Alpha Band Oscillations Track Temporal Orienting of Attention

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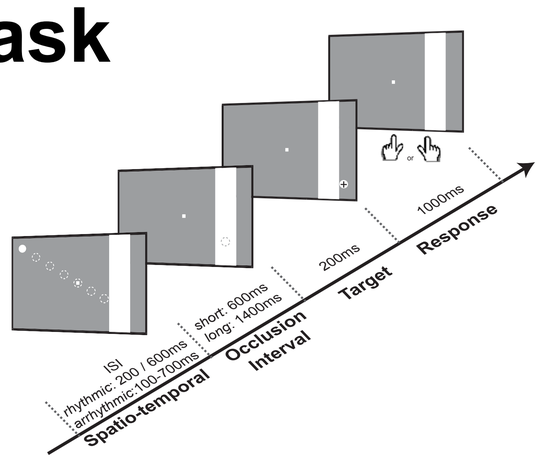
Experimental Questions

Previous studies have shown that temporal expectations induced by regular rhythms significantly enhance early visual potentials (P1) when combined with spatial expectation [1,2]. However, little is known about the cellular mechanisms that can mediate this effect. We tested the hypothesis that alignment of low-frequency oscillations to the timing of rhythmic or regular events provides a central mechanism for regulating cortical excitability by temporal expectations [3,4]. We also investigated wether temporal expectations influenced motor preparation (LRP).

In this study we asked:

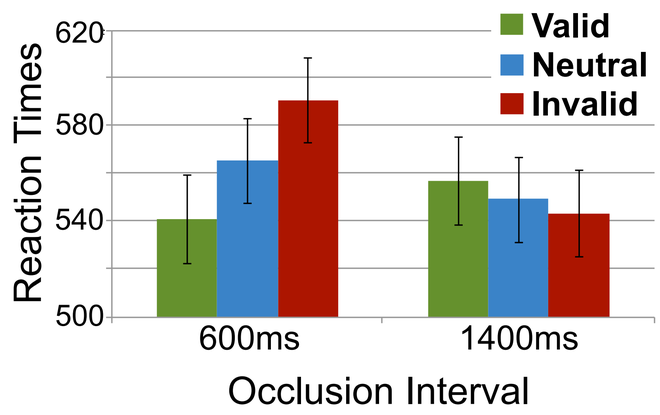
- Are early visual potentials modulated by temporal expectations in the presence of spatial expectations?
- Do temporal dynamics of oscillatory brain activity covary with temporal expectations?
- Do temporal expectations modulate event-related potentials linked to motor preparation ?

Task



Participants (20) viewed a white ball that appeared at the left side of a grey screen and moved across the screen in discrete steps following regular temporal rhythm or irregular intervals. The ball disappeared underneath an occluding band for one step. After reappearance, it contained either an upright or tilted cross. Participants made a forced discrimination accordingly.

Behavioural Results

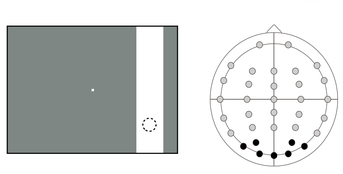


Temporal expectations significantly enhanced RTs.

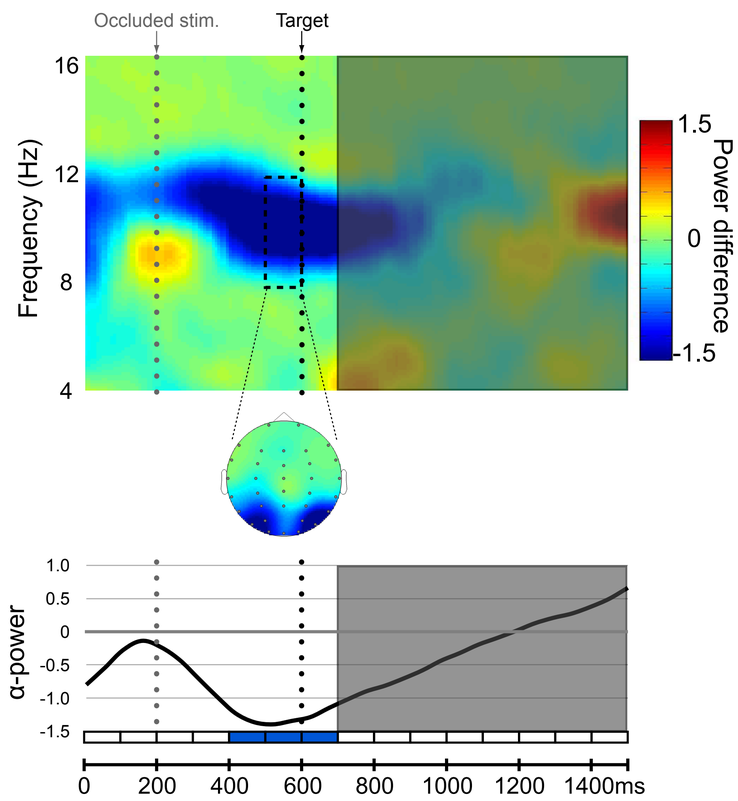
As expected, the effects occured mainly at the short-occlusion interval.

Temporal expectations are equated at the long-occlusion interval.

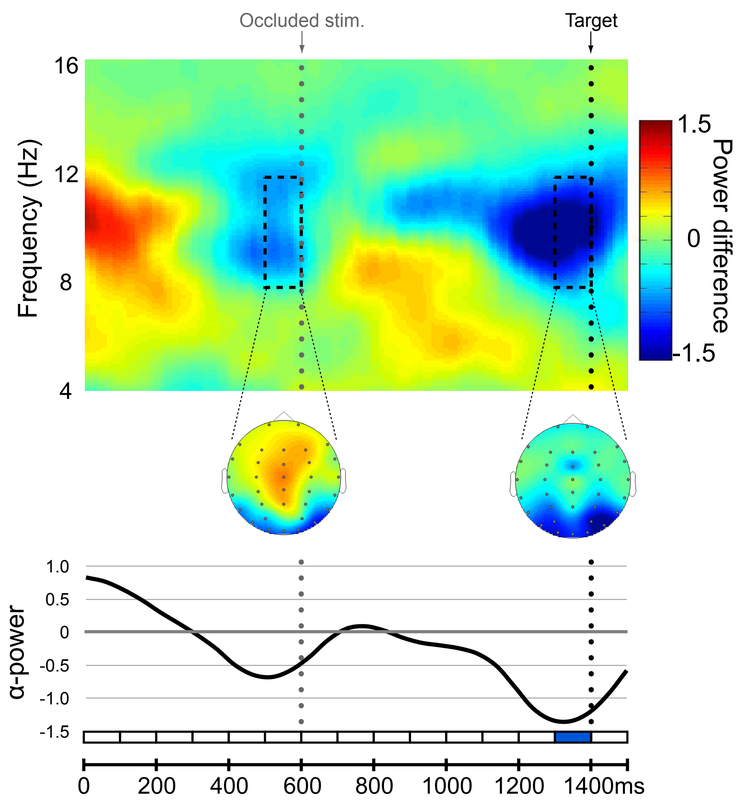
Time-Frequency Analysis



Fast Rhythm



Slow Rhythm



Desynchronization of alpha-band activity in anticipation of the appearance of the target in both rhythmic condition.

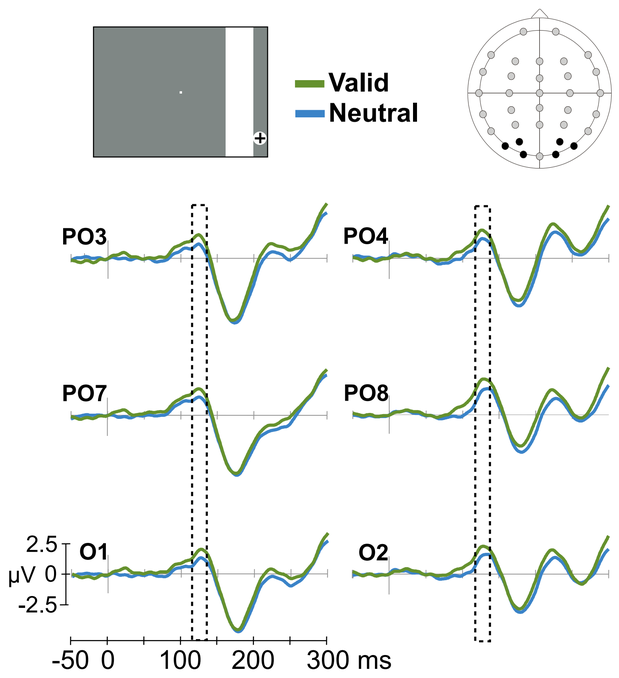
Slow rhythmic cues entrained slow brain oscillations in the alpha band.

Findings & Conclusions

- Temporal expectations significantly speeded responses.
- Our results replicate the synergistic interaction between spatial and temporal expectations in enhancing early visual perception (P1).
- Temporal expectations modulated the timing and amount of preparatory motor activity (LRP).
- Rhythmic cues entrained slow brain oscillations in the alpha band.
- We speculate that early visual perceptual modulation by temporal expectations could be induced by the entrainment of slow brain oscillatory activity in the alpha band.

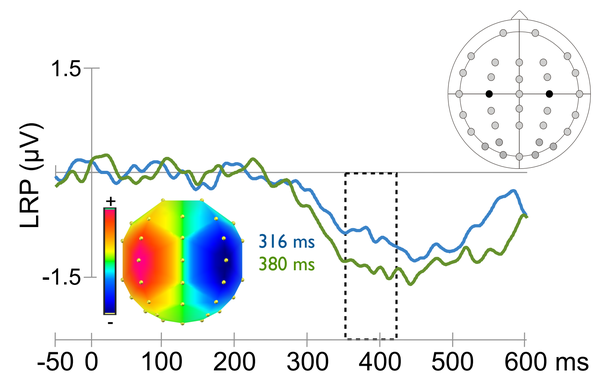
Event-Related Potentials

Early Visual P1 Potential



Temporal expectations enhanced the visual P1.

Lateralized Readiness Potential



The LRP was larger and started earlier in Valid trials.

EEG Methods

EEG was acquired from 40 channels at 1000Hz (AFZ ground, R mastoid reference) and re-referenced offline to the average of the mastoids.

ERPs elicited by valid and neutral trials were derived offline (-200, 600ms). Trials with eye movements, blinks or errors were excluded.

The **LRP** was obtained by recording over motor cortex contralateral to the response hand relative to ipsilateral motor cortex. LRP = [mean (C4-C3)left-hand + mean (C3-C4)right-hand] / 2. This gives a measure of motor preparation and execution, corrected for hemisphere asymmetries.

The **time-frequency analysis** was performed on unfiltered data, epoched from -700 to 1800 ms relative to the beginning of the occlusion period. A multitaper time–frequency transformation (5 cycles per time window) was applied to all electrodes in each trial. The data were normalised by subtracting the signal of the neutral (i.e. arrhythmic) condition from the rhythmic (i.e. fast or slow) conditions.

References

[1] Doherty, J.R. et al (2005). Synergistic effect of combined temporal and spatial expectations on visual attention. J. Neurosci. 25, 8259-8266.

[2] Correa, A., and Nobre, A. (2008). Neural Modulation by Regularity and Passage of Time. J. Neurophysiol. 100, 1649-1655.

[3] Lakatos, P et al (2008). Entrainment of Neuronal Oscillations as a Mechanism of Attentional Selection. Science 320, 110-113.

[4] Schroeder, C.E., and Lakatos, P. (2008). Low-frequency neuronal oscillations as instruments of sensory selection. Trends Neurosci., 1-10.

See also:
Nobre, A.C., and Coull, J.T. (2010). *Attention and Time*. Oxford University Press.

Supported by Programme Alßan & Oxford University Overseas Research Student Award Scheme

Nature Precedings - doi:10.1038/npre.2010.4509.1 : Posted 31 May 2010