Summary

Eye movements are essential to human visual perception. Human vision is only crisp at the center of gaze and visual acuity rapidly decreases in the periphery of the visual field. Therefore, we need to actively move our eyes to change our focus when we want to scrutinize different scene elements. Over the recent years, research studying the neural basis of visual perception has embraced the use of functional Magnetic Resonance Imaging (fMRI). For various reasons, eye movements, in spite of their obvious importance to visual perception, have scarcely been considered in fMRI research to date. This thesis attempts to make up arrears by studying the intricate link between eye movements and human visual perception using fMRI. Foremost, it aims to answer the following question:

"How does the human brain process visual information in relation to eye movements?"

This question encompasses two subsidiary questions. The first subsidiary question is: "How does the visual brain determine what parts of the scene are important to redirect our gaze at?" This question is answered in a series of experiments. Chapter 2 describes an experiment aimed at predicting to what extent stimulus features determine where people direct their gaze. We show how features of inspected patches from natural images differ from non-inspected ones, and show how these features can be used to predict where people look. In Chapter 3, we determine where color information is processed in the visual brain. This research explored the use of multivariate pattern analysis methods in brain research. In Chapter 4, these multivariate methods are used to show that eye fixations are meaningful events that can be used to study visual perception using fMRI research. This resulted in a novel technique – fixation based event-related (FIBER) fMRI – that allows incorporating natural viewing behaviour in fMRI paradigms. Next, in Chapter 5, we use the new FIBER approach to study the neural correlates of priority – a recently suggested construct that integrates context-based top-down attention and stimulus-driven bottom-up attention. In Chapter 5, we propose a new measure to calculate priority based on eye movements, show that it is different from current bottom-up measures of attention, and find that priority is represented in select visual cortical areas. The second subsidiary question of this thesis is: "Where
is the visual information processed that is acquired during natural viewing behaviour?” Chapter 6 describes an experiment that provides a first answer to this question. By applying FIBER, we show that visual information for different types of viewing behaviour is processed in distinct cortical regions.

In summary, this thesis contributes to answering the question how visual information is processed in the brain in relation to eye movements by: 1) showing that both brain responses and stimulus features can be used to predict where people direct their gaze; 2) providing a novel analysis method which allows incorporating natural viewing behaviour in fMRI research; 3) implementing an original approach for measuring priority; 4) revealing the organization of visual cortex for processing of perceived color, priority, and the information gathered during distinct types of viewing behaviour. Hence, the use of natural viewing behaviour in fMRI paradigms creates new pathways for studying human brain function.