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Mouse visual cortex as a limited resource system that self-learns an ecologically-general representation

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Studies of the mouse visual system have revealed a variety of visual brain areas in a roughly hierarchical arrangement, together with a multitude of behavioral capacities, ranging from stimulus-reward associations, to goal-directed navigation, and object-centric discriminations. However, an overall understanding of the mouse's visual cortex organization, and how this organization supports visual behaviors, remains unknown. Here, we take a computational approach to help address these questions, providing a high-fidelity quantitative model of mouse visual cortex. By analyzing factors contributing to model fidelity, we identified key principles underlying the organization of mouse visual cortex. Structurally, we find that comparatively low-resolution and shallow structure were both important for model correctness. Functionally, we find that models trained with task-agnostic, unsupervised objective functions, based on the concept of contrastive embeddings were substantially better than models trained with supervised objectives. Finally, the unsupervised objective builds a general-purpose visual representation that enables the system to achieve better transfer on out-of-distribution visual, scene understanding and reward-based navigation tasks. Our results suggest that mouse visual cortex is a low-resolution, shallow network that makes best use of the mouse's limited resources to create a light-weight, general-purpose visual system – in contrast to the deep, high-resolution, and more task-specific visual system of primates.

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