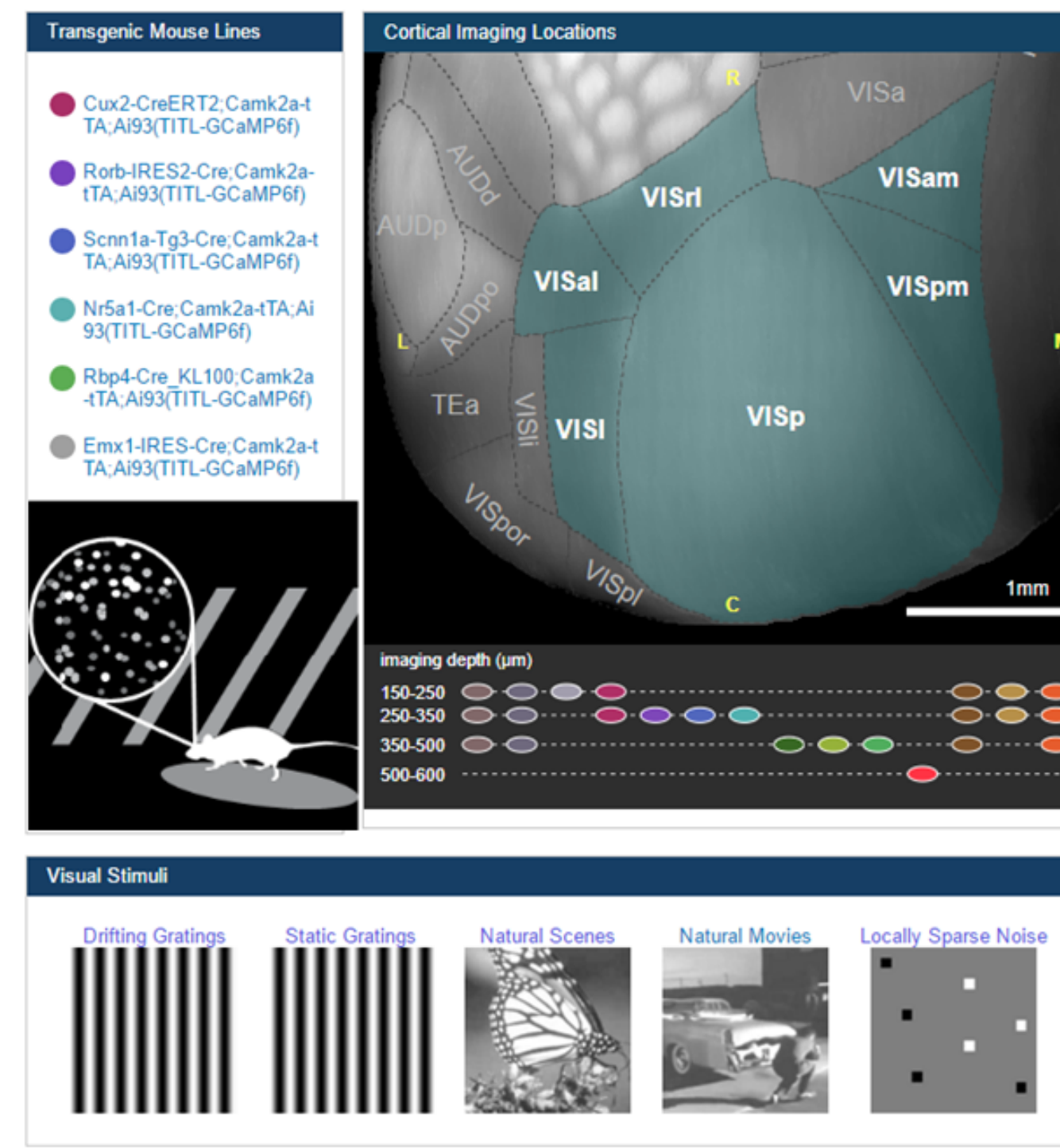


Highlights

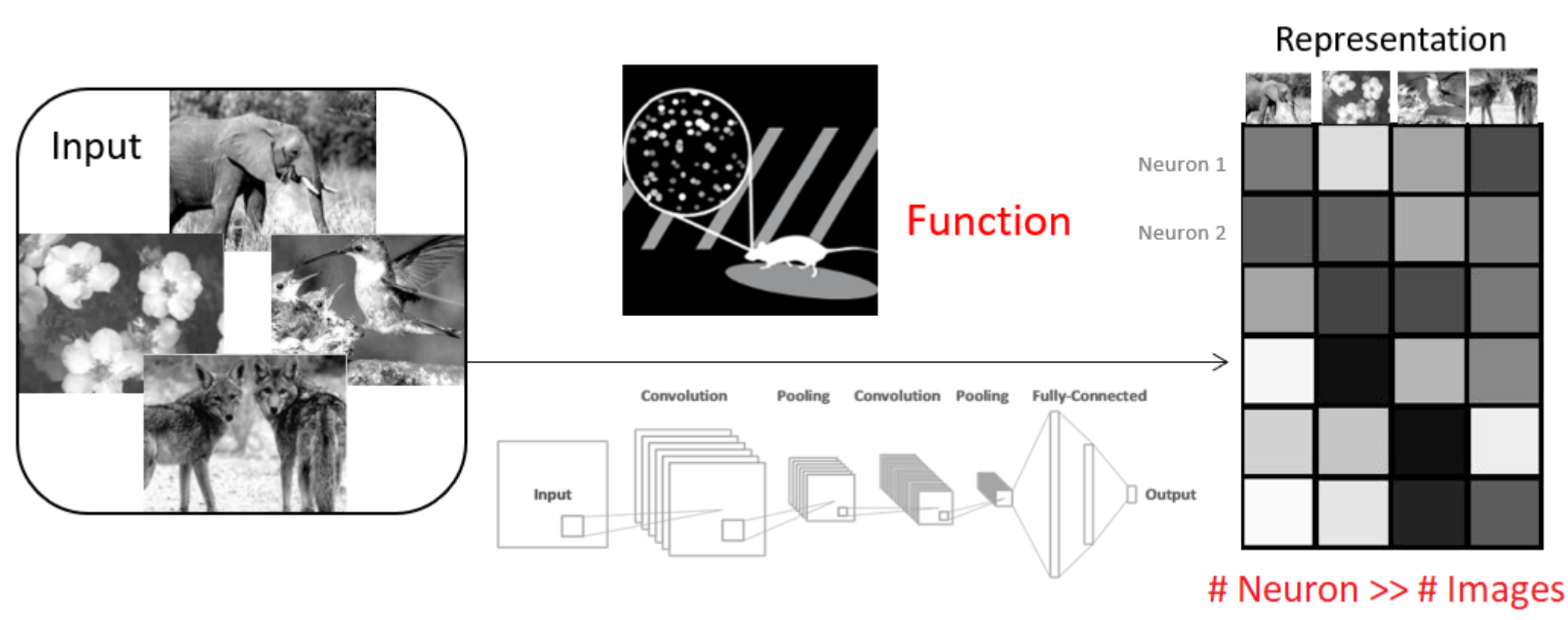
- The emerging large scale neural data sets usually have limited testing conditions and partially observed populations of neurons
- Deep nets reveal functional property of population coding, and can be used for testing robustness under limited data
- Mouse cortical areas are relatively high order representations, having a parallel organization rather than a sequential hierarchy, with the primary area VISp (V1) being lower order relative to the other areas

Allen Brain Observatory Enables Large Population Coding

- The Allen Brain Observatory presents the first standardized in vivo survey of physiological activity in the mouse visual cortex, featuring representations of visually evoked calcium responses from GCaMP6-expressing neurons in selected cortical layers, visual areas and Cre lines
- We use data from six areas of visual cortex (VISp, VISl, VISal, VISpm, VISam, VISrl) under natural scene stimuli

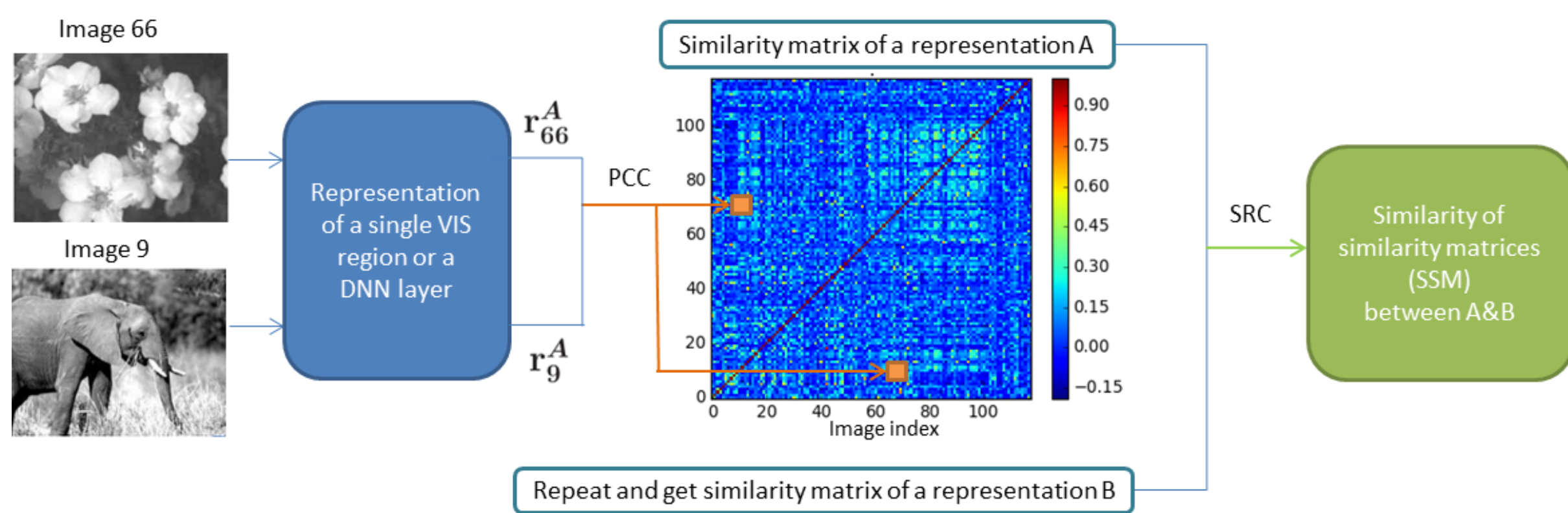


Schematic of Approach



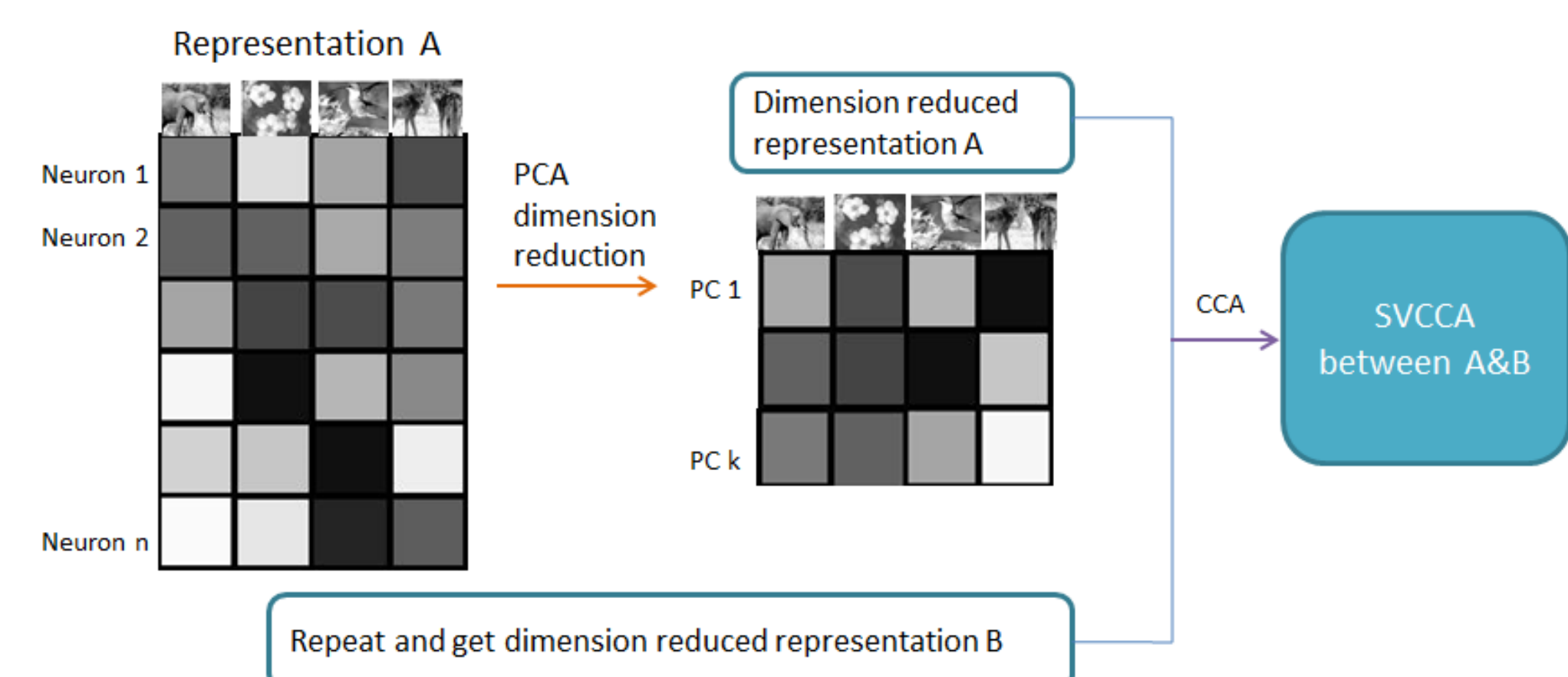
- Comparing representation matrices require proper metrics

Metric 1: Similarity of Similarity Matrices (SSM)



- PCC: Pearson correlation coefficient
- SRC: Spearman rank coefficient

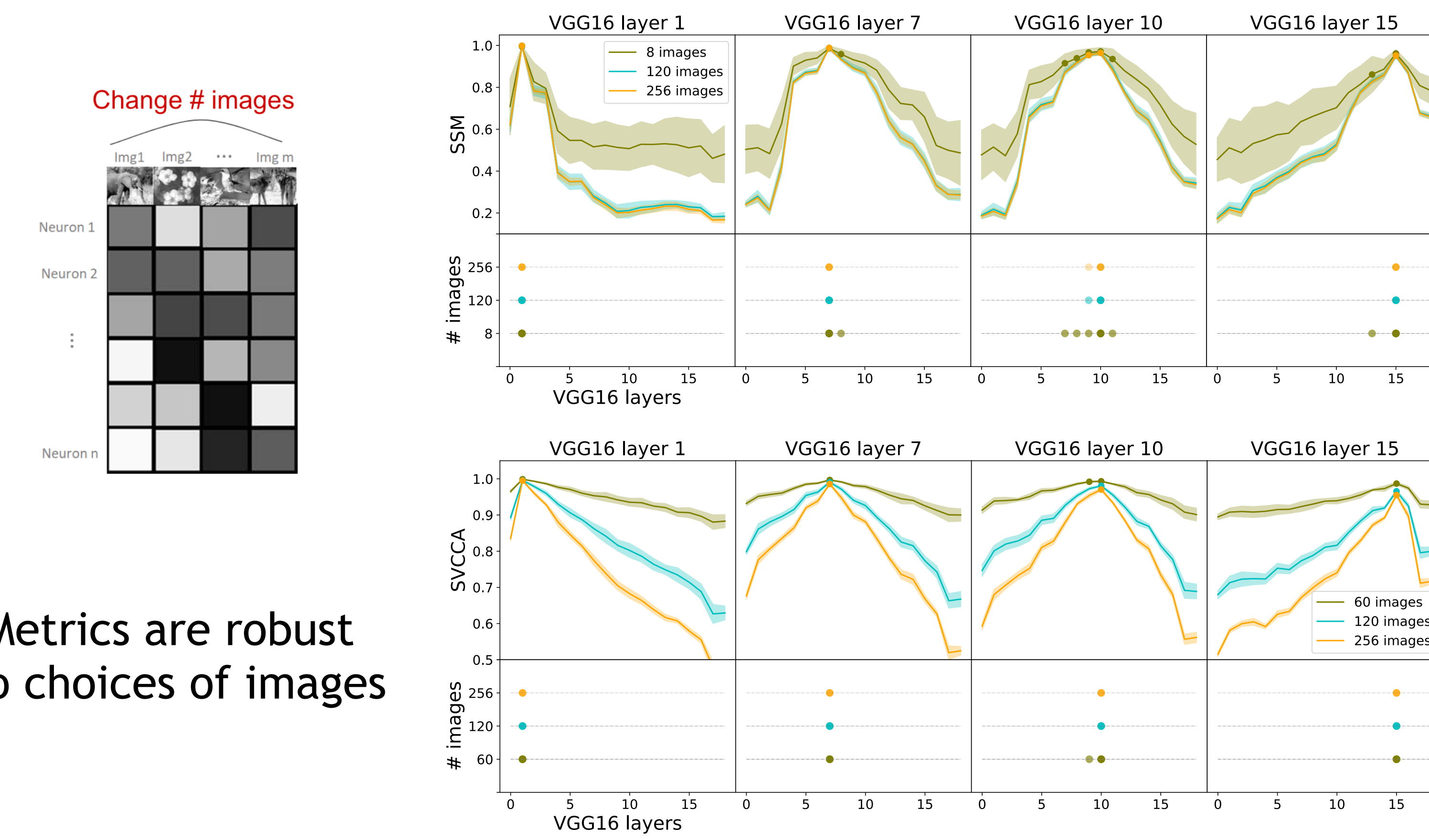
Metric 2: Singular Value Canonical Correlation Analysis (SVCCA)



- Reduce neuron dimension by PCA
- Take mean of top canonical correlation coefficients

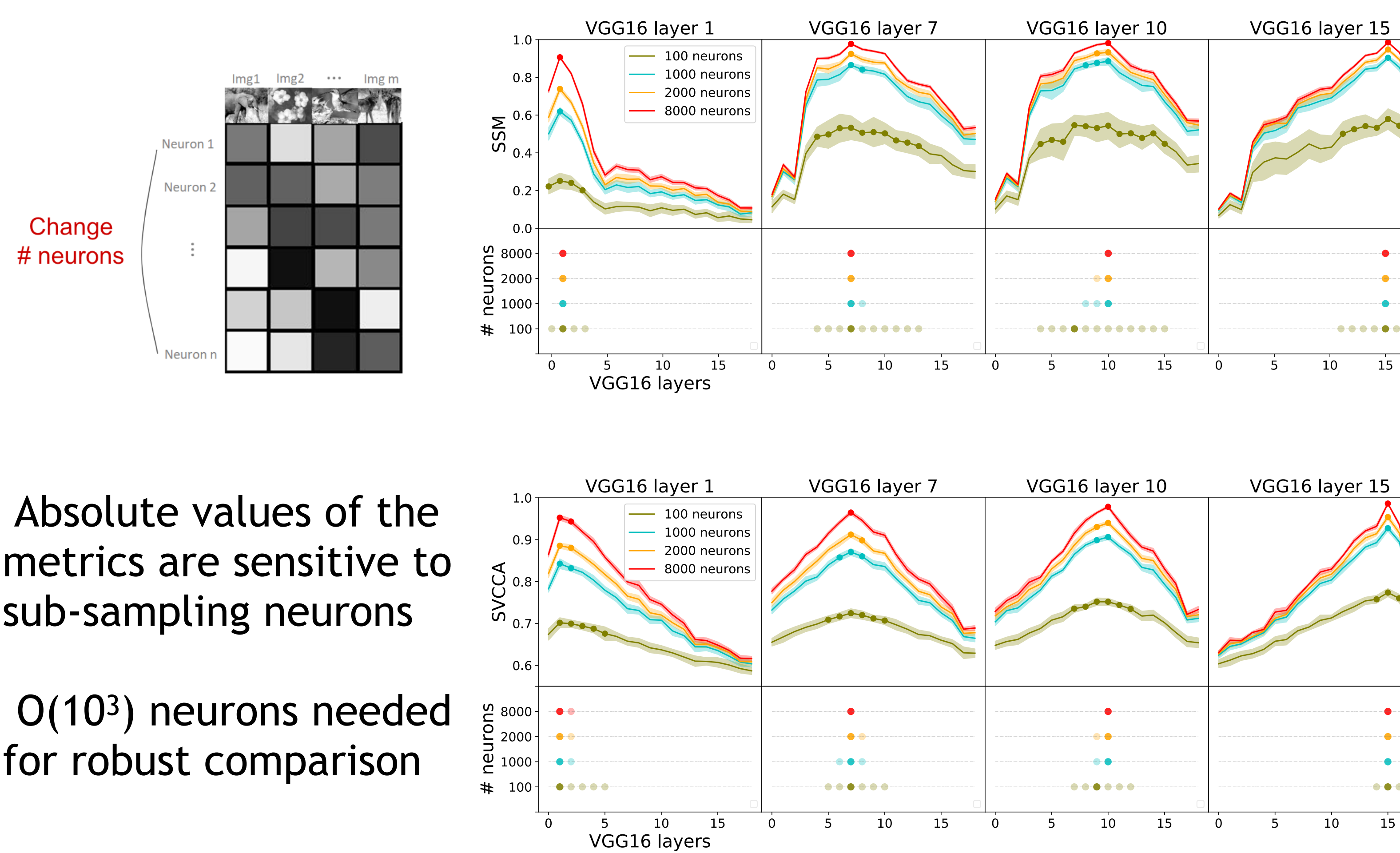
Metrics Robustly Differentiate Deep Neural Network Layers

VGG16 layers vs. VGG16 layers with different image sets



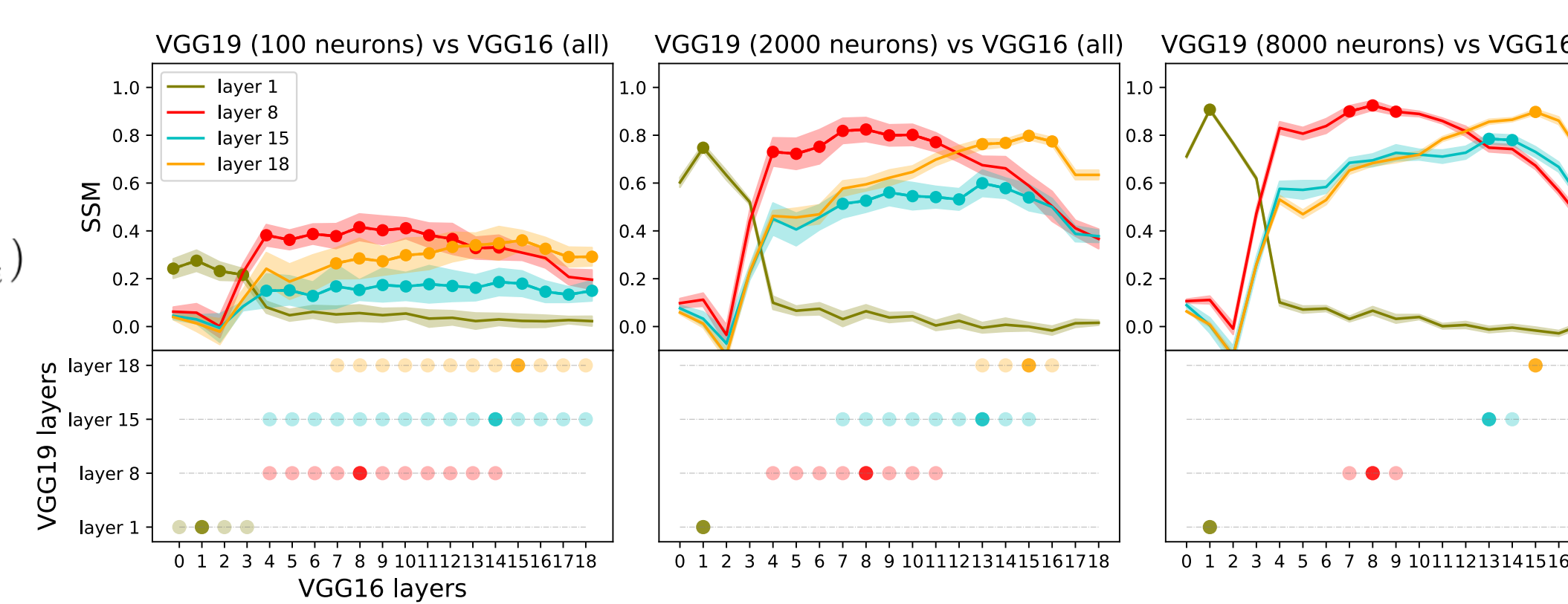
- Metrics are robust to choices of images

Sub-sampled VGG16 layers vs. VGG16 layers



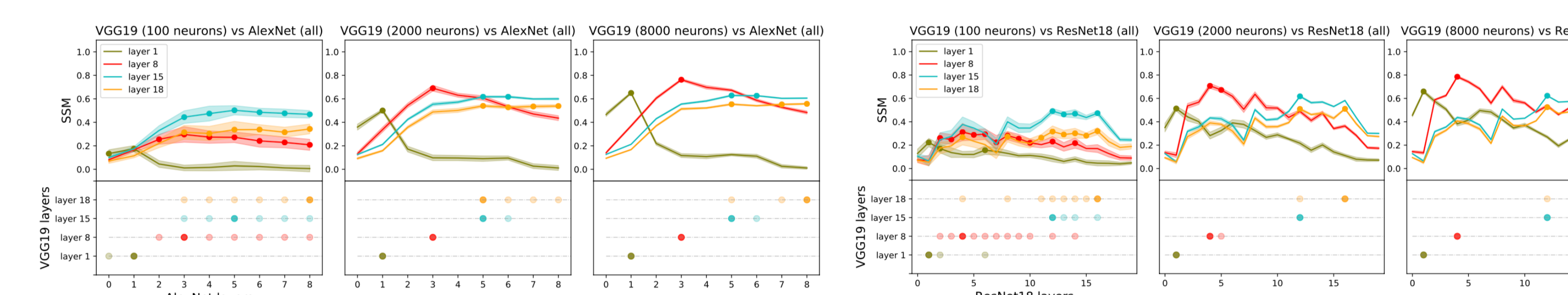
- Absolute values of the metrics are sensitive to sub-sampling neurons
- O(10³) neurons needed for robust comparison

Sub-sampled VGG19 layers vs. VGG16 layers



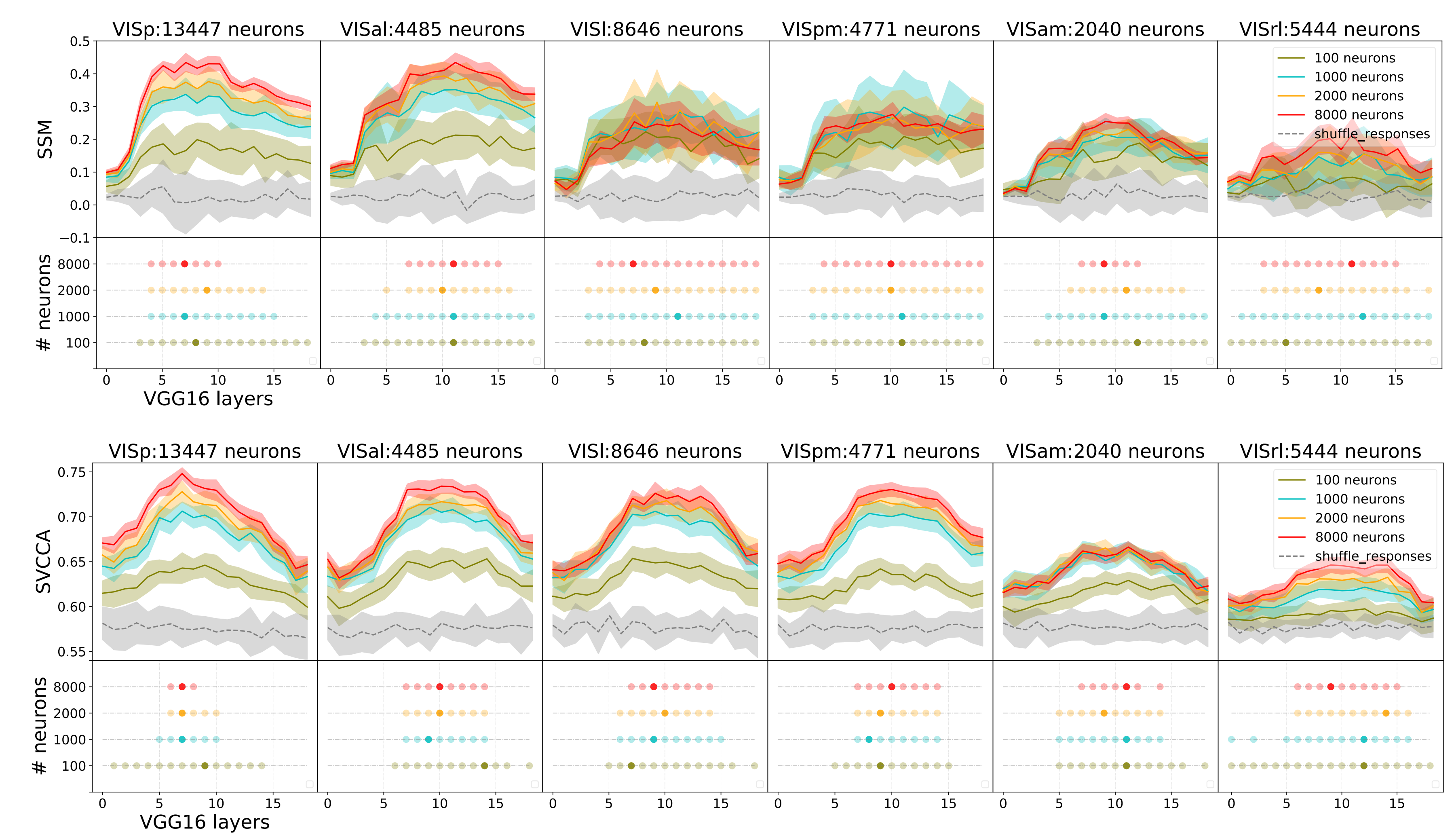
- VGG16-pseudo-depth $\arg\max_{i \in \text{layers of VGG16}} M(R_X, R_{VGG16_i})$
- Yardstick for studying representations

VGG16 is not cherry-picked



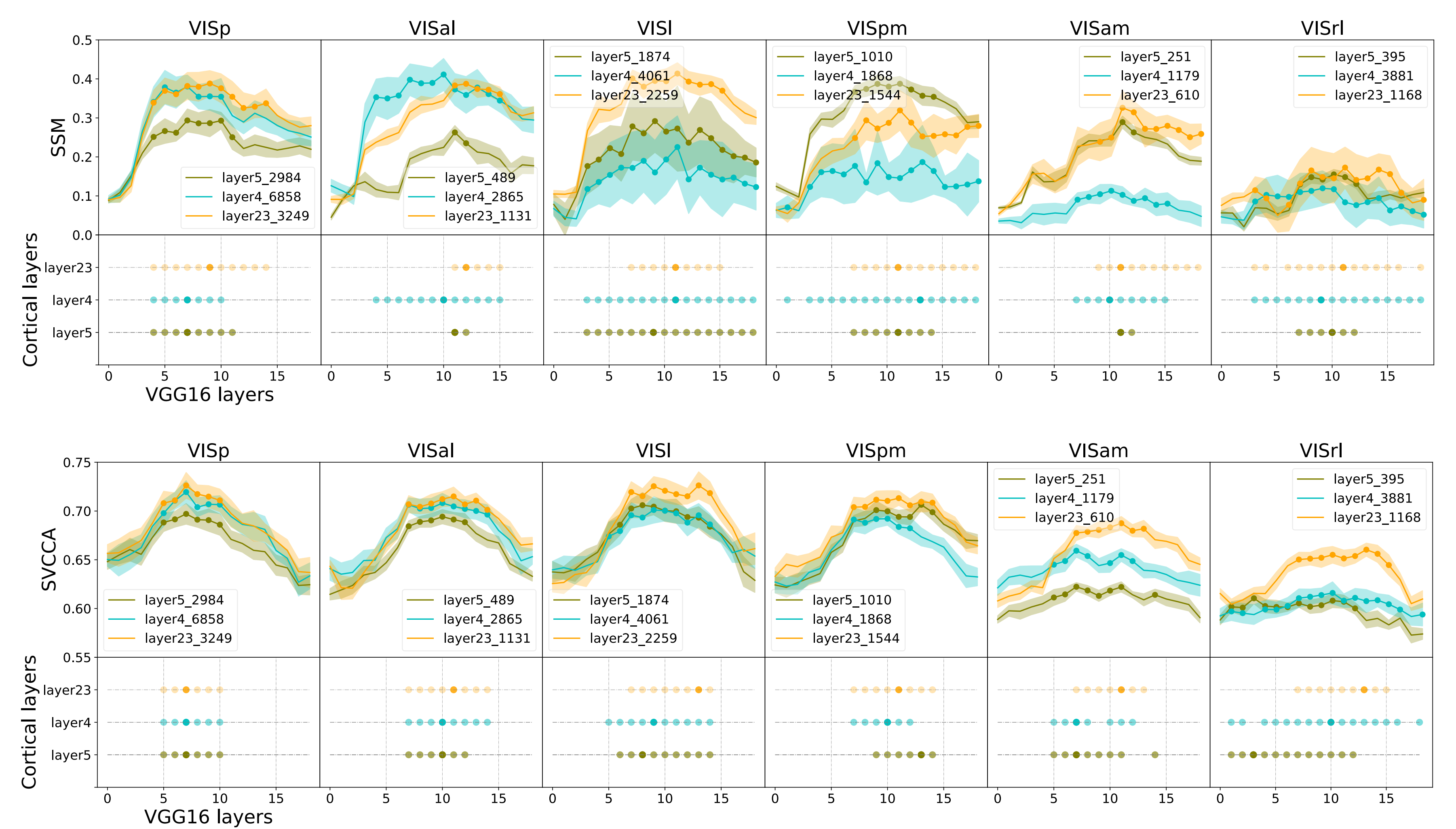
Metrics Reveal Functional Organization of Mouse Visual Cortex

Mouse visual areas vs. VGG16 layers



- Mouse visual areas are relatively high order representations
- Mouse visual cortex has a relatively flat hierarchy
- The primary area VISp (V1) is lower order relative to the other areas

Specific cortical layer and area vs. VGG16 layers



References

- [1.] de Vries, Saskia E J et al., A large-scale, standardized physiological survey reveals higher order coding throughout the mouse visual cortex, bioRxiv (2018)
- [2.] Yamins, Daniel L. K. et al., Performance-Optimized Hierarchical Models Predict Neural Responses in Higher Visual Cortex, PNAS (2014)
- [3.] Kriegeskorte, Nikolaus et al., Representational Similarity Analysis - Connecting the Branches of Systems Neuroscience, Front Syst Neurosci. (2008)
- [4.] Raghu, Maithra et al., SVCCA: Singular Vector Canonical Correlation Analysis for Deep Learning Dynamics and Interpretability, NeurIPS (2017)

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