A direct test of the binding by synchrony hypothesis in humans: The neural correlates of coherent object perception

ABSTRACT:

Objectives
This project had the following main goals: 1. to investigate the coupling between perception and oscillatory neural synchrony. 2. Neurophysiological correlates and temporal dynamics of perceptual decision. An important goal was to provide a critical test to the binding by synchrony hypothesis in humans.

Method
We have developed a set of paradigms involving long-range perceptual spatial integration.
Some of these paradigms included stimuli requiring interhemispheric integration (roof shaped patterns), and holistic integration for perceptual decision.

Results
We found that oscillation amplitude and phase coherence can be uncoupled when related with the emergence of perceptual decision. Moreover we identified that perception related different gamma band sub components that be traced to distinct neural modules within the perceptual decision network, as also tested by simultaneous EEG/fMRI.
Concerning the roof-shaped patterns, by analyzing the EEG signal resulting from coherent object perception of ambiguous/unambiguous stimuli we were surprised to identify common features of oscillatory activity in the beta-gamma frequency range. This particular subband seems to be involved in perception related changes in oscillatory patterning. The topography of EEG synchronization is this band seems to be not directly related to the emergence or disruption of bilateral synchronization and the areas involved in bilateral integration of such roof-shaped patterns.
Importantly, we were able to also implement data-driven approaches to test the hypothesis of binding by synchrony in humans which are critical to test model driven approaches.

Conclusions
In sum our data highlight a complex network of regions involved in perceptual decision making and seem to support a functional role for spatiotemporal patterns in the beta and gamma frequency range for perceptual integration, but do not support a direct role for the binding by synchrony hypothesis.

Keywords
EEG, fMRI, Holistic perception, Synchrony

Published Work:

Banca, P., Sousa, T., Catarina Duarte, I., & Castelo-Branco, M. (2015). Visual motion imagery neurofeedback based on the hMT+/V5 complex: evidence for a feedback-specific neural circuit involving neocortical and cerebellar regions. *Journal of Neural Engineering, 12*(6):066003. doi: 10.1088/1741-2560/12/6/066003

Castelo-Branco, M., & Castelhano, J. (2015). Perceptual decision making. In A. Toga (Ed.), *Brain mapping: An encyclopedic reference* (Vol. 3, pp. 401–408). Academic Press.

Castelhano, J., Bernardino, I., Rebola, J., Rodriguez, E. & Castelo-Branco, M. (2015). Oscillations or synchrony? Disruption of neural synchrony despite enhanced gamma oscillations in a model of disrupted perceptual coherence. *Journal of Cognitive Neuroscience, 27*(12), 2416-2426. doi: 10.1162/jocn_a_00863

Castelhano, J., Duarte, I. C., Wibral, M., Rodriguez, E., & Castelo-Branco, M. (2014). The dual facet of gamma oscillations: separate visual and decission making circuits as revealed by simultaneous EEG/fMRI. *Human Brain Mapping, 35*(10), 5219-5235. doi: 10.1002/hbm.22545

Intaité, M., Koivisto, M., & Castelo-Branco, M. (2014). Event-related potential responses to perceptual reversals are modulated by working memory load. *Neuropsychologia, 56*, 428-438. doi: 10.1016/j.neuropsychologia.2014.02.016

Intaite, M., Koivisto, M., Castelo-Branco, M. (2014). The linear impact of concurrent working memory load on dynamics of Necker cube perceptual reversals. *Journal of Vision, 14*(1), pii: 13. doi: 10.1167/14.1.13

Teixeira, M., Pires, G., Raimundo, M., Nascimento, S., Almeida, V., & Castelo-Branco, M. (2014). Robust single trial identification of conscious percepts triggered by sensory events of variable saliency. *PLoS One, 9*(1): e86201. doi: 10.1371/journal.pone.0086201

Researcher's Contacts:

Miguel Castelo-Branco
Visual Neuroscience Laboratory
Institute for Biomedical Imaging in Life Sciences (IBILI)
Faculty of Medicine, University of Coimbra
Polo III, Ciências da Saúde
3000-548 Coimbra, Portugal

Email: mcbranco@fmed.uc.pt