High dimensional sampling in random neural networks competes with deep learning models of visual cortex

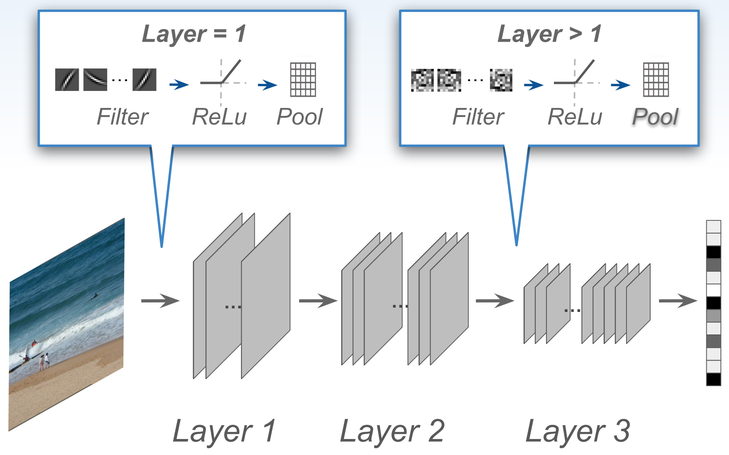
Atlas Kazemian, Eric Elmoznino, Michael F. Bonner

MOTIVATION

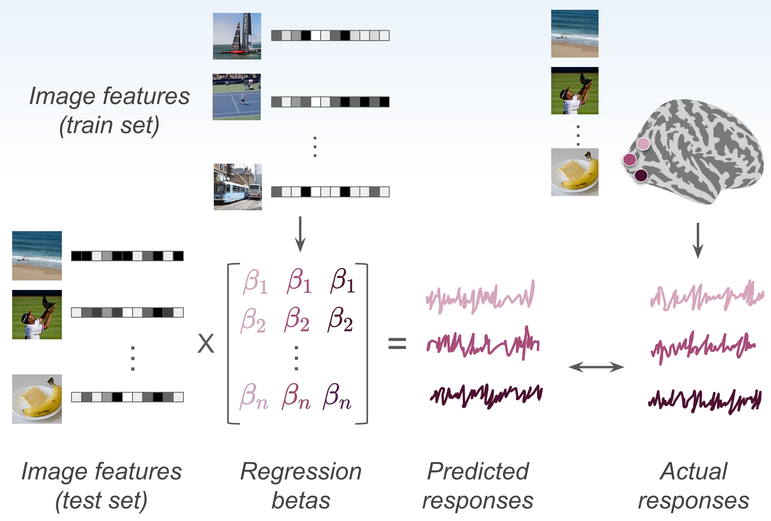
- The performance of convolutional neural networks (CNNs) as representational models of visual cortex is thought to be associated with task optimization [1-3].
- We hypothesize that there may be simpler statistical principles responsible for this, such as the latent dimensionality of representations [4]
- To test this, we develop a learning free CNN that uses high dimensional random sampling, and compare its performance with standard pre-trained CNN at modeling visual cortex.

METHODS

The Expansion Model architecture

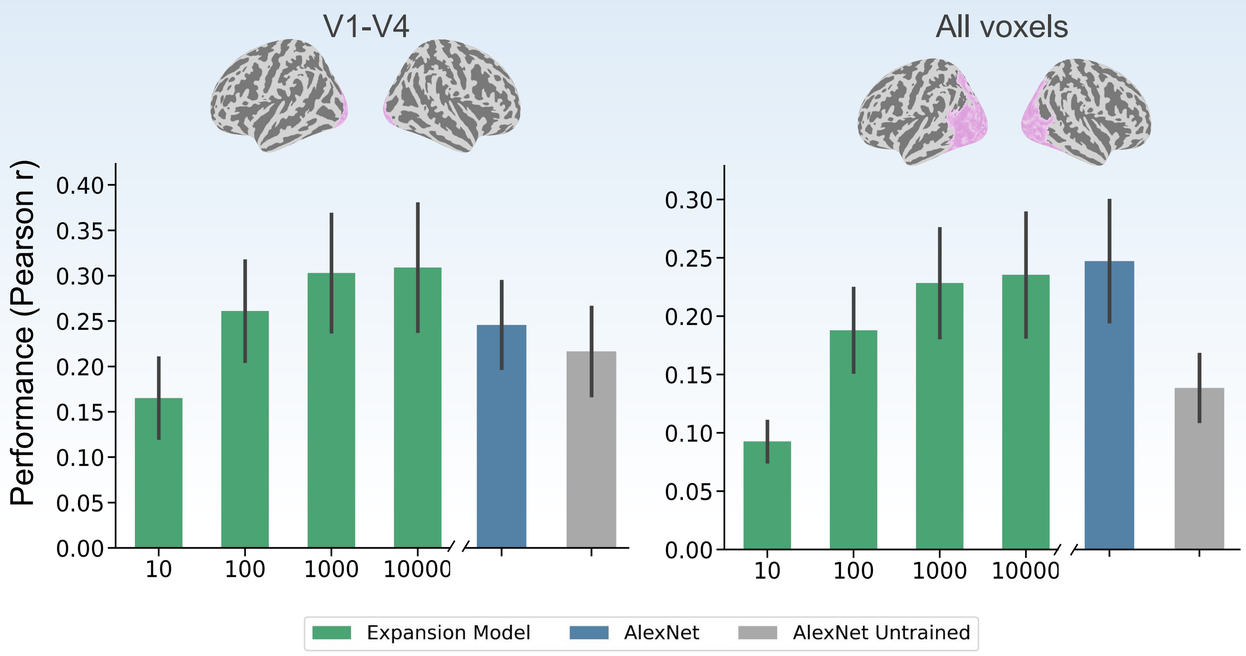


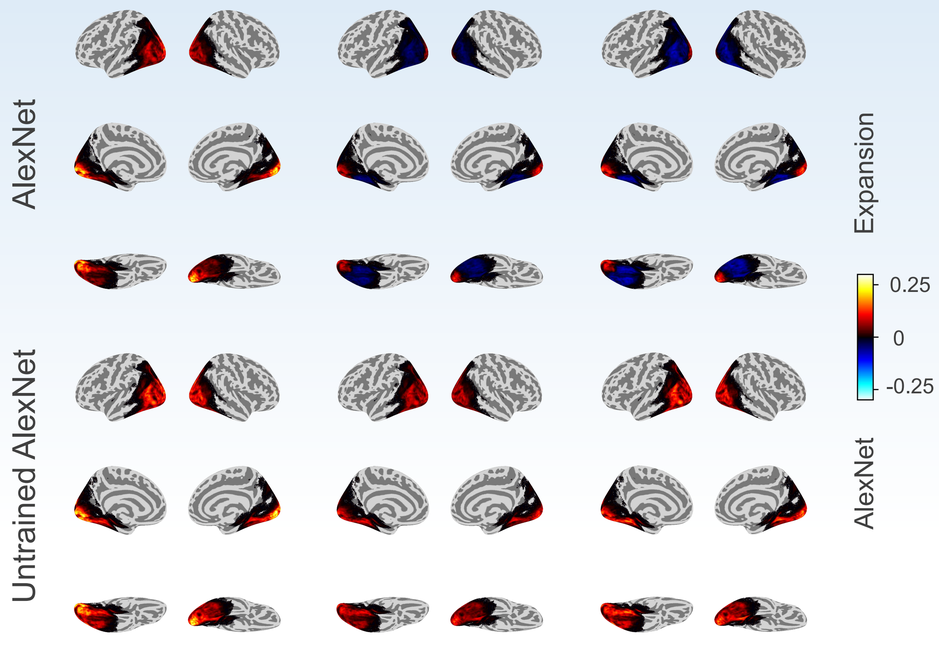
Mapping Procedure



RESULTS

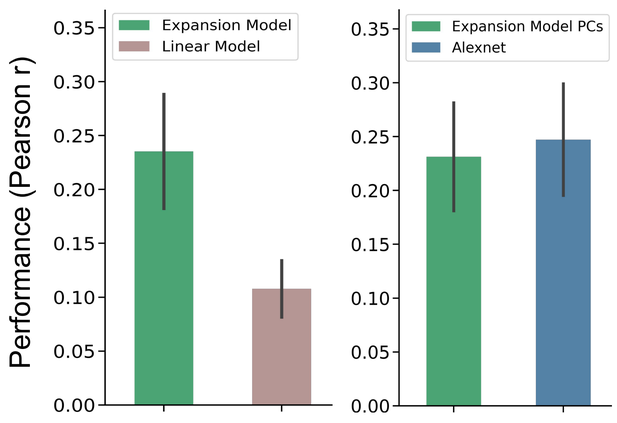
The Expansion model competes with a pre-trained CNN at modeling visual cortex



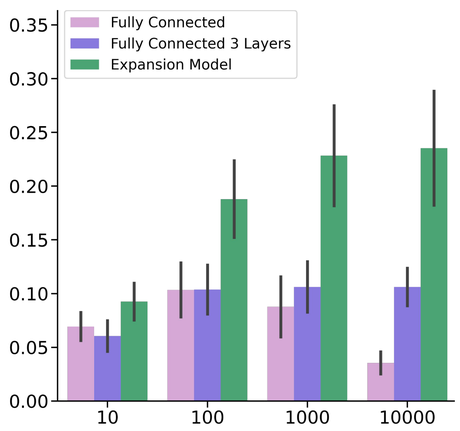


Q What factors drive encoding performance?

High dimensional regression does **not** drive performance

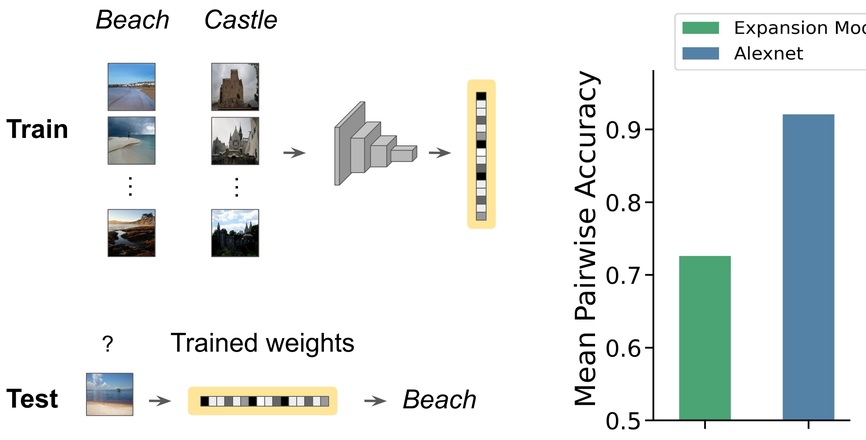


The *convolutional architecture drives* performance



Q Is the model good at image classification?

Not all high performing models of visual cortex are good at computer vision tasks



CONCLUSION

- An untrained model that expands the dimensionality of representations competes with a standard pre-trained CNN at modeling visual responses.
- The performance of the model is mainly associated with the convolutional architecture and high dimensional random sampling.
- The model's low image classification performance shows that this metric does not always correlated with brain-similarity.
- Our findings suggest that there may be a unifying set of statistical principles underlying deep neural networks and the visual cortex.

REFERENCES

[1] Yamins, D. L., Hong, H., Cadieu, C. F., Solomon, E. A., Seibert, D., & DiCarlo, J. J. (2014). Performance-optimized hierarchical models predict neural responses in higher visual cortex. *Proceedings of the National Academy of Sciences*, *111*(23), 8619–8624. https://doi.org/10.1073/pnas.1403112111
[2] Yamins, D. L., & DiCarlo, J. J. (2016). Using goal-driven deep learning models to understand sensory cortex. *Nature Neuroscience*, *19*(3), 356–365. https://doi.org/10.1038/nn.4244
[3] Cao, R., & Yamins, D. (2021b). Explanatory models in neuroscience: Part 2 – constraint-based intelligibility. arXiv. Retrieved from https://arxiv.org/abs/2104.01489 doi: 10.48550/ ARXIV.2104.01489
[4] Elmoznino, E., & Bonner, M. F. (2022). *High-Performing Neural Network Models of Visual Cortex Benefit from High Latent Dimensionality*. https://doi.org/10.1101/2022.07.13.499969