FROM VIDEO-BASED EYETRACKING
TO IMAGING BRAIN AND PERCEPTUAL CONSCIOUSNESS

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Recent progress in video-based eyetracking can be considered as a silent technological revolution in brain and behavioural sciences, approaching that of brain imaging methods. The importance of this methodology is quite obvious from the point of view of the ecological validity and practical implications of eyetracking. However, it is of a paramount significance for basic neurocognitive research as well. As a matter of fact, human eye movements are a common output of a number of philogenetically evolved and often (though not always) hierarchically organized brain systems. In this presentation, I will demonstrate how contemporary eyetracking research helps to disentangle their influences on task solution completing in a non-trivial way data obtained with neuroimaging methods.

Four groups of perceptual, cognitive and communicative tasks will be considered, with corresponding paradigms of eyetracking and neurocognitive studies. The first paradigm consists of the analysis of distractor influences on the duration of visual fixations during a free visual exploration of pictures. The second paradigm allows investigation of the role of attention in the process of perceiving static and dynamic visual scenes. The third investigates dissociations of the subjective focus of visual work and the physical location of visual fixations depending on the task at hand. Finally, the fourth paradigm is related to an analysis of the role of social gaze in processes of interpersonal communication. Up to five different brain systems seem to be at play in regulating parameters of eye movements in these experimental situations.

For instance, our habituation studies of distractor effect – a transient “freezing” of visual fixation in the actual position in response to a sudden optical event – reveals two completely different waves of saccadic inhibition at 90 and at 170 ms. Their origins could be tentatively identified with the superiour colliculus and the amygdala, respectively [1]. In a similar vein, two underlying systems seems to be at work in changing patterns of eye movement in the course of the exploration of static and particularly dynamic scenes such as VR simulation of hazardous traffic events. Indirect evidence helps us to identify the systems as the classical dorsal and ventral stream mechanisms of perceptual processing [2]. However we still lack direct confirmation of this caused by the low temporal resolution of most brain imaging methods. Comparable fMRI data exist in the case of social gaze studies (see [3]). Fig.1 illustrates the main effect contrasting a frontomedial and a (slight) right prefrontal activation during eye-to- eye contact with the predominantly parietal activation in an almost identical situation without such social gaze information. These prefrontal regions have been demonstrated to be involved in self-referential encoding [4, 5] while the posterior sites belong to the already mentioned dorsal stream structures. This is important in terms of

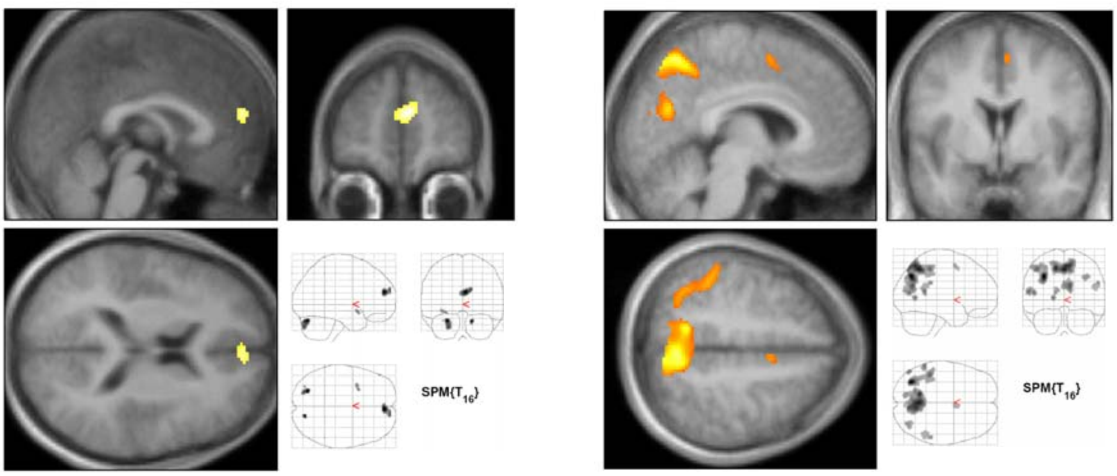

Fig.1 Typical BOLD-responses to the appearance of a virtual anthropomorphic agent looking either directly at the human observer (left) or at some imaginary location nearby of him/her (right)

the interpretation of the results. In addition, the data demonstrate that a single parameter of gaze direction in a social context can radically change the neurocognitive level of the information processing of the perceiver.

Current knowledge of the relationship between micro-behaviour of the human eye and the underlying brain processes allows new approaches to the visualisation of idiosyncratic individual perception. The first of these approaches, termed ‘attentional landscapes method’ [6], proposes a filtering of the visual scene in terms of the distribution of visual fixations. With the current differentiation of two modes of visual attention and their connection to ventral and dorsal streams it will be possible to reconstruct the subjective view of the situation as it is “seen” by more conscious ventral mechanisms of focal attention. Fig.2 illustrates another interesting aspect of this class of cognitively-motivated applications for eyetracking [7]. Here, attentional landscapes of expert and novice oncologists are compared while they are planning a neck dissection. Firstly, it is obvious that the distribution of focal attention in experts is much sharper – a feature we also observed in several other groups of experts, e.g. in cartography. Secondly and more importantly, through the measurement and rendering of such visualisations, thus far hidden personal views will become available for sharing with others, allowing enhanced and even entirely novel ways of communication, control and professional collaboration.

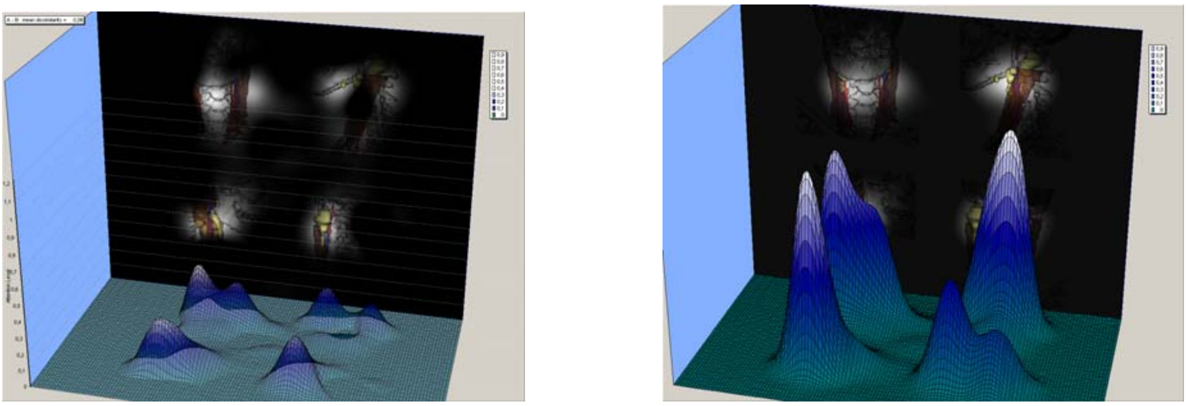

Fig. 2. Visualization of differences in conscious perception: novices *minus* experts (left), experts *minus* novices (right)

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