Usage Report for Fiscal Year 2024

Project Title: The neural mechanism of vison and memory in the human brain and effect of long-COVID on cognition using large imaging datasets

Name:
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1. Background and purpose of the project, relationship of the project with other projects

In the current project, we investigated the role of prefrontal cortex (PFC) in visual perception using neuroimaging and tools from machine learning models such as deep convolutional neural networks and generative adversarial networks.
The PFC has been found to be critical for conscious perception and high-level cognition (such as cognitive control, planning). The dysfunction of it has also been implicated in a variety of psychiatric disorders, most notably in schizophrenia. Cracking the computational codes employed by the PFC will be an important step towards understanding how the brain works.
We also planned to study the effect of long-COVID on cognition using large imaging datasets, but due to policy change by UK Biobank from Nov 2024, analyses on UK Biobank data were conducted in another platform (See Usage Report of RB230126 for details).

2. Specific usage status of the system and calculation method

In FY 2024, we primarily used Hokusai for the following project :

2.1 Identifying the images that will activate PFC within individuals [PFC-DNN project]
For this project, we used Hokusai for: storing the data/DNN models, extracting activations from DNNs, building regression models, running permutation tests and conducting additional analyses to identify the most PFC-activating images. Since last FY, we have expanded the project to simulate results using spiking neural networks.
This used ~1807271 hours on mpc and ~6437.8 hours on lmc (for manipulating large matrices).

2.2 Identifying the layers in the CNN models which can predict the uniformity of natural images
In this project, we used Hokusai for : storing the natural images, extracting saliency maps and parameters from models, running support vector machine models and permutation tests to identify the specific layers.
This used ~25970 hours on mpc.

2.3 Identifying the images with their parameters in computational models i.e. Sparse Coding Model and deep convolutional Neural Networks)
For this project, we used Hokusai for: training Deep convolutional Neural Networks (DCNN) and Sparse Coding Model (SPC) for natural images, extracting computational parameters (i.e. distinctiveness and reconstruction error), and running analysis for behavioral data.
This used ~4030 hours on mpc and ~300 hours on lmc (for manipulating large matrices).

3. Result

We found that there are more substantial individual differences across individuals in terms of which images tend to activate their PFC compared to those that tend to activate the visual regions. And this empirical observation was replicated in our simulation using spiking neural networks.
We found that in the middle and late stage of convolutional neural networks, the layer features can predict the uniformity level of natural images.
We found that distinctiveness and reconstruction error from DCNN or SPC modulate memory in individuals with aphantasia in a similar way.

4. Conclusion

Collectively, the results above highlight the critical role of PFC in visual perception, a previously underappreciated aspect of PFC functioning.
As a preliminary result, the generative processing captured by the sparse coding model is unlikely to be the same as what underlies voluntary visual imagery.

5. Schedule and prospect for the future

We have submitted the manuscript for this project, and it is now under review.

Fiscal Year 2024 List of Publications Resulting from the Use of the supercomputer

[Oral presentation]

Lin, Q. (2025 February). Individual differences in prefrontal coding of visual features. Upcoming virtual talk given to the Attention and Perception area at the Department of Psychology at University of Illinois Urbana-Champaign.

Lin, Q. (2024 October). Individual differences in prefrontal coding of visual features. Virtual talk given to the Computations of Subjective Perception lab (PI: Dobromir Rahnev) at Georgia Tech.

Lin, Q. & Lau, H. (2024 June). Individual differences in prefrontal coding of visual features. Talk at OHBM (Organization for Human Brain Mapping) Annual Meeting. Seoul, South Korea.

Lin, Q. & Lau, H. (2024 March). Individual differences in prefrontal coding of visual features. Poster at COSYNE. Lisbon, Portugal.

[Poster presentation]

Wang, J., Yildirim, I., Hakwan Lau, H., Lin, Q. (2025 January) . Exploring the Effects of Feedforward and Feedback Processing on Memory in Individuals with Aphantasia, The 3rd RIKEN CBS Co-Creation International Conference, Japan. Poster.

Wang, J., Yildirim, I., Hakwan Lau, H., Lin, Q. (2024 November). Exploring the Effects of Feedforward and Feedback Processing on Memory in Individuals with Aphantasia, RIKEN Center for Brain Science Retreat 2024, Japan. Poster.

[Others (Preprint)]

Ge, Y., Taschereau-Dumouchel, V., Lin, Q., Moharramipour, A., Sun, Z., & Lau, H. (2024). Representation of visual uniformity in the lateral prefrontal cortex. *bioRxiv*, 2024-07.