

【Grant-in-Aid for Scientific Research (S)】

Broad Section J



Title of Project : Visualizing neural representations of mental images

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Keyword : cognitive science, neuroscience, brain decoding

【Purpose and Background of the Research】

Mental images are a crucial component of our mind. Besides stimulus-induced perception, memory recall, dreams, and hallucinations also involve mental images. Experienced images can be different from the physical features of the stimulus in optical illusions. How are these diverse images generated in the brain? In psychology and cognitive neuroscience, mental images have been studied by indirect behavioral measures, and it has been difficult to visualize the specific contents. We have developed a brain decoding method combined with the representation of deep neural network, and used it to visualize perceptual and recalled images (Figure 1). In this study, we extend this visualization approach to elucidate the neural mechanisms that generate various kinds of mental images including illusions and dreams.



Figure 1. Deep image reconstruction

【Research Methods】

In this project, we assume that hierarchical image features are represented in multiple brain regions of the sensory cortex. We investigate how diverse mental images are generated from the processing of hierarchical neural representations. In particular, we will focus on bottom-up/top-down processing, the contribution of recurrent information processing, and the influences from non-visual areas.

Mental images are a subjective phenomenon, and this has hindered scientific inquiry. In this project, we will overcome this problem by using a visualization technique that combines brain decoding and deep neural networks (DNNs). This method quantifies human brain activity patterns as DNN hierarchical features corresponding to the same image content. It also visualizes the process of mental image generation (Figure 2).

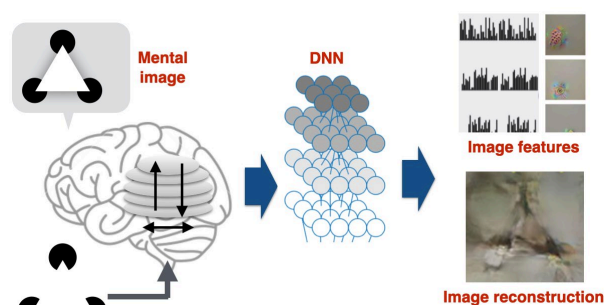


Figure 2. Our approach

【Expected Research Achievements and Scientific Significance】

The approach of this project may bring about a paradigm shift in psychology and cognitive neuroscience by producing a means of objectively revealing subjective contents and enabling detailed analysis at the level of specific image features in the mind. It is also expected to contribute to the development of brain-based communications, brain-machine interfaces, the diagnosis of mental disorders, and the creation of new artistic expressions.

【Publications Relevant to the Project】

- Shen, G., Horikawa, T., Majima, K., Kamitani, Y., 2019. Deep image reconstruction from human brain activity. *PLOS Computational Biology* 15, 1006633. <https://doi.org/10.1371/journal.pcbi.1006633>
- Horikawa, T., Kamitani, Y., 2017. Generic decoding of seen and imagined objects using hierarchical visual features. *Nature Communications* 8, 15037. <https://doi.org/10.1038/ncomms15037>

【Term of Project】 FY2020-2024

【Budget Allocation】 151,300 Thousand Yen

【Homepage Address and Other Contact Information】

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