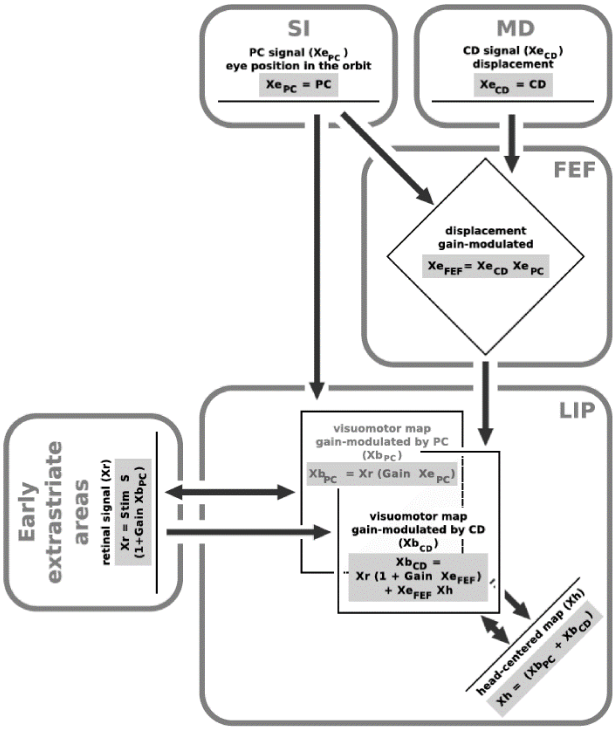
Spatial Cognition

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 600785

Brain circuits underlying visual stability across eye movements – converging evidence for a neuro-computational model of area LIP

Ziesche A, Hamker FH. (2014) Brain circuits underlying visual stability across eye movements - converging evidence for a neuro-computational model of area LIP. *Front Comput Neurosci.,* 8(25), 1-15.

The understanding of the subjective experience of a visually stable world despite the occurrence of an observer's eye movements has been the focus of extensive research for over 20 years. These studies have revealed fundamental mechanisms such as anticipatory receptive field shifts and the saccadic suppression of stimulus displacements, yet there currently exists no single explanatory framework for these observations. We show that a previously presented neuro-computational model of peri-saccadic mislocalization accounts for the phenomenon of predictive remapping and for the observation of saccadic suppression of displacement (SSD). This converging evidence allows us to identify the potential ingredients of perceptual stability that generalize beyond different data sets in a formal physiology-based model. In particular we propose that predictive remapping stabilizes the visual world across saccades by introducing a feedback loop and, as an emergent result, small displacements of stimuli are not noticed by the visual system. The model provides a link from neural dynamics, to neural mechanism and finally to behavior, and thus offers a testable comprehensive framework of visual stability.



The computational model with its layers and their way of interaction: The three input signals (stimulus Xr, eye position Xe_{PC} and corollary discharge Xe_{CD}) are fed into two LIP maps (Xb_{PC}, Xb_{CD}) which are gain modulated by the corresponding signal. The activities of all simulated LIP neurons are combined in an interaction map Xh, which then determines the response of the model, e.g. the perceived spatial position of a stimulus or the displacement of the fixation point.

In this article, a mathematically detailed illustration of the model is given – a short overview over the model structure can be found in the Figure. Additionally, simulations of two interesting phenomena are described: The predictive remapping and the SSD. In particular, a comprehensive explanation of the function of predictive remapping in SSD is offered, proposing that it relies on an intact projection from eye position modulated cells to eye displacement modulated cells. Any disruption of these connections, e.g. by suppressing corollary discharge, should diminish predictive remapping, which then should lead to a disturbed behaviour in SSD tasks. However, the potentially most important achievement of this model is its ability to generalize across different studies, as previously shown for the systematic localization errors of briefly flashed bars in complete darkness (Ziesche and Hamker, 2011). In sum, the model offers a fresh, new view onto the role of predictive remapping in the subjective perception of a stable world and provides several testable predictions.

References:

Ziesche A, Hamker FH. (2011) A computational model for the influence of corollary discharge and proprioception on the perisaccadic mislocalization of briefly presented stimuli in complete darkness. *J Neurosci.,* 31(48):17392-405.