Estimating the Functional Dimensionality of Neural Representations

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Presentation Abstract Summary Recent advances in multivariate fMRI analysis stress the importance of information inherent to voxel patterns. Key to interpreting these patterns is estimating the underlying dimensionality of neural representations. Dimensions may correspond to psychological dimensions, such as length and orientation, or involve other coding schemes. Unfortunately, the noise structure of fMRI data inflates estimates and thus makes it difficult to assess the true underlying dimensionality of the signal. To address this challenge, we developed a novel approach to identify brain regions that carry reliable task-modulated signal and to derive an estimate of the signal's functional dimensionality. We combined singular value decomposition with nested cross-validation to find the best low-dimensional projection of a pattern of voxel-responses at a single-subject level. We validated our method on simulated data of varying underlying dimensionality and found it robustly estimated the true dimensionality across different noise levels. We further applied our method to three published fMRI data sets involving visual categorization tasks. Dimensionality was revealed in fronto-parietal areas in a manner that bolstered the authors' original claims and suggested additional nuances revealed by the sensitivity and generality of the method. Together, our results indicate the theoretical value of identifying and characterizing the dimensionality of neural representations.

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