



# Biologically inspired modelling of target selection and eye movements in moving agents

Markus Raabe\* & Mark W. Greenlee\*

\* Institute of Experimental Psychology, University of Regensburg



## The STREP Decisions in Motion

The research goals of the STREP "DECISIONS-IN-MOTION" will be to describe the neural mechanisms used to guide behaviour in complex visual scenes, in which the observer is in motion and navigates to avoid moving objects. We will derive neural models that explicitly make use of a hierarchy of sensory areas (low-, mid-, high-level visual areas) to extract meaningful information about the location and motion of objects in the environment. The outputs of these units will feed into a decision-making process that will weight these inputs and relations between them based on utility functions. This approach will lead to an improved design of augmented cognition systems to support robotic control systems to extract object information from moving scenes.

## Biologically inspired modelling – Workpackage 1.1 (University of Regensburg)

Biological models of motion processing and the control of smooth pursuit eye movements for target selection, made while the observer is in motion, will be developed using a multimodal modelling approach which combines theory (testing of hypothetical models) and data driven (generating new hypotheses by exploratory analyses) methods. This procedure will lead to an improved understanding of the interplay between oculomotor and motion-sensitive sensory brain regions. Figure 1 shows the iterative process. The aim of workpackage is to test the effect of coherent background motion on the subject's ability to detect and act on the presence of a visual target. The experiment described below is a first draft to approach these goals.

## Combined data- and theorydriven modelling approach

Identification of active Brain Regions during different tasks by 3T fMRI

Investigation of effective connectivity by Granger Causality Mapping (voxel-wise Identification of the dependencies from one region on another)

Defining a model inspired by the explored brain regions and their effective connectivity

Verifying the model with Dynamic Causal Modelling (modelling neuronal activity used to predict fMRI activity)

Fig. 1: The design cycle of the combined data- and theorydriven modelling approach

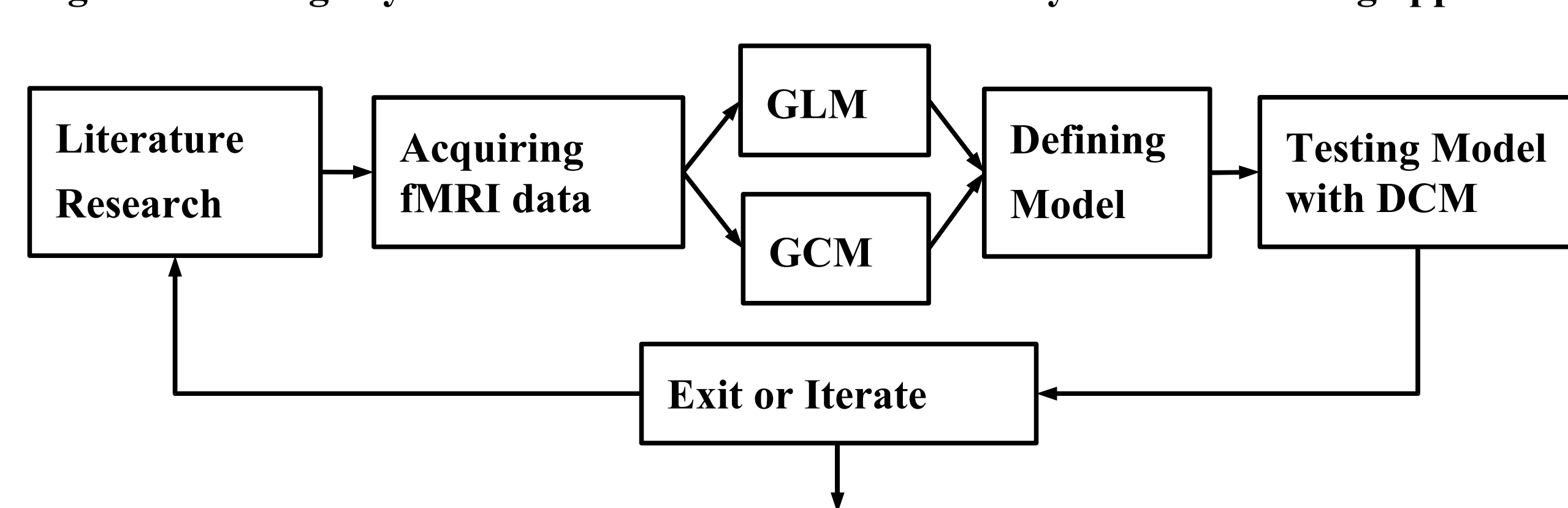
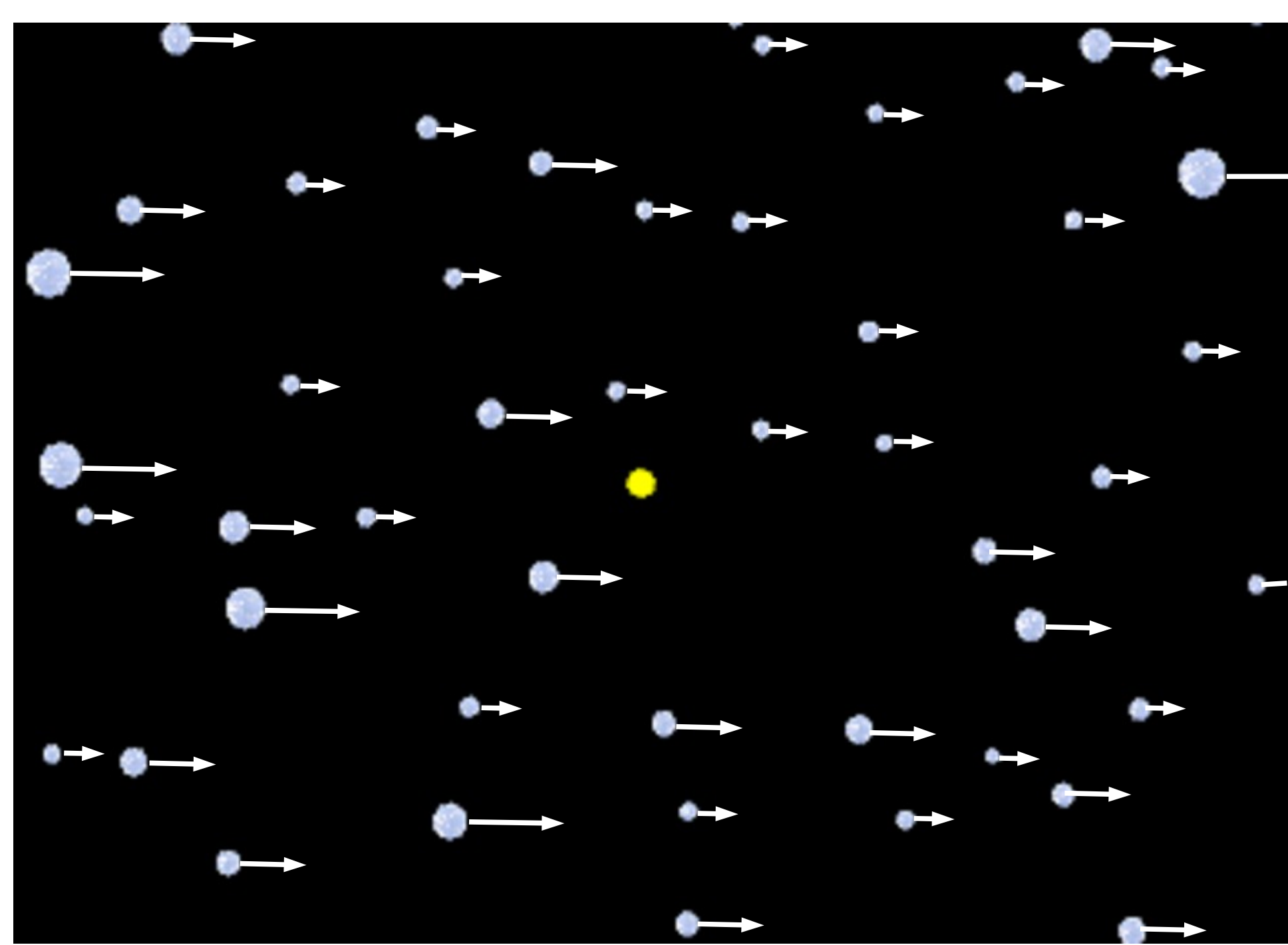
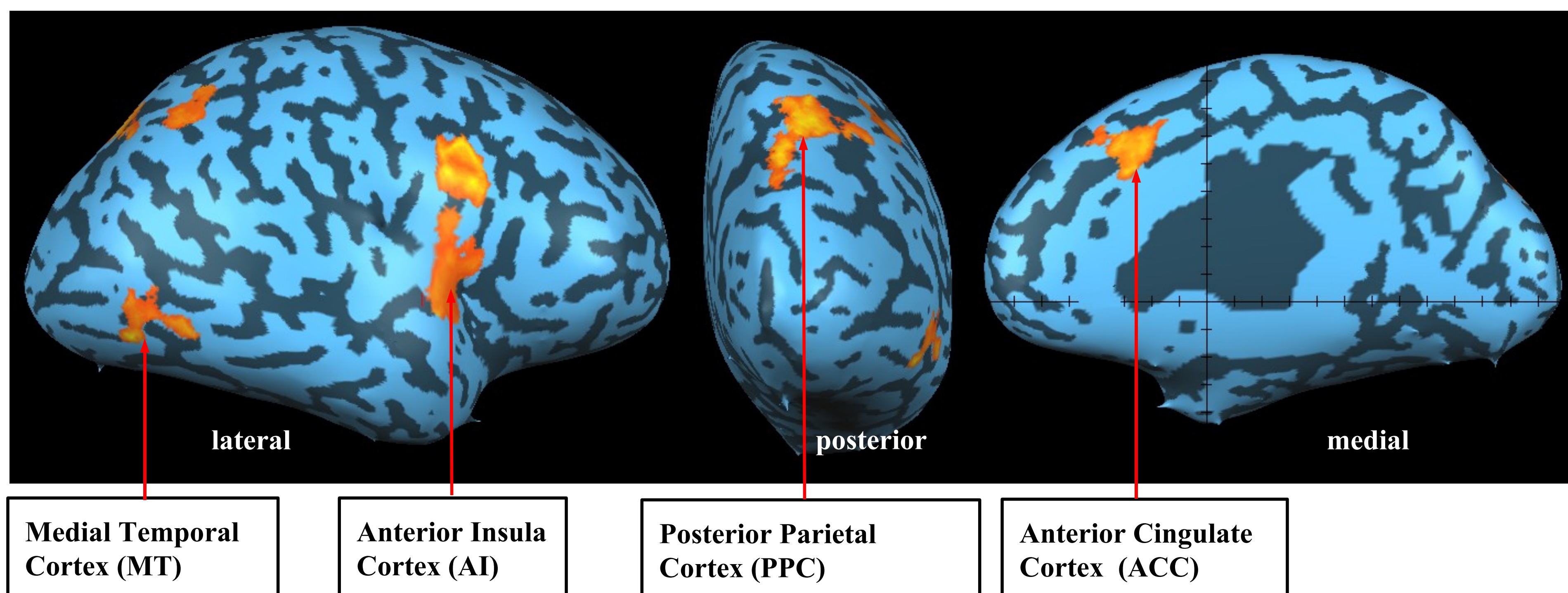


Fig. 2: Translating 3D coherent dot motion



(velocity represented by arrow length)

Fig. 3: Activated brain regions in coherently moving dots (translation + expansion/contraction in depth) weighted and compared with simple translation and expansion/contraction (rendered on the right hemisphere of an inflated cortex in Talairach Space)



## Introduction and Approach

This pilot study was conducted to develop a modelling approach for target selection and eye movements in moving agents. In real world conditions observers are seldom exposed to unidirectional coherent optic flow. When the observer moves, his direction sometimes changes and so does the direction of the optic flow. In our pilot study we have examined the perception of optic flow in simulated flowfields. We also explored the stimulus conditions that evoked the sense of self motion (vection). In our virtual reality environment in a 3-Tesla (Siemens Allegra) fMRI scanner, we defined 3D random-dot kinematograms (RDK) which were either static or coherently animated in-plane translating from left to right (see Fig. 2), in-depth expanding-contracting RDKs as well as a combination of these motion types. Consequently the combination of both conditions represents a higher level of perceptual change and state switching which enables us to examine the brain areas related to motion perception and vection. Each RDK was presented for 40s in duration, during which time the dot motion cycled repetitively through expansion/contraction or through frontoplanar translation. We conducted fast functional MRI (TR = 1) to improve the temporal resolution of the recorded brain activation.

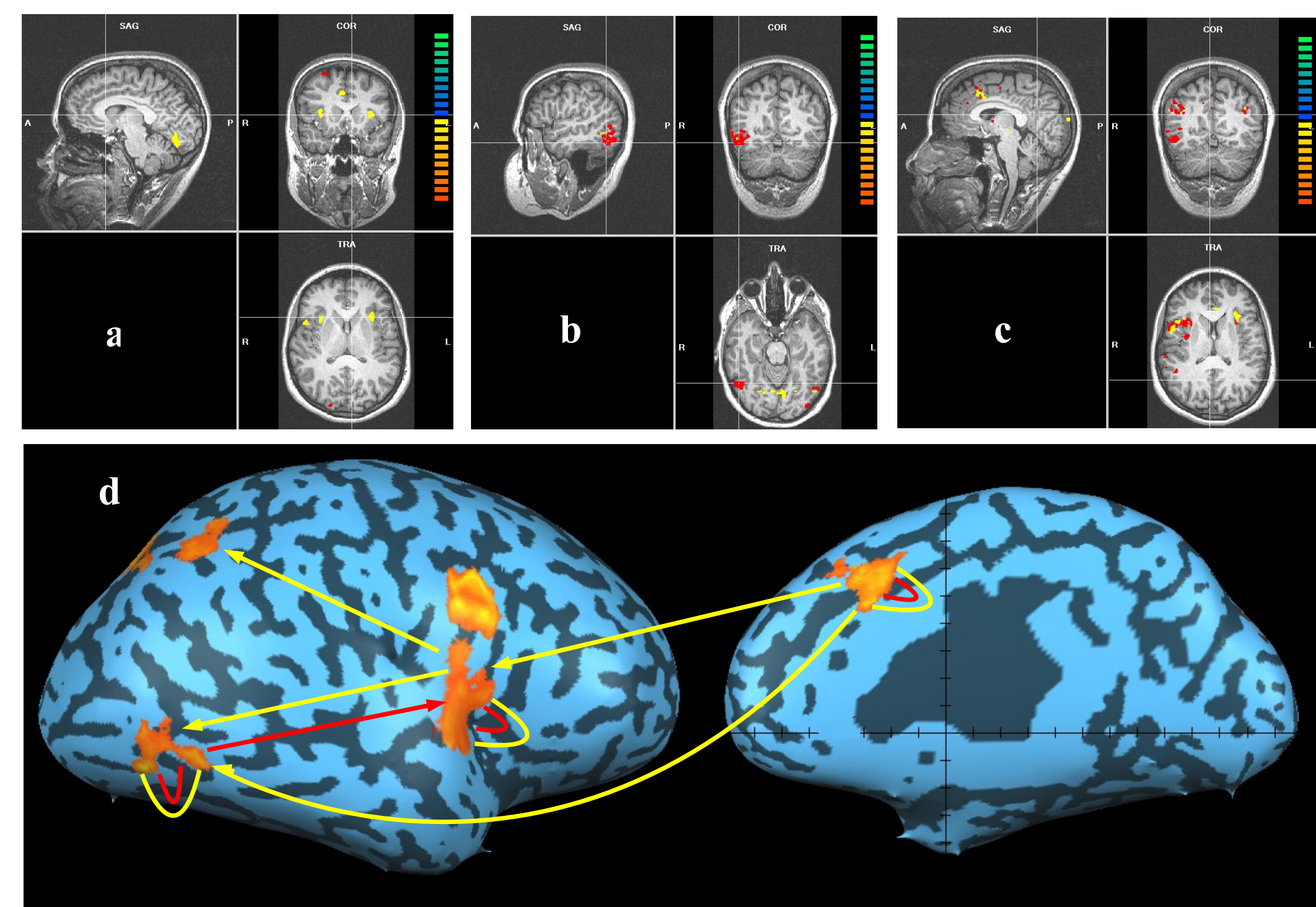
## Results

The combined condition translation + expansion-contraction was weighted and compared with simple translation and expansion-contraction conditions. In this contrast ( $p < 0.01$ , FDR corrected) we found activated areas in the medial temporal cortex (MT), the anterior insula (AI), the posterior parietal cortex (PPC) and the anterior cingulate cortex (ACC; see Fig. 3). Moreover, we found a deactivation in a small region in the insula cortex (see Figure 5). Applying Granger Causality Mapping (GCM) to MT and AI in a merged motion processing condition ( $p < 0.05$ ; FWE corrected) shows MT activation being dependent on activation in AI, ACC (see Fig. 4.a) and V1 (see Fig. 4.b). AI activation seems to be dependent on the co-activation of ACC (see Fig. 4.c). Furthermore activation in PPC and MT seems to be dependent on the co-activation of AI (see Fig. 4c,d). Further comparisons with the processing of the static dot control condition seem to support the reported connectivity which appears predominantly during motion processing.

## Discussion

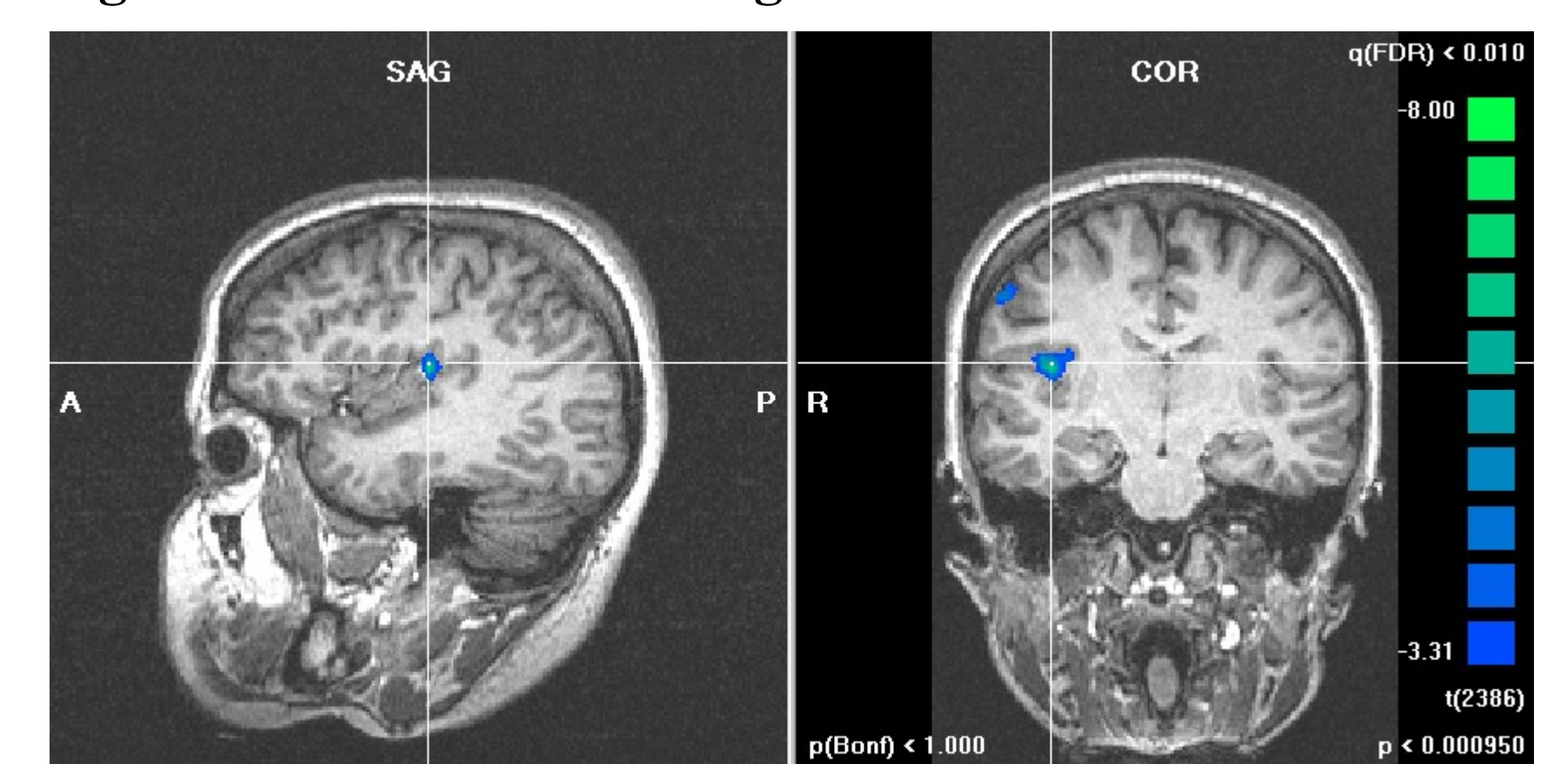
Perceptual changes and state switching during coherent optic flow perception is characterized by significant activity in motion-sensitive processing areas (MT/MST) and integrative areas (PPC). These activations appear to be modulated by regions related to attention (AI & ACC). GCM revealed significant interactions between these areas (fig. 4). The deactivation in the insula which is otherwise involved in the processing of vestibular information (Eickhoff et al. Human Brain Mapping, 2006) could underlie the sense of vection reported by the participant. The presented work provides a first estimation for a biologically inspired model of brain connectivity and its dynamic interplay in the processing of optic flow fields. As a next step the preliminary model has to be verified by a DCM analysis and passed through further development steps incorporating enhanced experimental conditions which include the analysis of eye movements and the sense of vection.

Fig. 4: Dependencies from peaks in MT (4.a and 4.b) and AI (4.c) on all other voxels (yellow colour: to / red colour: from) during motion processing.



(Figure 4.d gives an overview of most of the connections)

Fig. 5: Deactivated brain region in the insula cortex



Contact: [Markus@Raabe.tv](mailto:Markus@Raabe.tv)  
URL: [www.decisionsinmotion.org](http://www.decisionsinmotion.org)