Universal scale-free representations in human and mouse visual cortex

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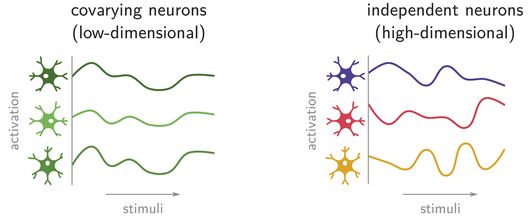
How is sensory information distributed in the population activity of visual cortex?

Covariances between neurons constrain the information content of visual representations



The **covariance spectrum** quantifies the visual information at *all scales* of variance

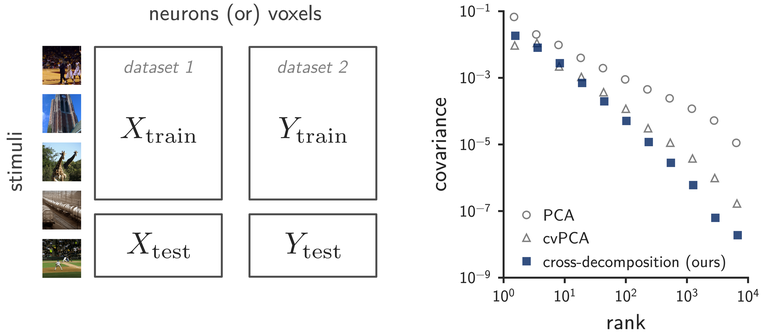
Extract covariance spectra using *cross-decomposition*

1 **Learn latent dimensions** shared between two *independent datasets*

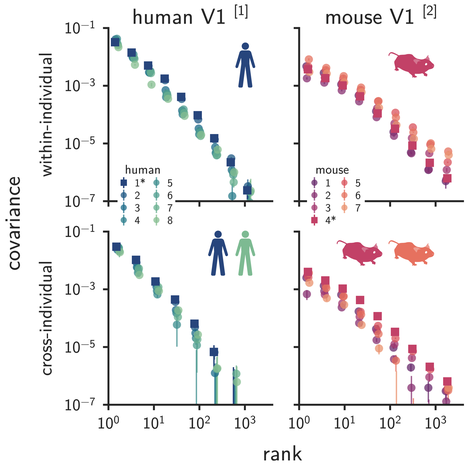
$$\mathrm{cov}\,(X_{\mathrm{train}}, Y_{\mathrm{train}}) = U\Sigma V^{\top}$$

2 **Evaluate variance** that generalizes to *novel stimuli*

$$\hat{\Sigma} = \mathrm{cov}\,(X_{\mathrm{test}}, Y_{\mathrm{test}})$$



Universal power-law covariance spectra ...



... *within* individuals, across trials

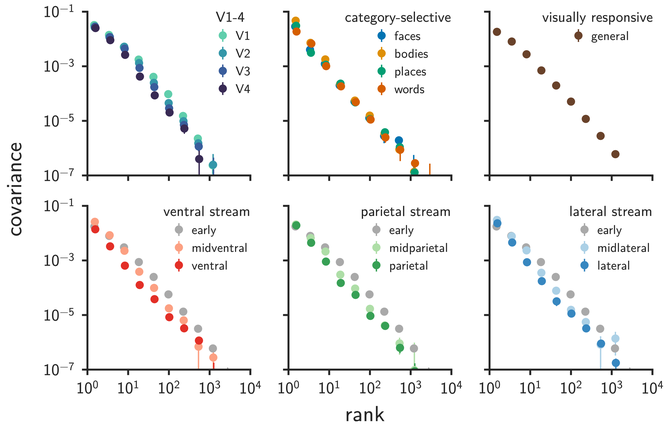
Scale-free covariance structures support the immense flexibility and expressivity of the visual system [2-4]

... shared *between* individuals

Strong convergence in natural scene representations despite idiosyncrasies of neural anatomy and experience [5]

*cross-individual spectra are relative to the *starred* individuals*

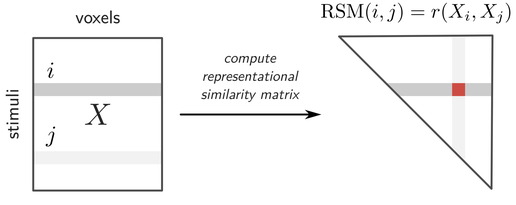
... that are observed *throughout* human visual cortex



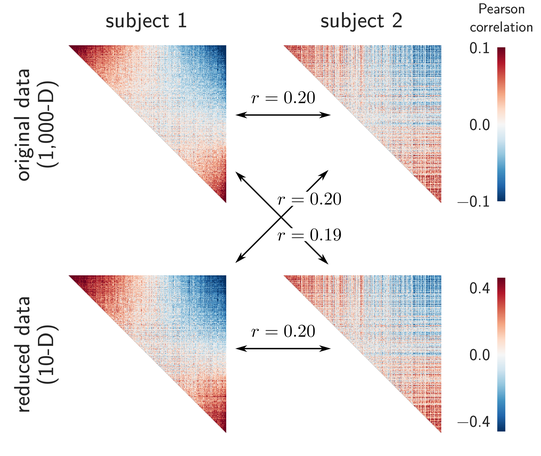
A potential *general organizing principle* of visual cortex representations

RSA is insensitive to high-dimensional structure

Standard methods in cognitive neuroscience [6] are not sensitive to the reliable information encoded in high-rank dimensions



Spearman correlations between RSMs are not affected by projecting the data onto the 10-D subspace that carries maximum variance



1 **Allen et al. (2022)** Nature Neuroscience
2 **Stringer et al. (2019)** Nature
3 **Elmoznino & Bonner (2024)** PLoS Computational Biology
4 **Sorscher et al. (2021)** PNAS
5 **Haxby et al. (2011)** Neuron
6 **Kriegeskorte (2008)** Frontiers in Systems Neuroscience