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論　文　内　容　の　要　旨

氏　名　（　大石　浩輝　）	
論文題名	The structural and functional properties of the human visual pathway（ヒト視覚系の機能と構造）

論文内容の要旨

Our visual perception is based on the process in the visual pathway. For the last decades, many neuroimaging studies using functional magnetic resonance imaging (fMRI) have elucidated the functional organization of the human visual pathway and its relationship to visual perception. Because the anatomical structure of the human visual pathway has been mostly studied in the postmortem human brain, little is known about how the anatomical structure relates to functional organization and visual perception. The reason is it is only recently that the non-invasive quantitative structure imaging of living human brains has become available.

This dissertation includes two studies, which quantified the structure of the human visual pathway, primarily using a macromolecular tissue volume (MTV) mapping. MTV is a recently proposed quantitative structural MRI method, which is sensitive to a fraction of non-water macromolecules.

In the first study, I attempted to non-invasively identify subdivisions of the lateral geniculate nucleus (LGN), a key thalamic nucleus that receives projections from retinal neurons and in turn projects to the cortex. The LGN is composed of two main subdivisions, magnocellular and parvocellular subdivisions. The non-invasive identification of these subdivisions has been difficult because the *in vivo* structural neuroimaging method for quantifying the properties of LGN subdivisions has not yet been established. Here, I measured MTV in the living human brain and found the gradual MTV changes within LGN, which enabled us to identify the LGN subdivisions. An fMRI experiment further revealed that the subdivisions showed different sensitivities to visual stimuli. This study provides a novel method for non-invasively investigating the structural properties of LGN subdivisions in living human brains, which can be combined with functional or behavioral experiments.

In the second study, I investigated the neuroanatomical basis of individual differences in stereopsis, one of the fundamental visual functions. There are huge inter-individual differences in the ability to discriminate depth from binocular disparity (stereoacuity). Here, I investigated the neuroanatomical basis of the inter-individual differences in stereoacuity. Based on the previous studies showing that several areas in both dorsal and ventral visual pathways are involved in stereopsis, I hypothesized that the white matter tract connecting those areas is the crucial anatomical substrate for stereopsis. I investigated how the human stereoacuity relates to white matter properties by combining psychophysics, diffusion MRI and MTV. As a result, I found that the MTV along the right vertical occipital fasciculus (VOF), a major tract connecting dorsal and ventral visual areas, was highly correlated with stereoacuity. By fMRI experiment, I further found that binocular disparity stimuli activated the dorsal and ventral visual regions near VOF endpoints. These results suggest that stereo perception is associated with dorso-ventral communication through the VOF.

These two studies have provided an important foundation for future studies that investigate the relationship between perception, function and structure in the human visual pathway.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

ヒトの視知覚と脳の構造の関係を明らかにするためには、生きているヒトの視覚経路の構造を可視化して視機能との対応を明らかにする必要がある。申請者は、二つの研究から視覚系におけるヒト脳構造の理解を飛躍的に高めることに成功した。

一つ目の研究では、ヒト生体脳において、視覚情報処理に関わる神経核である外側膝状体のサブ領域を構造的MRI計測によって可視化する手法を開発し、ヒト死後脳との比較、機能的MRI計測との比較および再現性の検証によってその確からしさを十分に証明した。今後本手法を用いて、外側膝状体のサブ領域の機能の違いや眼疾患との関連を調べる研究が進展することが期待される。

二つ目の研究では、両眼像の位置ずれ(両眼視差)を手掛かりに奥行きを知覚する能力である両眼立体視力の大きな個人差を説明する神経基盤を明らかにした。申請者は両眼立体視力計測および構造的MRI計測を同一被験者に行い、両者の関連を調べることで、ヒト両眼立体視力が背側と腹側の視覚領域をつなぐ白質線維束である垂直後頭束の神経組織密度と関連することを明らかにした。

以上二つの研究は、ヒト視知覚と脳構造の関連の解明に大きく貢献するものであり、博士号授与に値するものと認める。