Extending population receptive fields to new domains

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A goal in sensory neuroscience is to be able to predict responses to arbitrary inputs. Population receptive field (pRF) modeling has been an important step toward this goal. PRFs generalize the concept of receptive fields from single neurons to neuronal populations measured with fMRI or electrocorticography (ECoG), providing a computational framework to link sensory inputs to neuronal outputs. PRFs have been widely adopted for spatial vision, advancing understanding of how neuronal encoding differs across visual areas, task, and subject populations. Here, we extended this approach to two new domains: temporal vision and sensorimotor processing.

For temporal vision, we developed a model that takes an arbitrary stimulus time-course as input and predicts time-resolved neuronal population outputs in multiple visual areas. The model uses canonical neuronal computations - filtering, exponentiation, and gain control - and reveals how different visual areas integrate information over time and adapt to ongoing or repeated inputs. The results show increasingly longer temporal integration and more pronounced adaptation in later visual areas compared to V1, V2, and V3. The model applies to ECoG, fMRI, and multi-unit spiking, thereby providing a computational framework within which to compare these measures and better understand how they relate to one another.

Like visual cortex, sensorimotor cortex is organized into topographical maps. We developed a pRF model of sensorimotor responses that reveals an orderly and coherent cortical representation of the hand. we modeled each cortical location with a Gaussian receptive field centered on one of the 5 digits, with a standard deviation specified in digits. We found that a detailed somatotopy can be obtained in both M1 and S1 during finger movements, showing that individual finger representations are interconnected in sensorimotor cortex. This model applies to both ECoG and fMRI and provides a framework for in-depth investigation of cortical motor representation and sensorimotor integration.

Together, our new results demonstrate the feasibility of applying quantitative forward modeling to sensory and motor function.