The representation of texture statistics in visual cortical networks of the mouse

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Hierarchical processing of visual information



Hubel and Wiesel 1962, 1968, Schrimpf et. al., 2020, Yamins and DiCarlo 2016

CNNs mimic hierarchical representation of the brain



Yamins and DiCarlo 2016, Zhuang et. al., 2021, Lindsay 2020

The computations occurring in mid-level areas remain unknown



Portilla & Simoncelli 2000, Freeman & Ziemba et. al., 2013, Okazawa et. al., 2015, 2017, Jagadeesh & Gardner 2022

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Addressing these questions in the mouse animal model





Conand & Burkhalter 2007, Wang & Burkhalter 1993

Synthesis algorithm using VGG16



Synthesized texture and scramble pairs



Matching power spectrum and orientation content



Can mice see textures?



High-throughput behavioral system



Go no-go behavioral tasks

- 1. Texture/scramble detection task: Main goal is to distinguish textures from scrambles.
- 2. Texture/texture discrimination task: Main goal is to distinguish between two families of textures.



Where z is the inverse cumulative density function of a normal distribution.

Video of expert mouse doing the task (3X speed)



Texture/texture go/no-go task



What is the neural substrate underlying the encoding of texture statistics in the mouse visual cortex?



Mean response to textures and scrambles in V1/LM



Texture modulation across higher visual areas





What is the single-cell and population level substrate underlying this differential selectivity?





Example responses of four single neurons



Texture selectivity across all cells higher in LM



Relating population activity to behavior





Linking neural representations and behavioral output

• Trained a binary logistic regression classifier on the neural data to discriminate textures from scrambles just like the mouse behavior.



 Rocks was the worst performing family in both the classifier (p < 0.035) and mouse behavior (p < 0.03). Is the worse neural and behavioral discriminability of the "Rocks" family related to the statistical properties of these images?

Computing intercluster distances in PS space

• Calculated the intercluster distances for all the four PS statistics groups.

 $d_{norm} = rac{d_{ ext{tex,sc}}}{rac{1}{2}(r_{ ext{tex}}+r_{ ext{sc}})}$

- Of all the image statistics only the energy statistics showed a correspondence with the neural and behavioral discriminability.
- These statistics were also the most complex



Energy cross-correlation statistics

Energy statistics aligned with behavioral and neural performance



Geometrical changes between layers





Cohen & Chung et. al., 2020, Chung & Abbott, 2021