# Imaging imagery

# SUMMARY

This thesis sheds light on the functional architecture of several cortical areas in the human visual system during visual perception and imagery. It employed high-resolution 7 Tesla functional magnetic resonance imaging (fMRI) for both mapping and decoding of brain activation patterns within human visual cortex. Depth perception evoked by binocular disparity including multiple visual feature encodings, visual imagery of motion as well as letters, and top-down influences on the visual system exploited by mental imagery have been investigated. A general introduction to the subject matter is presented in chapter one.

In Chapter 2 ("Overlapping feature representations in human visual cortex: Binocular disparity and axis-of-motion tuning mapped in human area MT using ultra-high field fMRI"), depth perception induced by binocular disparity was investigated. This led to a deeper understanding of the functional architecture within the human middle temporal area (hMT) with respect to its computational properties and encodings. Exploiting submillimetre functional resolution ultra-high field fMRI, binocular disparity and direction-of-motion tunings in hMT were examined. Systematic fine-grained disparity tunings, alongside axis-of-motion tunings were found. This study was the first to demonstrate overlapping tuning maps for two distinct visual features, i. e. binocular disparity and direction-of-motion, in an extrastriate area of human visual cortex using a fully crossed and controlled experimental design. This shed light on how the brain maps multiple basic visual features within one cortical area.

Chapter 3 ("Decoding the direction of imagined visual motion using 7 T ultra-high field fMRI") continued this line of thought by examining not only perceived, but also merely imagined visual content within the same hierarchical structures of the visual system. The direction of imagined visual motion was successfully decoded from primary visual areas on a single-subject level. Top-down influences during imagery led to remarkably similar activation in early visual cortex as perception. The application of multi-voxel pattern analysis to high-resolution functional data of twelve subjects demonstrated that imagery of visual motion activated the earliest levels of the visual hierarchy and that the extent and location of the activation varied between subjects. The approach enabled classification not only of complex imagery, but also of actual content, in that the direction of imagined motion, out of four options, was successfully identified in most subjects and with high accuracies. These high-accuracy findings not only shed light on the constituents of mental imagery, but also on the feasibility of decoding specific sub-categorical imagery content from brain imaging data.

Finally, in Chapter 4 ("Reconstructing and decoding imagined letters from the visual system using ultra-high field fMRI"), the previous results were taken one step further and applied to enable visual reconstruction of concrete specific imaging content. For the first time, the successful reconstructions of visual field images (visualising recognisable content of a complex mental image) was achieved on a single trial level. Imagined letter shapes were reconstructed and decoded from submillimetre resolution fMRI data of two subjects baring striking resemblance to the presented letter shapes, especially when focusing on the earliest visual areas. This demonstrated significant overlap between reconstructed visual field images of perception data, imagery data, and the actually presented stimuli. Furthermore, successful classification of different letter features (edgy versus curvy) based on data from visual word-form area using multi-voxel pattern analysis was accomplished. This proof of concept could be the first step towards more elaborate studies on visual field image reconstruction of imagined everyday stimuli and towards the development of more natural and directly content-based brain-computer-interfaces.

A discussion of all findings is presented in chapter five. In summary, this thesis provided new evidence on the fine-grained organisation of visual areas in the human brain during visual perception and during mental imagery, employing state-of-the-art ultra-high resolution functional imaging.