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# Low-dimensional embedding of neural responses in anaesthetic monkey V1

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# High-dimensional neural responses

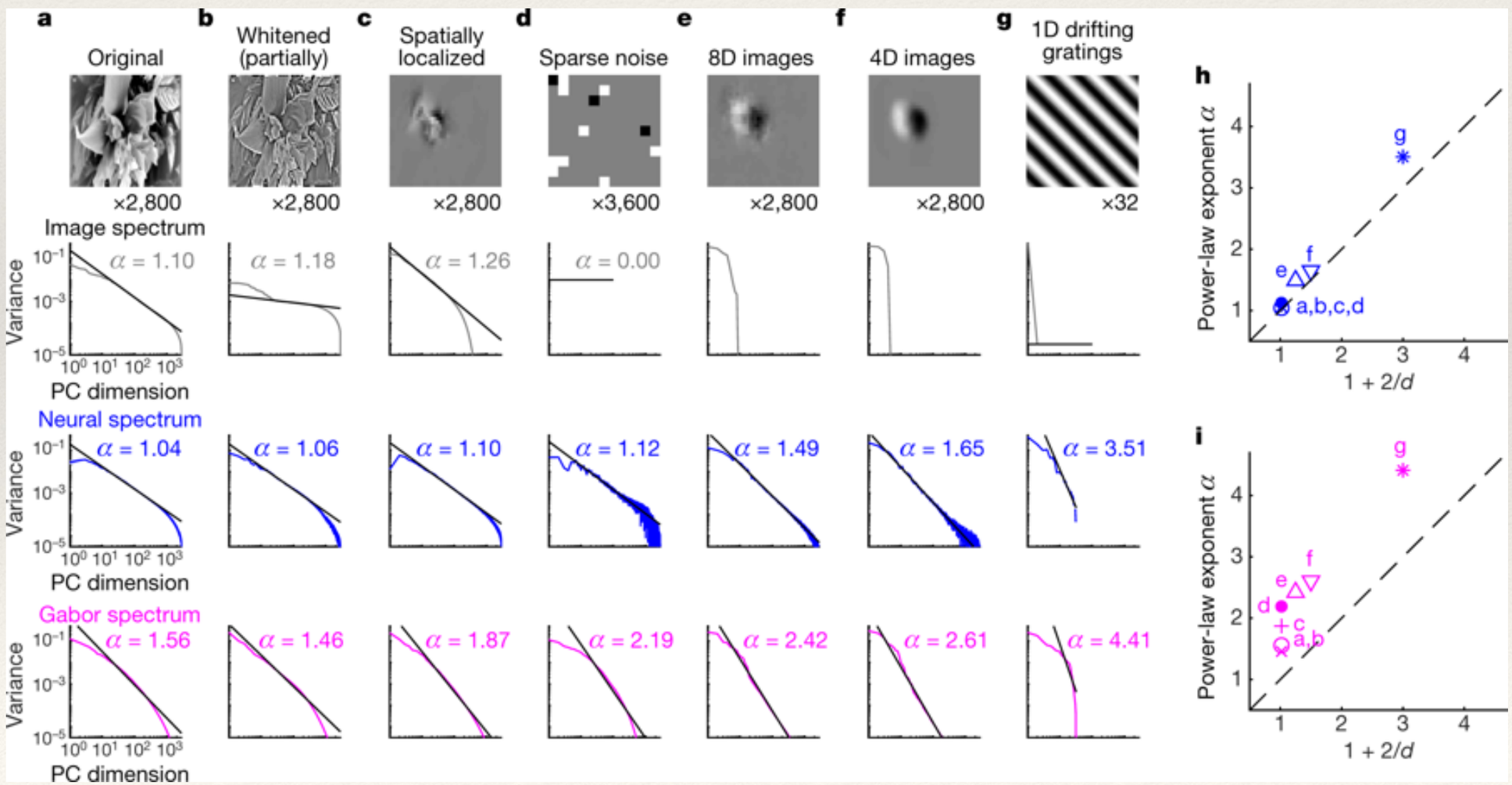
## High-dimensional geometry of population responses in visual cortex

Carsen Stringer[1,2,6]*, Marius Pachitariu[1,3,6]*, Nicholas Steinmetz[3,5], Matteo Carandini[4,7] & Kenneth D. Harris[3,7]*

# High-dimensional neural responses

Primary visual cortex response :

- Consistent with a lower-dimensional manifold…
- Dimensionality is intrinsic (not imposed by stimulus)



# High-dimensional neural responses

- Is observed high dimensionality a byproduct of linear transformation?
- If applying non-linear transformation, would a low-dimensional manifold be sufficient to depict stimulus encoding?
- To what extent does the brain state/spontaneous activity constrain stimulus response dimensionality? (Low-dimensional brain state, ex: anaesthesia)

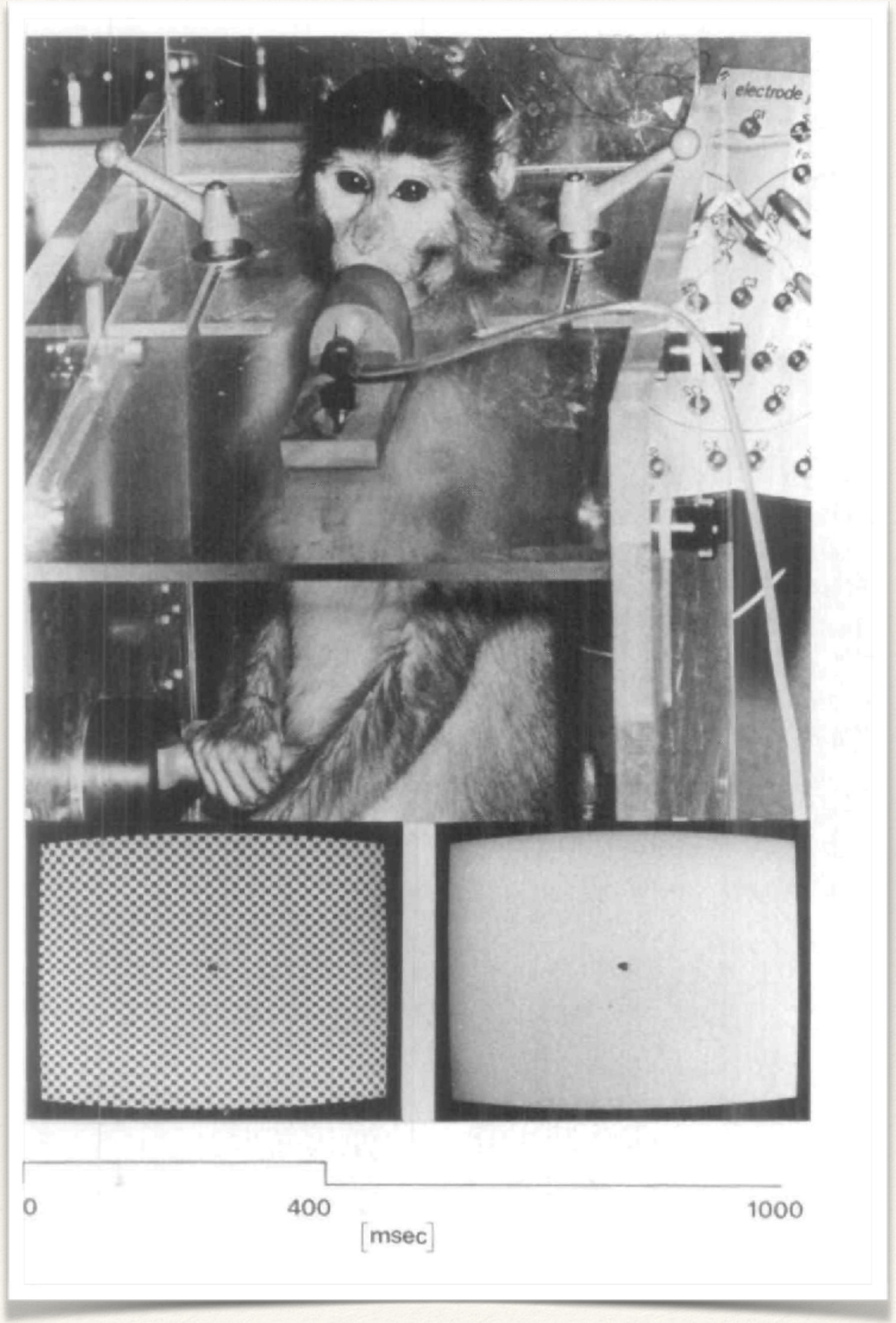
*Different brain state: Anaesthetised adult Macaca fascicularis monkeys*

# Primary visual cortex

**Evoked activity**

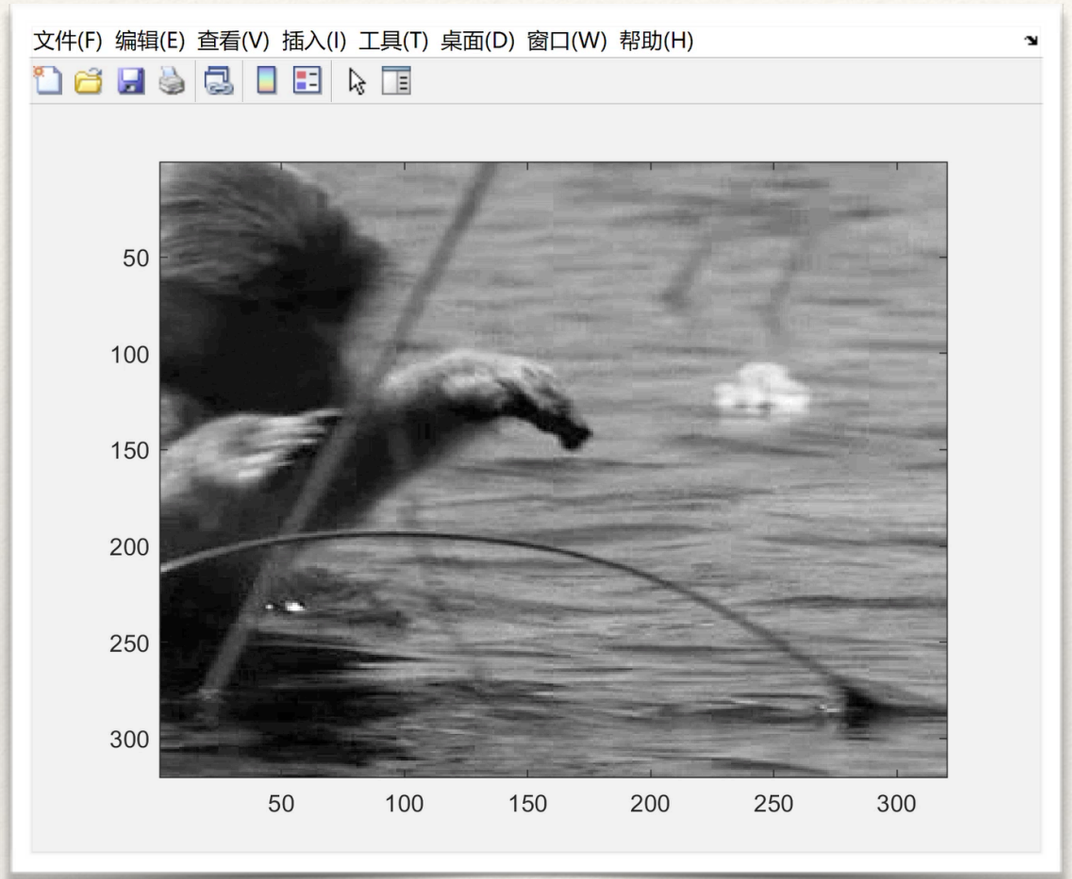
1. drifting sinusoidal gratings
2. a continuous natural scene
3. white noise

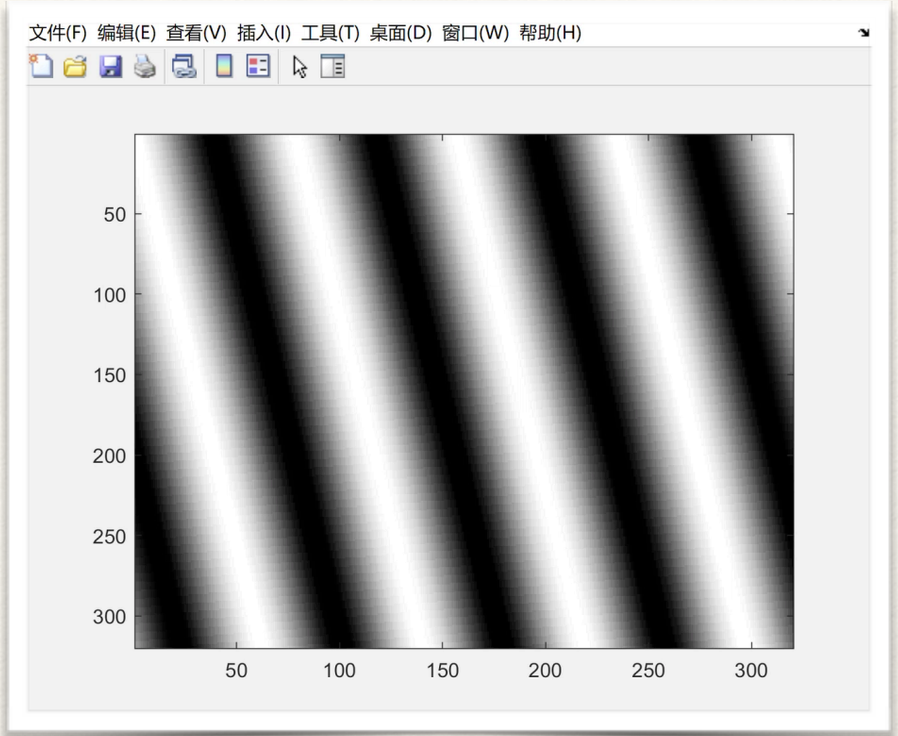
123 neurons

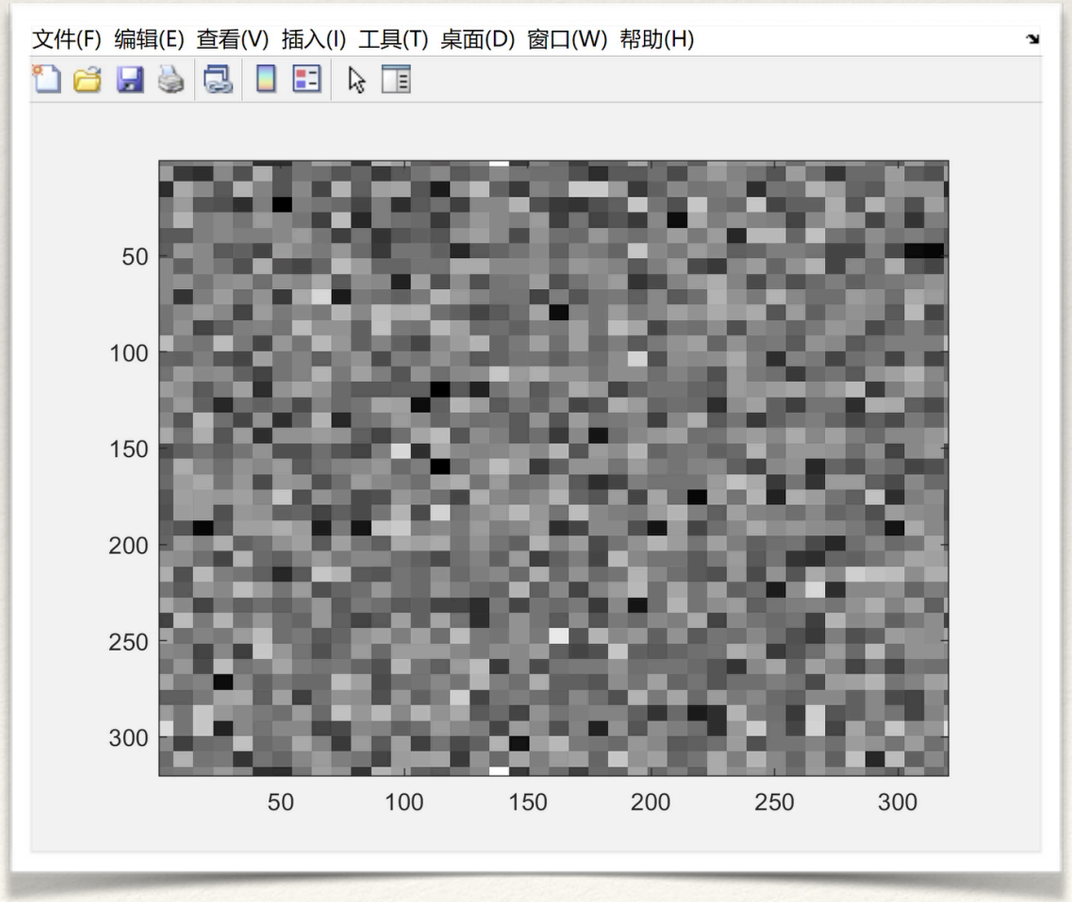



Marel, Dagnelie & Spekreijse (1981)

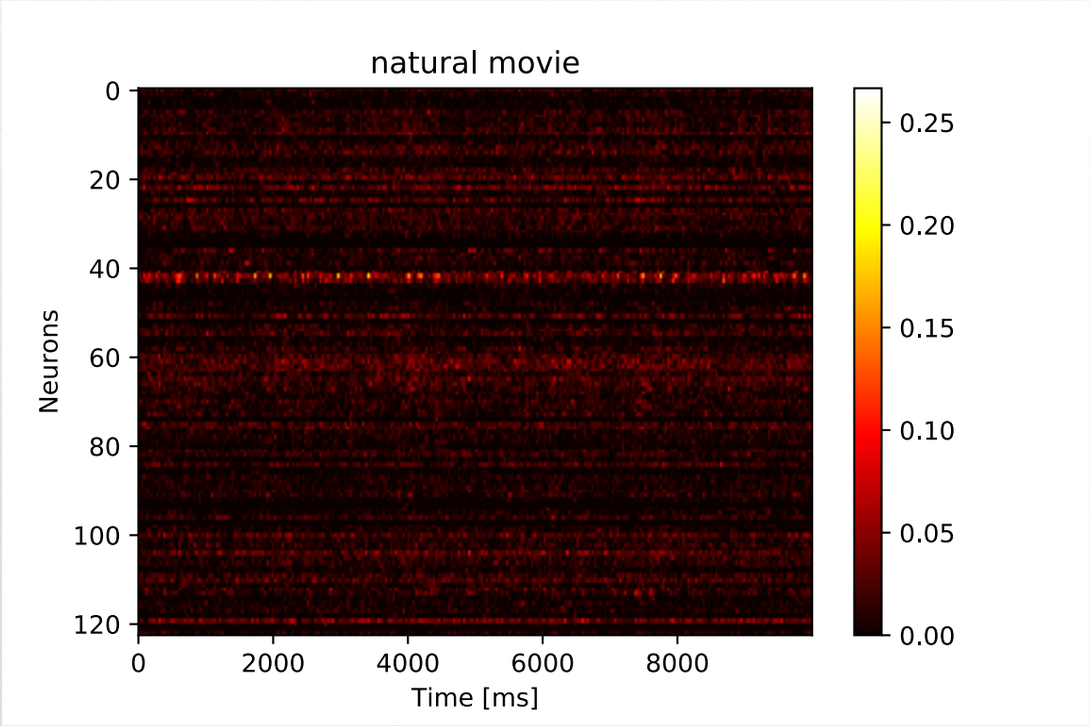
# Visual stimuli

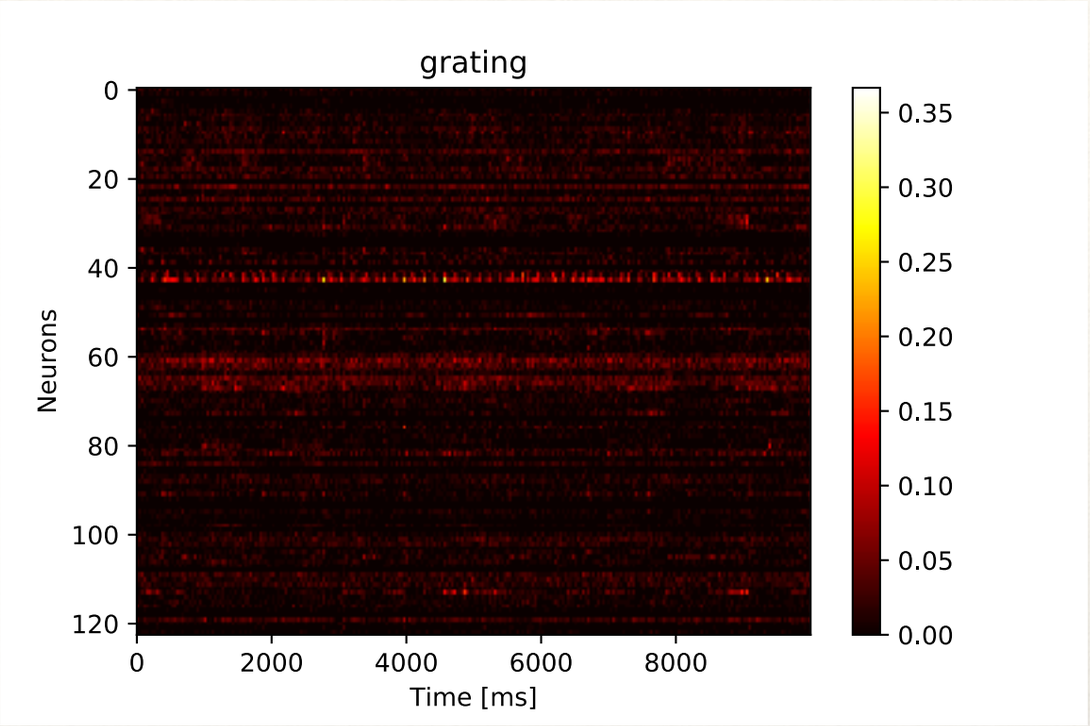


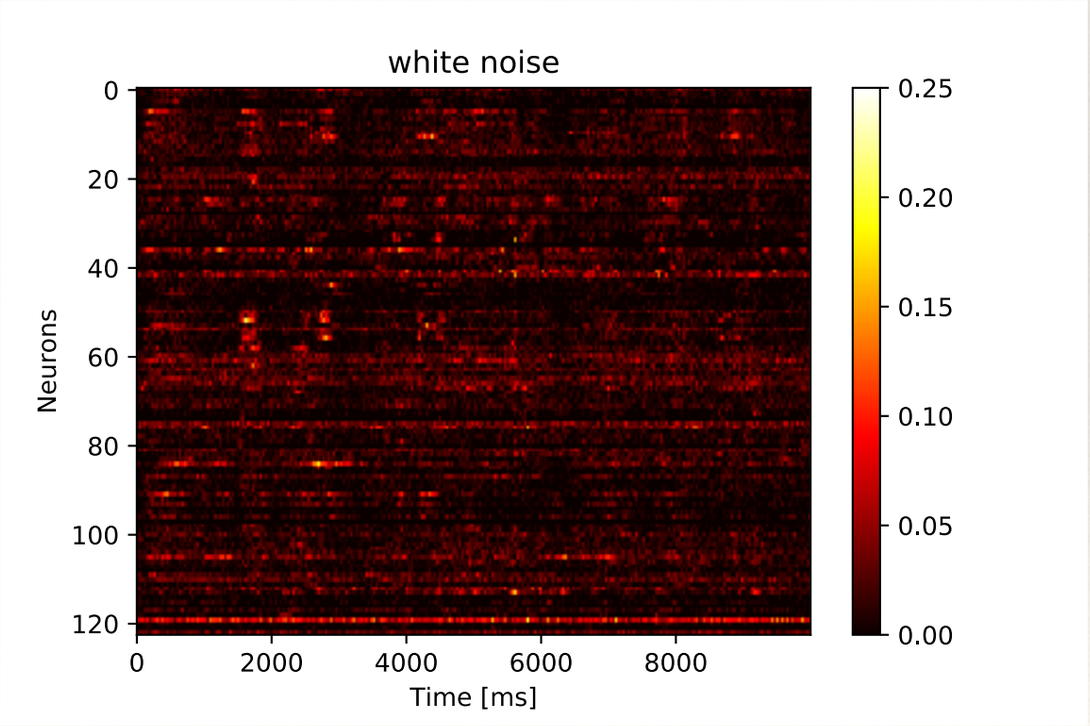



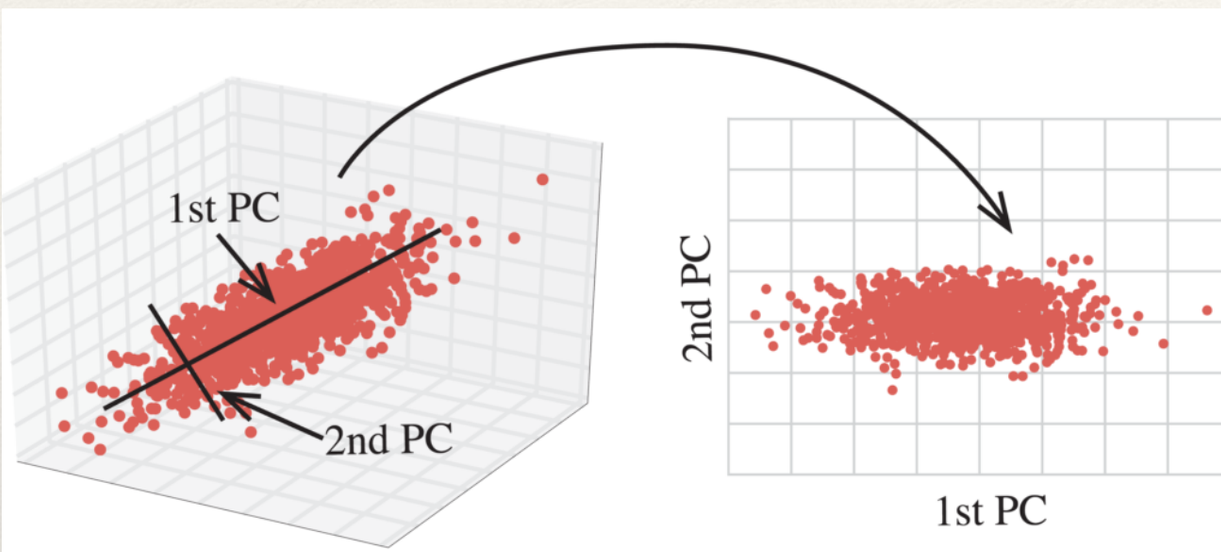
# Neural responses

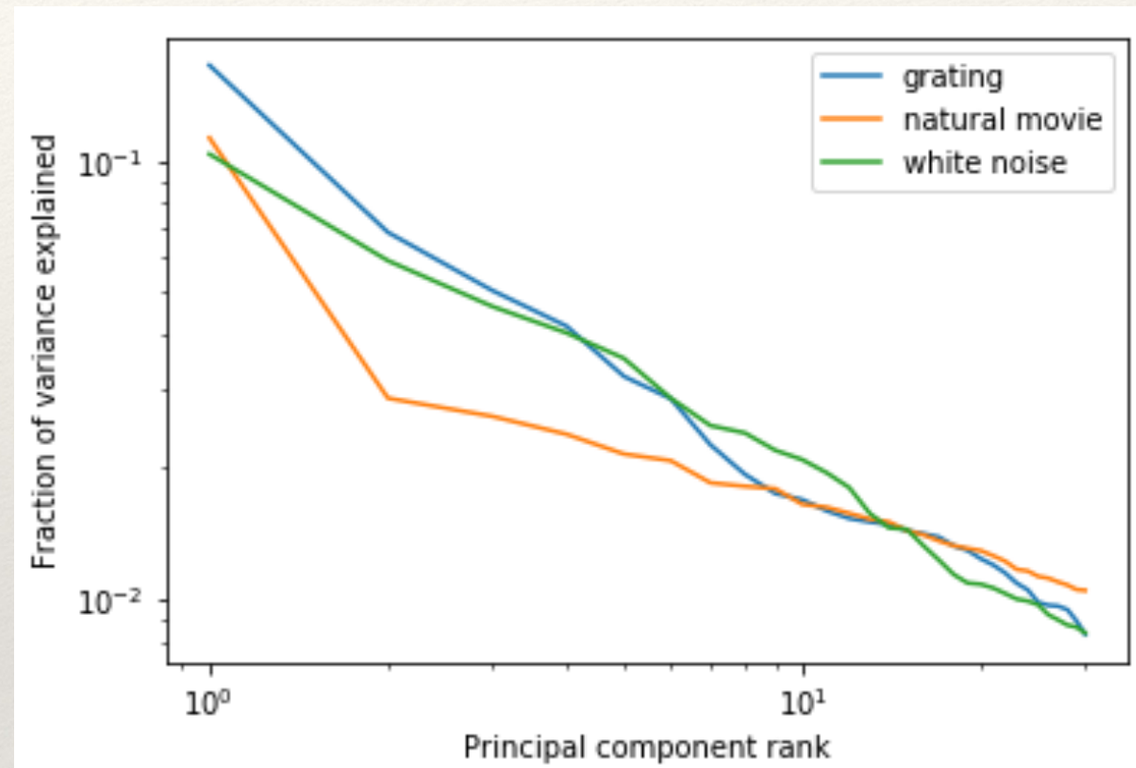


# Linear - PCA: dimensionality?



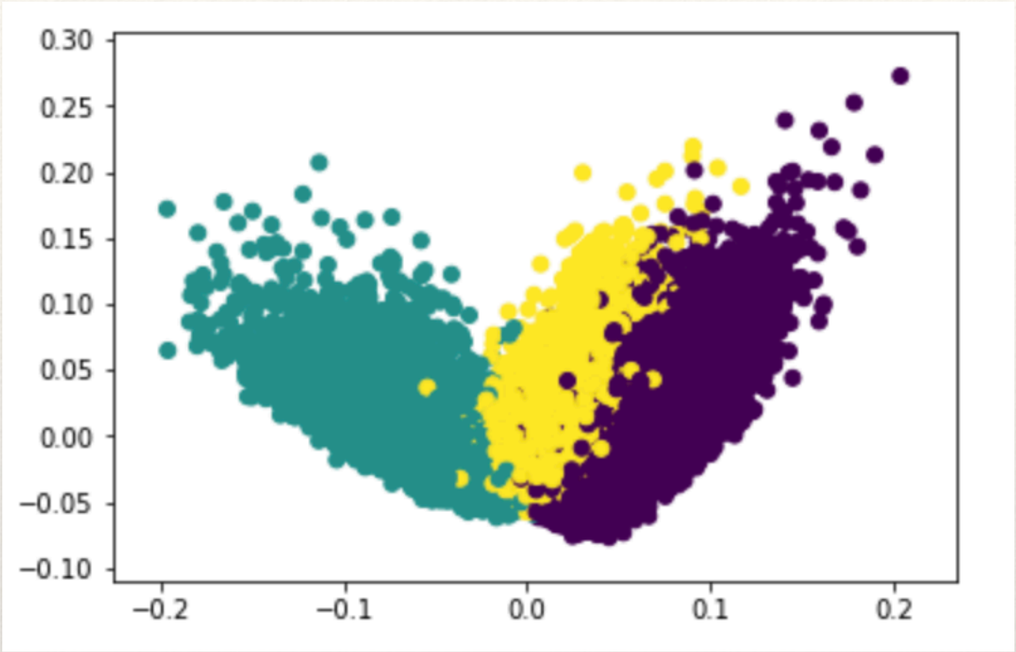




- Power-law scaling also observed in anesthesia… high-dimensional responses?

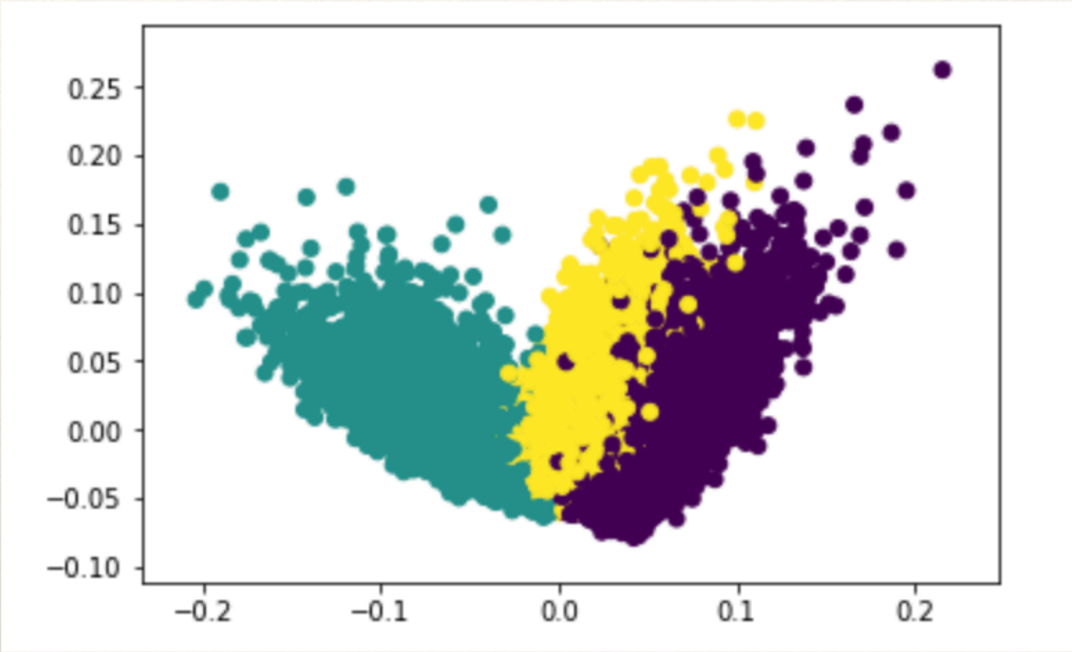
https://medium.com/@TheDataGyan/dimensionality-reduction-with-pca-and-t-sne-in-r-2715683819

# Linear - PCA: dimensionality?

Train data

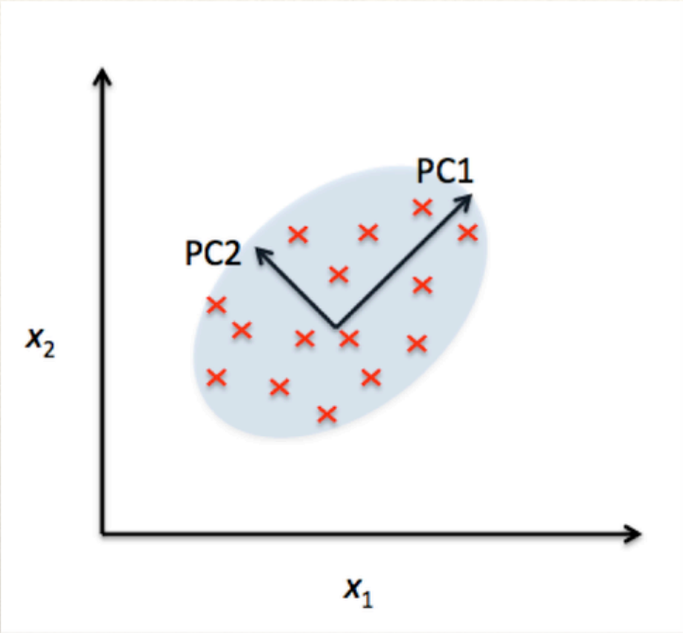



Test data

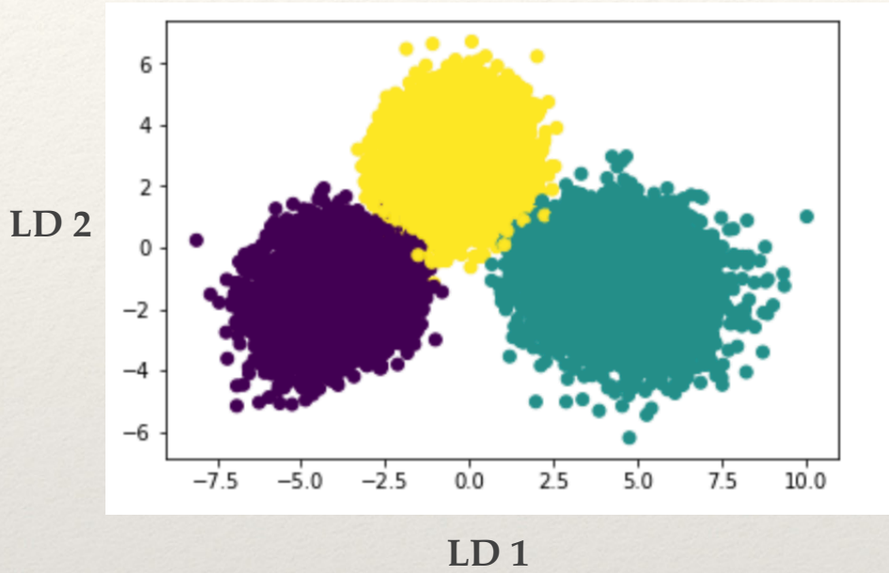



- 2 principal components, K-nearest neighbour classifier accuracy = 92.34%

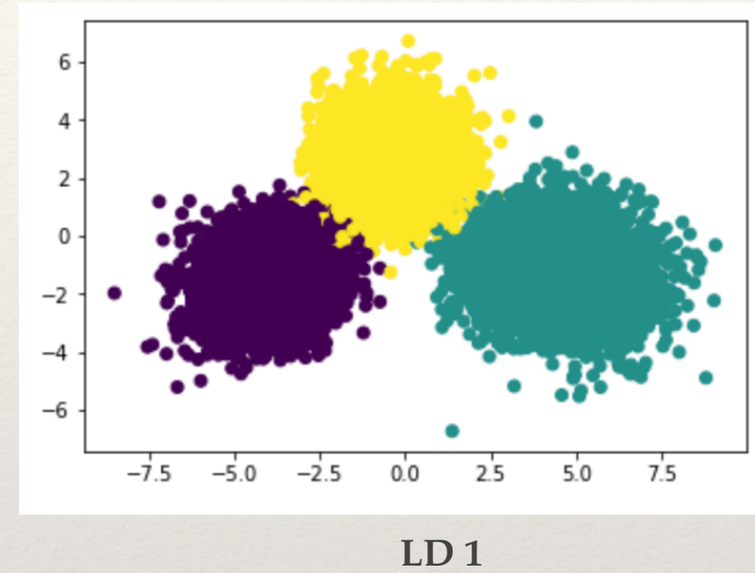
# Linear - LDA vs PCA: improvement?

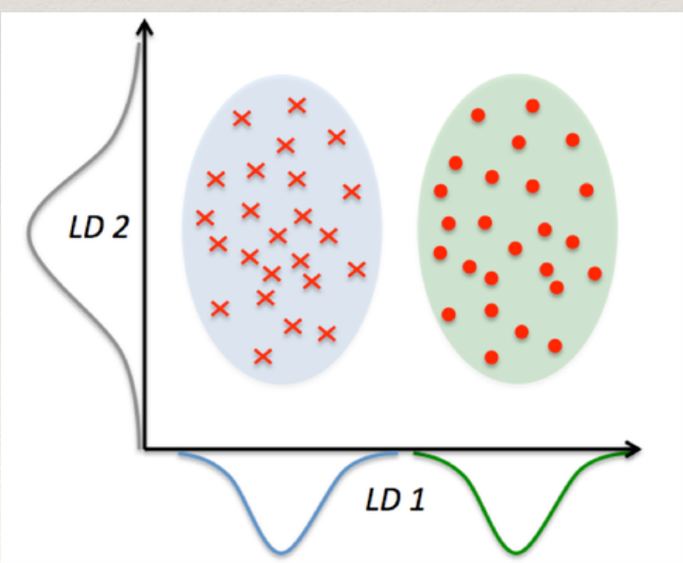



Train data




Test data

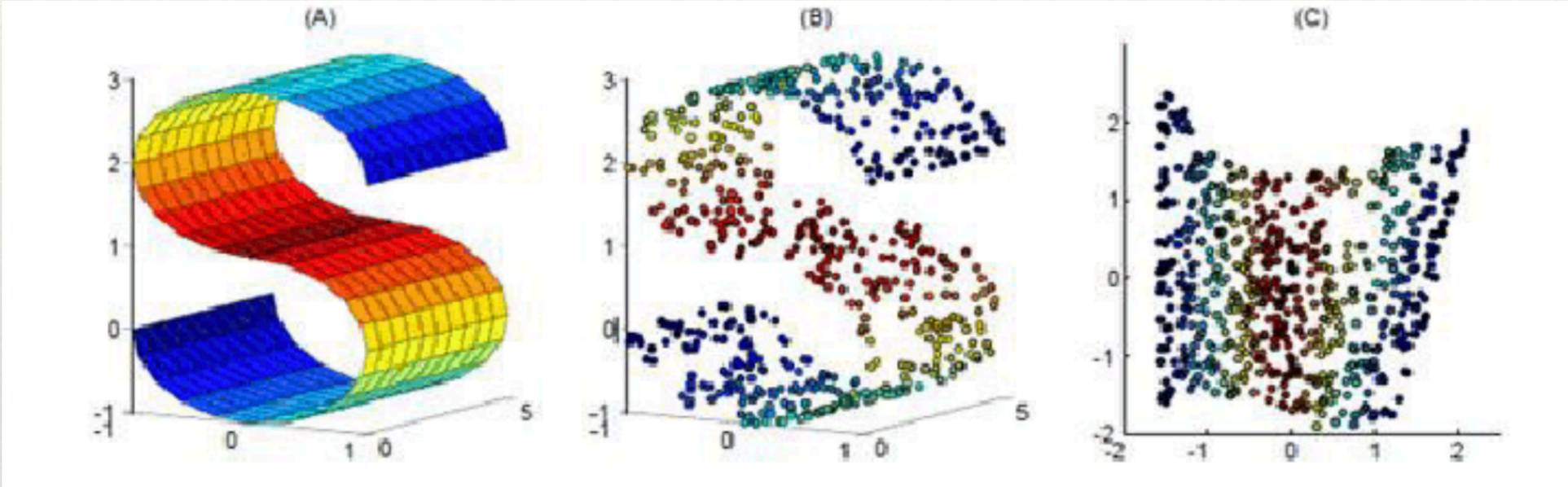



- 2 components, K-nearest neighbour classifier accuracy = 99.79%
- After shuffling labels = 33.00% = chance level

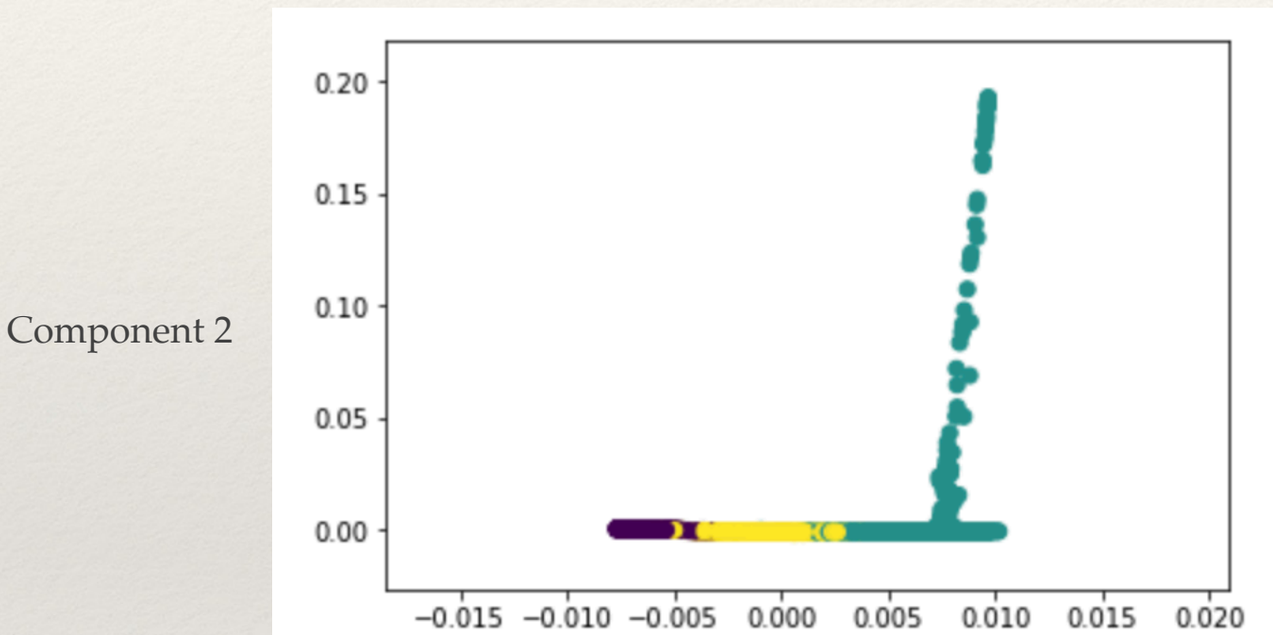
https://sebastianraschka.com/faq/docs/lda-vs-pca.html

# Linear vs non-linear: LLE

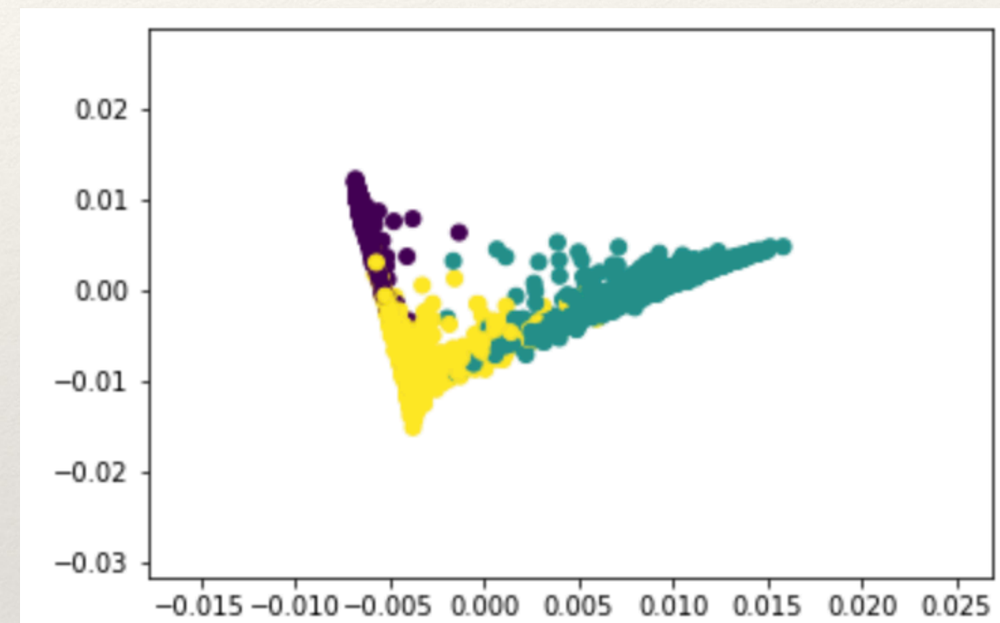


# Linear vs non-linear: LLE

Train data




Test data




- 2 components, K-nearest neighbour classifier accuracy = 98.14%

# Take-home points

- Neural responses also appear high-dimensional in anaesthesia in the monkey
- Linear transformations (PCA and LDA) allow for good classification of stimulus type, suggesting the neural responses to each type lies on linearly separable low-dimensional manifolds
- When not considering labels, non-linear (LLE) method outperforms linear (PCA)
- Suggesting a low-dimensional latent representation, encoded/decoded in a non-linear way?

# Questions?

# Thank You!

https://github.com/wuyxiquanquan/Monkey

# References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5. Stringer, C., Pachitariu, M., Steinmetz, N., Carandini, M., & Harris, K. D. (2019). High-dimensional geometry of population responses in visual cortex. *Nature*, 1.

6. Tenenbaum, J. B., De Silva, V., & Langford, J. C. (2000). A global geometric framework for nonlinear dimensionality reduction. *science*, *290*(5500), 2319-2323.