# The efficient cause of science



**Document status and date:**
Published: 01/01/2023

**DOI:**
10.26481/dis.20230502sb

**Document Version:**
Publisher's PDF, also known as Version of record

# ✽ Impact

functional Magnetic Resonance Imaging (fMRI) has revolutionized the way researchers examine the brain. However, the high (or ultra high) resolution of fMRI comes at a cost of a colossal amount of data. Even though computers are getting more powerful and accessible, analyzing fMRI data can still be computationally heavy and time consuming. The main objective of this work was to provide an arsenal of computational methods, which individually or together can reduce the computational burden. Although these methods were specifically developed to model population receptive fields (pRFs) and connective fields (CFs); they can be conveniently extended to other domains.

In **Chapter 2**, we demonstrate that it is now possible to faithfully map pRFs of millions of voxels in the order of seconds. This can indeed save researchers a lot of their precious time. Such a fast mapping was made possible by hash-encoding (Sutton and Barto, 2018) the stimulus space, which tremendously reduces memory requirements. Linear models are widely used for their simplicity and interpretability. The linear models with a large and relatively sparse predictor space, can benefit from hash-encoding to accelerate the linear mapping. A drastic reduction in memory requirements has an added benefit of mapping the pRFs in an online fashion (real-time pRF mapping). This can largely impact development of brain-computer interfaces (BCIs) for helping *locked-in* patients. In a recent proof-of-concept work by Goebel et al. (2022), it was demonstrated that such an online pRF mapping can be used to reconstruct imaged letters in real-time. This can pave a way for developing a letter speller BCI which can, in real-time, reconstruct imagined letters and display them back to the participants, in MRI scanners, as feedback.

In **Chapter 3**, we propose a novel method for modelling CFs, which are a natural extension to the pRFs. In this chapter, we not only tackle the computational inefficiency of CF modelling, but also propose a unified CF and pRF model. To achieve this, we combine algebraic Dynamic Mode Decomposition (aDMDc; Fonzi et al., 2020), which stems from the field of fluid dynamics, with the hash-encoding of the stimulus space (Bhat et al., 2021). This goes to show that these methods are very generalized and can be used to tackle a variety of different problems ranging from fluid mechanics to computational neuroimaging. We further, in **Chapter 4**, use DMD to investigate the similarities and differences between mental imagery and perception tasks. In this preliminary work we observed spatio-temporal characteristics of mental imagery and perception, to be largely arbitrary. However, we observed very similar aggregated CFs between the two tasks and subjects. The DMD-based methods can indeed enrich how we study not just vision, but also the brain as a dynamical system.