Sharpening attention through alpha and gamma oscillations

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Marseille, 21th of September 2017
Selecting information in a complex world
## Attentional role of alpha and gamma oscillations

<table>
<thead>
<tr>
<th><strong>Alpha (10Hz)</strong></th>
<th><strong>Gamma (&gt;30Hz)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional inhibition</td>
<td>Active processing</td>
</tr>
<tr>
<td>Internally controlled</td>
<td>stimulus-induced</td>
</tr>
</tbody>
</table>

Fries et al. (2015, Neuron)
Varela et al. (2001, Nature Neuroscience)
Jensen et al. (2015, TINS)
Klimesch et al. (2007, BRR)
Alpha modulation by attention

**Alpha** (10Hz)
Functional inhibition
Internally controlled

Fixation  Cue  Target (50 ms)
0.8 ± 0.2 s  0.8 ± 0.2 s

Phase under control?

Jensen, Gips, Bergmann, Bonnefond (2015, TINS)
Klimesch et al. (2007, BRR)

Capilla et al. 2012

MEG
**Alpha modulation by attention**

**Alpha** (10Hz)
Functional inhibition
Internally controlled

Bonnefond and Jensen (2012, Curr. Biol.)
Bonnefond and Jensen (2013, Comm. Int. Biol.)
Alpha modulation by attention

**Alpha** (10Hz)
Functional inhibition
Internally controlled

memory items

distracter target

Bonnefond and Jensen (2012, Curr. Biol.)
Bonnefond and Jensen (2013, Comm. Int. Biol.)
Alpha modulation by attention

**Alpha** (10Hz)

Functional inhibition
Internally controlled

Bonnefond and Jensen (2012, Curr. Biol.)
Bonnefond and Jensen (2013, Comm. Int. Biol.)
Alpha modulation by attention

**Alpha** (10Hz)

Functional inhibition
Internally controlled

Network with alpha phase adjusted

Bonnefond and Jensen (2012, Curr. Biol.)
Bonnefond and Jensen (2013, Comm. Int. Biol.)
Alpha modulation by attention

**Alpha** (10Hz)
Functional inhibition
Internally controlled

**NO**
Attention and Temporal Expectations Modulate Power, Not Phase, of Ongoing Alpha Oscillations

Rosanne M. van Diepen¹, Michael X. Cohen¹, Damiaan Denys¹,², and Ali Mazaheri³

**YES**
Top-down control of the phase of alpha-band oscillations as a mechanism for temporal prediction

Jason Samaha¹, Phoebe Bauer³, Sawyer Cimaroli³, and Bradlev R. Postle⁴,⁵

*EEG*
**Alpha (10Hz)**

Functional inhibition

Internally controlled

- Three possible syllables: ‘pi’, ‘ti’, ‘ki’
- 75% incongruent pairs
- 25% congruent pairs

Visual vs. auditory

Solis-Vivanco, Jensen & Bonnefond (submitted)
**Alpha modulation by attention**

**Alpha** (10Hz)

Functional inhibition
Internally controlled

- Three possible syllables: ‘pi’, ‘ti’, ‘ki’
- 75% incongruent pairs
- 25% congruent pairs

**Condition*power*phase effect:**
- Fastest reaction time for good phase and low power
- Slowest reaction time for bad phase and high power

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Solis-Vivanco, Jensen and Bonnefond (submitted)
Gamma modulation by attention

**Alpha** (10Hz)
- Functional inhibition
- Top-down controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced

Change in gamma power, frequency and inter-areal synchrony with attention

Fries(2016, Neuron)
**Gamma modulation by attention**

**Gamma** (>30Hz)
Active processing
stimulus-induced

memory items
distracter
target

Bonnefond and Jensen (2012, Curr. Biol.)
Bonnefond and Jensen (2013, Comm. Int. Biol.)
**Alpha-gamma coupling modulation by attention**

**Alpha** (10Hz)
- Functional inhibition
- Internally controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced

**Cross-frequency coupling**

Gamma activity

Alpha activity

Osipova et al. 2008; Voytek et al. 2010; Spaak et al. 2012; Bahramisharif et al. 2013
Alpha-gamma coupling modulation by attention

**Alpha** (10Hz)
- Functional inhibition
- Internally controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced

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**Peak-locked time frequency**

Bonnefond and Jensen (2015, Plos One)
Alpha-gamma coupling modulation by attention

**Alpha** (10Hz)

Functional inhibition

Internally controlled

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Fries et al. (2015, Neuron)
Varela et al. (2001, Nature Neuroscience)
Jensen et al. (2015, TINS)
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Alpha-gamma coupling modulation by attention

**Alpha** (10Hz)
- Functional inhibition
- Internally controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced

memory items

- 

- V
- T
- F
- K
- R
- T

1.1s

- 

- 

Bonnefond and Jensen (2015, Plos One)

Implementation?
Alpha-gamma coupling modulation by attention

**Alpha** (10Hz)
- Functional inhibition
- Internally controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced
Alpha-gamma coupling modulation by attention

**Alpha (10Hz)**
- Functional inhibition
- Internally controlled

**Gamma (>30Hz)**
- Active processing
- Stimulus-induced

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Superficial

Deep

Significant MI

**Phase dependent Alpha-Gamma correlation**

Time relative to alpha peaks
- Infragranular alpha

During stimulus processing?

Spaak, Bonnefond, Maier, Leopold, Jensen (2012, Curr. Biol.)
Alpha-gamma coupling modulation by attention

**Alpha** (10Hz)
- Functional inhibition
- Internally controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced

Memory items
- Distraction
- Target

Significant MI

Bonnefond and Jensen (2015, Plos One)
**Alpha-gamma coupling modulation by attention**

**Alpha** (10Hz)
- Functional inhibition
- Internally controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced

A. **Stimulus processing**

![Waveform diagram showing alpha and gamma activity]

Memory item  |  Distractor

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Jensen, Gips, Bergmann, Bonnefond 2014, *TINS*
Bonnefond, Kastner, Jensen 2017, *eNeuro*
**Alpha** (10Hz)
Functional inhibition
Internally controlled

**Gamma** (>30Hz)
Active processing
Stimulus-induced

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Gutteling, Bonnefond, Self, Jensen (in prep.)
**Alpha** (10Hz)
Functional inhibition
Internally controlled

**Gamma** (>30Hz)
Active processing
stimulus-induced

---

Bonnefond, Van Kerkoerle, Roelfsema, Jensen (in prep.)
Framework

**Alpha** (10Hz)
- Functional inhibition
- Internally controlled

**Gamma** (>30Hz)
- Active processing
- Stimulus-induced

Bonnefond, Kastner and Jensen (2017, eNeuro)
Thank you for your attention.