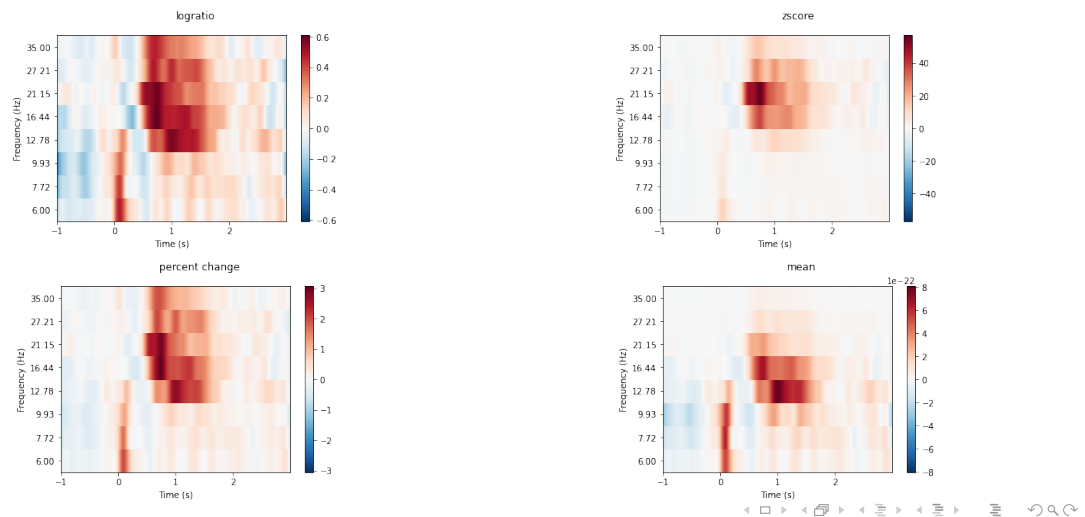
Baseline correction

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Oscillations cont.

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Baseline correction



Mads Jensen (RUR, IMC, & CFIN)

Oscillations cont.

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Communication through coherence

Navigation icons: back, forward, search, etc.

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Oscillations cont.

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Communication through coherence

A mechanism for cognitive dynamics: neuronal communication through neuronal coherence

Pascal Fries^{1,2}

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

Navigation icons: back, forward, search, etc.

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Oscillations cont.

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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

[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)

Two types of communication:

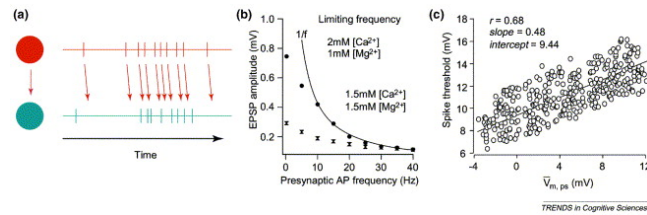
- effective communication
- anatomical communication

Hypothesis

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

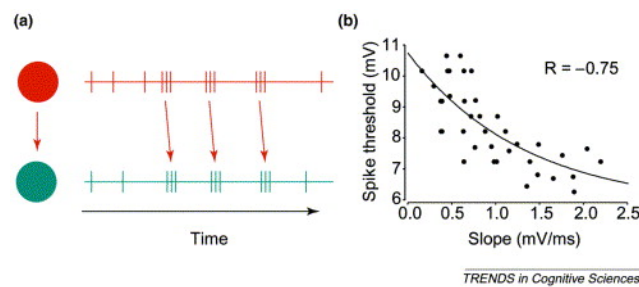
(Fries, 2005, p. 474)

Communication through coherence



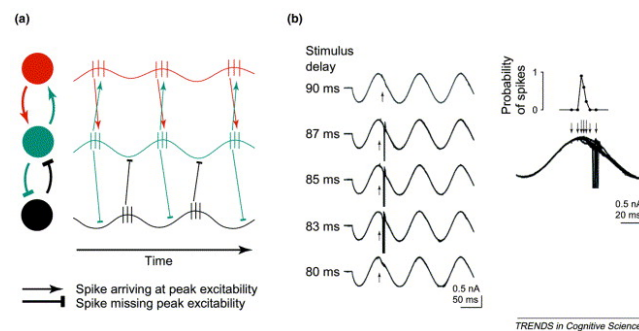
(Figure from Fries, 2005)

Communication through coherence



(Figure from Fries, 2005)

Communication through coherence



(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

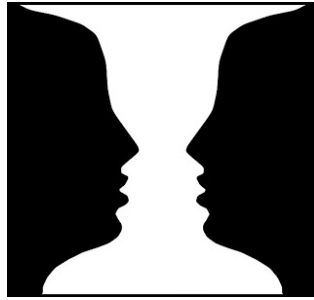
Early visual brain areas reflect the percept of an ambiguous scene

Lauri Parkkonen^{a,1}, Jesper Andersson^{a,b}, Matti Hämäläinen^{c,d}, and Riitta Hari^{a,e,1}

^aBrain Research Unit, Low Temperature Laboratory, Helsinki University of Technology, FIN-02015 TKK, Finland; ^bOxford Centre for Functional Magnetic Resonance Imaging of the Brain, University of Oxford, John Radcliffe Hospital, Oxford OX3 9DU, United Kingdom; and ^cAthinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA 02129; ^dHarvard-MIT Division of Health Sciences and Technology, Massachusetts Institute of Technology, Cambridge, MA 02139; and ^eDepartment of Clinical Neurophysiology, Helsinki University Central Hospital, FIN-00290 Helsinki, Finland

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

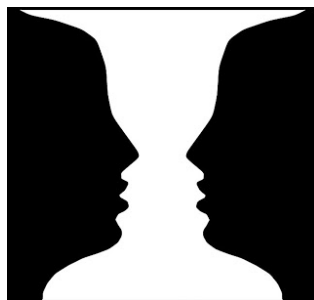
Early visual brain areas reflect the percept of an ambiguous scene



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

Navigation icons: back, forward, search, etc.

Early visual brain areas reflect the percept of an ambiguous scene

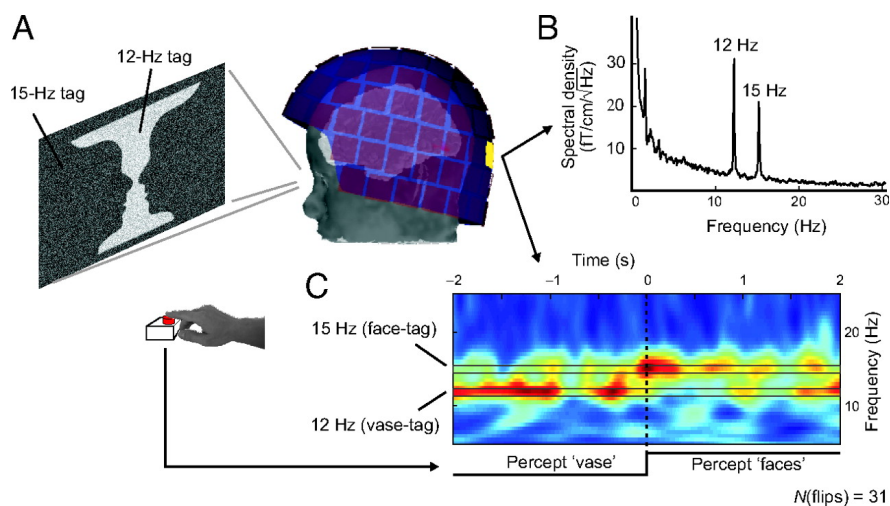


Is the difference in “vase vs face” perception an early or late cognitive process?

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

Navigation icons: back, forward, search, etc.

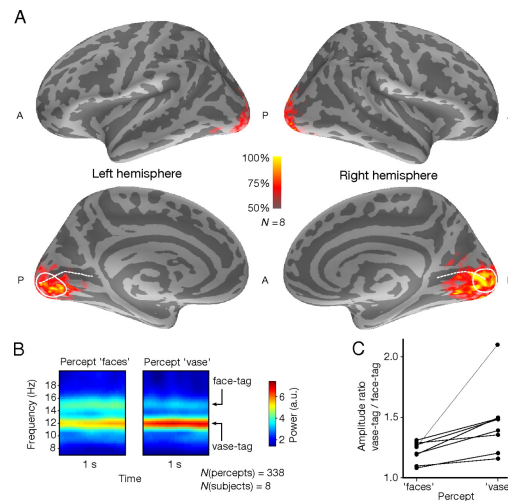
Early visual brain areas reflect the percept of an ambiguous scene



(Figure from Parkkonen et al., 2008)

Navigation icons: back, forward, search, etc.

Early visual brain areas reflect the percept of an ambiguous scene



(Figure from Parkkonen et al., 2008)

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Oscillations cont.

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Entrainment of Alpha Oscillations

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

Eelke Spaak, Floris P. de Lange, and Ole Jensen

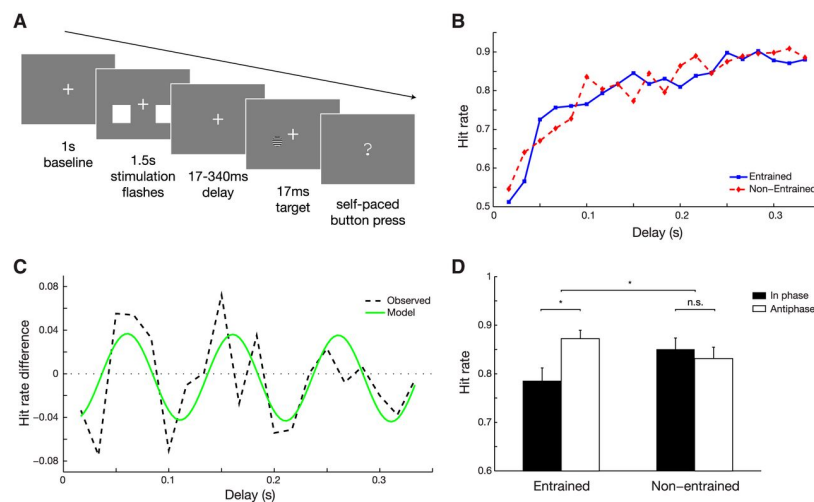
Donders Institute for Brain, Cognition, and Behaviour, Centre for Cognitive Neuroimaging, Radboud University Nijmegen, 6525 EN Nijmegen, The Netherlands

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Oscillations cont.

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Entrainment of Alpha Oscillations



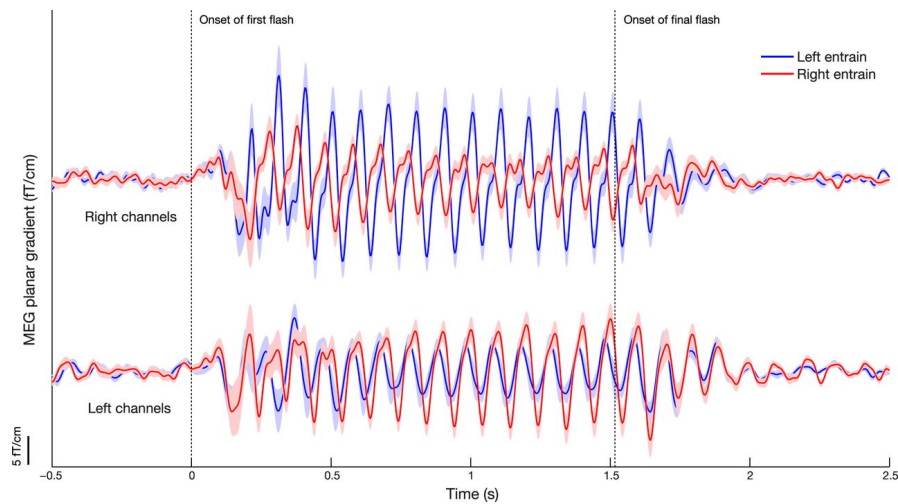
(Figure from Spaak et al., 2014)

Mads Jensen (RUR, IMC, & CFIN)

Oscillations cont.

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Entrainment of Alpha Oscillations



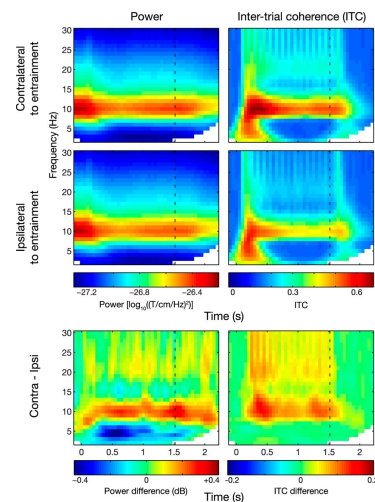
(Figure from Spaak et al., 2014)

Mads Jensen (RUR, IMC, & CFIN)

Oscillations cont.

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Entrainment of Alpha Oscillations



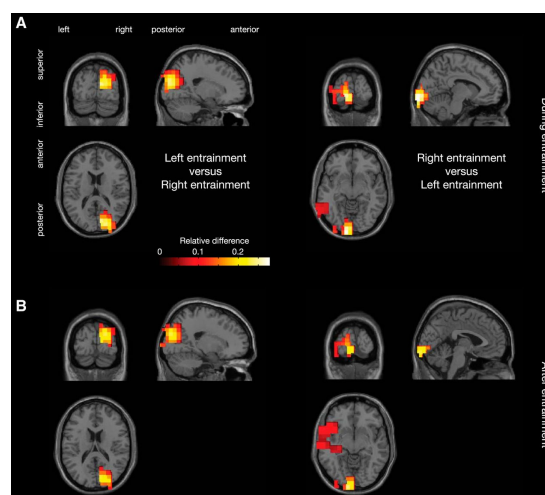
(Figure from Spaak et al., 2014)

Mads Jensen (RUR, IMC, & CFIN)

Oscillations cont.

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Entrainment of Alpha Oscillations



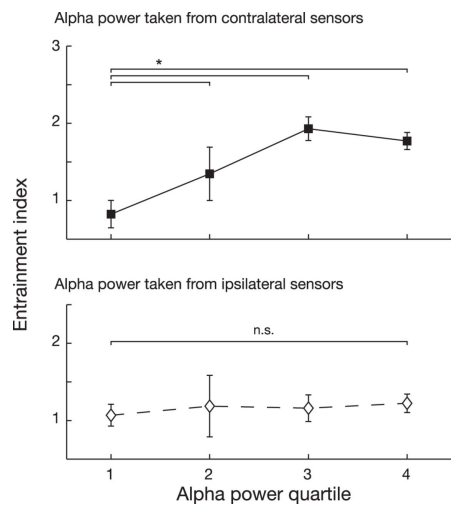
(Figure from Spaak et al., 2014)

Mads Jensen (RUR, IMC, & CFIN)

Oscillations cont.

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Entrainment of Alpha Oscillations



(Figure from Spaak et al., 2014)

Mads Jensen (RUR, IMC, & CFIN)

Oscillations cont.

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Summary so far...

Summary

Recording brain data

Mads Jensen (RUR, IMC, & CFIN)

Oscillations cont.

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Summary

Recording brain data

- spatial vs temporal resolution

Summary

Recording brain data

- spatial vs temporal resolution
- origins of the signals

Summary

Recording brain data

- spatial vs temporal resolution
- origins of the signals

Brain data and signal properties

Summary

Recording brain data

- 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)

Summary

Recording brain data

- spatial vs temporal resolution
- origins of the signals

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Electrophysiology

Summary

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Electrophysiology

- Volume conduction

Summary

Recording brain data

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Electrophysiology

- Volume conduction
- source reconstruction

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Cognition as brain rhythms

Summary

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Cognition as brain rhythms

- methods for quantifying brain rhythms

Summary

Recording brain data

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Cognition as brain rhythms

- methods for quantifying brain rhythms
- frequency bands and functions

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Electrophysiology

- Volume conduction
- source reconstruction

Cognition as brain rhythms

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

References I

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- Parkkonen, L., Andersson, J., Hämäläinen, M., & Hari, R. (2008). Early visual brain areas reflect the percept of an ambiguous scene. *Proceedings of the National Academy of Sciences*, 105(51), 20500–20504. <https://doi.org/10.1073/pnas.0810966105>

References II

Spaak, E., de Lange, F. P., & Jensen, O. (2014). Local Entrainment of Alpha Oscillations by Visual Stimuli Causes Cyclic Modulation of Perception. *Journal of Neuroscience*, 34(10), 3536–3544. <https://doi.org/10.1523/JNEUROSCI.4385-13.2014>