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Assessing the brain response to the Rotating Snake illusion by TD-fNIRS

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Introduction: There are a variety of static images that evoke illusory motion perception to the observer. One example is the Rotating Snakes proposed by Kitaoka [1], where circles appear to rotate in the peripheral vision due to a particular arrangement of colors. To our knowledge, there are just two studies of this kind of illusion using neuroimaging techniques: one using functional magnetic resonance imaging fMRI [2] and one using continuous wave (CW) functional near-infrared spectroscopy (fNIRS) [3]. In this study we have measured the cortical hemodynamic response to this type of stimulus by Time Domain (TD) fNIRS, aiming at adding valuable information in understanding and localizing which brain areas are involved in the processing of this illusion.
Material and methods: We used a multichannel 16-source 8-detector dual-wavelength (687 and 826 nm) TD-fNIRS device [4] to compare the hemodynamic response function (HRF) signal related to a static illusory-motion image (Rotating Snakes) with respect to two control stimuli: a color changed version of the original one, inducing no motion illusion (static control), and a movie in which the 'Rotating Snakes'effectively rotate (real motion control). Starting from the fMRI results, reporting no difference between the illusion and the static control image for the signal measured in the primary visual cortex V1, we placed the optodes on the occipito-temporal region, to cover the motion sensitive area of the visual cortex V5/hMT, and on the prefrontal cortex, to monitor a possible cognitive involvement. For the data analysis, we applied a time-gating approach to remove the superficial contribution to the cortical signal [5], then fitted the resulting hemodynamic concentration courses with a HRF constructed using two gamma functions [6].
Results: Preliminary results for three adult participants show significant activations in the occipito-temporal channels for all the three stimuli, while no significant activation was observed in the frontal cortex, indicating a minimal cognitive load. The illusion and real motion stimuli produced similar activation patterns characterized by an increase in oxygenated hemoglobin and a decrease in deoxygenated hemoglobin, though real motion movie elicited slightly stronger responses. In contrast, the static control stimulus yielded weaker and delayed responses, suggesting diminished motion processing.
Conclusion: According to fMRI data, the results obtained in this preliminary study suggest the possibility of detecting and distinguishing brain responses to static illusory patterns, such as the Rotating Snakes illusion. Furthermore, we are currently investigating the coupling between subject-specific channels and corresponding cortical areas through Monte-Carlo simulations [7], hence improving the localization of V5/hMT region involved in the processing of motion with TD-NIRS.

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