

Exploring variability patterns across fMRI statistic maps

Elodie Germani¹, Elisa Fromont^{2*}, Camille Maumet^{1*}

¹ Univ Rennes, Inria, CNRS, Inserm, Rennes, France

² Univ Rennes, IUF, Inria, CNRS, IRISA, Rennes, France

* Joint senior authorship

Introduction

- Neuroimaging workflows are **highly flexible** with many possible choices at each step of an analysis (Carp 2012).
- Different analytical choices can cause **variation in the results** (Botvinik-Nezer et al. 2020).
- Exploring the **pipeline space** is essential to **understand the relationships** between results and to **guide researchers** with good practices.

→ Identifying groups of pipelines that provide similar results.

→ Assessing the stability of these groups in different contexts.

Materials & Methods

HCP many pipelines dataset

- The **Human Connectome Project** (Van Essen et al. 2013): **1080 participants** with **MOTOR** task fMRI data, with **6 base contrasts** to study.

- Pipelines constrained on **specific parameters**:

Software package
SPM or FSL

Smoothing kernel
FWHM 5 or 8 mm

Motion regressors
0, 6 or 24

HRF derivatives
Included (1) or not (0)

→ **24 different pipelines**

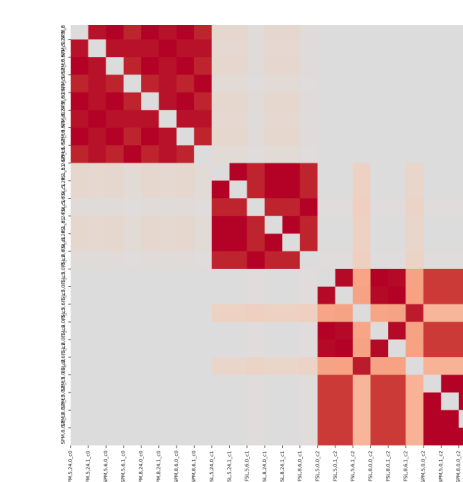
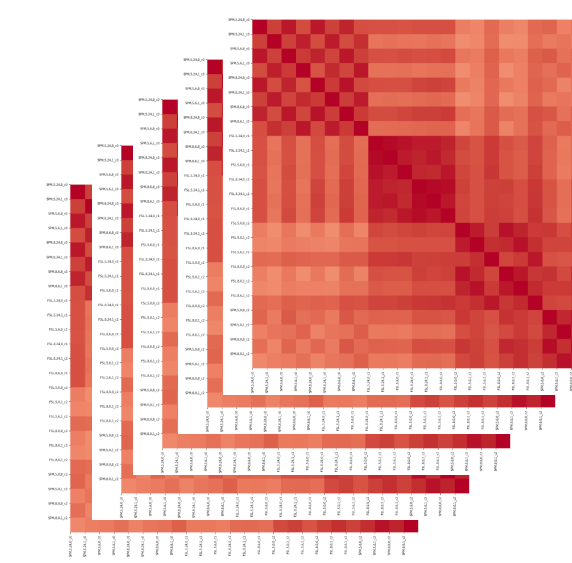
- **1000 groups** of **50** randomly sampled participants.

Code available at:

https://gitlab.inria.fr/egermani/hcp_pipelines

Louvain method for community detection

Extraction of communities from large networks based on the optimization of modularity (Blondel et al. 2008).



1. Correlation matrices between **maps of different pipelines** for each group.
2. Reorganize **each group matrix** with Louvain communities.
3. Global matrix of pipelines with **occurrence of belonging to the same partition** across all groups.
4. Reorganize **global matrix** with Louvain communities.

→ Matrix and graph organized based on similarity of pipelines statistic maps across different groups.

SAME DATA, DIFFERENT PIPELINES

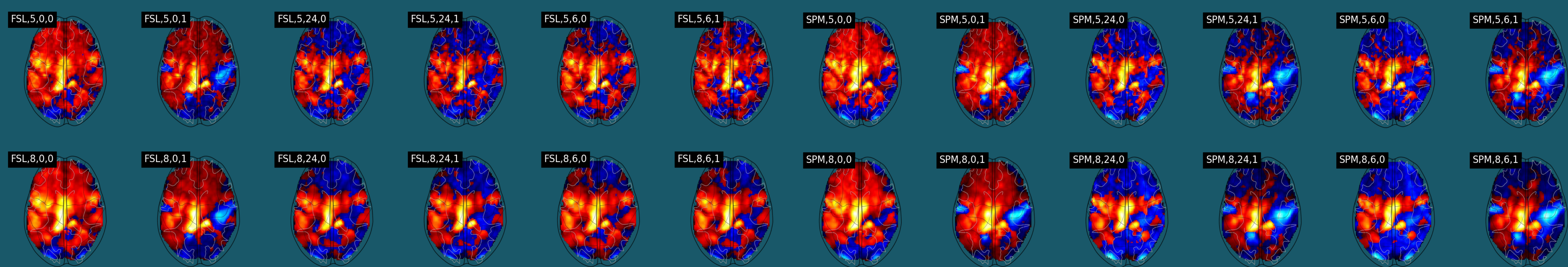


Fig1. Group-level statistic maps (N=50) obtained with 24 different pipelines for the contrast right-hand. Pipelines are named as followed: Software, Smoothing kernel, Motion regressors, HRF derivatives.

Results

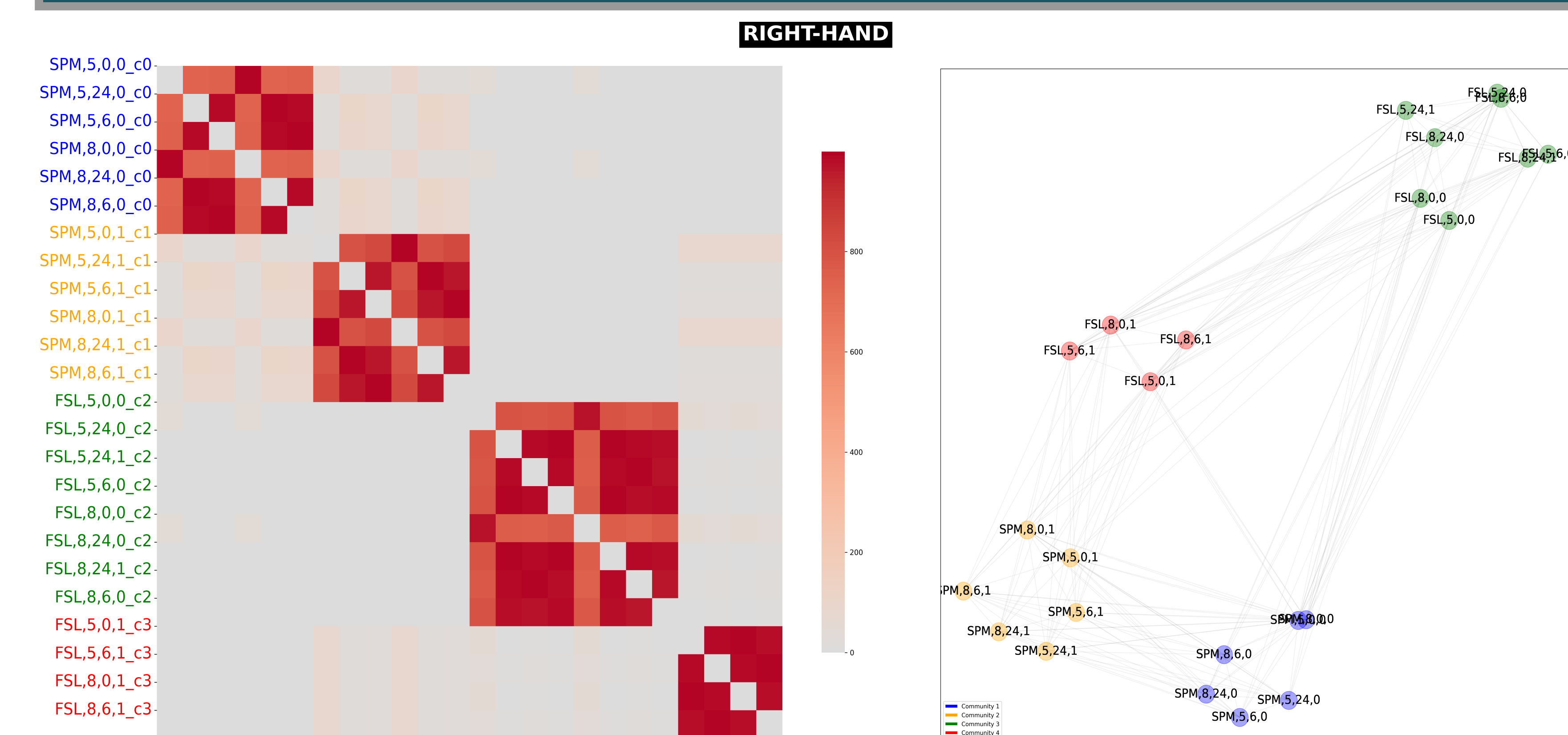


Fig2. Louvain matrix and graph representing the number of times pipelines belong to the same community for pipelines across different group-level statistic maps of the contrast right hand.

- ✓ **Stability of communities of pipelines across different groups of participants.**
- ✓ **Pipelines grouped with those sharing specific parameters:** same pipelines, **different smoothing** → same community
- ✓ **Global activation patterns** are consistent between communities.
- ✓ **Small differences** regarding the extent of the activation area.
- ✓ **Similar number and groups of pipelines in communities for right hand and left hand: robustness to the global contrast.**
- ✓ **Communities are different for the contrast right foot.**

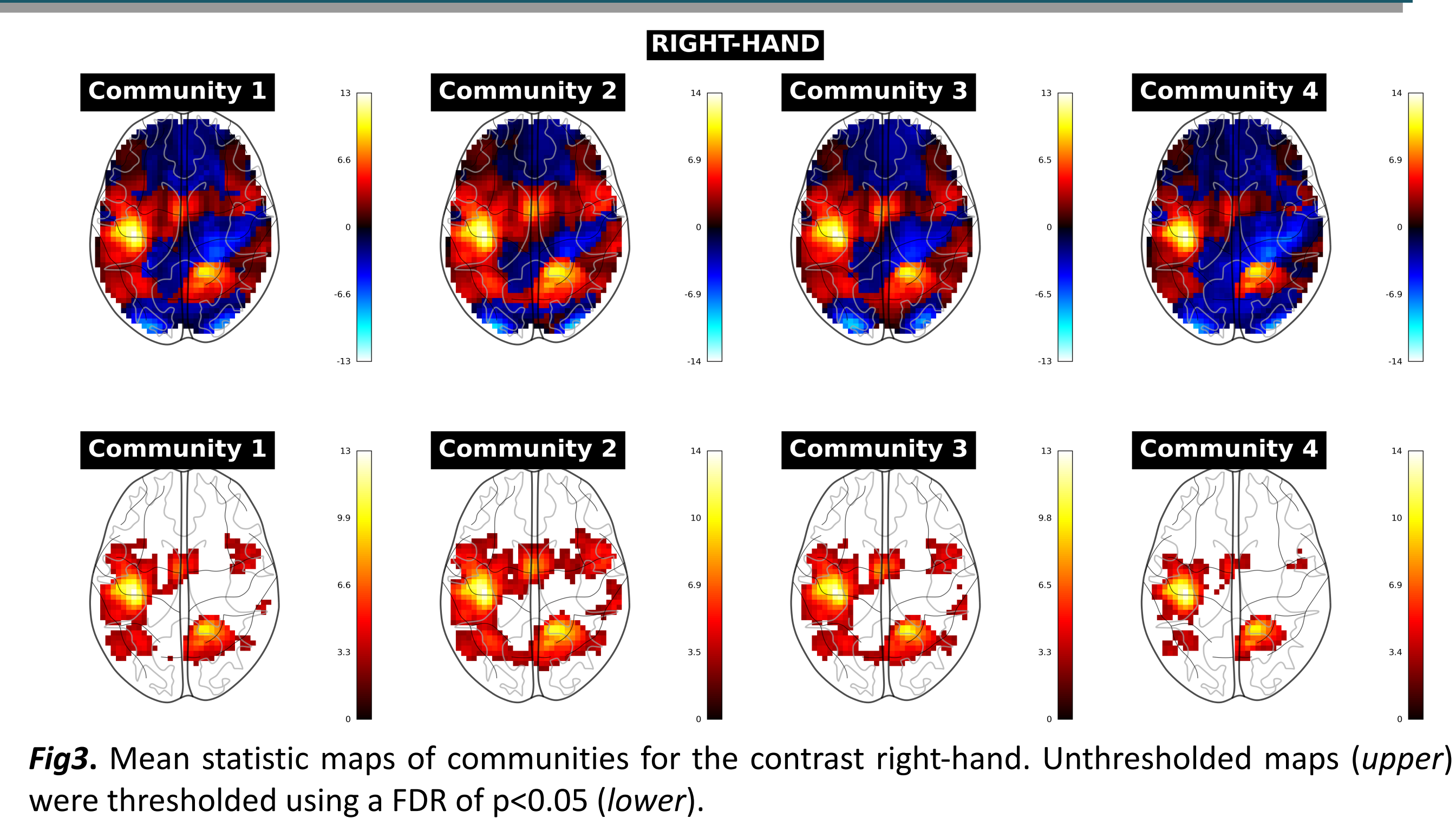


Fig3. Mean statistic maps of communities for the contrast right-hand. Unthresholded maps (upper) were thresholded using a FDR of $p < 0.05$ (lower).

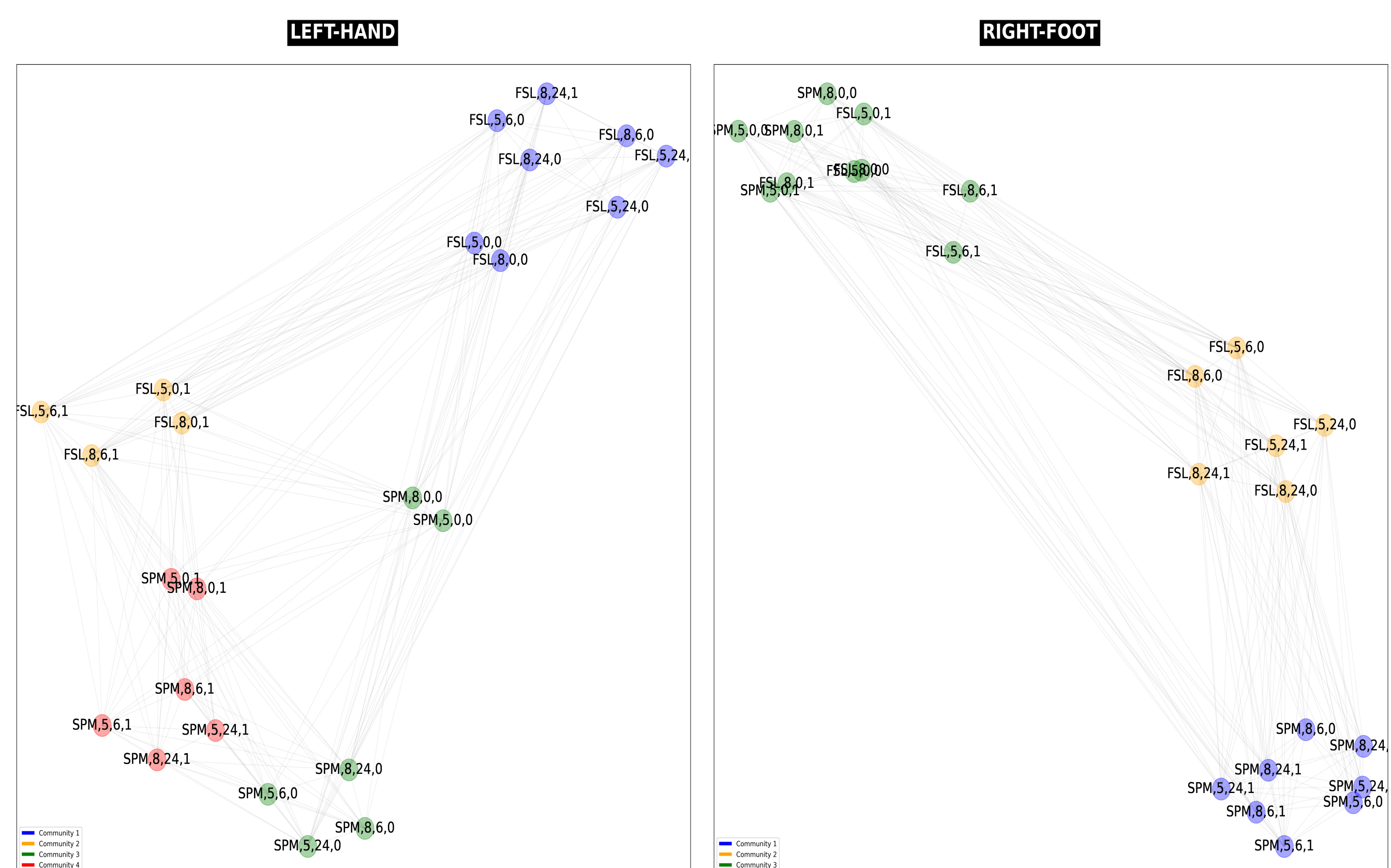


Fig4. Louvain graphs representing number of times pipelines belong to the same community across different group-level statistic maps for the contrasts right foot (right) and left hand (left).

Conclusion

Pipelines have **different behaviors depending on contrasts**, probably due to specific properties of the data. Further work will be needed in order to determine **specific patterns of the communities**, understand **why some pipelines behave differently** and how to use these patterns to **tackle analytical variability** with, for instance, style transfer techniques.

References

Botvinik-Nezer, R. et al. 2020. « Variability in the analysis of a single neuroimaging dataset by many teams ». Nature.
Carp, J. 2012. « On the Plurality of (Methodological) Worlds: Estimating the Analytic Flexibility of fMRI Experiments ». Frontiers in Neuroscience.

Van Essen, D. C., for the WU-Minn HCP Consortium. (2013). « The WU-Minn Human Connectome Project: An overview ». NeuroImage.
Blondel, V. et al, 2008. « Fast unfolding of communities in large networks », Journal of Statistical Mechanics: Theory and Experiment, vol. 2008, no 10.

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