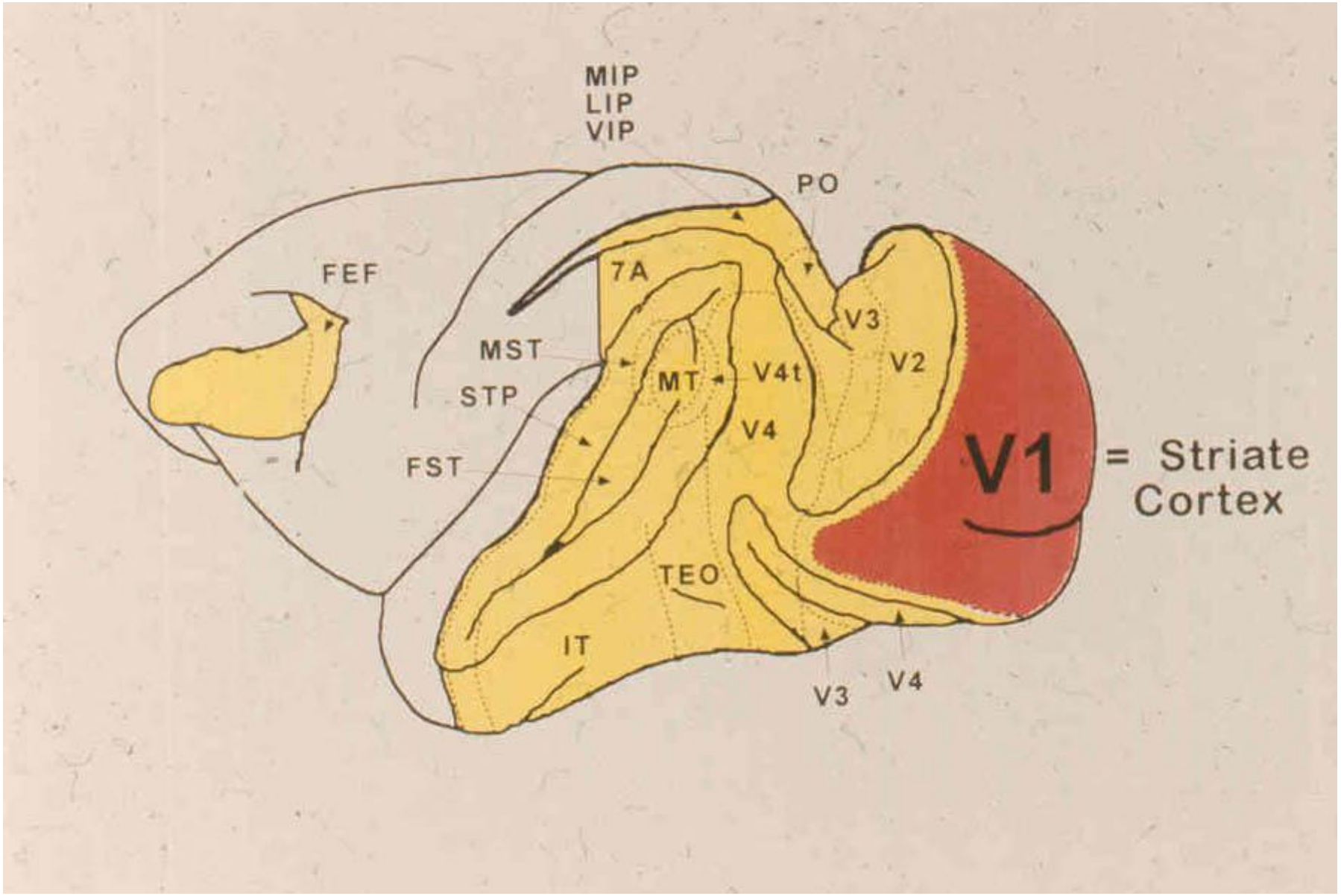
Deep Neural Networks Rival the Representation of Primate IT Cortex for Core Visual Object Recognition

[Cadieu *et al*., *PLoS Computational Biology* 2014]

(Slides by Sumeet Agarwal)

Left Cerebral Cortex of a Macaque

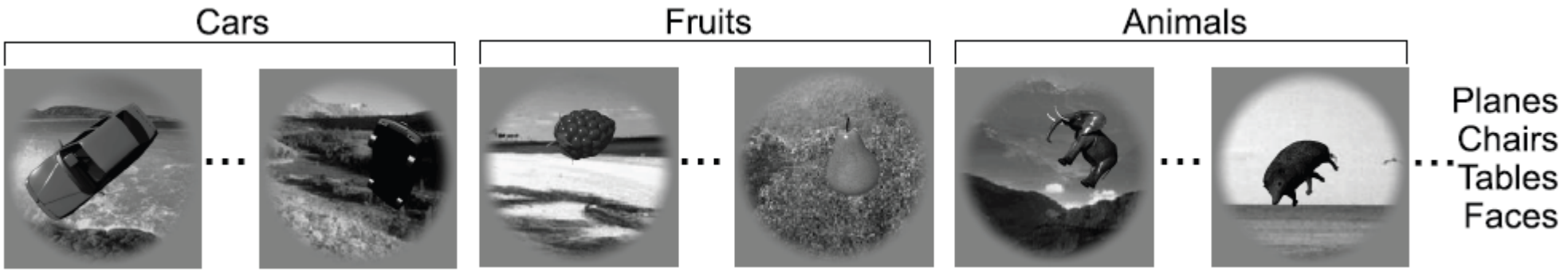


[Scholarpedia]

Visual Object Recognition

- How do we recognise objects despite variation in position, pose, scale, and background?
- Key problem in higher-order visual perception
- Need to create a **representation** (found in IT cortex for primates) that is selective for object identity and robust to variations
- Can computational models like neural networks learn such representations?

Data

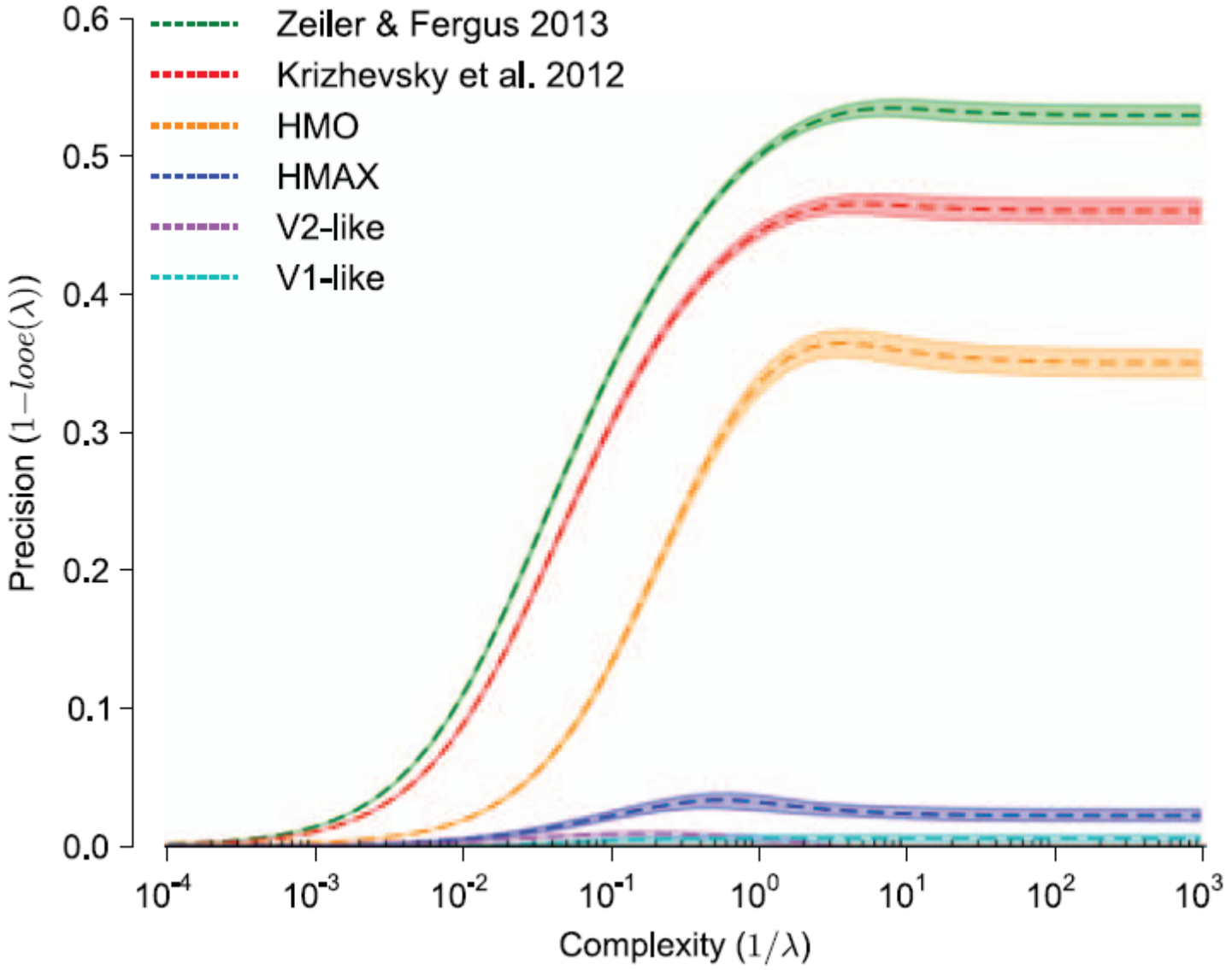


7 categories X 7 exemplars X 40 instances (varying position, scale, rotation/pose, and background) = 1960 images

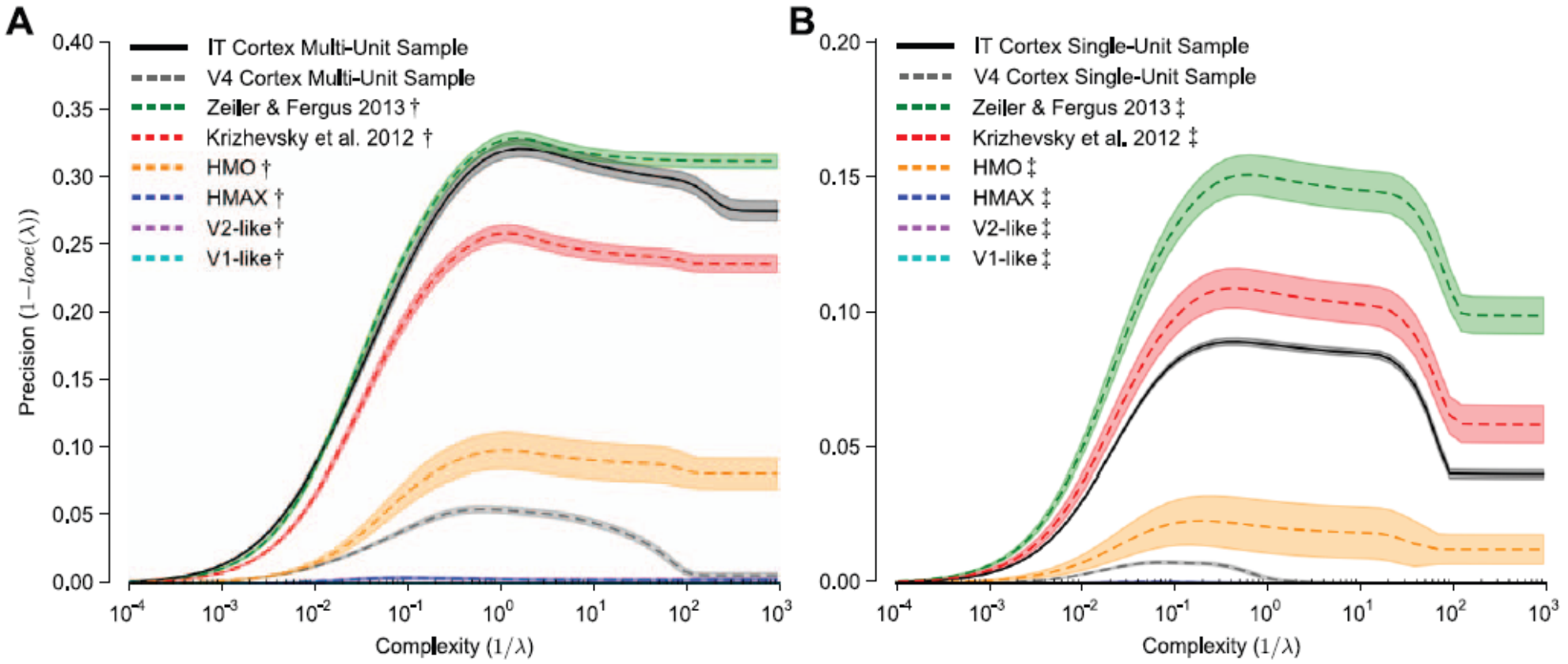
Approach

- Objective is to compare deep neural net representations with actual neural representations
- For actual representations, images shown to macaque monkeys and multi-unit and single-unit recordings (in IT cortex and V4 cortex) taken via a multi-electrode array
- Kernel analysis used to compare the performance of different representations for the object classification task (after equalising for noise and subsampling)

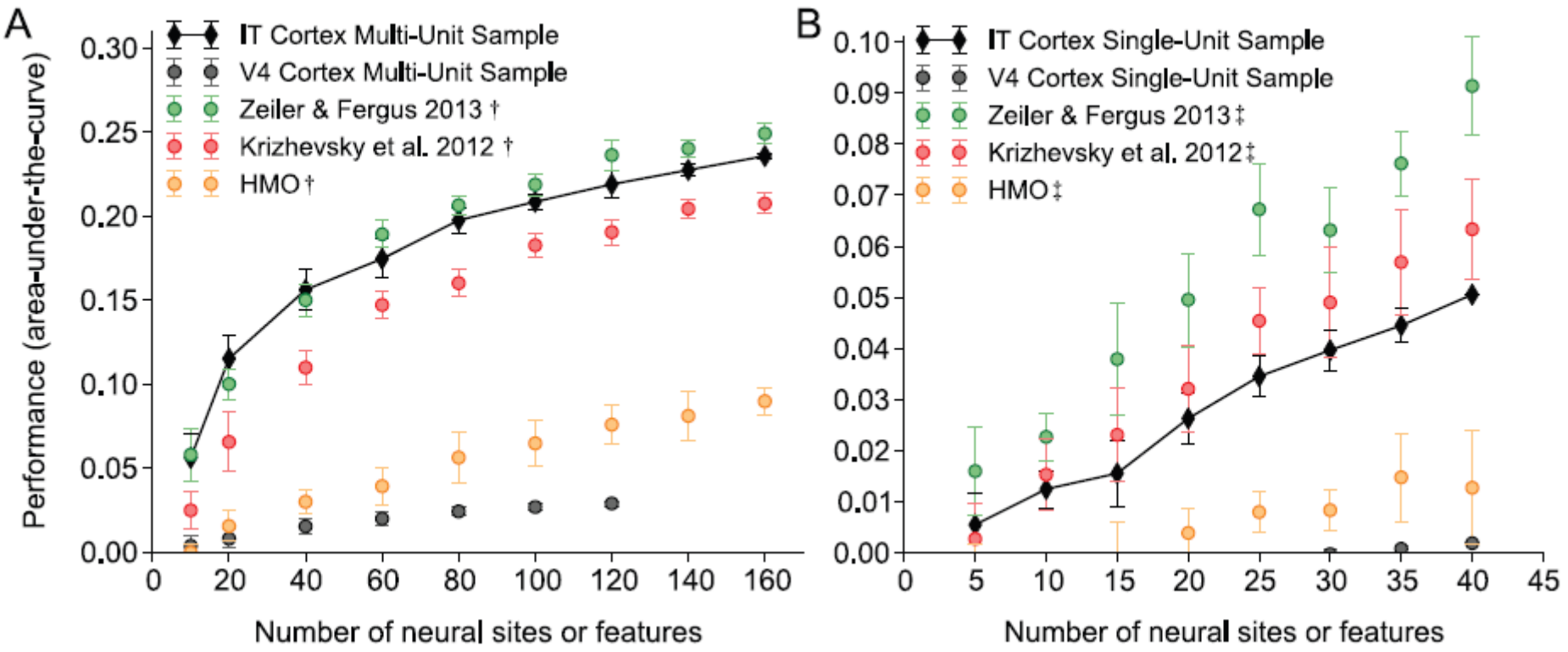
Kernel analysis curves of model representations



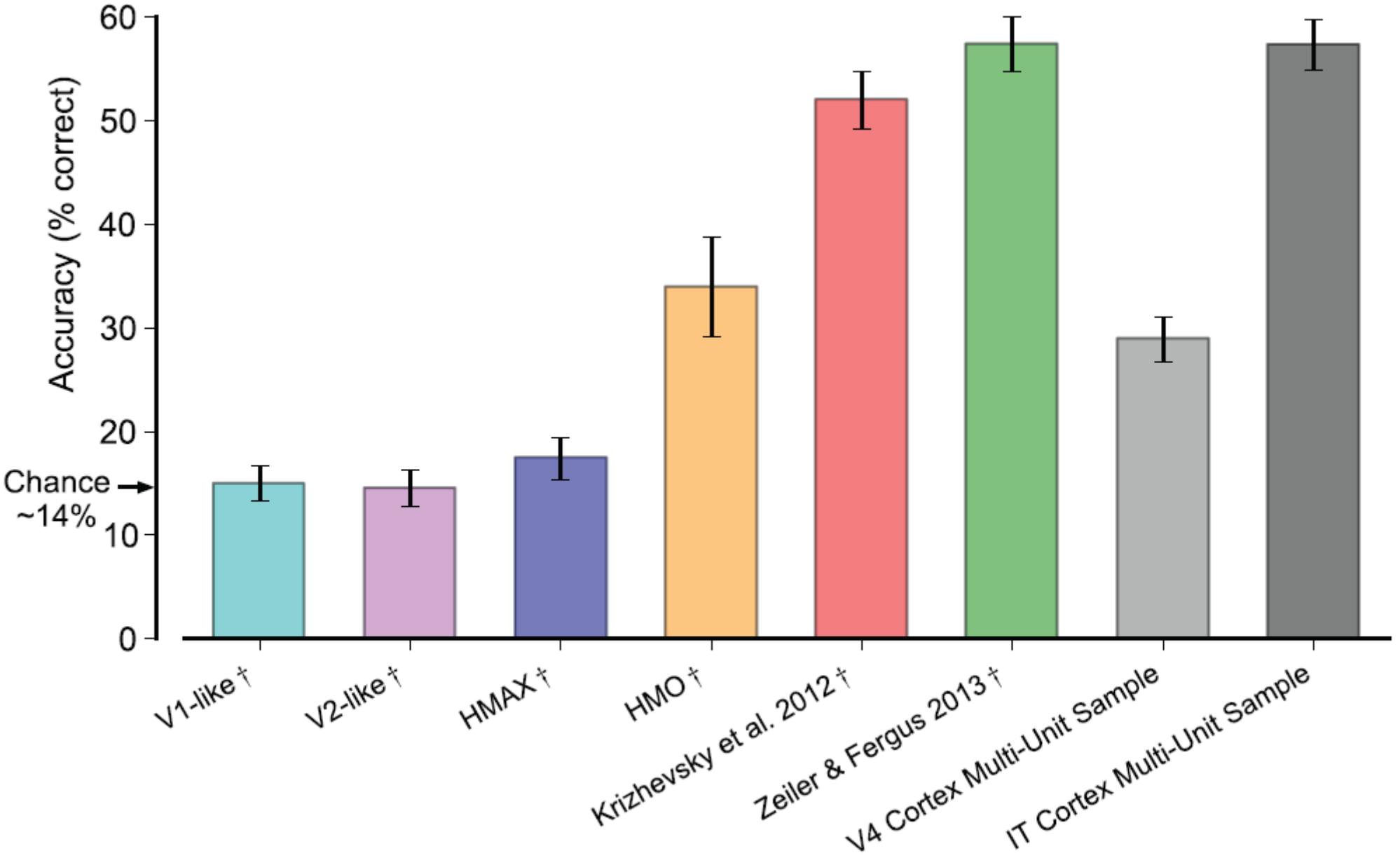
Kernel analysis comparison of model and neural representations



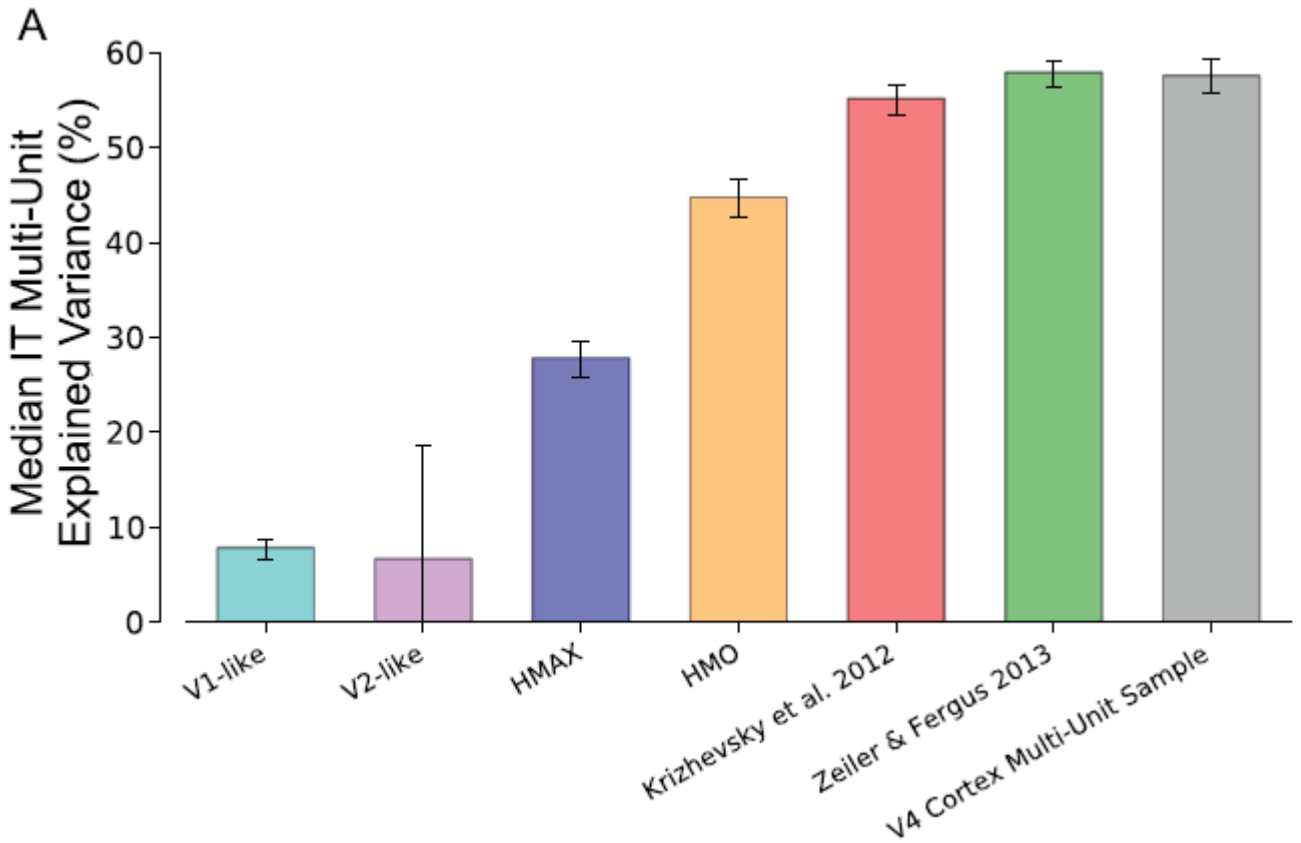
Sampling effects

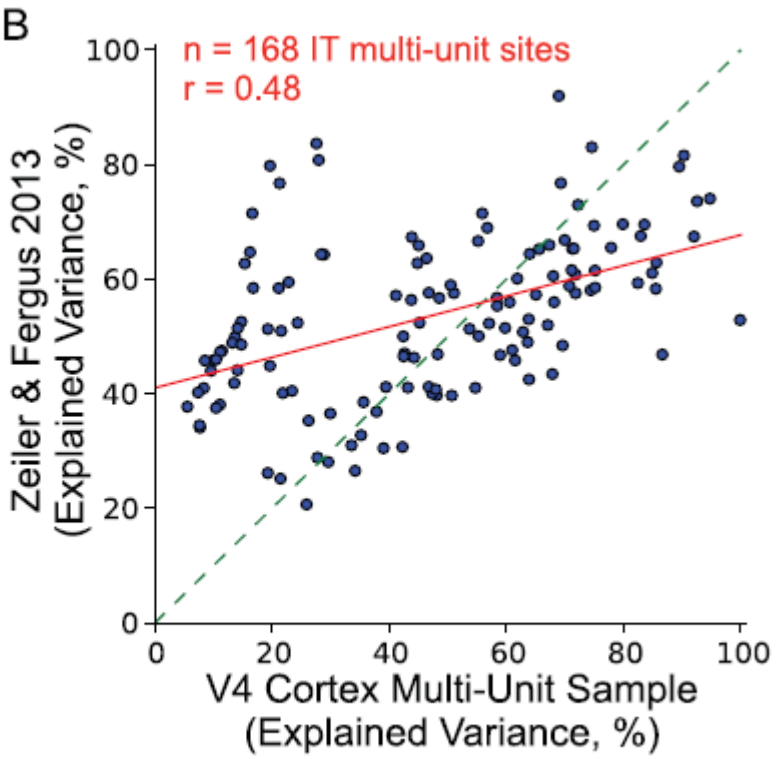


SVM classification performance

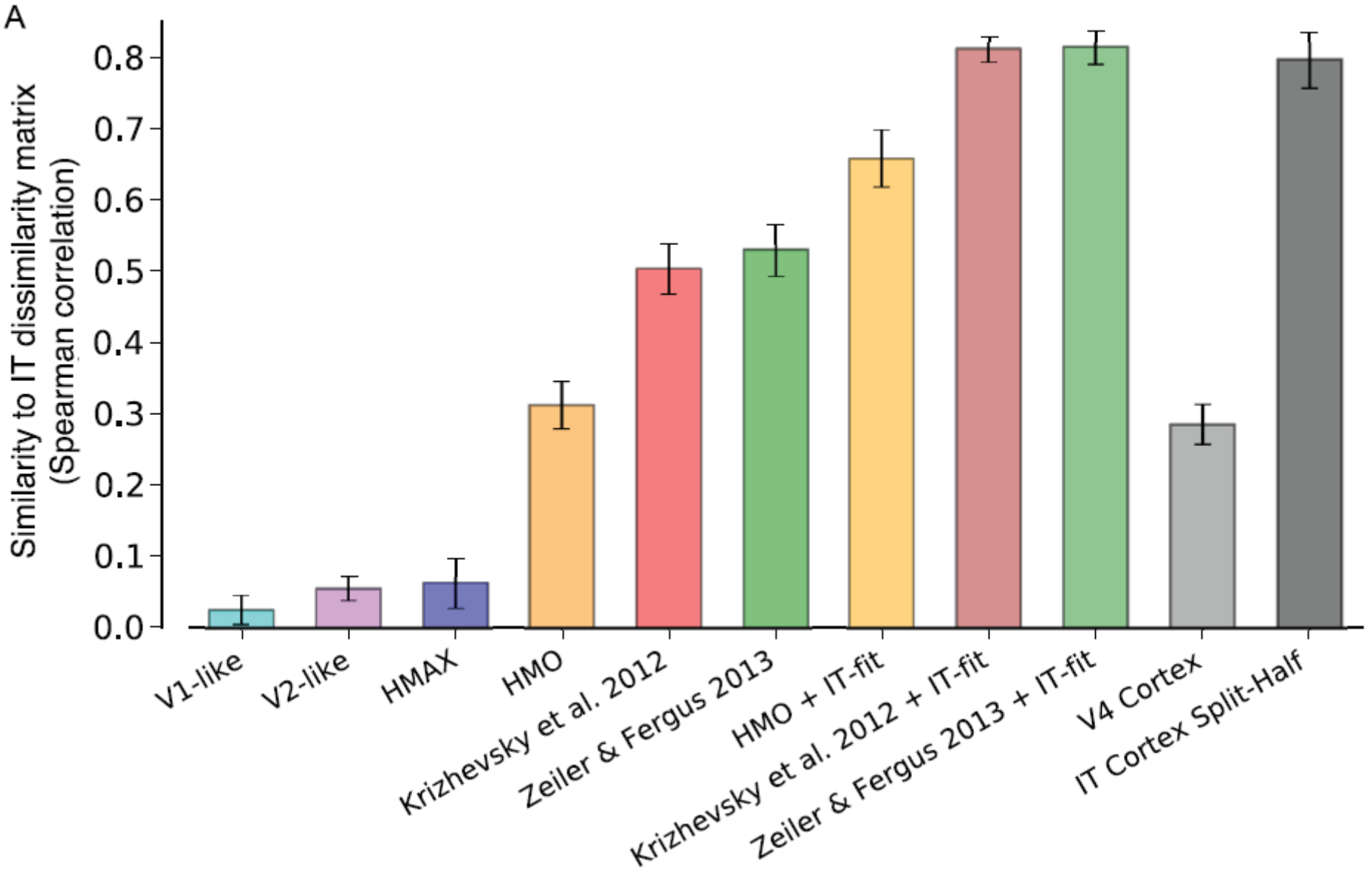


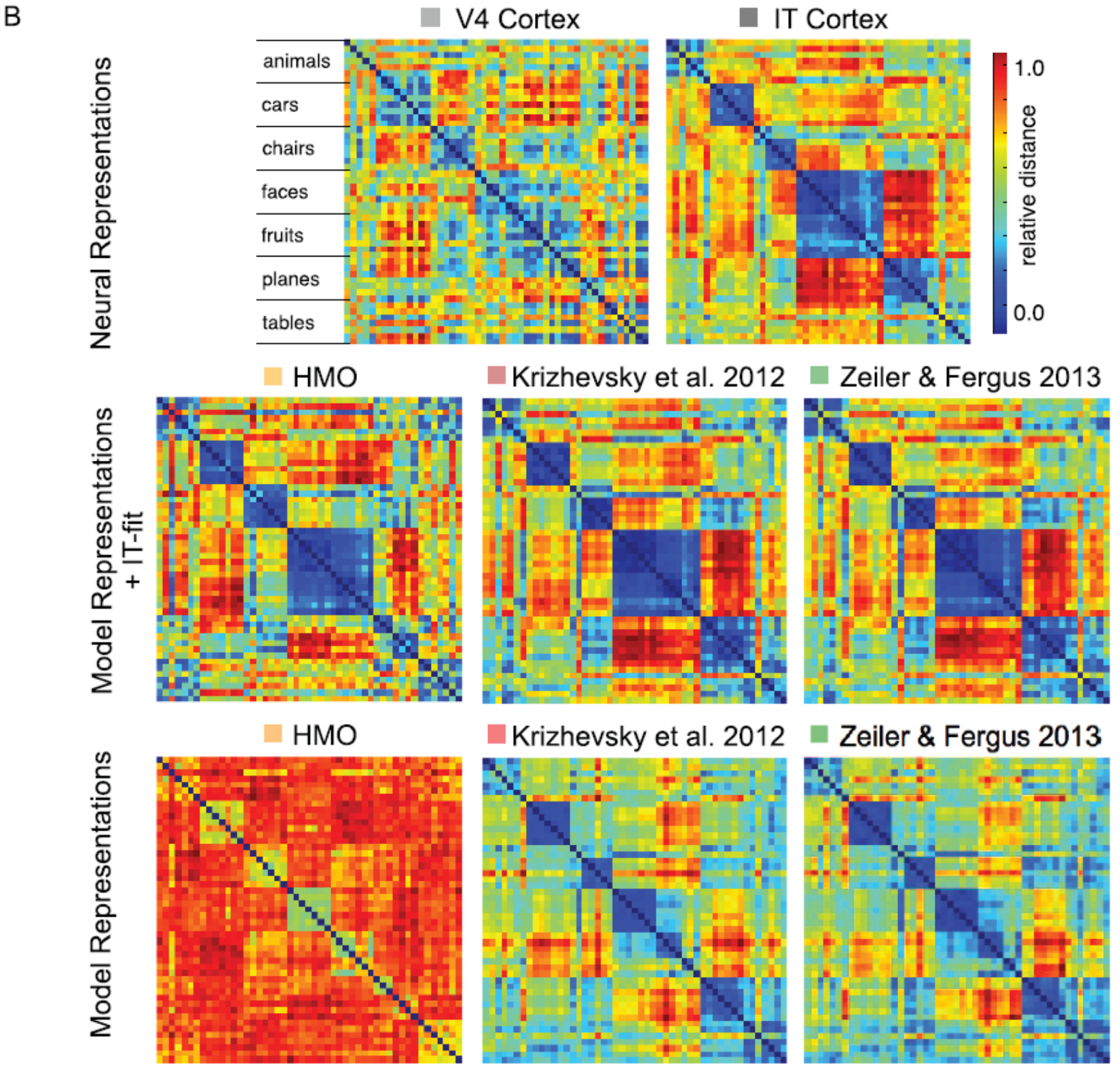
Predictability of IT cortex representations





Object-level representational similarity analysis




B
V4 Cortex
IT Cortex
Neural Representations
animals
cars
chairs
faces
fruits
planes
tables
1.0
relative distance
0.0
HMO
Krizhevsky et al. 2012
Zeiler & Fergus 2013
Model Representations + IT-fit
HMO
Krizhevsky et al. 2012
Zeiler & Fergus 2013
Model Representations

Our evaluations show that, unlike previous bio-inspired models, the latest DNNs rival the representational performance of IT cortex on this visual object recognition task. Furthermore, we show that models that perform well on measures of representational performance also perform well on measures of representational similarity to IT, and on measures of predicting individual IT multi-unit responses. Whether these DNNs rely on computational mechanisms similar to the primate visual system is yet to be determined, but, unlike all previous bioinspired models, that possibility cannot be ruled out merely on representational performance grounds.