InterTVA: a multimodal MRI study of individual differences in voice identification.

Data analysis and sharing strategies. Ongoing and future projects.

Sylvain Takerkart, Bastien Cagna
Virginia Aglieri, Pascal Belin

Institut de Neurosciences de la Timone (UMR 7289)

20/12/2018 RMN Centre IRMf

Outline

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Context

- work anchored in two teams and one core facility @ INT:

- Methods and Computational Anatomy
  MECA, O. Coulon
- Neural Bases of Communication
  BANCO, P. Belin
- Neuroinformatics and Information Technology
  NIT, S. Takerkart, O. Coulon

- ...and a long-lasting collaboration with the machine learning team, QARMA @ LIS

Inter-individual differences: brain shape

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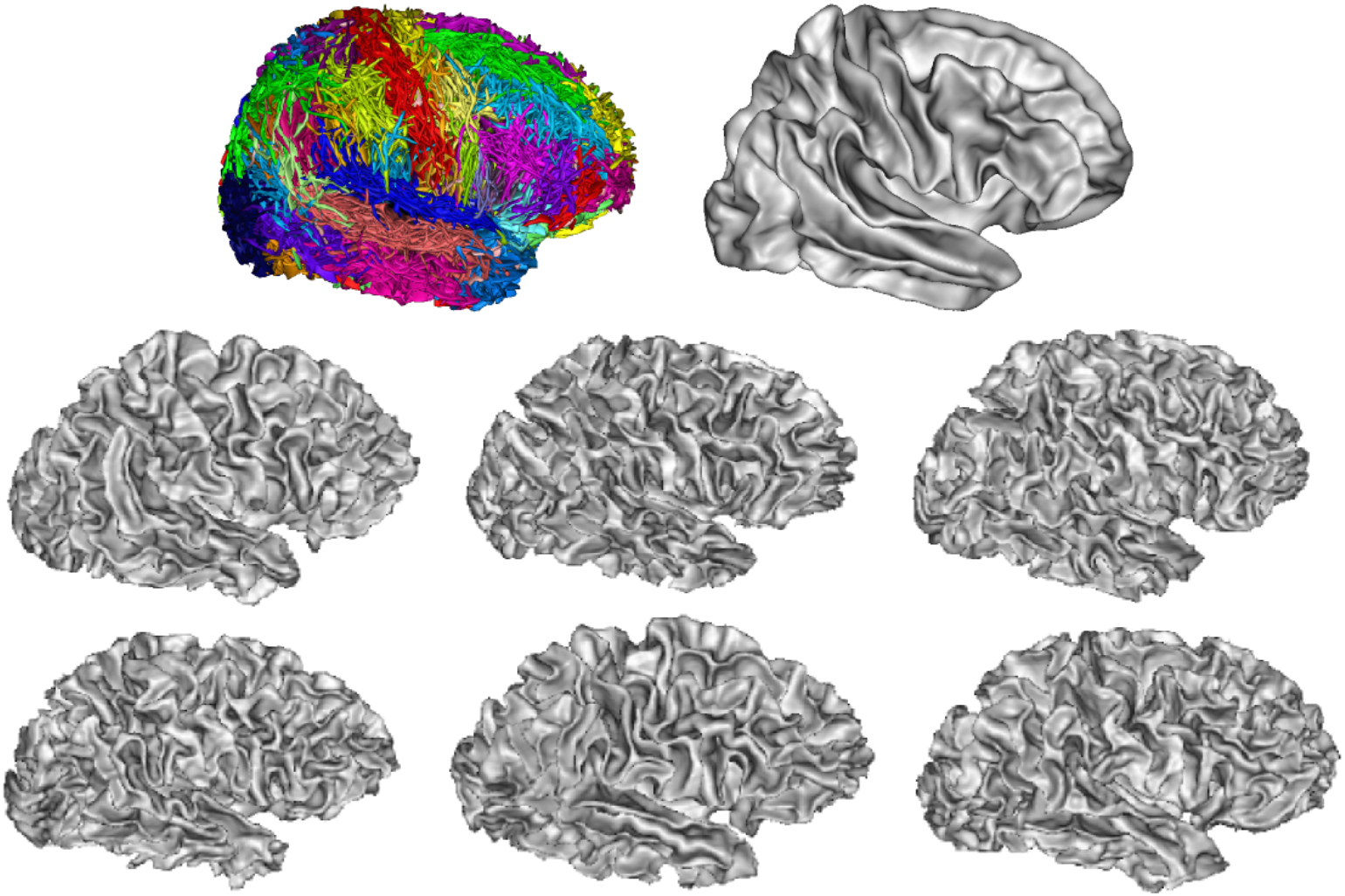
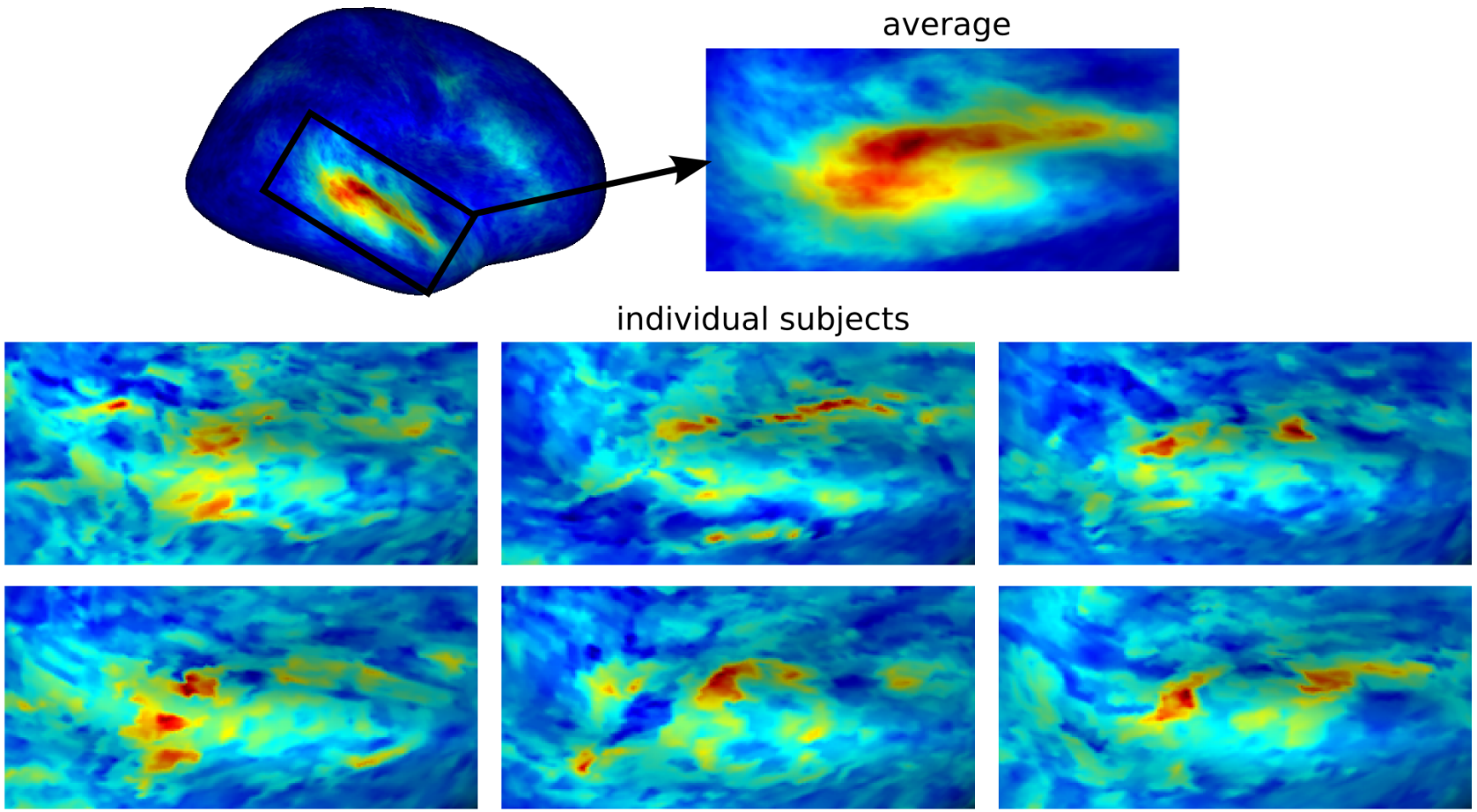


Inter-individual differences: brain activity



Functional variability...

- signal or noise?

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- should we ignore it? try to overcome it? to understand it?

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- signal or noise?
- should we ignore it? try to overcome it? to understand it?
- our objectives:
  - overcoming variability (with better models)
  - characterizing variability (with other modalities)
  - understanding the links with behavior (with new methods)

InterTVA

- acquisition funded by a machine-learning ANR project

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- multi-modal data set!
- neuroscience: neural substrate of speaker identification
- machine learning: multi-modal machine learning

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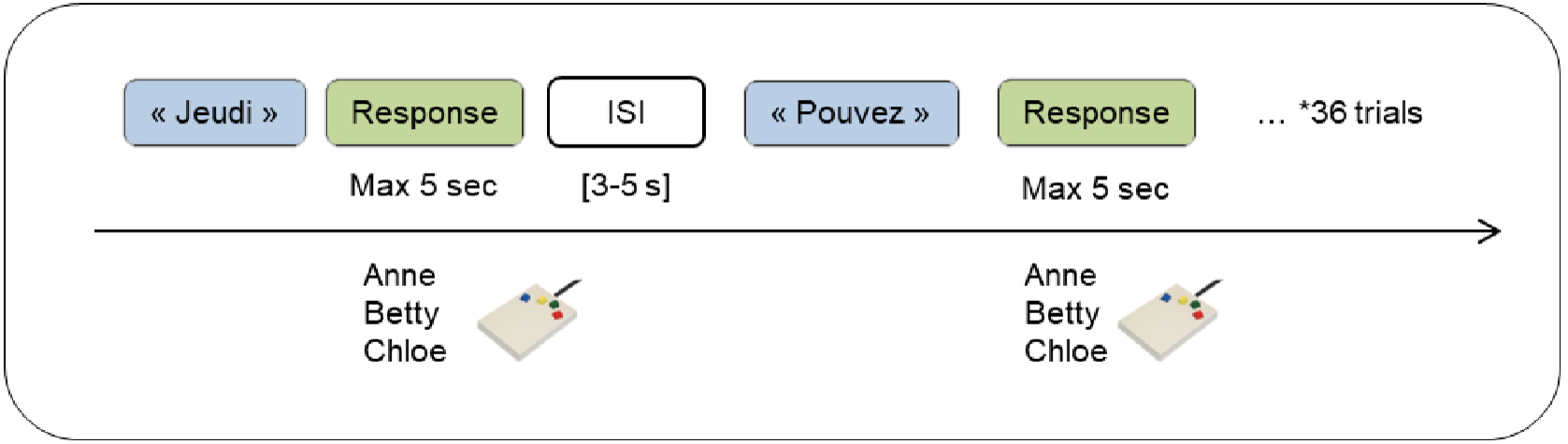
Content

- hi-res anatomy (T1, T2)
- hi-quality diffusion MRI
- resting state
- fMRI: event-related voice localizer (1 run)
- fMRI: speaker identification (4 runs)
- fMRI: voice calibrator (1 run)
- fMRI: natural conversation (1 run)

- HCP-like acquisitions
- 1h45 of scanning, with a pause in the middle

Speaker identification task

Virginia Aglieri's PhD thesis



Connectivity scans

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- connectivity allows predicting differences in activation patterns

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- Tavor, Smith, and Jbabdi (2016). Task-free MRI predicts individual differences in brain activity during task performance. Science 352, 213-216.

- Saygin, Z.M., Osher, D.E., Koldewyn, K., Reynolds, G., Gabrieli, J.D.E., and Saxe, R.R. (2011). Anatomical connectivity patterns predict face selectivity in the fusiform gyrus. Nature Neuroscience 15, 321-327.

Functional localizer and beyond

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- ...towards function-based alignment

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- ...towards function-based alignment

- Hyper-alignment: Haxby, J.V., Guntupalli, J.S., Connolly, A.C., Halchenko, Y.O., Conroy, B.R., Gobbini, M.I., Hanke, M., and Ramadge, P.J. (2011). A Common, High-Dimensional Model of the Representational Space in Human Ventral Temporal Cortex. Neuron 72, 404-416.

- Nenning, K.-H., Liu, H., Ghosh, S.S., Sabuncu, M.R., Schwartz, E., and Langs, G. (2017). Diffeomorphic functional brain surface alignment: Functional demons. NeuroImage.

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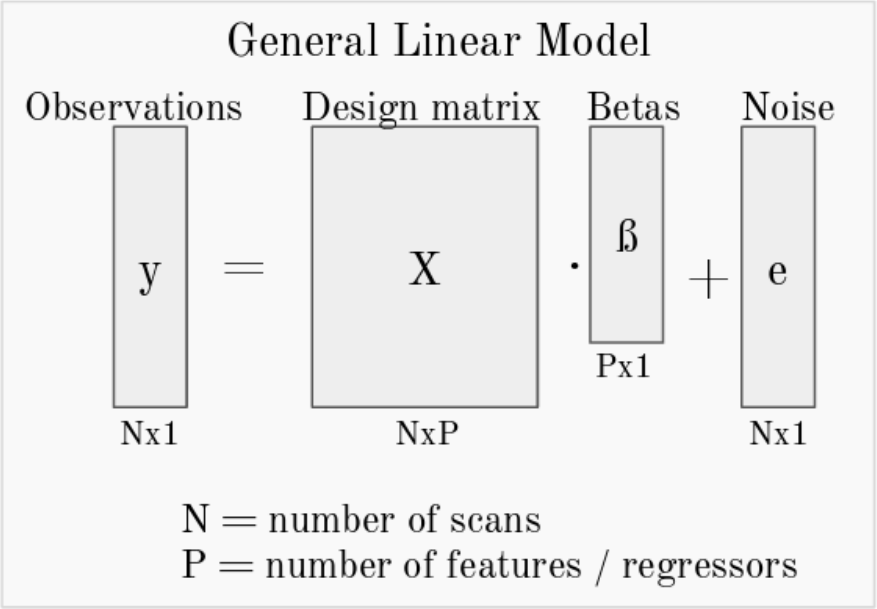
Design Efficiency

- Henson R.N. (2015) Design Efficiency. In: Arthur W. Toga, editor. Brain Mapping: An Encyclopedic Reference, vol. 1, pp. 489-494. Academic Press : Elsevier

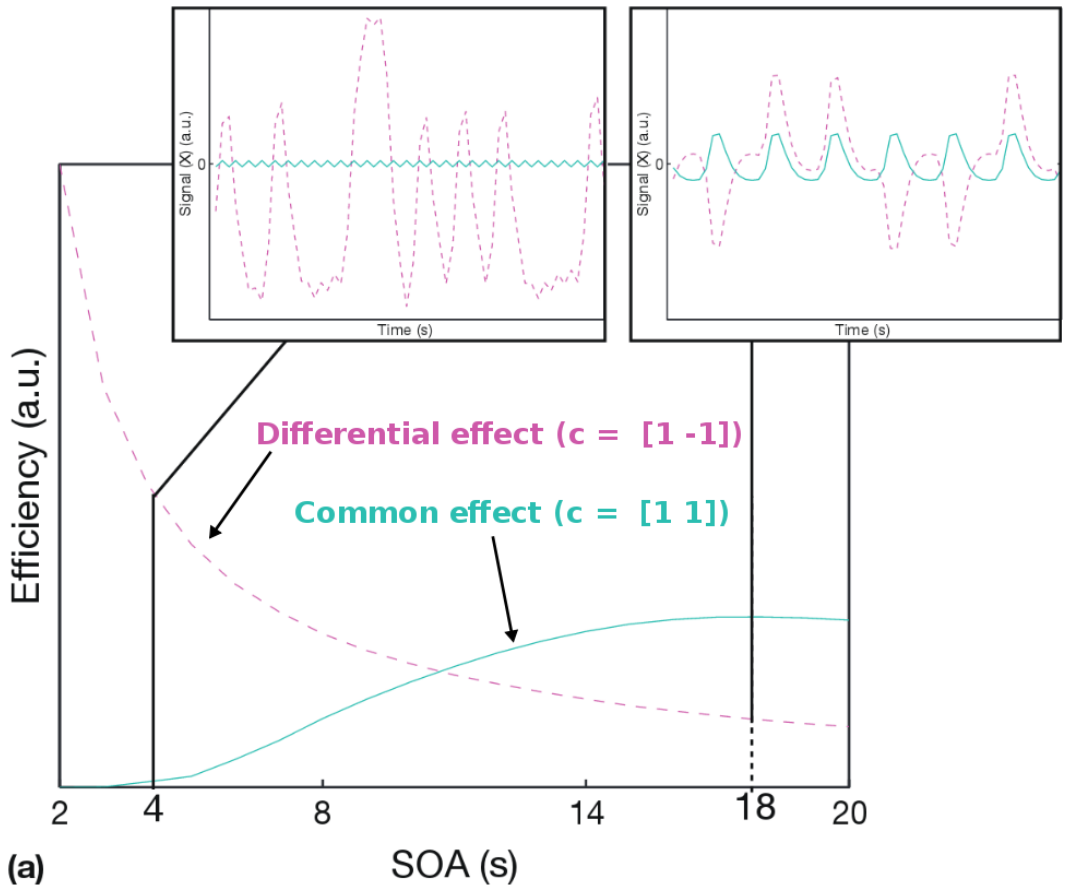
- Review of papers from Bucaras, Chawla, Friston, Hagberg in 1999/2002

Definition of the design efficiency

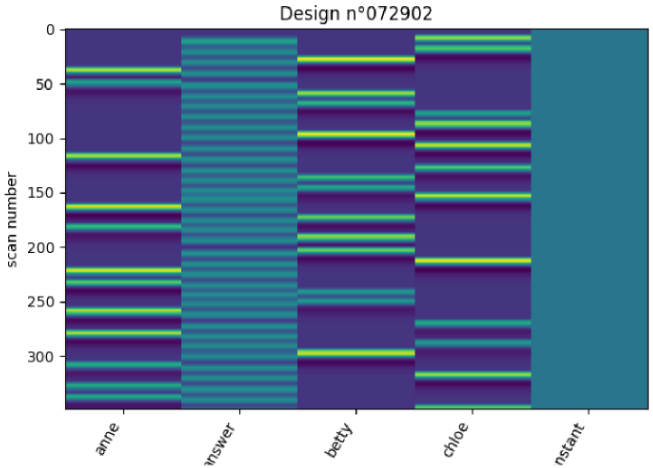


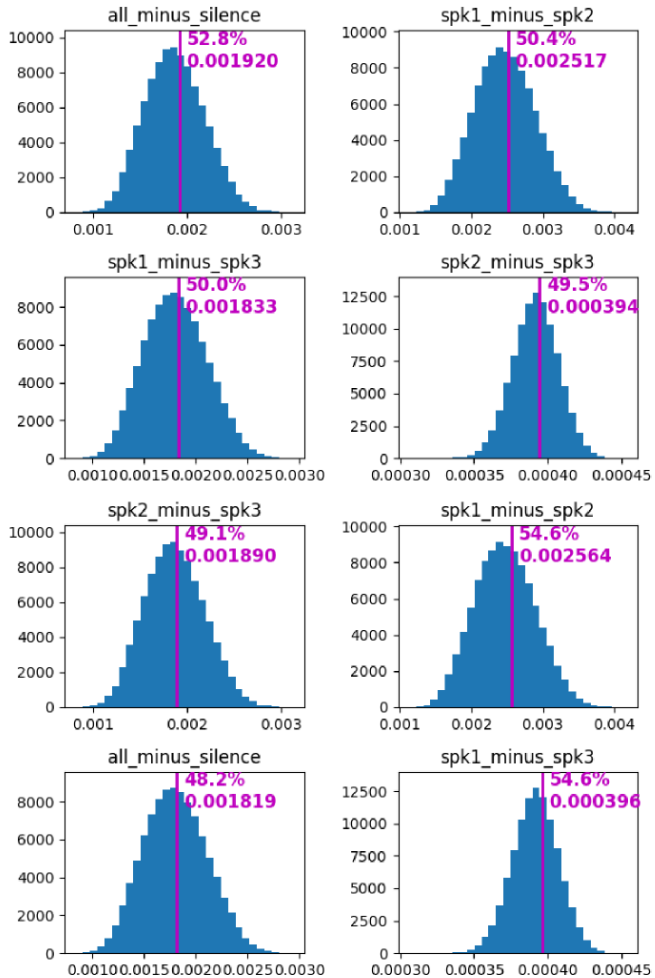
- T-statistic: $T(df) = \frac{c\beta}{\sqrt{c(X^T X)^{-1} c^T \sigma^2}}$
- Efficiency: $e = \frac{1}{(c(X^T X)^{-1} c^T)}$
- vary X

Choose the best Stimulus-Onset Asynchrony

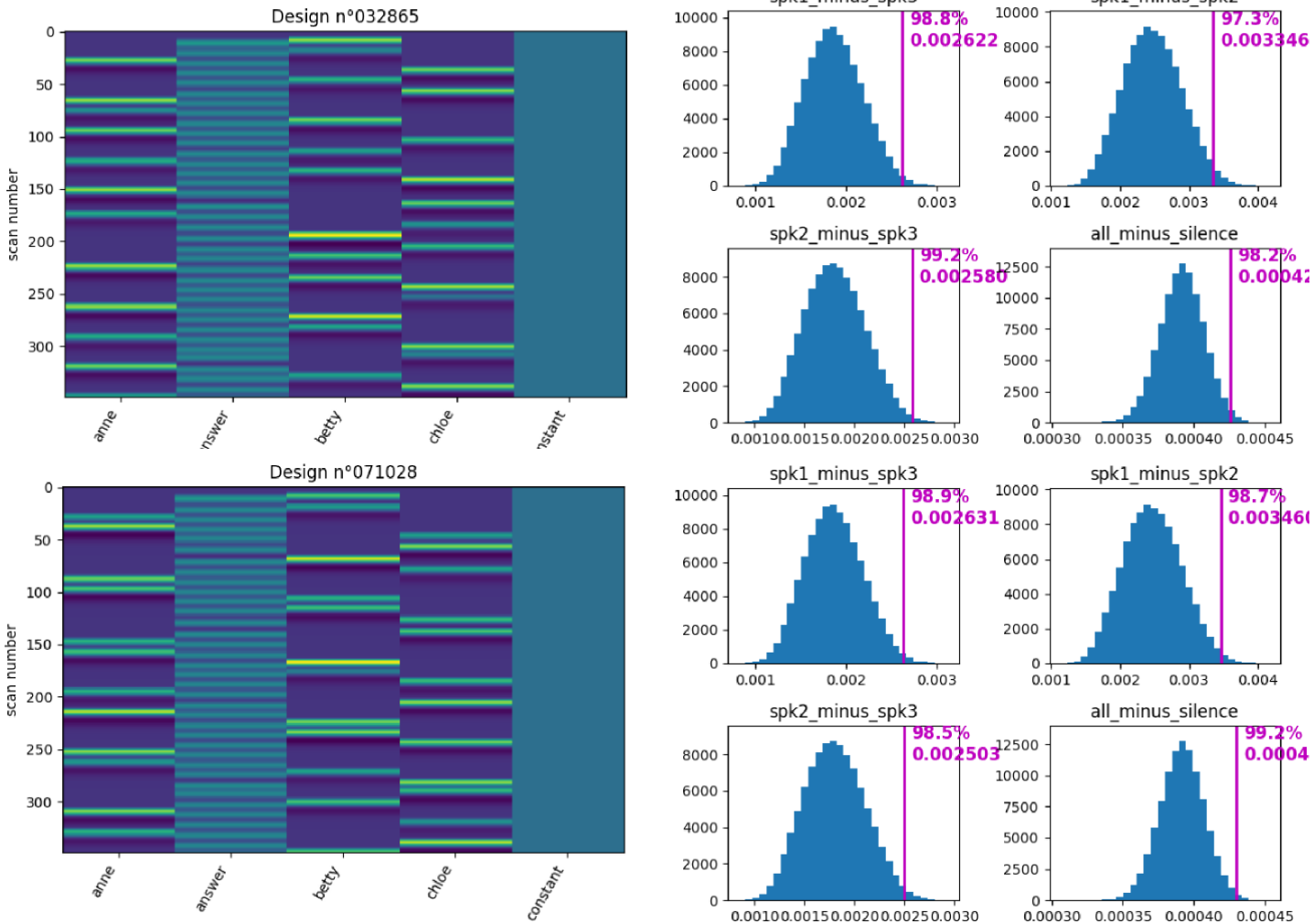


Find the perfect condition order





Find an optimal condition order



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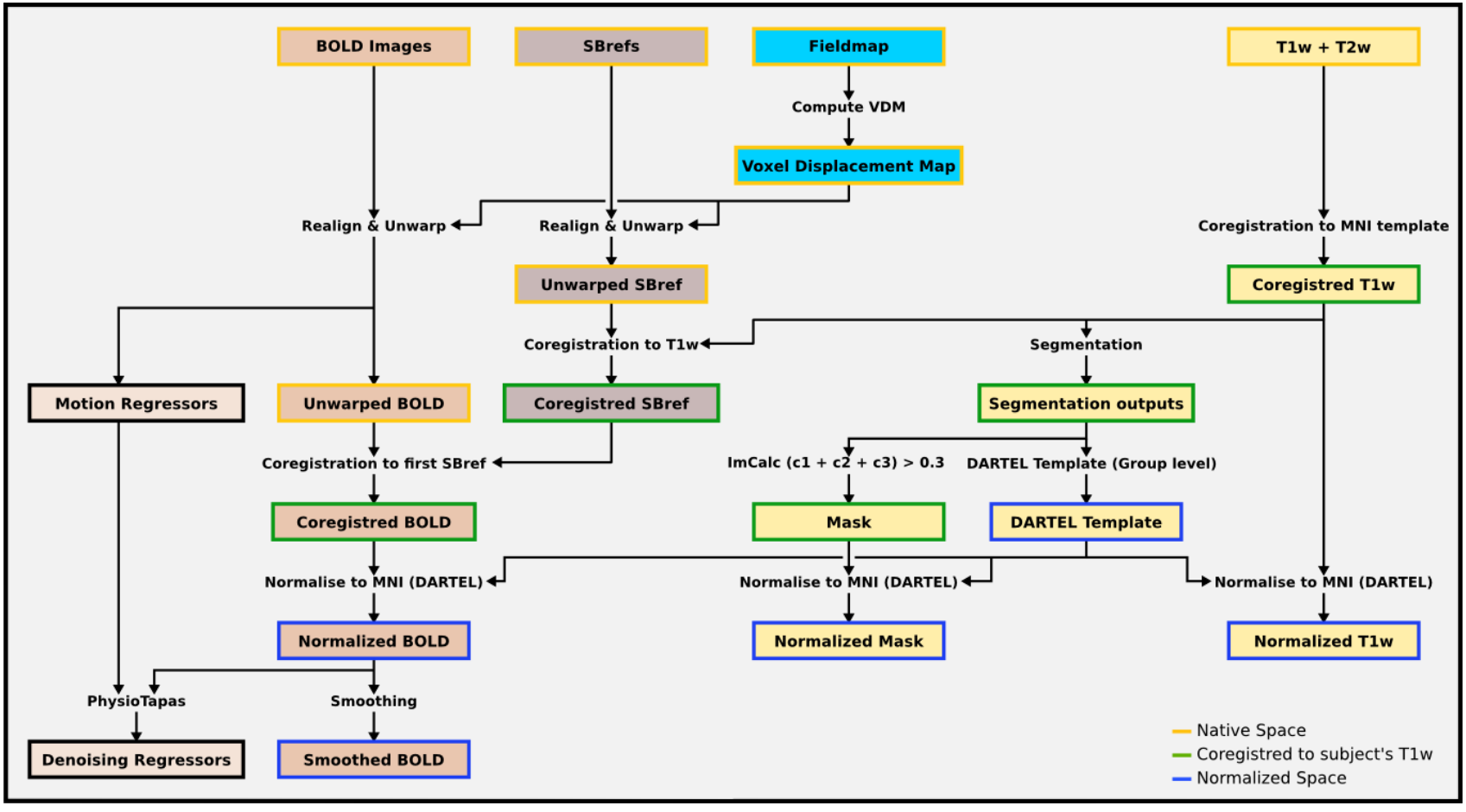
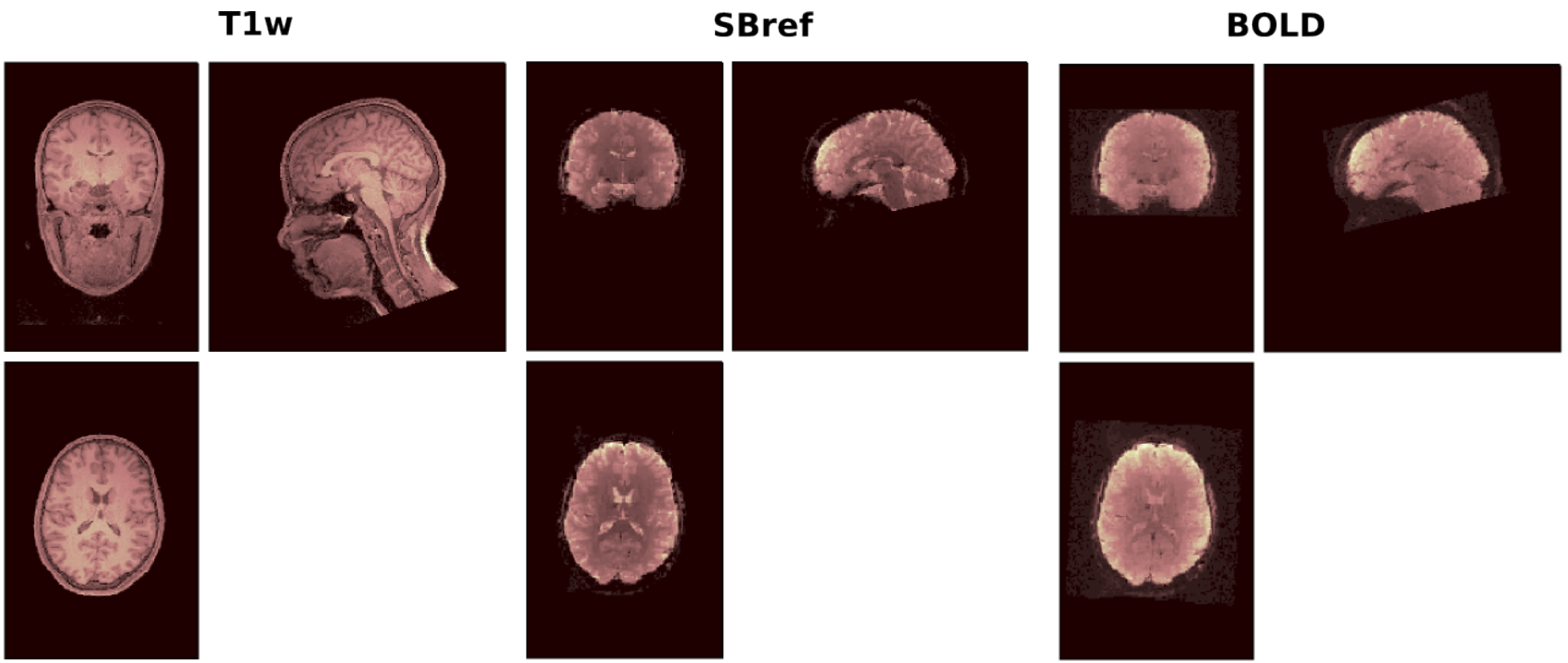
From raw to group normalized BOLD signal



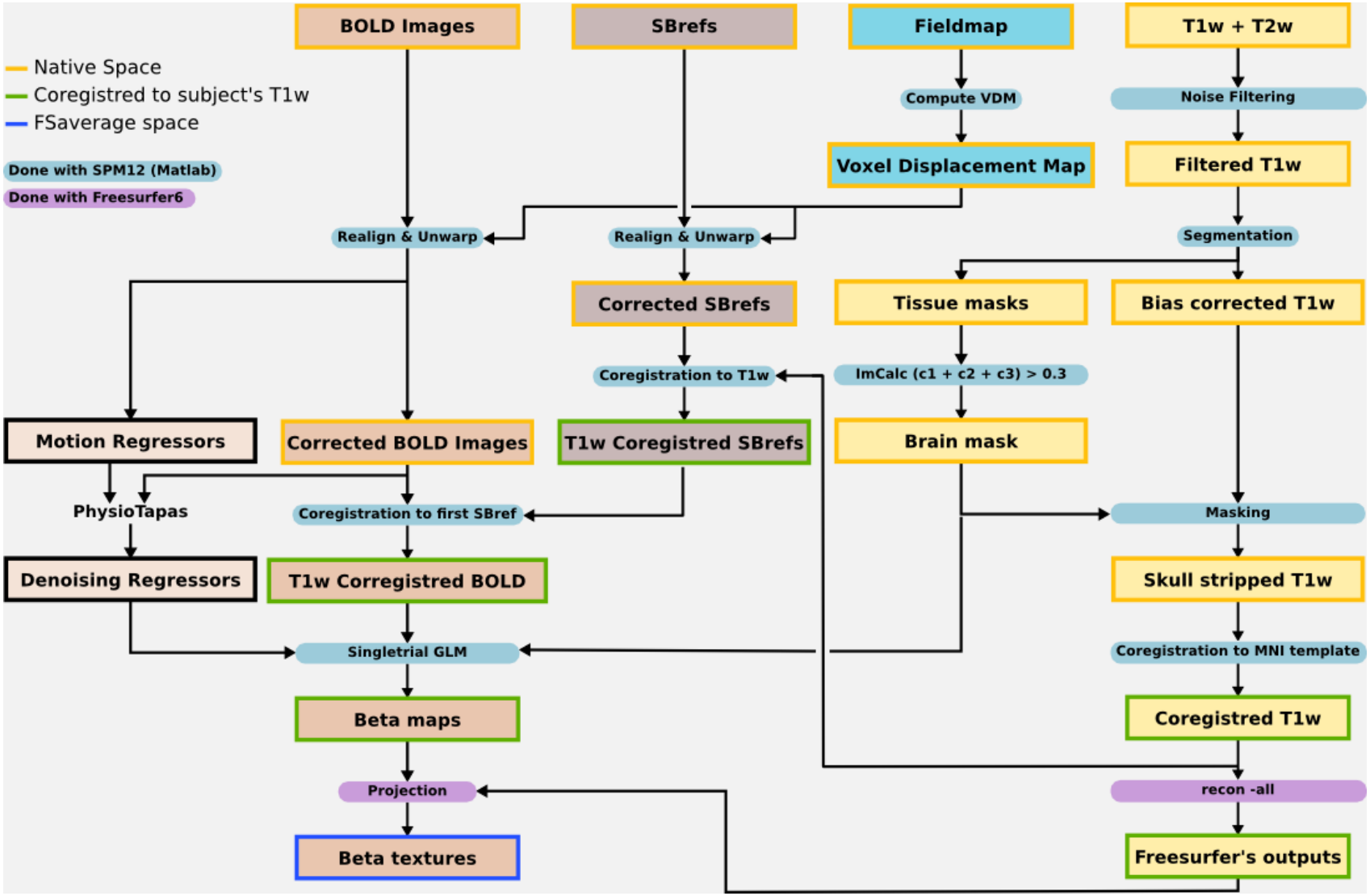
Coregistration through SBref



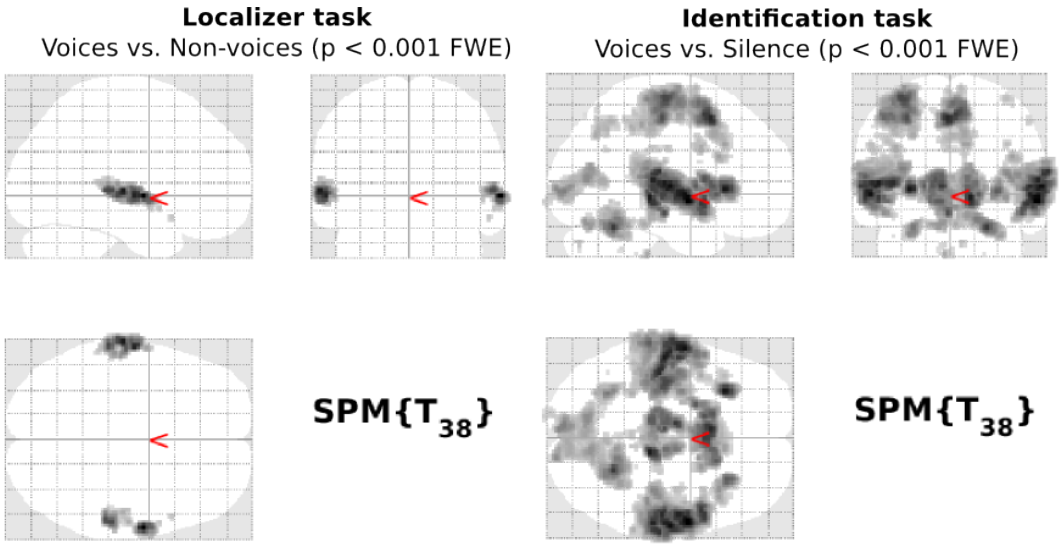
Noise regressors

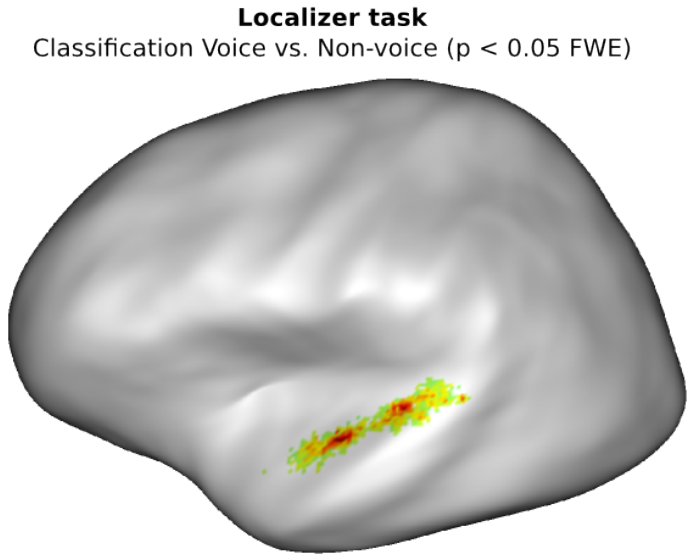
- Motion regressors
  - 6 motions regressors
- ROI PCA
  - 12 PCA components for white matter
  - 12 PCA components for CSF

Surfacic pre-processing



Are our MRI tasks activating something ?

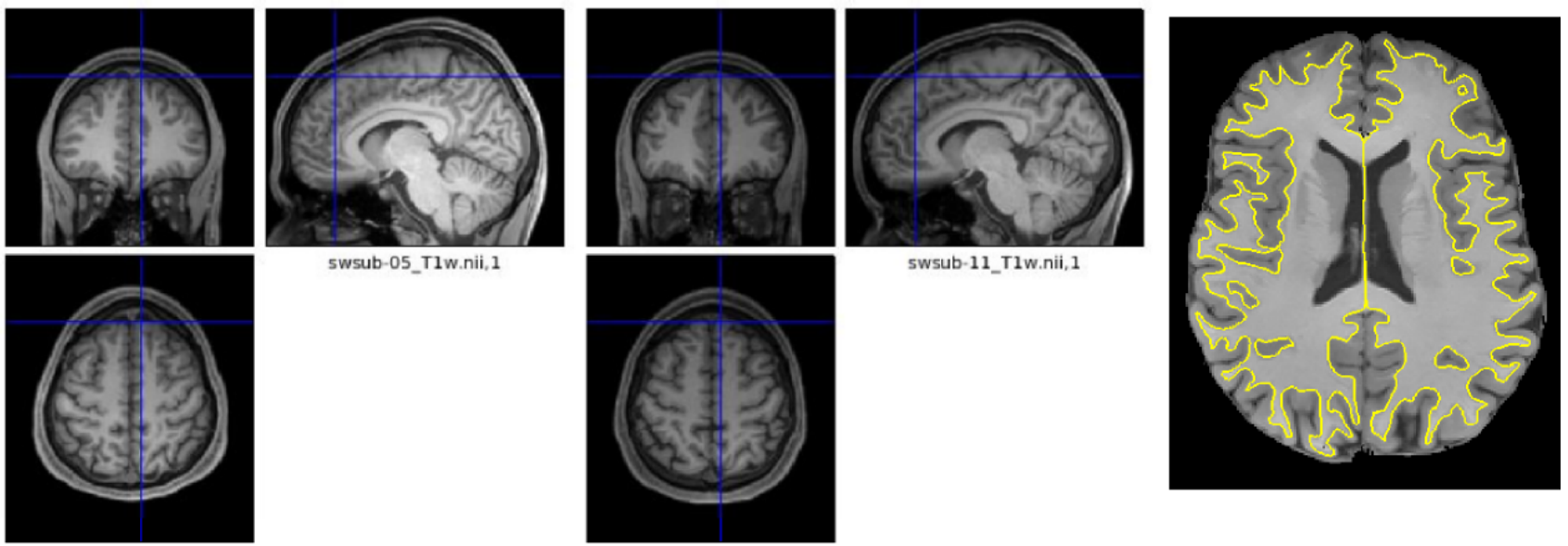




Outline

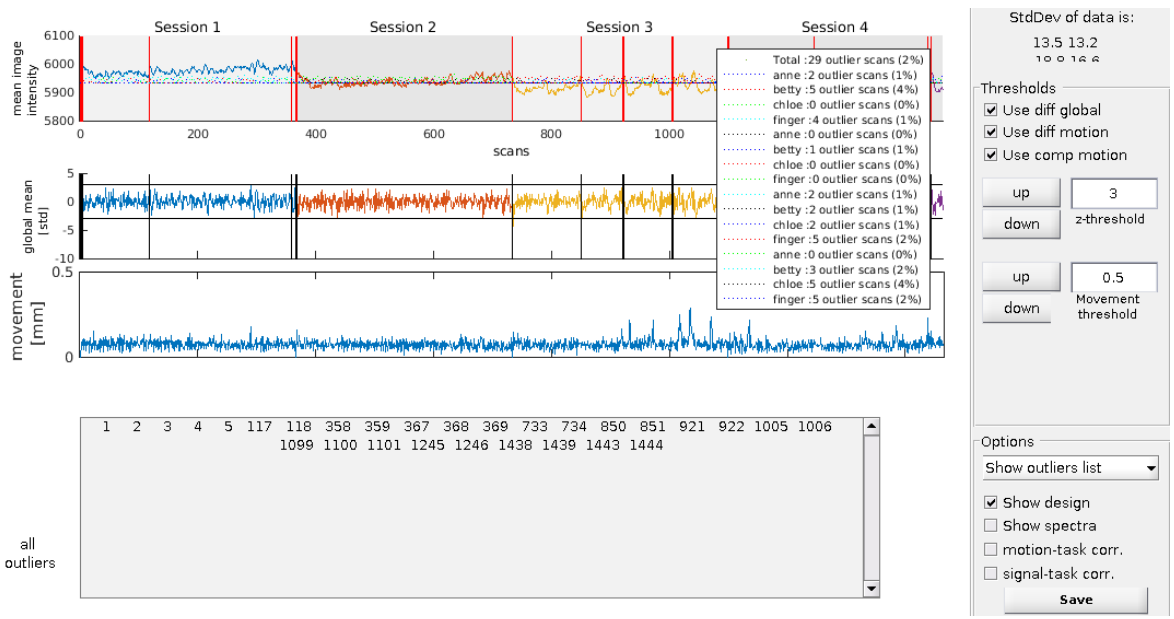
Quality check (1/3)

- Visual inspection
  - ~~HCP pipeline~~



Quality check (2/3)

- ART: movement and artifacts control
  - Motion threshold: 0.5mm
  - Global signal change threshold: 3std
  - Exclusion criteria: more than 20% volumes are outliers
  - Exclusion of 1 subject



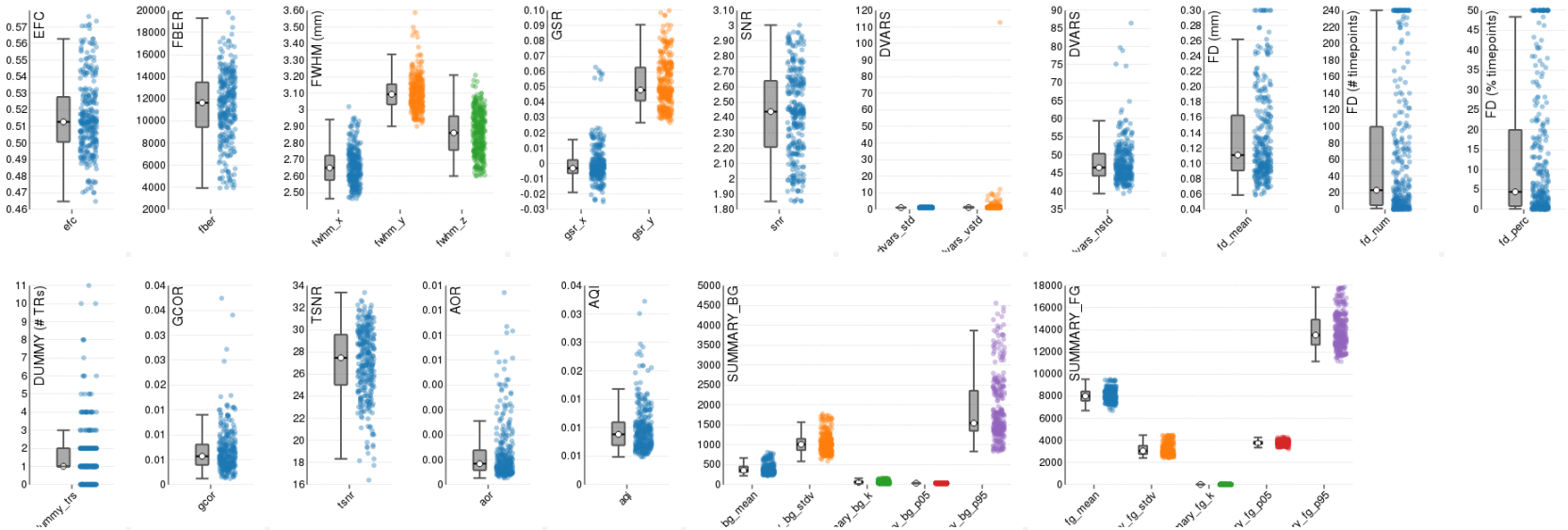
Quality check (3/3)

- MRIQC

MRIQC: group bold report

Summary

- Date and time: 2018-07-26, 07:01.
- MRIQC version: 0.10.4.



Outline

Sharing data on OpenNeuro

- Data of 40 subjects will be public soon (180 Go)
  - Anatomical: T1w + T2w
  - Voice Localizer
  - Voice Identification
  - Resting state
  - Diffusion
- Online BIDS Validator:
  `http://bids-standard.github.io/bids-validator/`
- Dataset descriptor article in preparation (Scientific Data)

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Graphical representations of brain patterns

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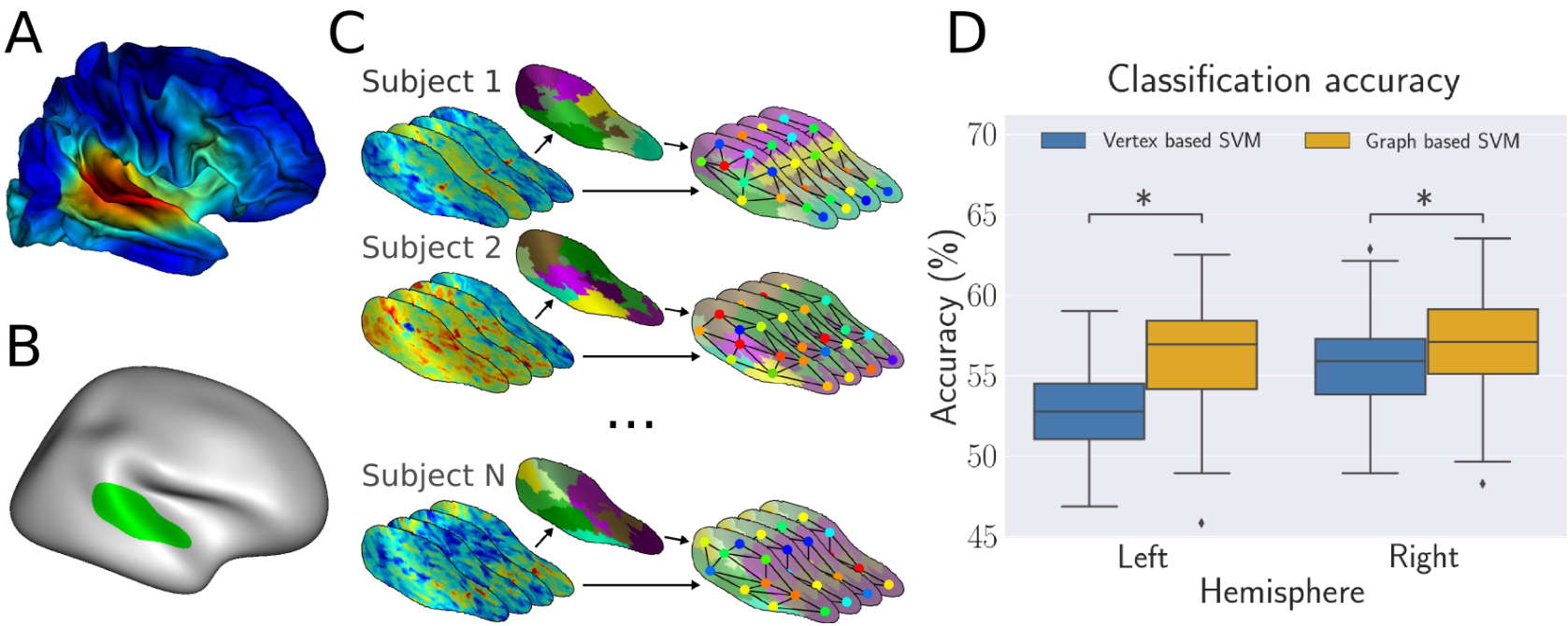

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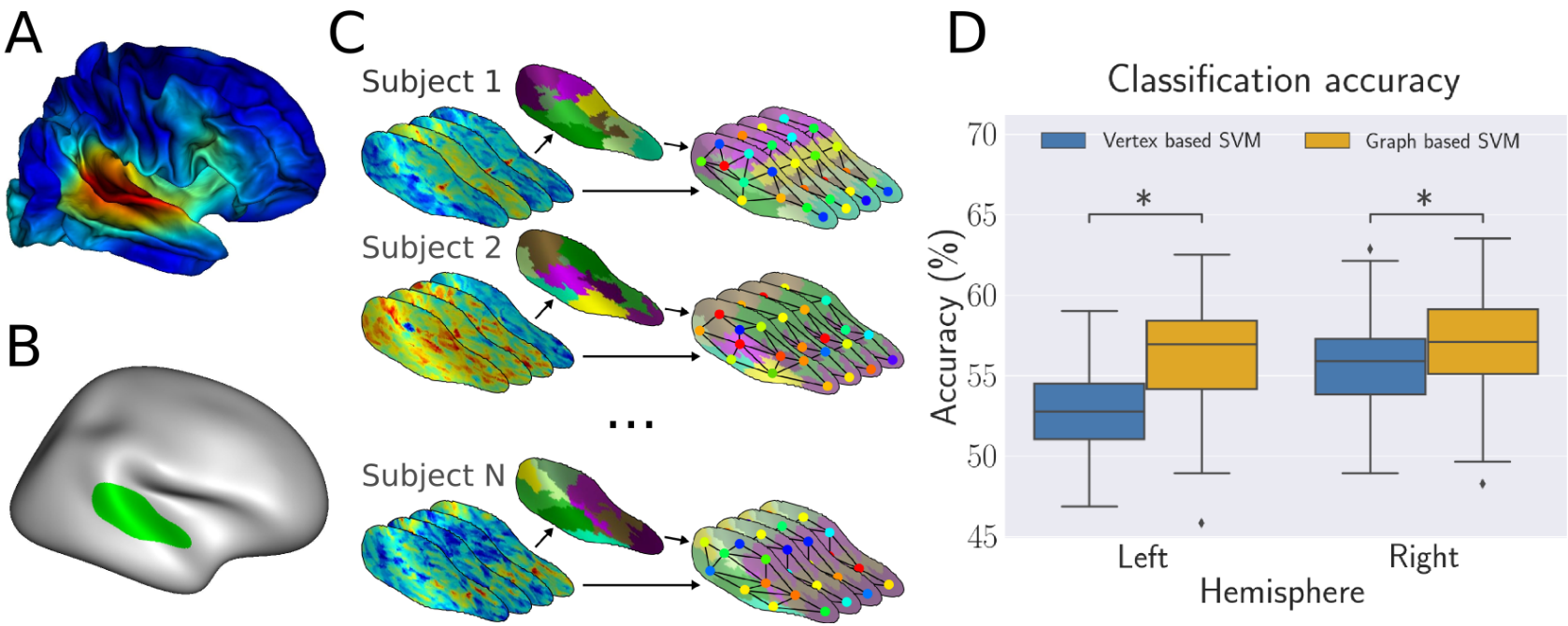

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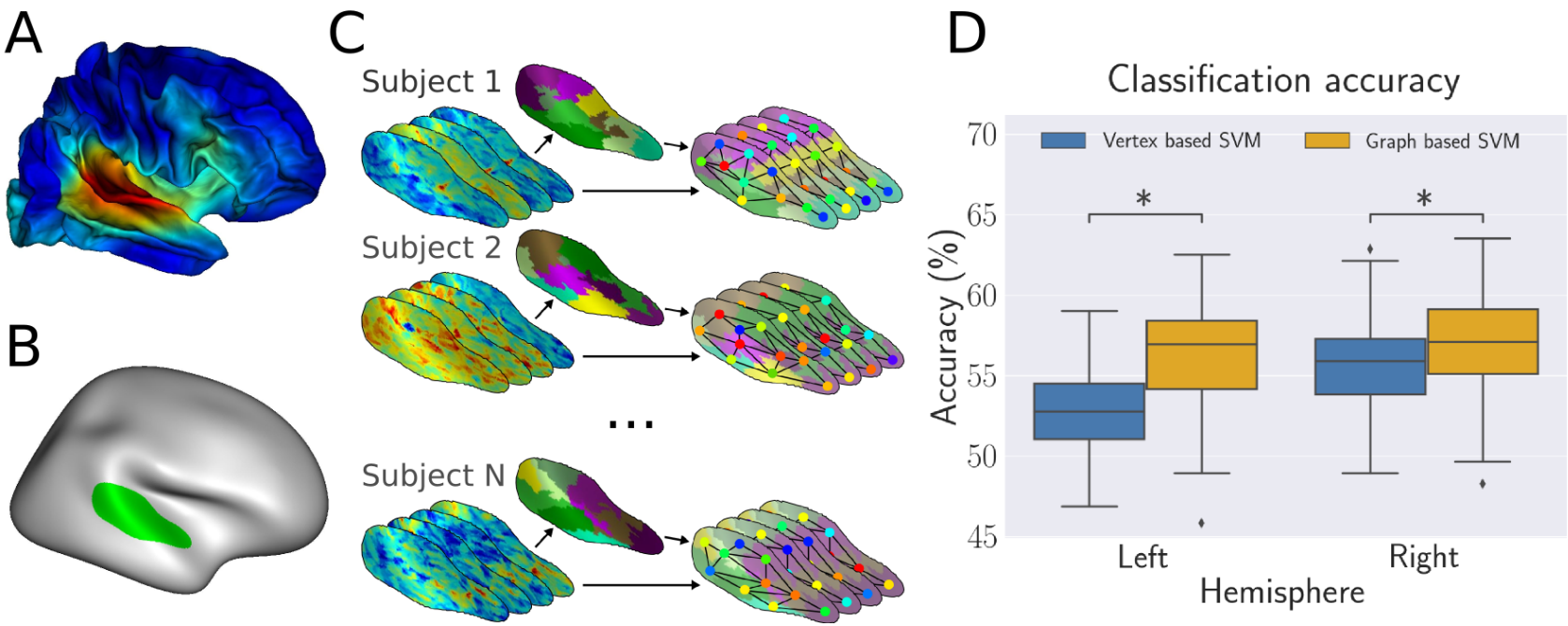
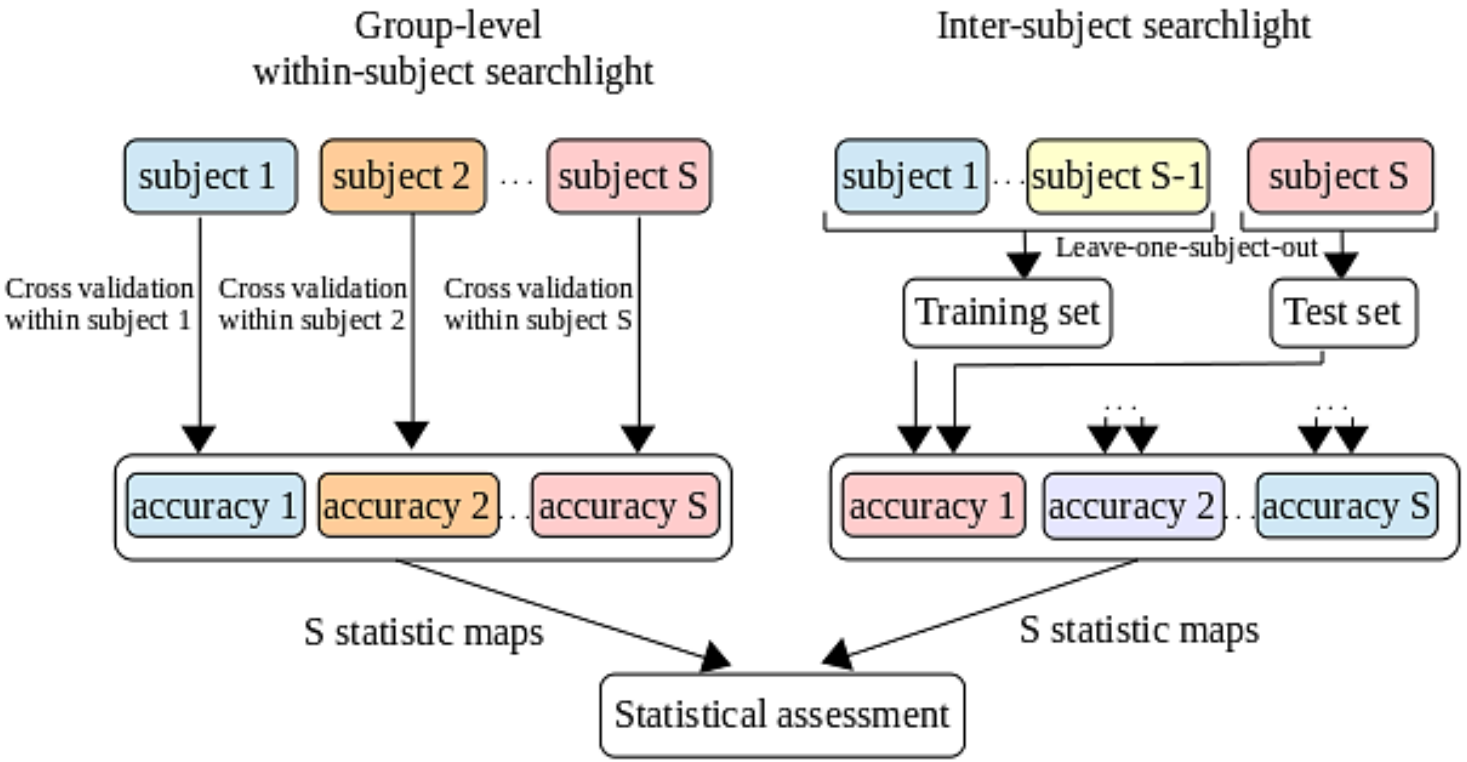


Takerkart et al, *PlosOne* 2014 (fMRI)
Takerkart et al, *Medical Image Analysis* 2017 (aMRI)
Takerkart et al, *Graph-based Representations* 2017 (dMRI)

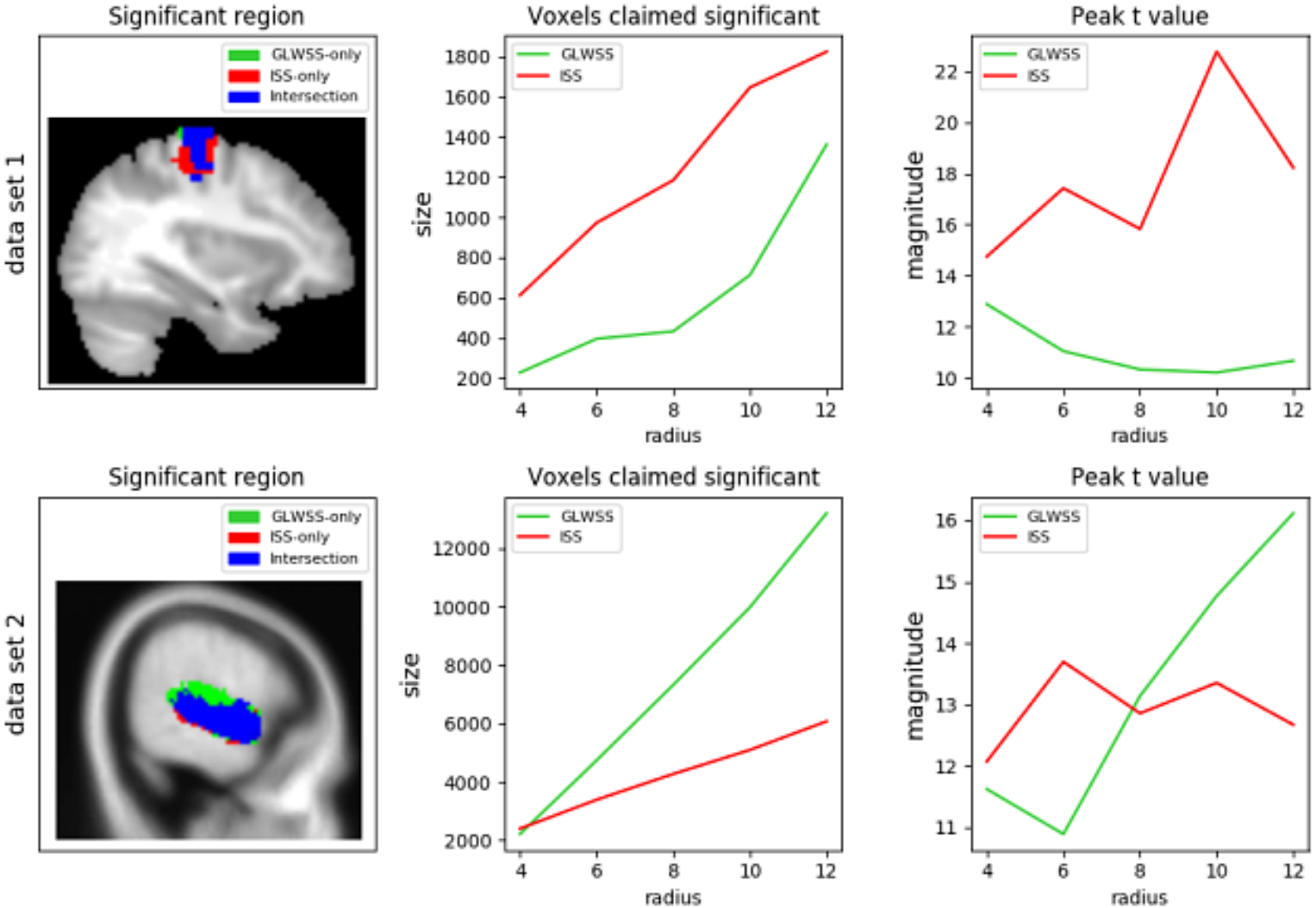
Outline

Within- vs. inter-subject learning

Qi Wang's PhD thesis (with LIS)



Group-level MVPA



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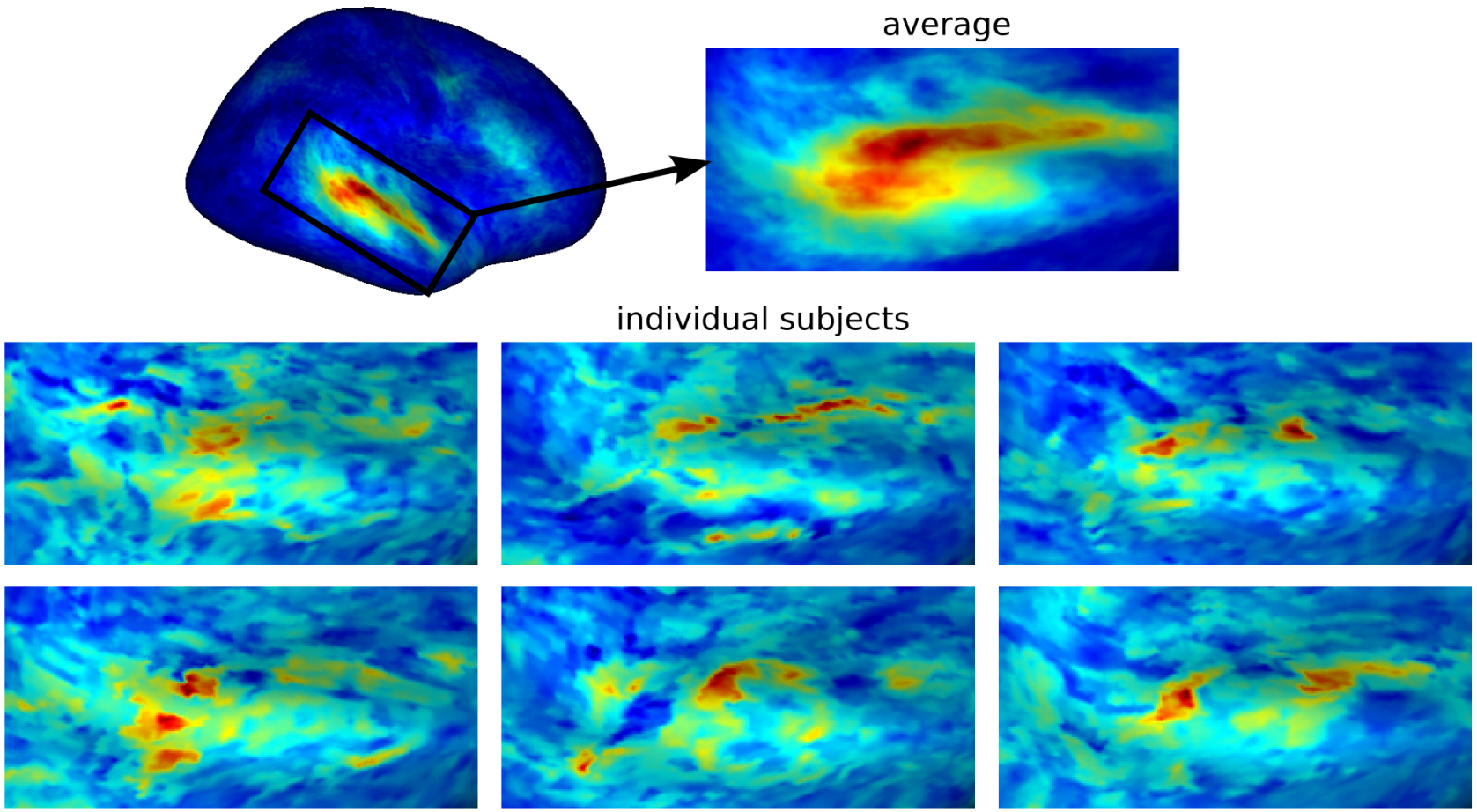
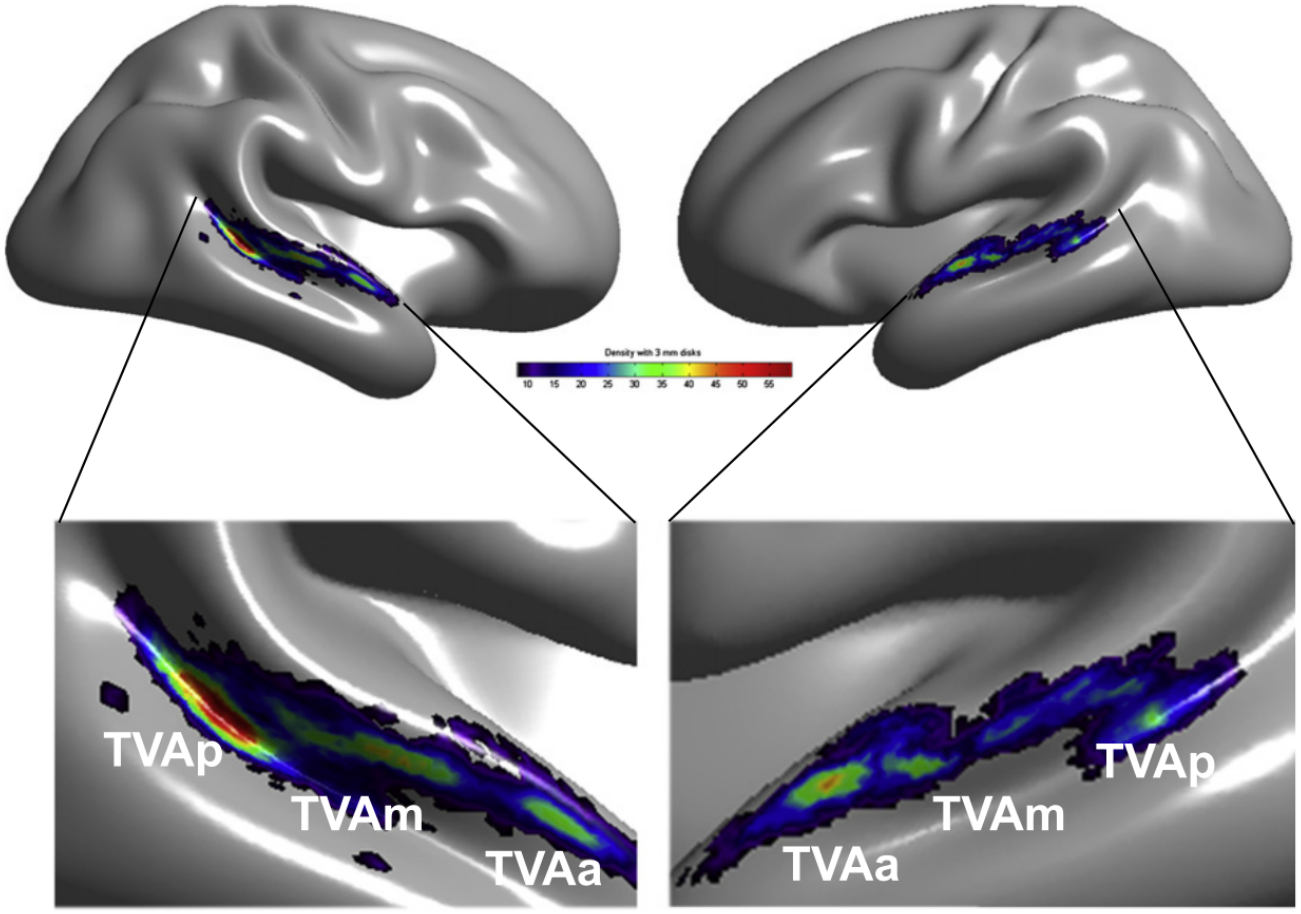
Variability in the temporal voice areas

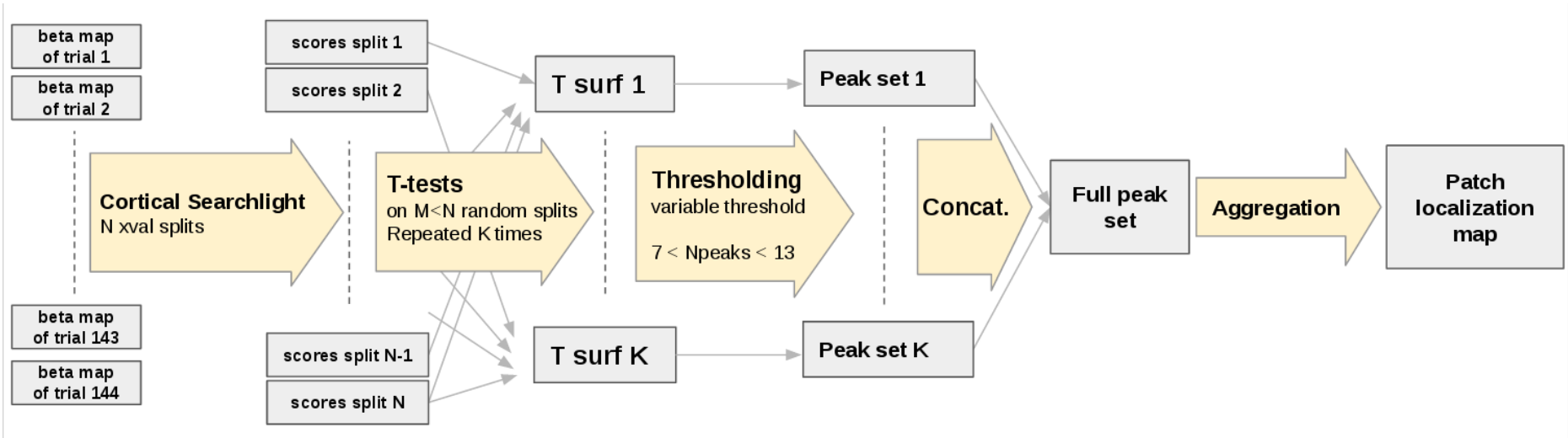


Towards voice patches in humans

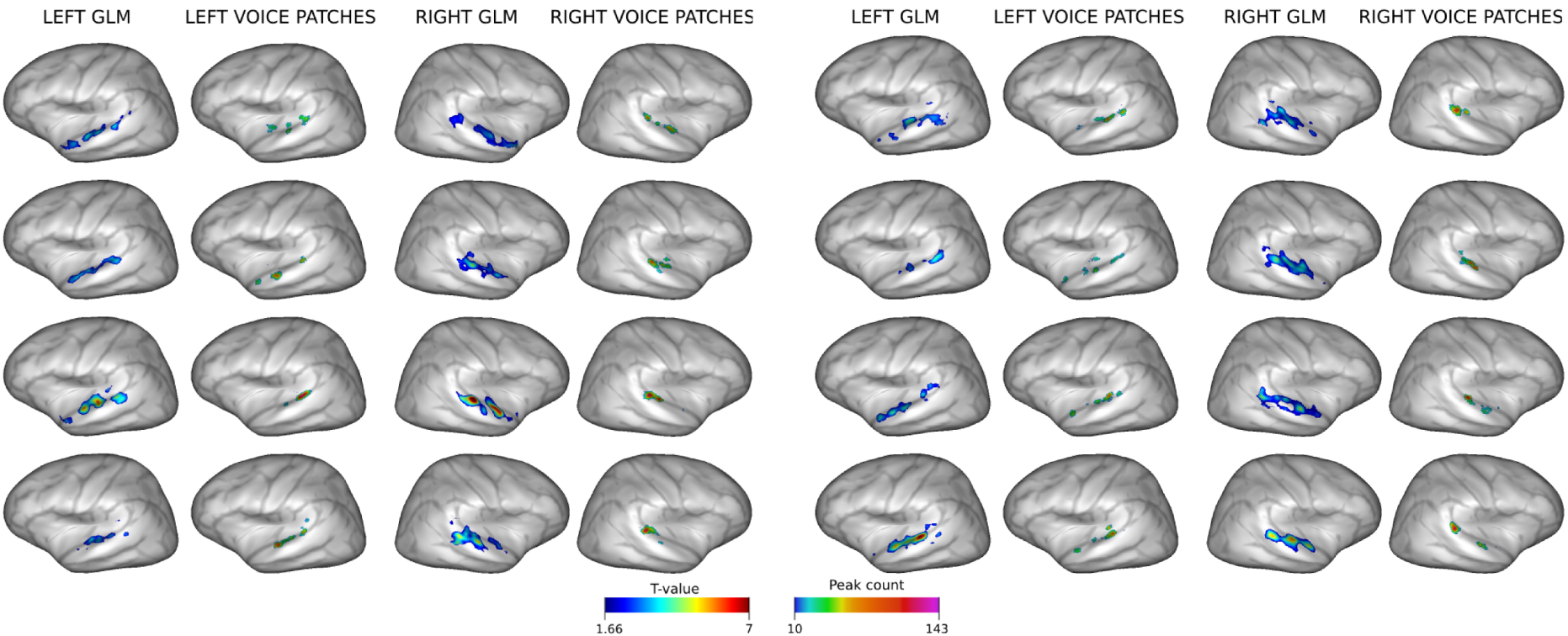


Pernet, 2015

A detection method for individual voice patches



Individual voice patches: results



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...using the anatomy

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- Link between depth and BOLD amplitude

(Bodin, Takerkart, Belin, Coulon. 2017)

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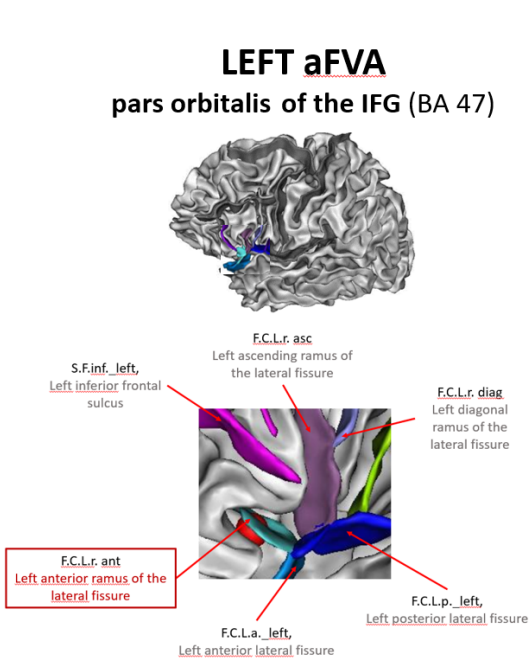
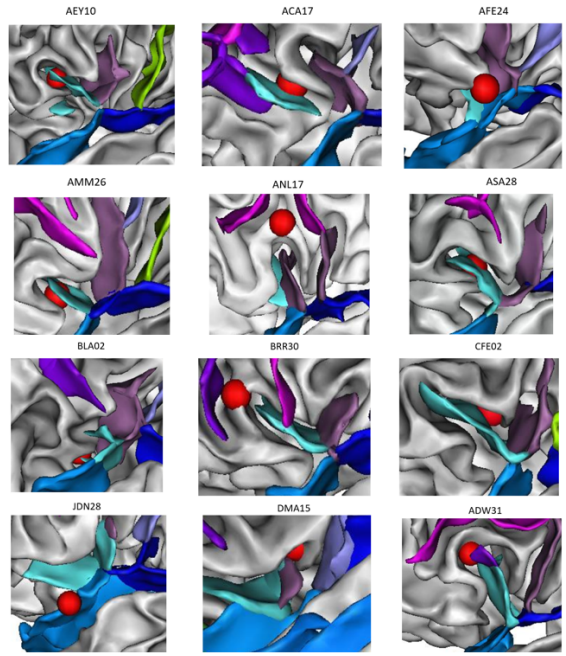
- Position of patches and sulci (Isaure Michaud's M2)





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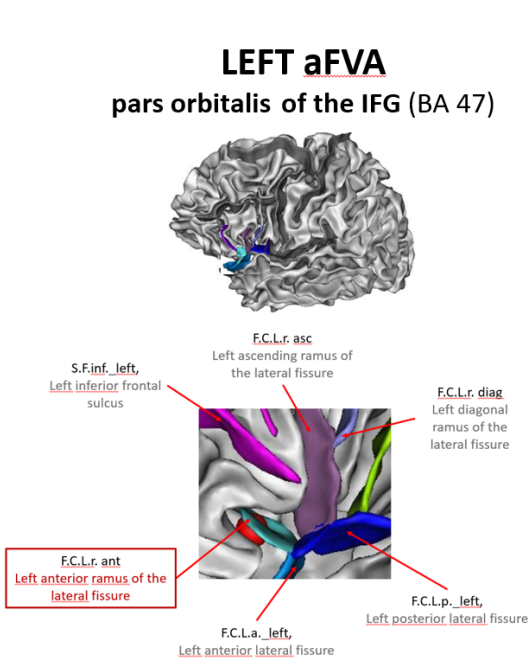
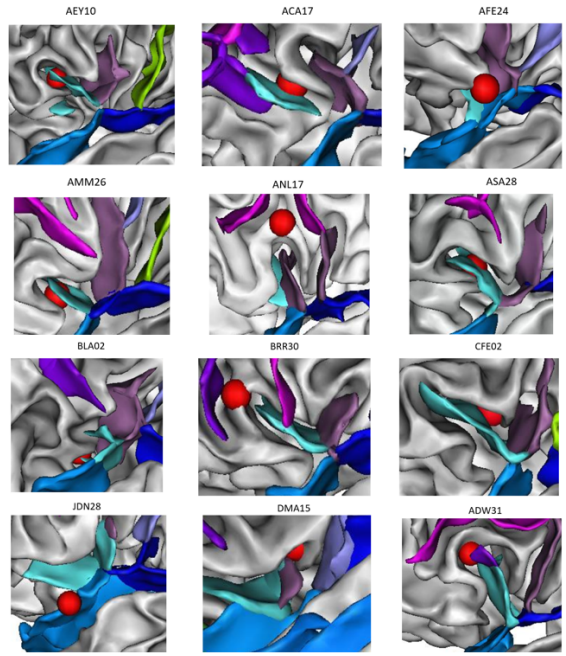


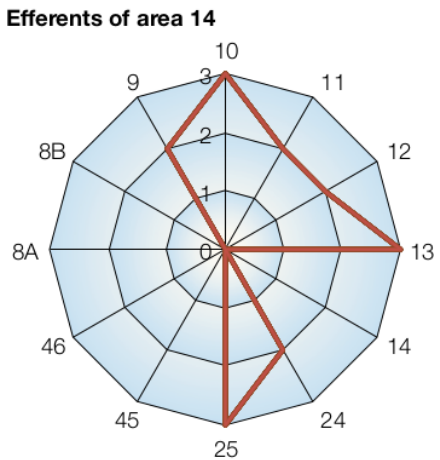


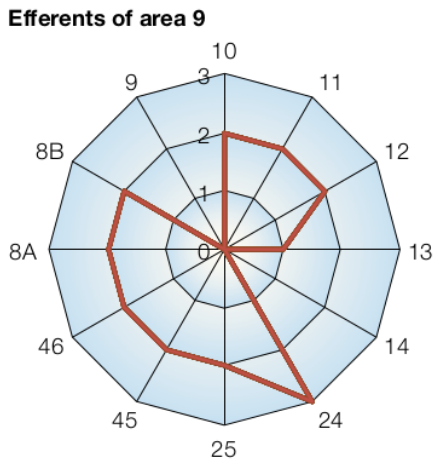
- Organization of the sulcal pits (position, patterns...)
- Location of the *pli de passage*

...using connectivity

...using connectivity

- connectivity fingerprint (Passingham, 2002)
- "each cortical area has a unique pattern of cortico-cortical connections"





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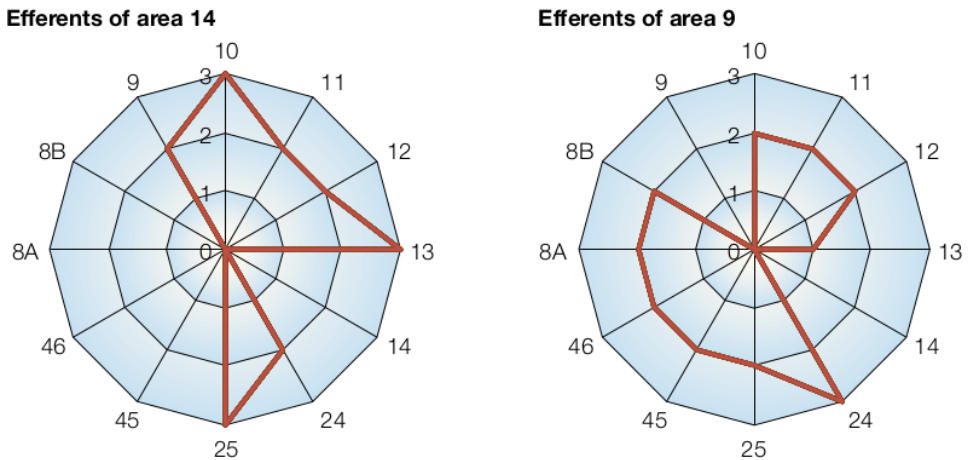

- ...long-range connectivity (Saygin, 2011)
- ...short-range (e.g across banks of the STS)

Outline

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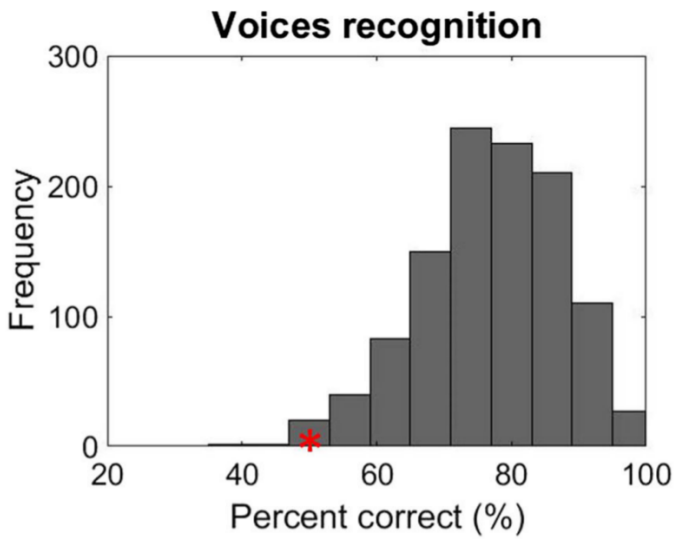
Standard approaches

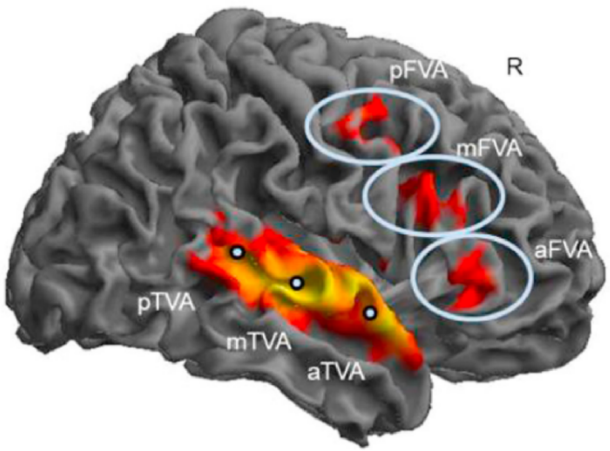
- massively univariate analyses (2 sample t-tests, correlations)

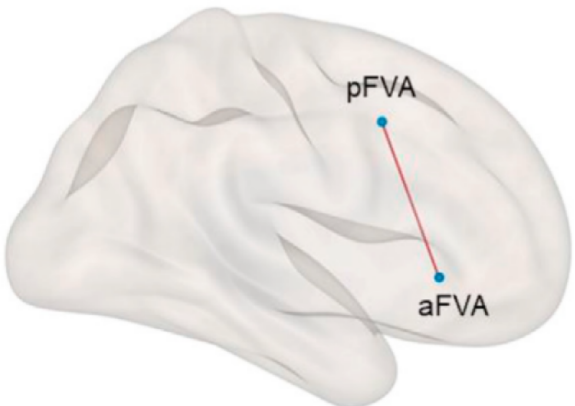
- one brain feature vs. the behavioral variable (categorical or continuous)

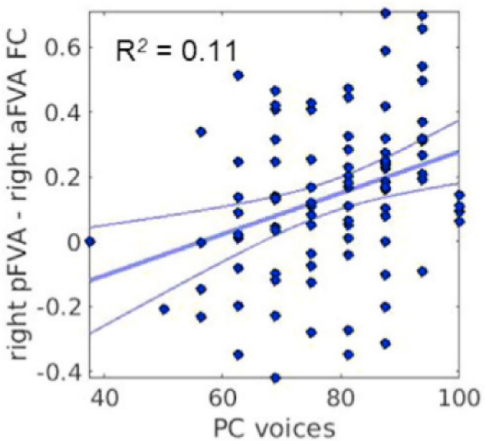


Aglieri et al., *Behavioral Research* 2017

Behavior - connectivity







Aglieri, Chaminade, Takerkart, Belin, *NeuroImage* 2018

Expertise - activation patterns

- our hypothesis: experts have more robust cortical representations

Expertise - activation patterns

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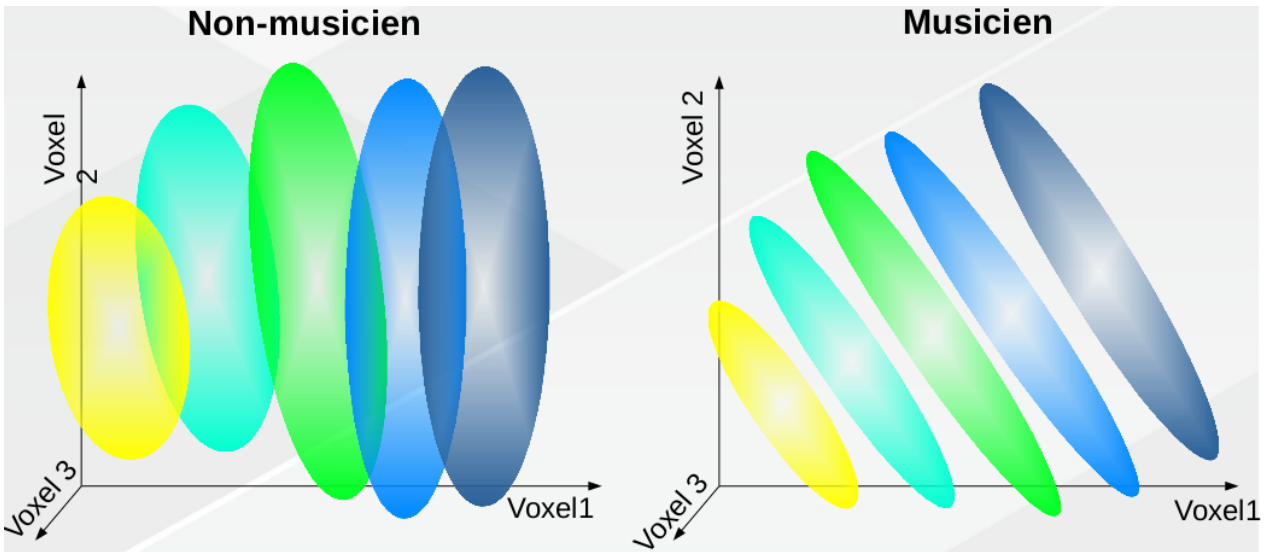
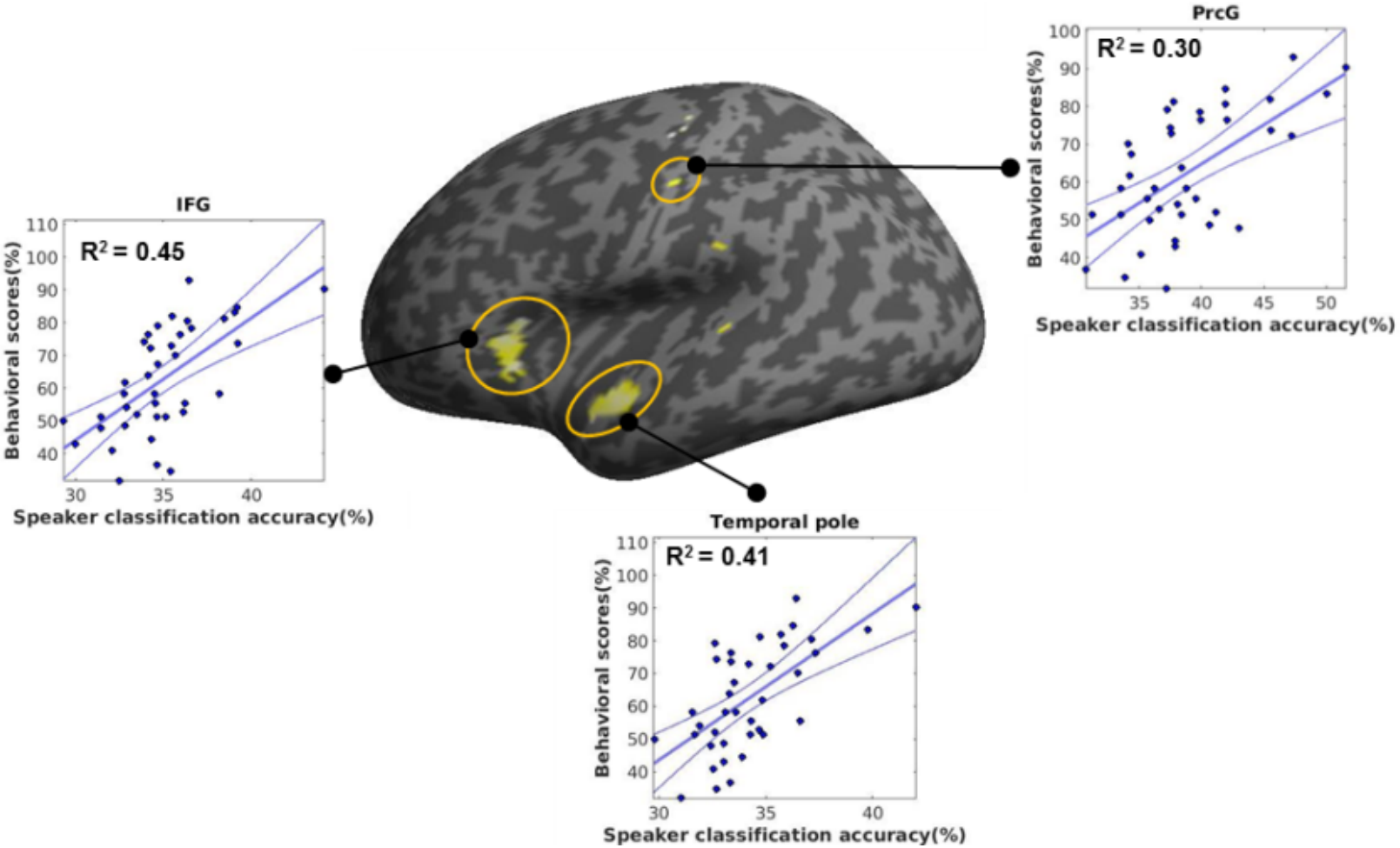
- ... i.e more distinct activation patterns



- Charles Dabard's M2 (difference in left auditory cortex)

Behavior - activation patterns



Aglieri, Cagna, Takerkart, Belin, (almost) submitted

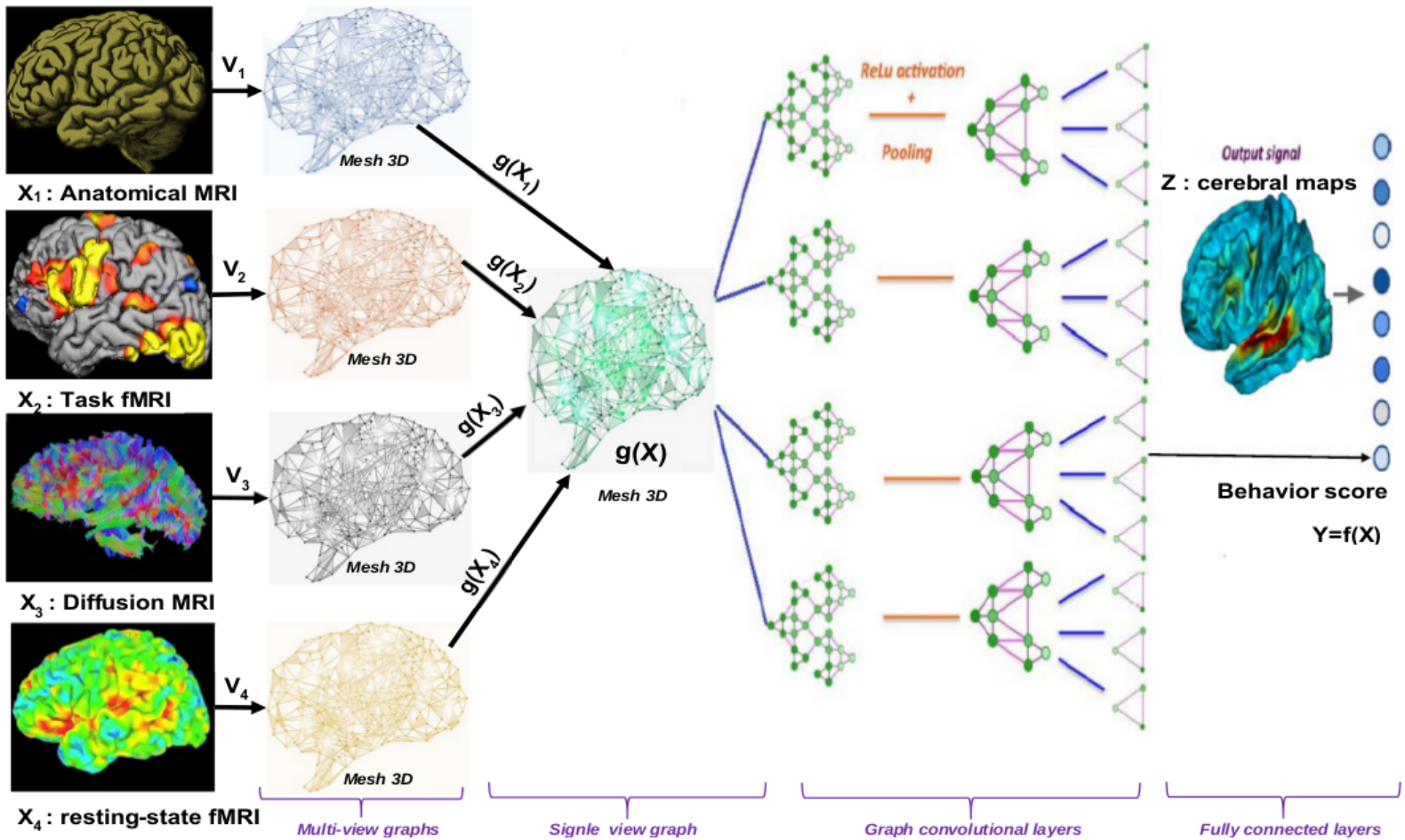
Outline

Learning multi-modal representations

Akrem Sellami's postdoc (with LIS)

Learning multi-modal representations

Akrem Sellami's postdoc (with LIS)



THANKS!

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Bastien Cagna, Virginia Aglieri, Pascal Belin

Aurélie Ponz

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Sylvain.Takerkart@univ-amu.fr

`http://www.int.univ-amu.fr`
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