Local vs. global brain representations

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Lukas Snoek & Steven Scholte

L.Snoek@uva.nl

University of Amsterdam

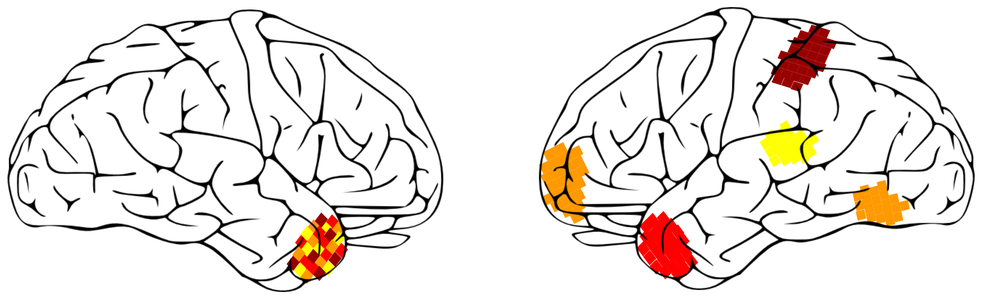
Introduction

The brain is anatomically and functionally organized at **different scales**, from neurons in cortical columns to brain-wide functional networks. However, Multivoxel patterns analysis (MVPA) of fMRI data is often **limited to local voxel patterns** using ROI-based or searchlight analyses[1].

This assumption of local representations stands in contrast with the **emerging network-perspective** on the representation of "high-level" information and processes (e.g. emotions, motivation)[2].

To test whether high-level information is represented large-scale functional networks, we aimed to decode high-level information using a set of **brain-wide clusters** instead of **local voxel patterns**. To extract these brain-wide clusters, we implemented a novel cluster-based thresholding and transformation of MVPA features.

Local? **Global?**



We hypothesized that **high-level information is represented as a set of spatially- segregated clusters across the brain**

Methodology & Results

Data set

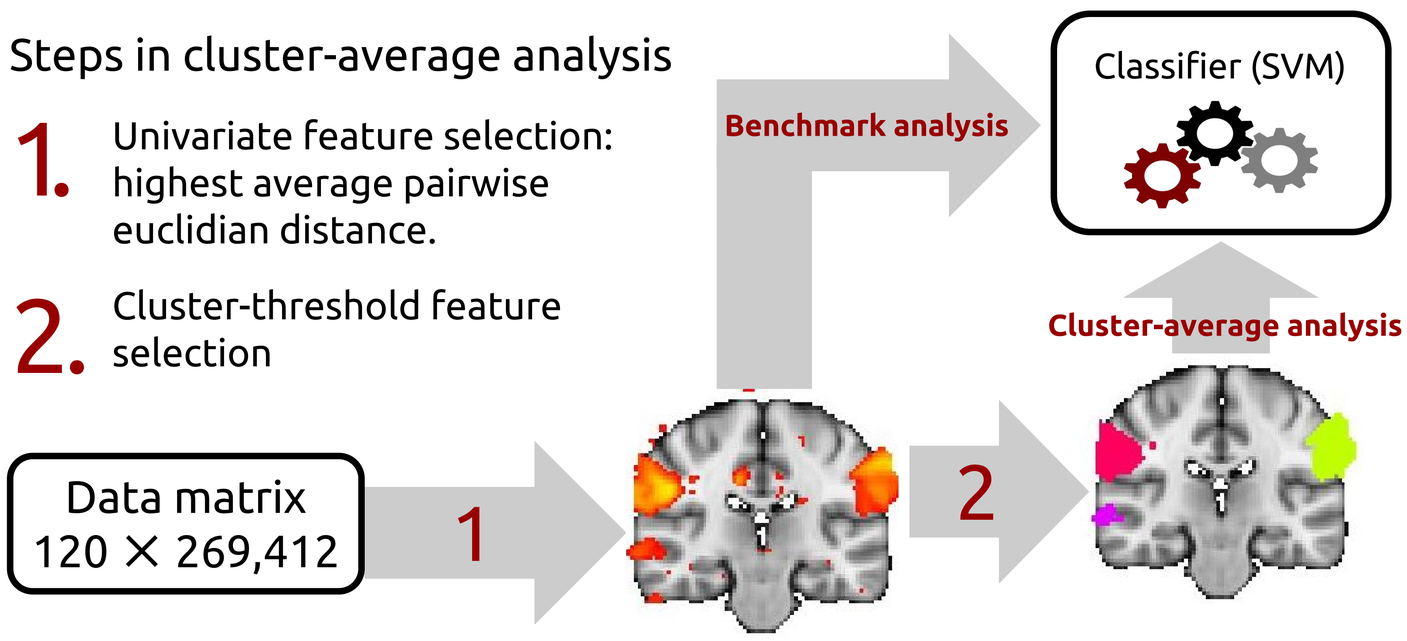
We used data from an existing dataset on the neural representations of self-focused emotional experience[3], which contained three conditions (40 trials each) known to be represented within global functional networks. Neural patterns per trial consisted of first-level (GLM) t-statistics from all voxels in the grey matter.

Analysis

To test the scale of representation, we contrasted a classification model using voxels as features (*benchmark analysis*) with a model using clusters as features (*cluster-average analysis*).

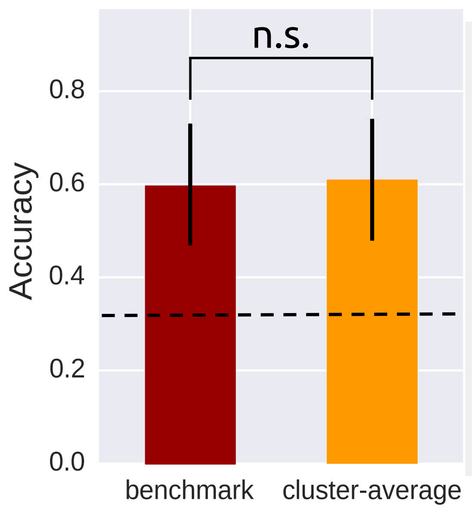
Steps in cluster-average analysis

1. Univariate feature selection: highest average pairwise euclidian distance.
2. Cluster-threshold feature selection



Results

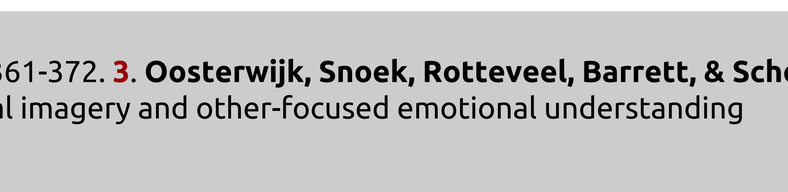
It is possible to decode using a set of spatially-segrated clusters!



Importantly, for the same classification accuracy, **only 27.1 features** (SD: 4.1) were used in the cluster-average analysis — a **97% reduction in features**!

Exploratory analysis + results

In addition the global scale, we investigated whether we could also decode accurately within **local ROIs** - we indeed could in 62 (out of 110) ROIs!



Discussion & Conclusion

- High-level information can be decoded from **brain-wide networks** consisting of spatially-segregated clusters;
- In addition to global representations, high-level information may be simulateously represented in local patches of cortex.
- This provides interesting opportunities to analyses that combine these different types of information (e.g. **ensemble methods**)

This study suggests a **multiscale functional organization** in the brain; moreover, it provides an alternative to voxel-based MVPA methods that allows for analysis of whole-brain representations. As the outlined cluster-based MVPA method **greatly lowers the data's dimensionality**, it opens up possibilities for the application of more sophisticated machine learning algorithms to fMRI data.

1. **Hanyes** (2015). *Neuron*, *87*(2): 257-270. 2. **Barret & Satpute** (2013). *Current Opinion in Neurobiology, 23*(3): 361-372. 3. **Oosterwijk, Snoek, Rotteveel, Barrett, & Scholte**. (submitted). Shared States: Using MVPA to explore the neural overlap between self-focused emotional imagery and other-focused emotional understanding