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In order to grasp an object in their visual field, humans orient their visual axis to targets of interest. While scanning their environment, humans perform multiple saccades (rapid eye movements that correct for a position error between eye and target) to align their visual axis with objects of interest. Humans are also able to track objects that move in their environment by means of smooth pursuit eye movements (slow eye movements that correct for any velocity error between eye and target, i.e. for any retinal slip).

The appearance of a moving stimulus in the environment elicits smooth pursuit eye movements with a latency of around 100ms. Accordingly, the smooth pursuit system accounts for a change in the trajectory of a moving target with a similar delay. Due to this delay, the oculomotor system needs to develop strategies to avoid the build up of position error during tracking of a moving target. To do so, the oculomotor system uses prediction to try and anticipate the future target trajectory. However, this strategy is limited to conditions where target trajectory is predictable. Otherwise, primates have to combine pursuit and saccades in visual tracking of unpredictable moving targets to avoid large position error.

This thesis focuses on both the prediction mechanisms and the interactions between saccades and pursuit. In order to investigate prediction mechanisms, we asked human subjects to pursue a moving target when it was transiently occluded. During occlusions, subjects continued to pursue the invisible target. This thesis demonstrates that this predictive pursuit response is based on a dynamic internal representation of target motion, i.e. a representation that evolves with time. This internal representation could be either built up by repetition of the same target motion or extrapolated on the basis of the pre-occlusion target motion. In addition, it is shown that during occlusions, saccades are adjusted in order to account for the large variability of the smooth pursuit response. As a consequence, it shows that the smooth pursuit command is used by internal models in order to predict future smooth pursuit response. These results demonstrate that both prediction and internal models are necessary to track the invisible and the visible.

Jean-Jacques Orban de Xivry was born in 1979 in Uccle (Belgium). In 1997, he entered the Université catholique de Louvain (UCL). He became an Engineer in Applied Mathematics in 2002. His thesis was devoted to the study of predictive saccades during anticipation of a moving target. He then started a Ph. D. in the oculomotor research group at UCL under the supervision of Professor P. Lefèvre. From 2002 to 2007, he was a Ph. D student and research assistant at CESAME (Centre for Systems engineering and Applied Mechanics). His major interests focus on the predictive mechanisms that drive smooth pursuit eye movements and on the interaction between saccades and pursuit.



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DÉCEMBRE 2007

Thèse présentée en vue de l'obtention du grade
de docteur en sciences appliquées

Faculté des sciences
appliquées

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