



Variations in Neuronal Selectivity Create Efficient Representational Geometries for Perception

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Our visual capabilities depend on neural response properties in visual areas of our brains. Populations of neurons exhibit a wide variety of selective response properties, but the reasons for this diversity are unknown. Here, we related the distribution of neuronal tuning properties to the information capacity of the population. In particular, we study how tuning heterogeneity affects geometry and coding efficiency in populations of neurons. Our results from theory, simulations, and analysis of recordings from macaque primary visual cortex (V1) reveal that diversity of amplitude and bandwidth drive complementary changes to the representational geometry of a population. Amplitude diversity pushes the centers of the representations further apart, whereas bandwidth heterogeneity decorrelates the center locations. These geometric changes separate out representations for distinct stimuli, creating more efficient encoding. We study how both types of diversity affect the population code in the context of two different perceptual tasks: discrimination and identification. While both types of diversity improve encoding for both tasks, their distinct impacts on geometry make each more beneficial for one of the two tasks. Amplitude diversity impacts coding efficiency more for discrimination than it does for identification, while bandwidth diversity has a stronger impact on identification. These complementary effects indicate the importance of both types of diversity for perception. Because tuning diversity exists across species and brain areas, our results suggest a fundamental population coding strategy that may be applicable to a wide range of behavior. Finally, this work establishes connections between multiple levels of neural processing -- from the distributions of single neuron properties, to population-level representations, and to perception.

vision, psychophysical discrimination, psychophysical identification, neural geometry, population coding