Organization of Neural Population Code in Mouse Visual System

II-62
COSYNE 2018

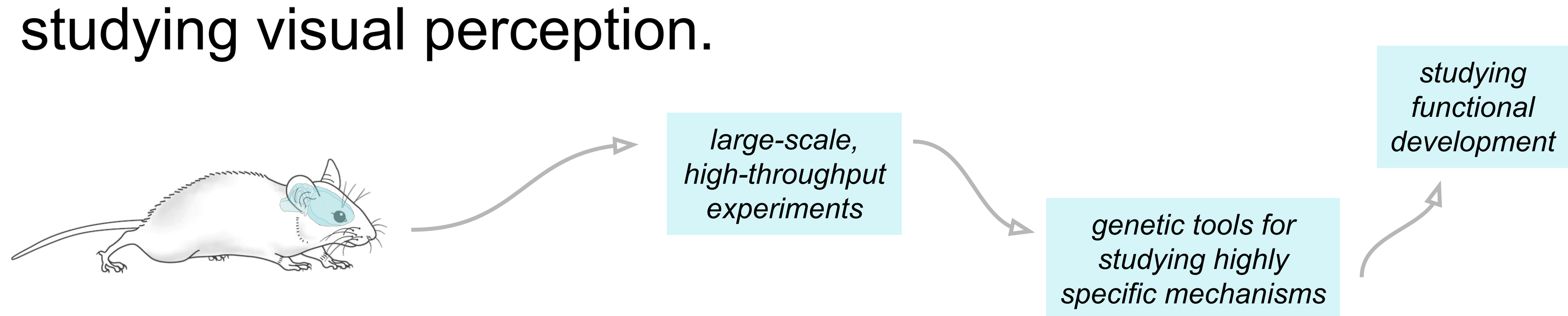
Kathleen Esfahany[1,3], Isabel Siergiej[2], Yuan Zhao[3], Il Memming Park[3]

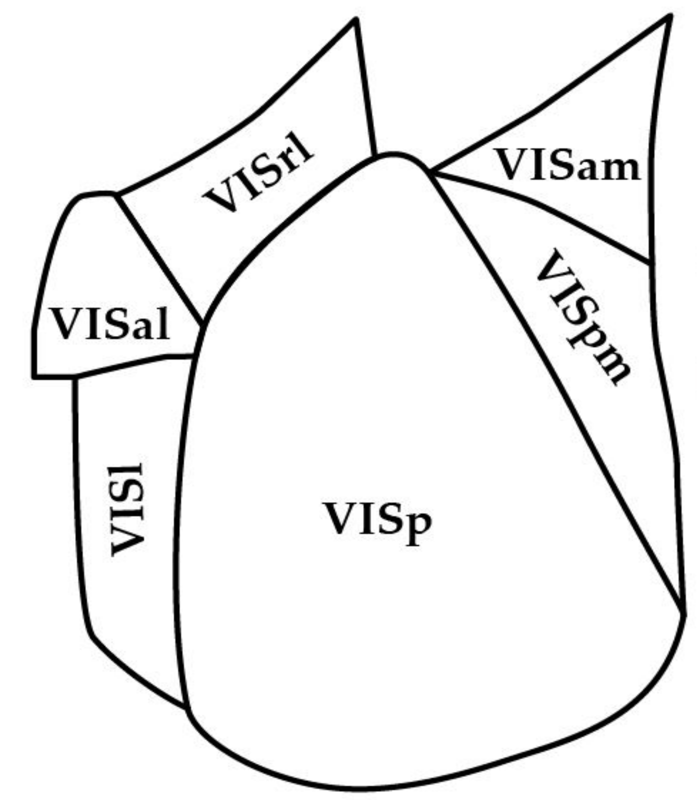
1. InSTAR, Ward Melville High School, NY
2. Department of Computer Science, Cornell University, NY
3. Department of Neurobiology and Behavior, Stony Brook University, NY

Stony Brook University

Motivation

The mouse has emerged as a powerful model system for studying visual perception.

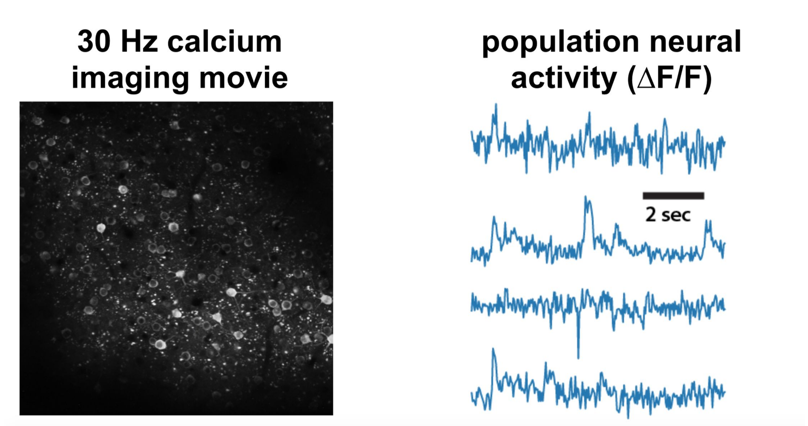


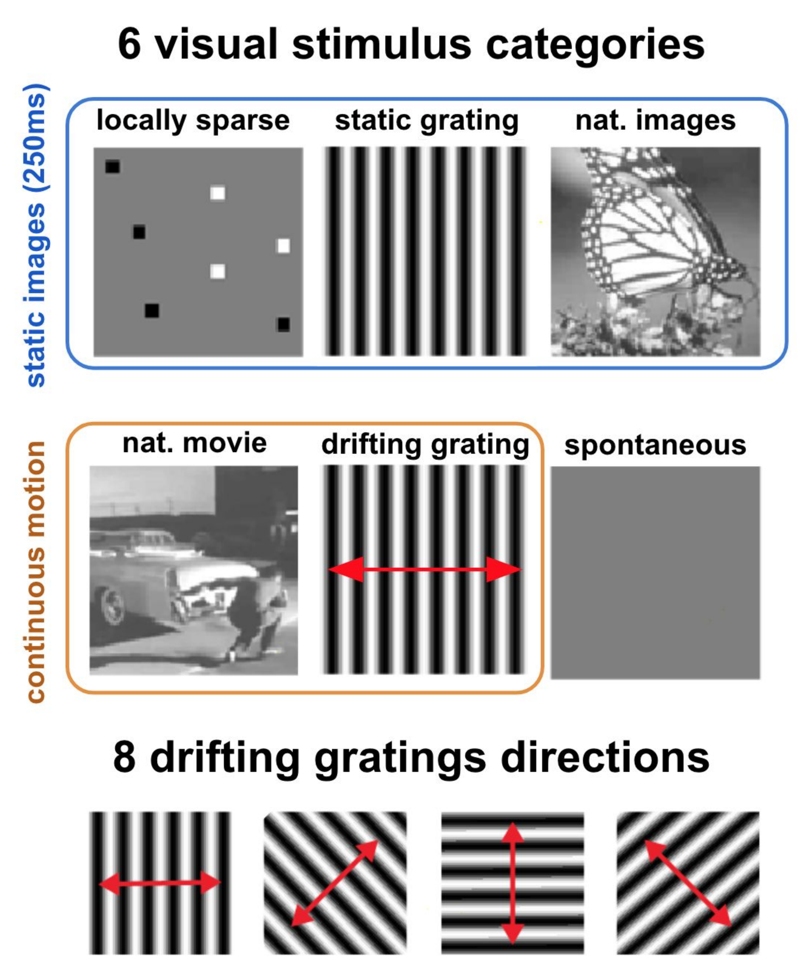


Goal: Characterize the neural population code associated with six cortical areas in the mouse visual system

Data from the Allen Brain Observatory

- *In vivo* two-photon calcium imaging data, quantified as ΔF/F





- To form **samples**, we calculated the mean ΔF/F over 10s (stimulus classification) or 2s (direction classification) intervals
- To form **neural feature vectors** in R^n, where *n* is the number of neurons in the population, the means were z-scored for each neuron and combined

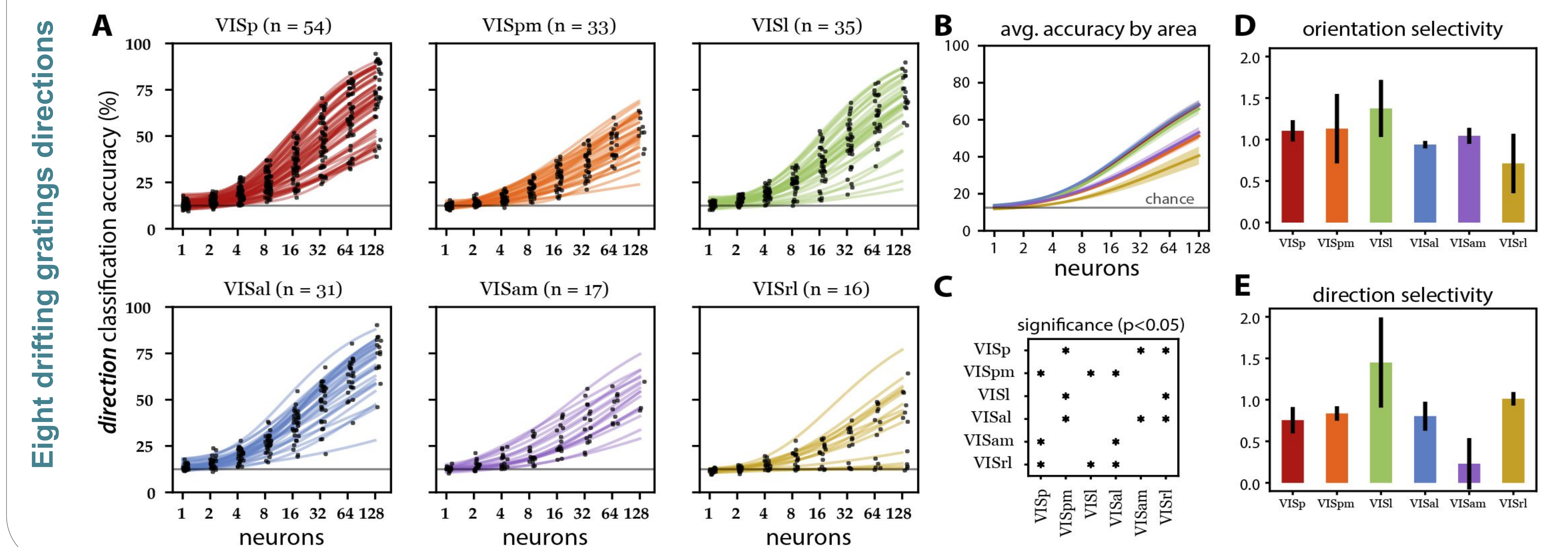
Classification

- Support Vector Machines and Multinomial Logistic Regression
- Accuracy values are the mean over 10 random subsamples of sizes $n = \{2^0, 2^1, 2^2, \ldots\}$ up to the number of neurons in the population
- We extrapolated the accuracy as a function of population size using the following generalized logistic function with 3 parameters {a, b, c} with constraints a ≥ 0, c ≥ 0, and b ∈ [0,1].

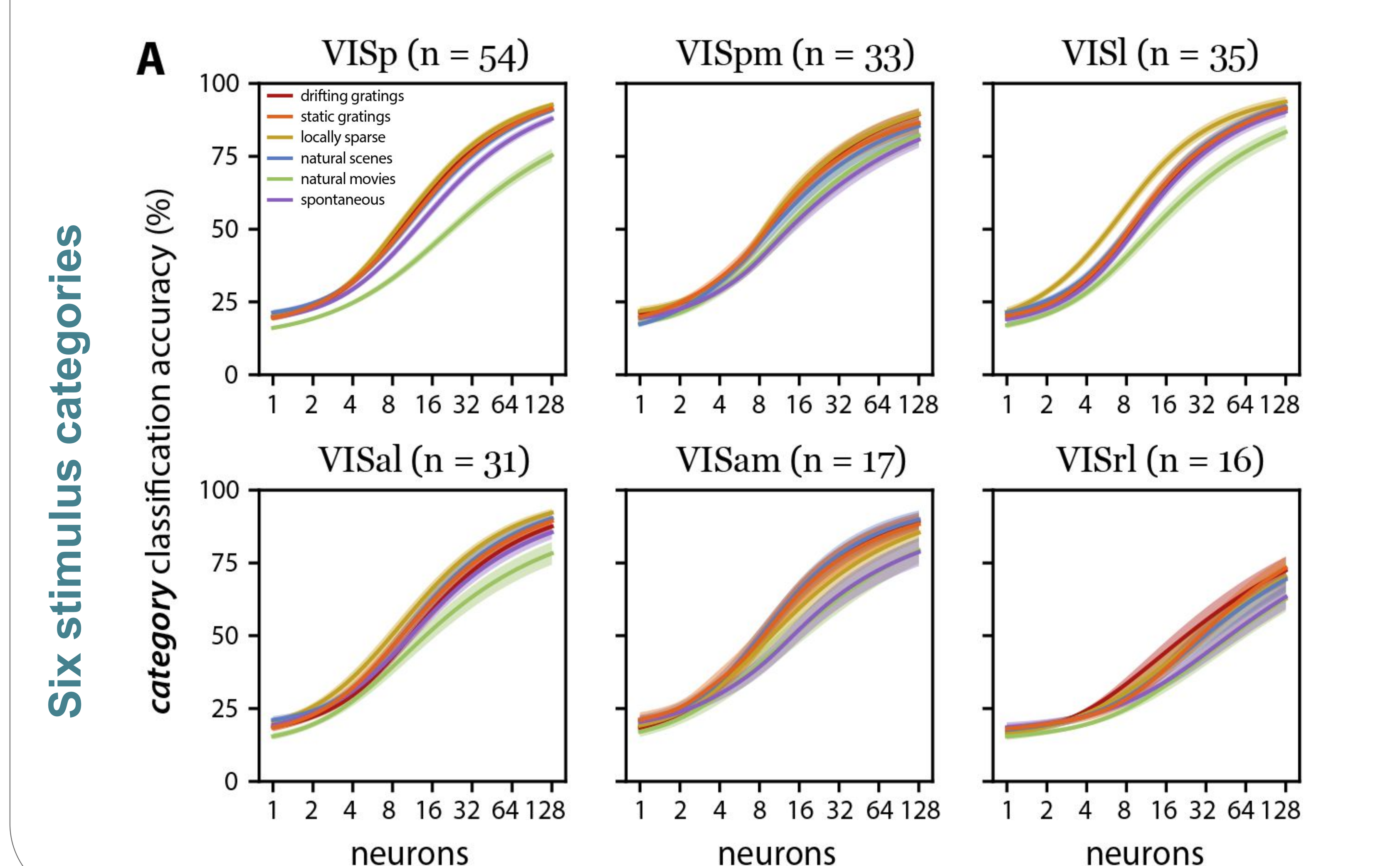
$$\mathrm{accuracy}(n) = \frac{1-c}{(1+e^{-an})^b} + c$$

Decoding Results

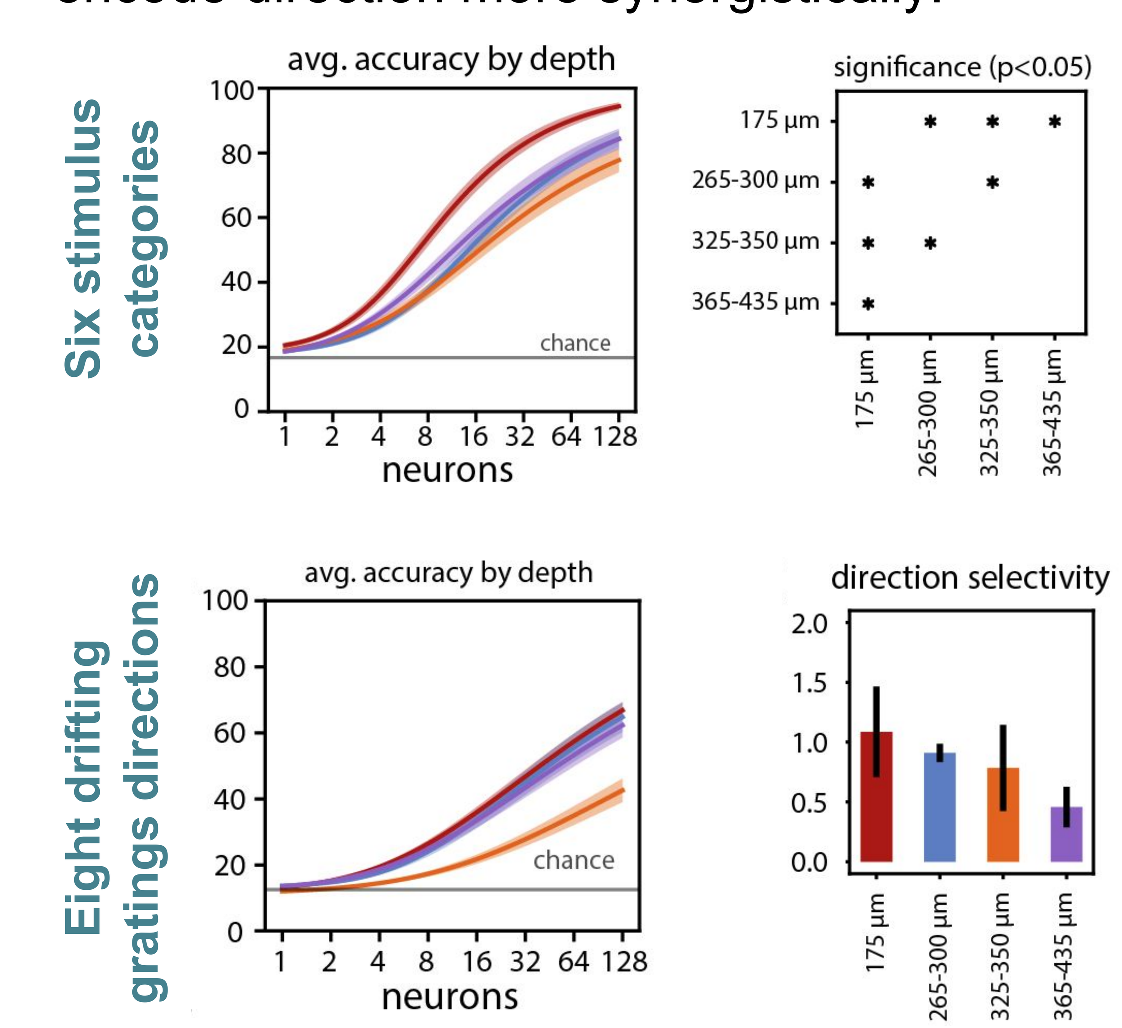
Spatiotemporal structure of stimuli are differentially encoded among visual areas. Areas with similar overall population performance display differences in encoding synergism and redundancy based on DSI.



Anatomically adjacent areas display similarities in both decoding tasks, supporting the existence of information processing streams.



Superficial layers are more informative about spatiotemporal signatures. Deeper layers encode direction more synergistically.



References

Allen Institute for Brain Science (2017). Visual coding overview. http://observatory. brain-map.org/visualcoding/. accessed: 2017 July 1.

Marshel, J. H. H., Garrett, M. E. E., Nauhaus, I., & Callaway, E. M. M. (2011). Functional Specialization of Seven Mouse Visual Cortical Areas. *Neuron*, *72*(6), 1040–1054. https://doi.org/10.1016/j.neuron.2011.12.004

Murakami, T., Matsui, T., & Ohki, K. (2017). Functional Segregation and Development of Mouse Higher Visual Areas. *The Journal of Neuroscience*, *37*(39), 731–17. https://doi.org/10.1523/JNEUROSCI.0731-17.2017