# Slave to the rhythm

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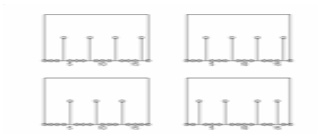
## 1. Introduction

Phase coding is the transmission of information through temporal relations, and may be used on short time scales by the brain [1]. Within a neuronal network that changes only slowly at the synaptic level, transient conditions of phase-locking may quickly alter its function. Does such frequency-domain behaviour play a role in the flexibility of the brain, and the ability to exert cognitive control?

*The bottom-right pattern is not in phase with the other three; note that the overall rate is the same.*



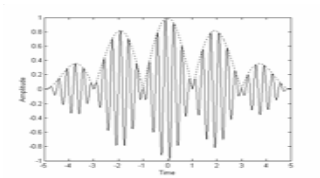
## 2. Method

Subjects performed a task-switching task, providing conditions of changing and maintaining task sets. Task sets differed on the modality to respond to and which hand to respond with. Within these conditions, subjects could or could not actually prepare. The mixture model was used to estimate the proportions of observations from prepared and unprepared reaction time distributions [2]. This allowed preparation odds to be assigned on a trial-by-trial basis.

## 3. Analysis

Wavelet analysis of the EEG provides measures of instantaneous amplitude and phase locking in specified frequency bands. Differences between the time courses of these measures were studied for the variables in the task-switching design: alternation – repetition, prepared – unprepared, etc.

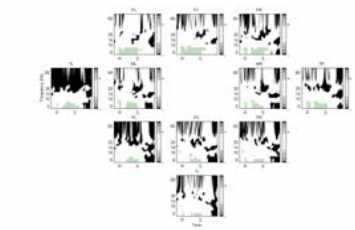
*An example of instantaneous amplitude: the dotted line bounding the signal.*



## 4. Theta: preactivation?

Pre- and post-stimulus theta amplitude covaries with reaction time. When subjects are fast, frontal areas shows higher theta-band activity pre-stimulus. When they are slow, parietal areas show higher post-stimulus theta-band activity.

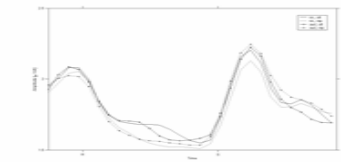
*Time-frequency plot of the difference between fast and slow trials.*



## 5. Theta: switching?

In a task in which subjects only had to switch between modalities, occipital theta increased during the preparation interval when subjects were to switch to a visual task.

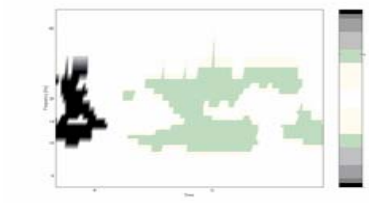
*The time course of theta amplitude for visual and auditory, switch and maintain trials.*



## 6. Mu and beta: motor preparation

Mu and beta amplitude over motor areas lateralize when preparing a task involving only the left or right response hand.

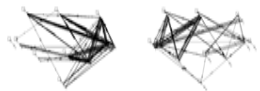
*Time-frequency plot for the left – right hemisphere difference, for left- minus right-hand preparation.*



## 7. Phase-locking

In the beta band, switching hand is associated with frontal - motor phase-locking. This effect was non-significant for repetition trials. Could this be evidence for the role of phase-locking in the mechanisms of cognitive control?

*Significant phase-locking differences between left- and right-hand switching.*



## 8. Conclusion

The brain shows clear frequency-domain behaviour related to different conditions in a task-switching design. The next question is: why? Hypotheses must be generated that are precise enough to be falsified by the data presented here, yet still have relevance on a cognitive level. Such hypotheses seem most likely to be found in the behaviour of biologically realistic, phase-sensitive neuronal network simulations.

*References:*

[1] Singer, W. (1990). Time as Coding Space. *Current Opinion in Neurobiology*, 9:189 – 194.

[2] De Jong, R. (2000). An intention-activation account of residual switch costs. In S. Monsell and J. Driver (Eds.), *Attention and Performance XVIII: Cognitive control*. Cambridge: MIT Press.

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