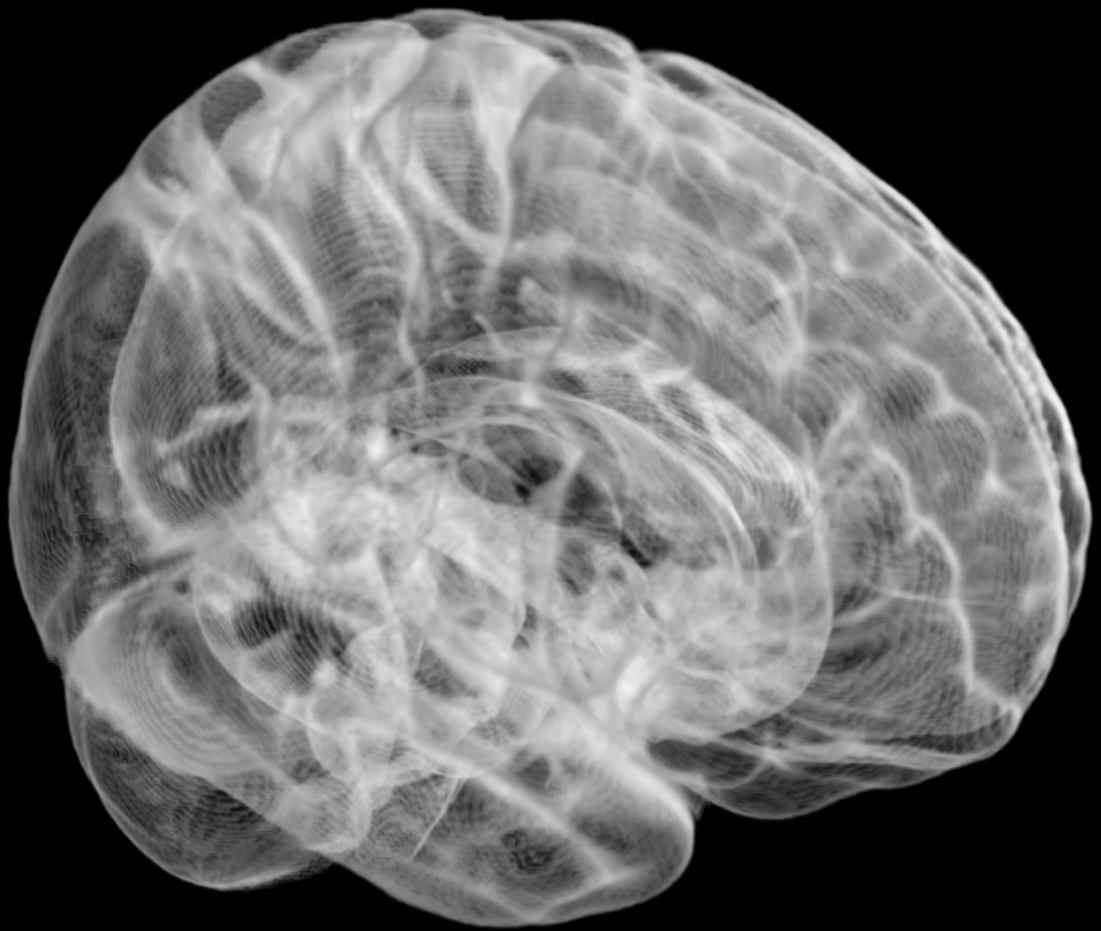
Nilearn:

Machine learning for brain imaging in Python

Gaël Varoquaux

INRIA/Parietal

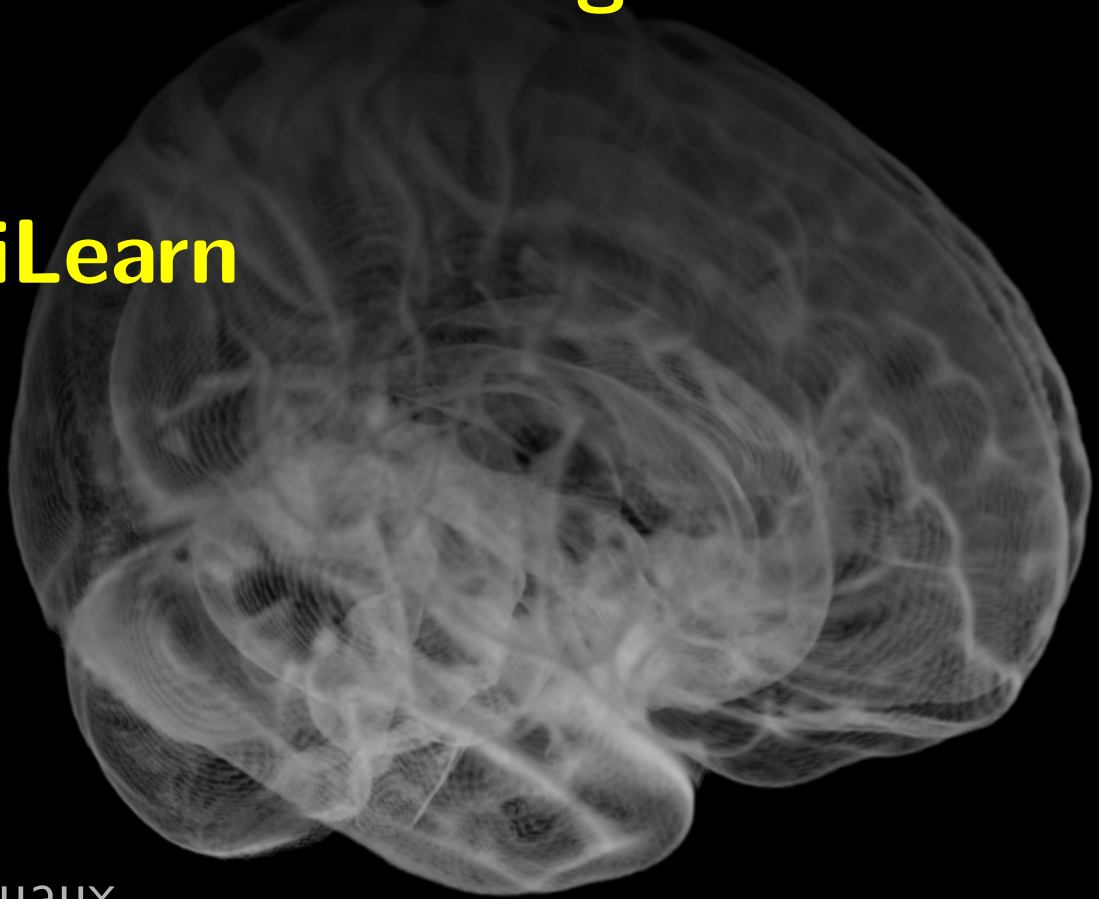


PARIETAL

Inria

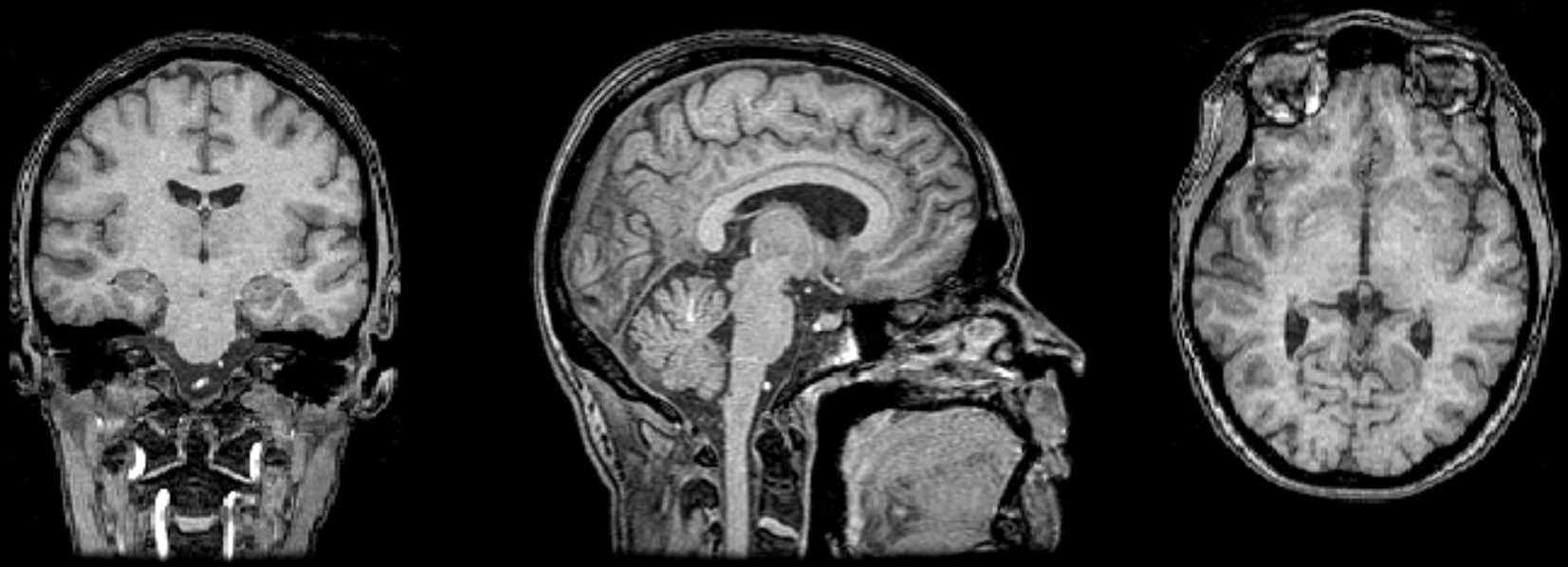
NeuroSpin

1. **Magnetic Resonance Imaging of the brain**
2. **Machine learning and brain imaging**
3. **NiLearn**



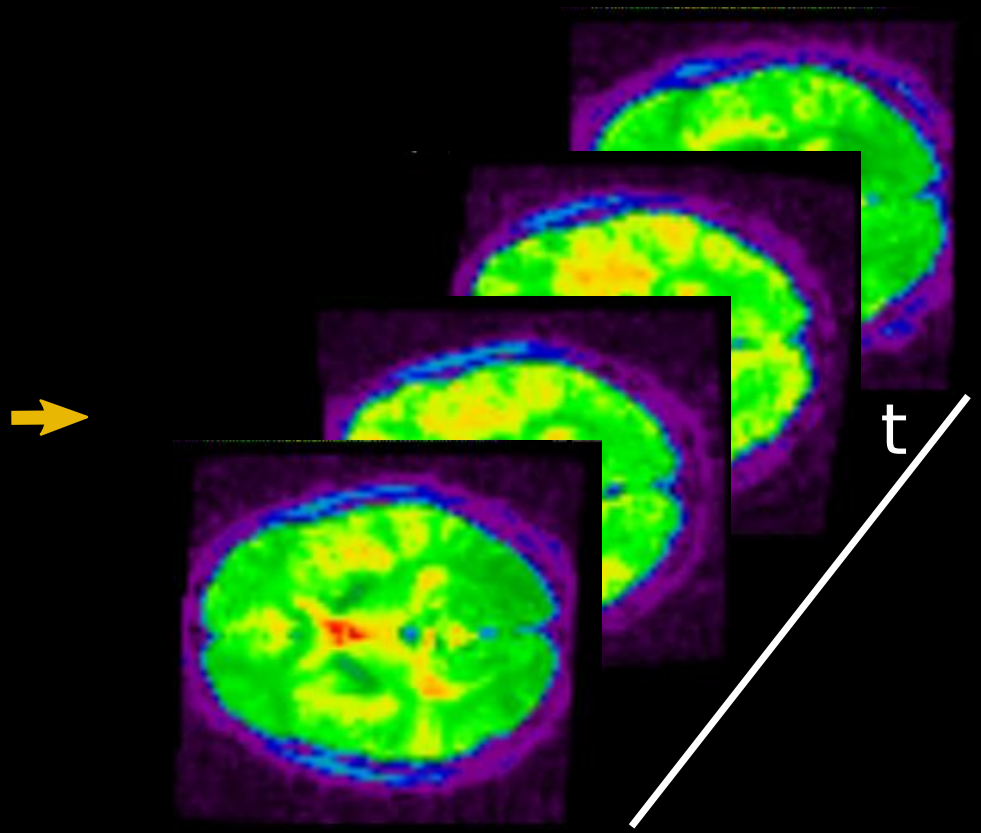
1 Magnetic Resonance Imaging of the brain

1 anatomical MRI



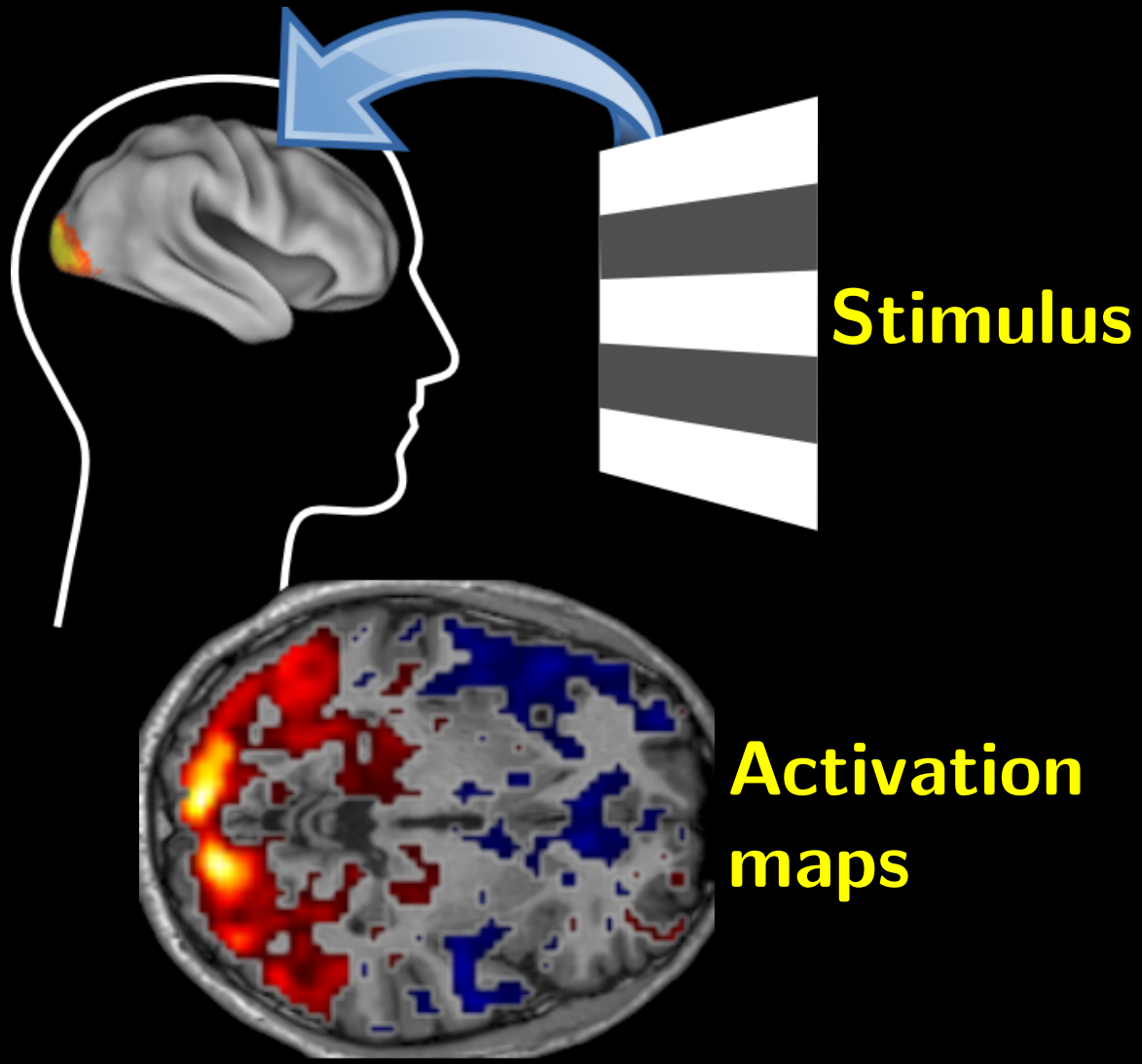
- Lesions? Bleeding?
- Shape, cortical thickness

1 functional MRI (fMRI)



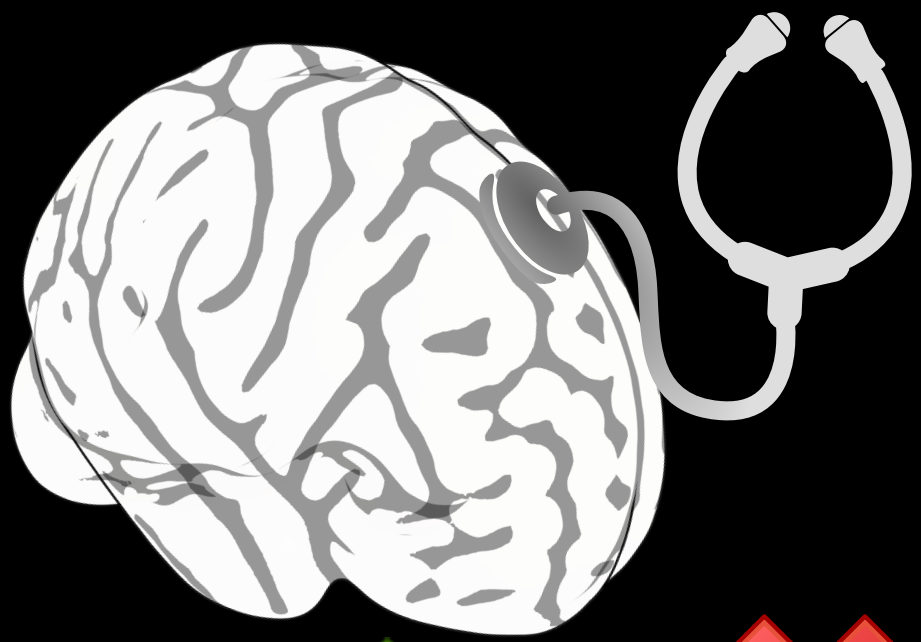
Time-resolved recordings of brain activity

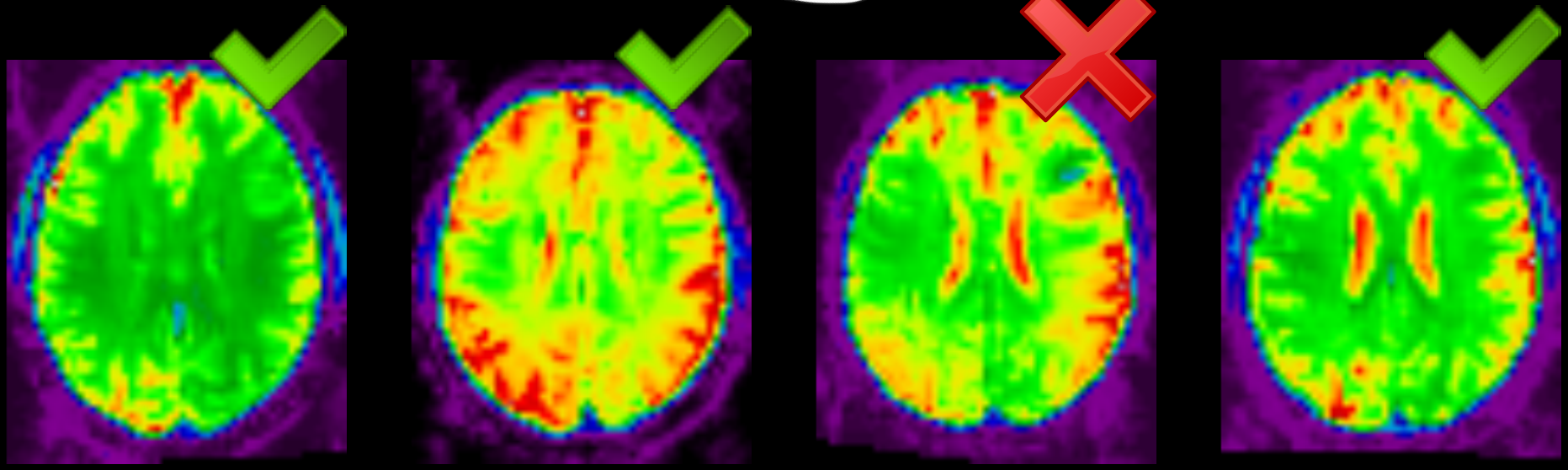
1 Mapping cognitive processes with fMRI



2 Machine learning and brain imaging

Medical applications





2 Some prediction problem

Diagnosis

Finding the nature or cause of a disease condition

Pronosis

Predicting the future evolution of the condition

$\Rightarrow$ Therapeutic indications

Early biomarkers

Measures enabling the detection of disease before standard symptoms

$\Rightarrow$ Population screening

Quantitative biomarkers

Metric to follow disease progression

$\Rightarrow$ Drug development

2 More than prediction accuracy

Cannot replace the physician:

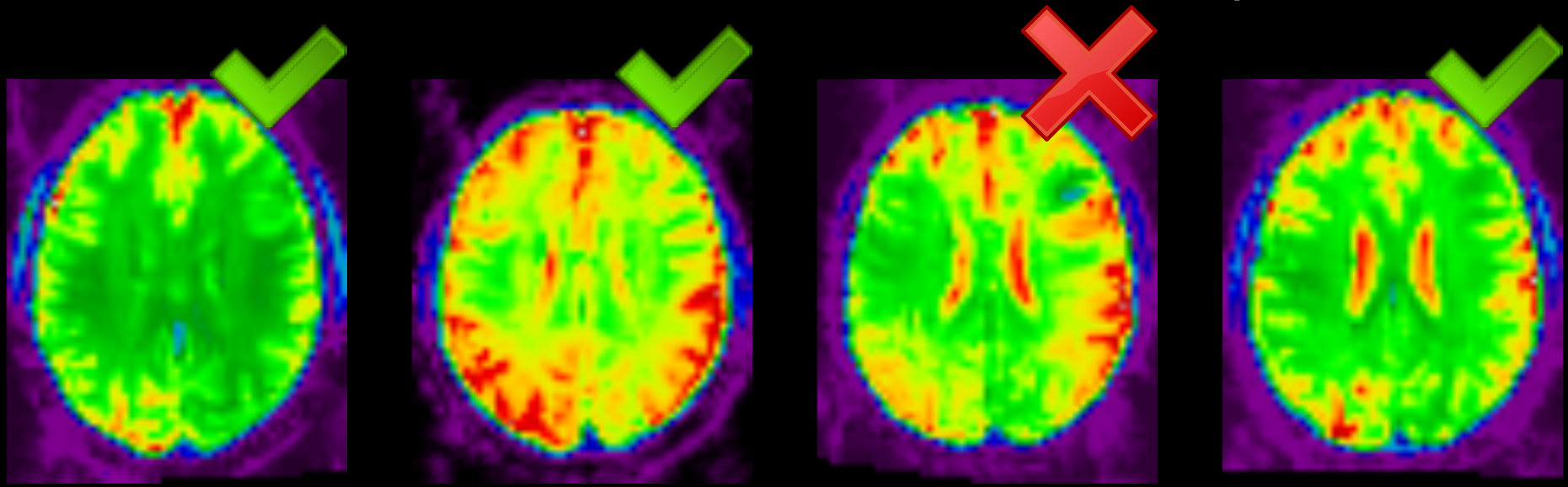
- Patient history
- Therapeutic strategies subject to logistics

...

$\Rightarrow$ No black-box

Segmentation, denoising task

as much as prediction



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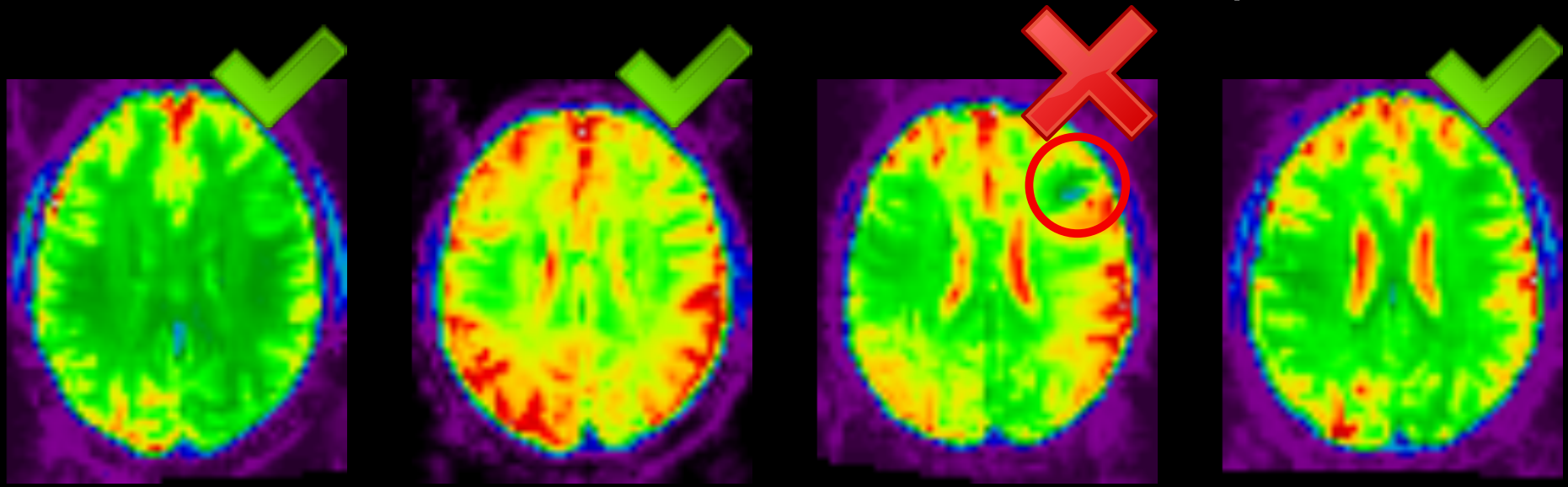
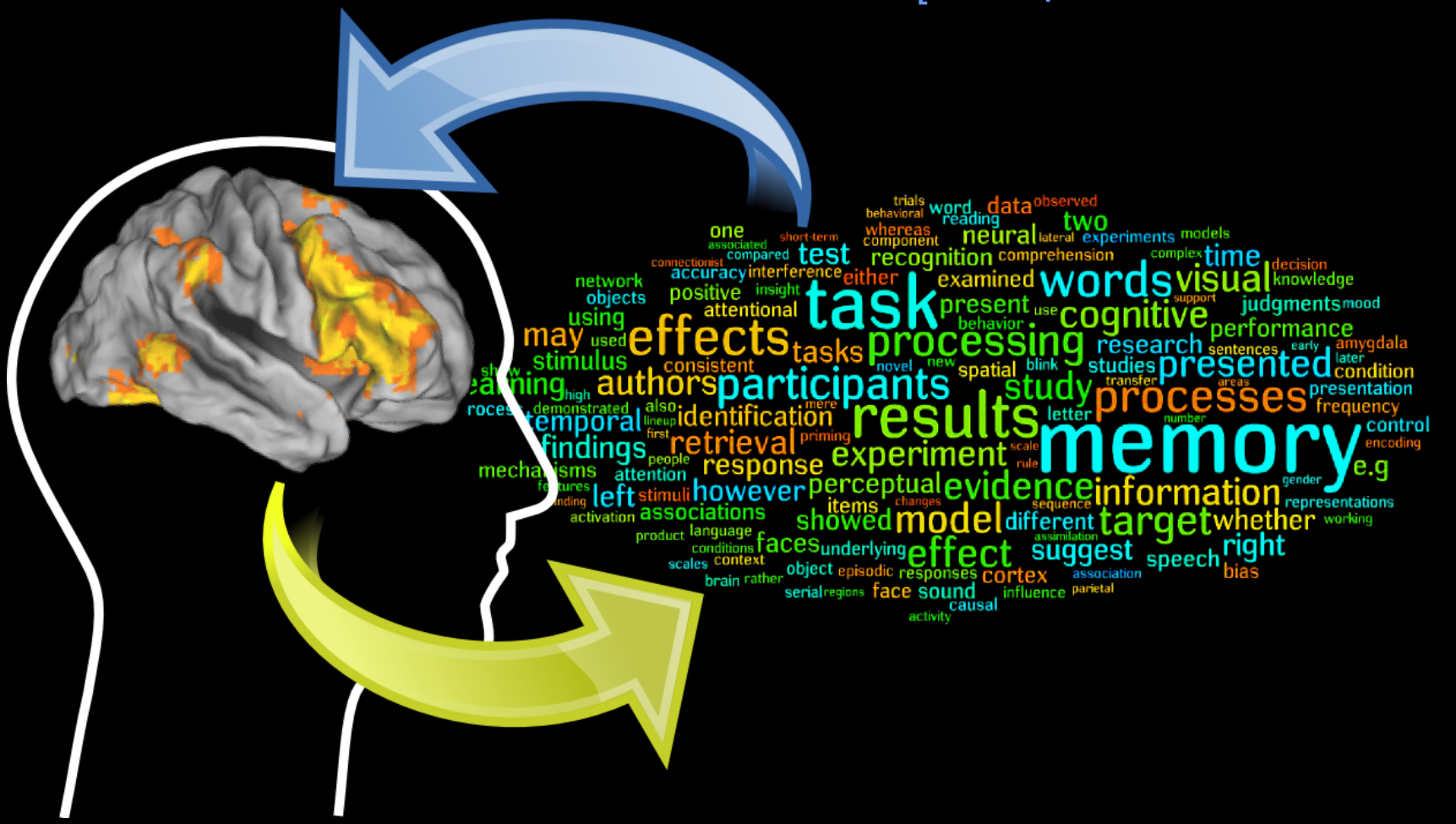


Understanding brain function

Cognitive neuroimaging:
from neural activity to thoughts

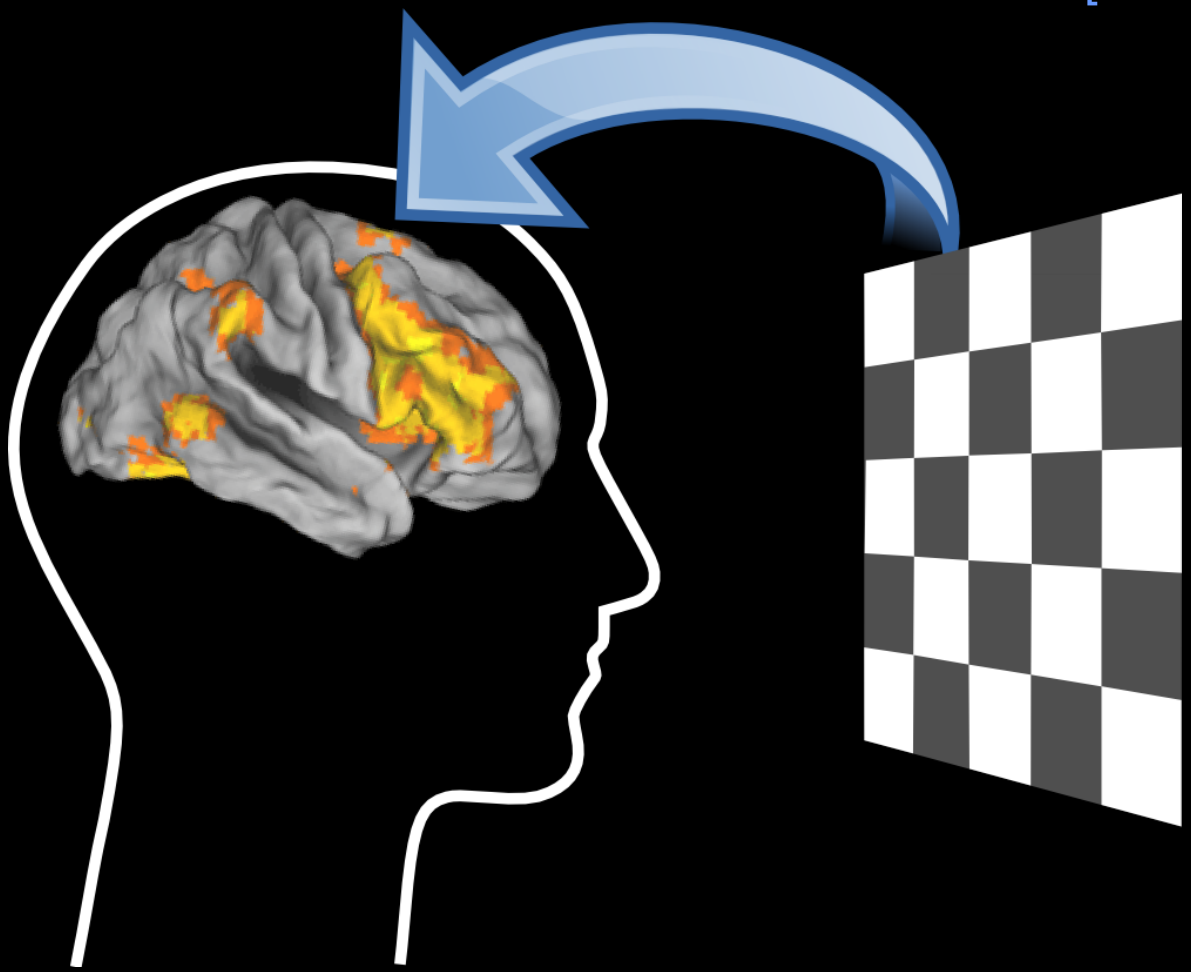
[Varoquaux & Thirion, 2014]



Learn a bilateral link between brain activity and cognitive function

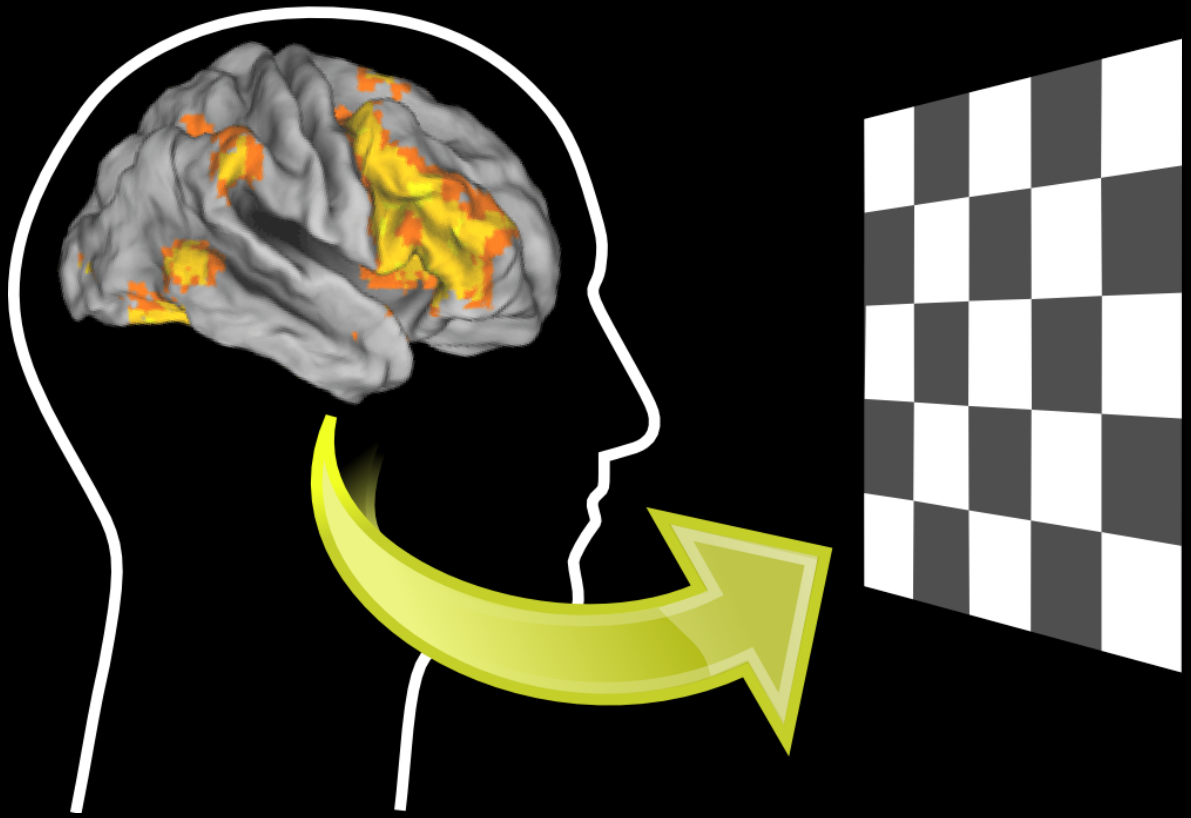
2 Machine learning for cognitive neuroImaging

[Varoquaux & Thirion, 2014]



Predicting neural response:
encoding models

[Varoquaux & Thirion, 2014]



"Brain reading": **decoding**

3 NiLearn

Machine learning for Neuro-Imaging in Python

`http://nilearn.github.io`

3 Going beyond the IEEE publication

- How to we reach our target audience (neuroscientists)?
- How do we disseminate our ideas?
- How do we facilitate new ideas?

3 Going beyond the IEEE publication

- How to we reach our target audience (neuroscientists)?

  For neuroscience research

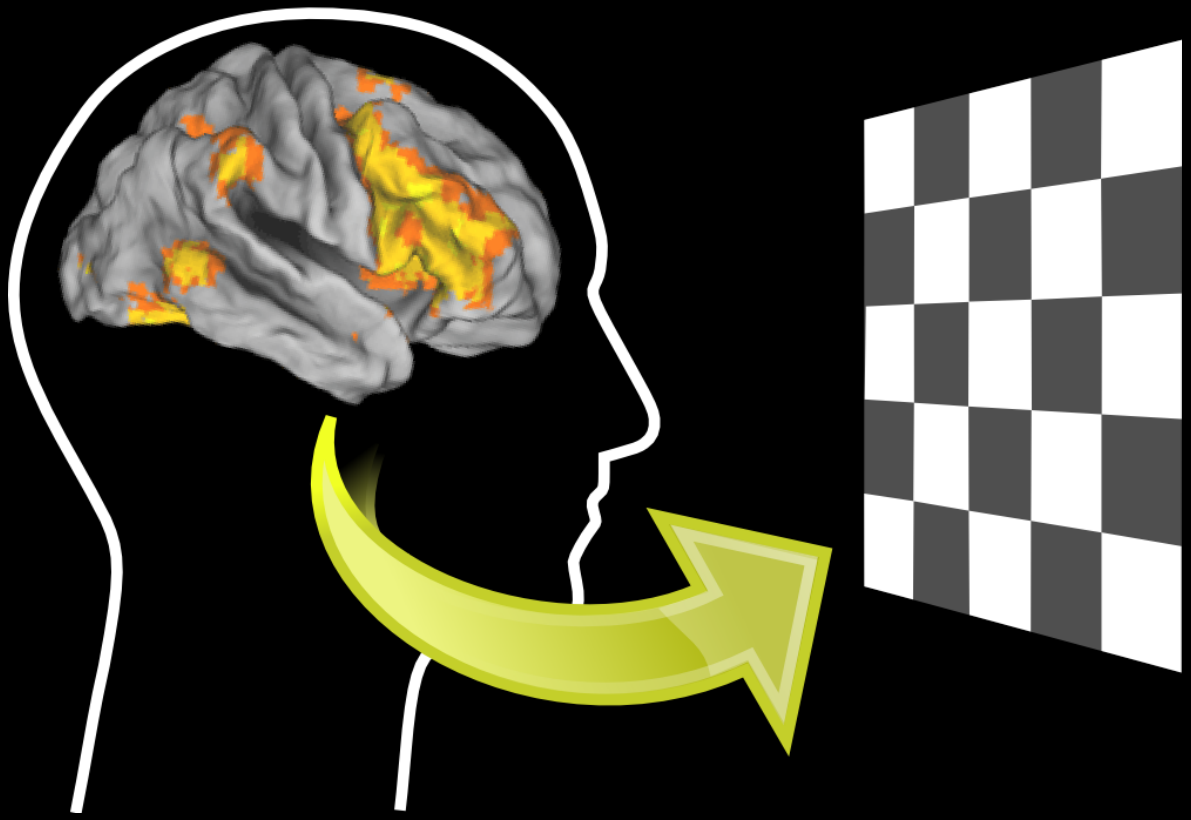
- How do we disseminate our ideas?

  For applied-math research

- How do we facilitate new ideas?

  For our own lab

Visual image reconstruction from human brain activity
[Miyawaki, *et al.* (2008)]



"brain reading"

36 years ago ... back to the future

Visual image reconstruction from human brain activity
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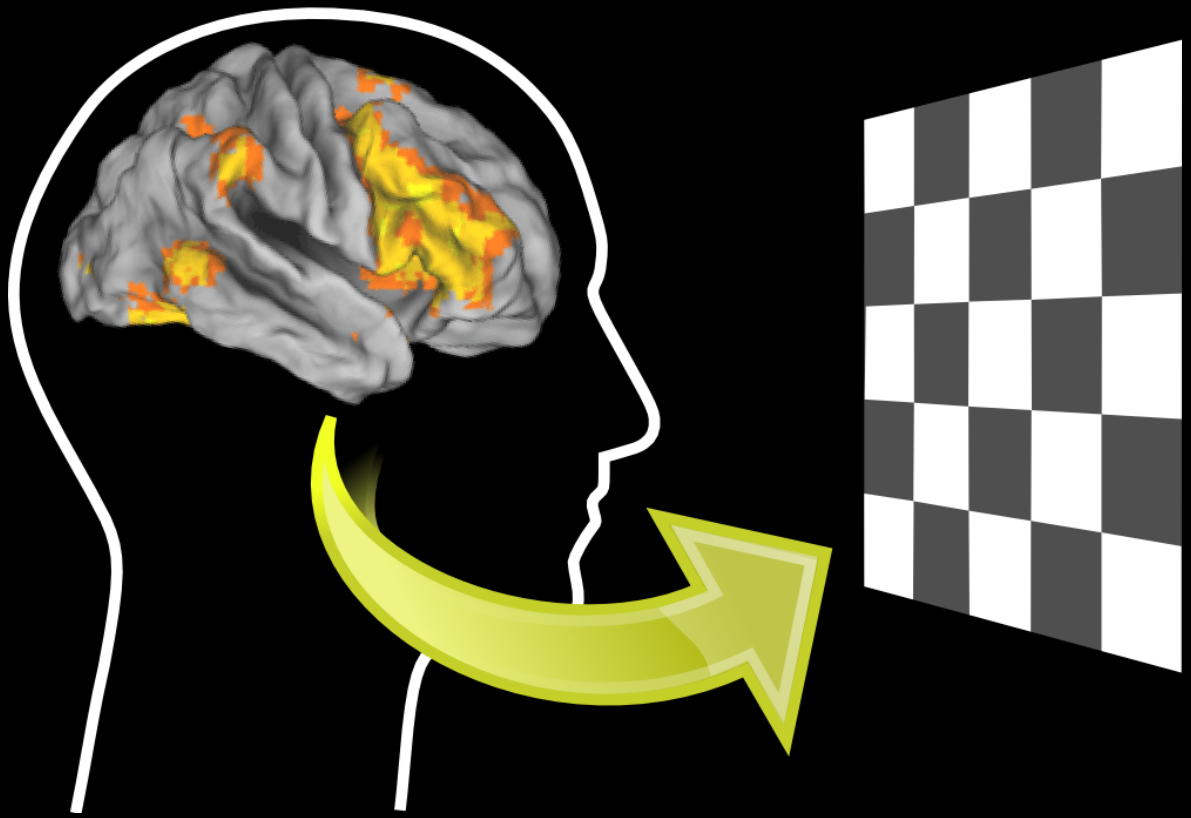


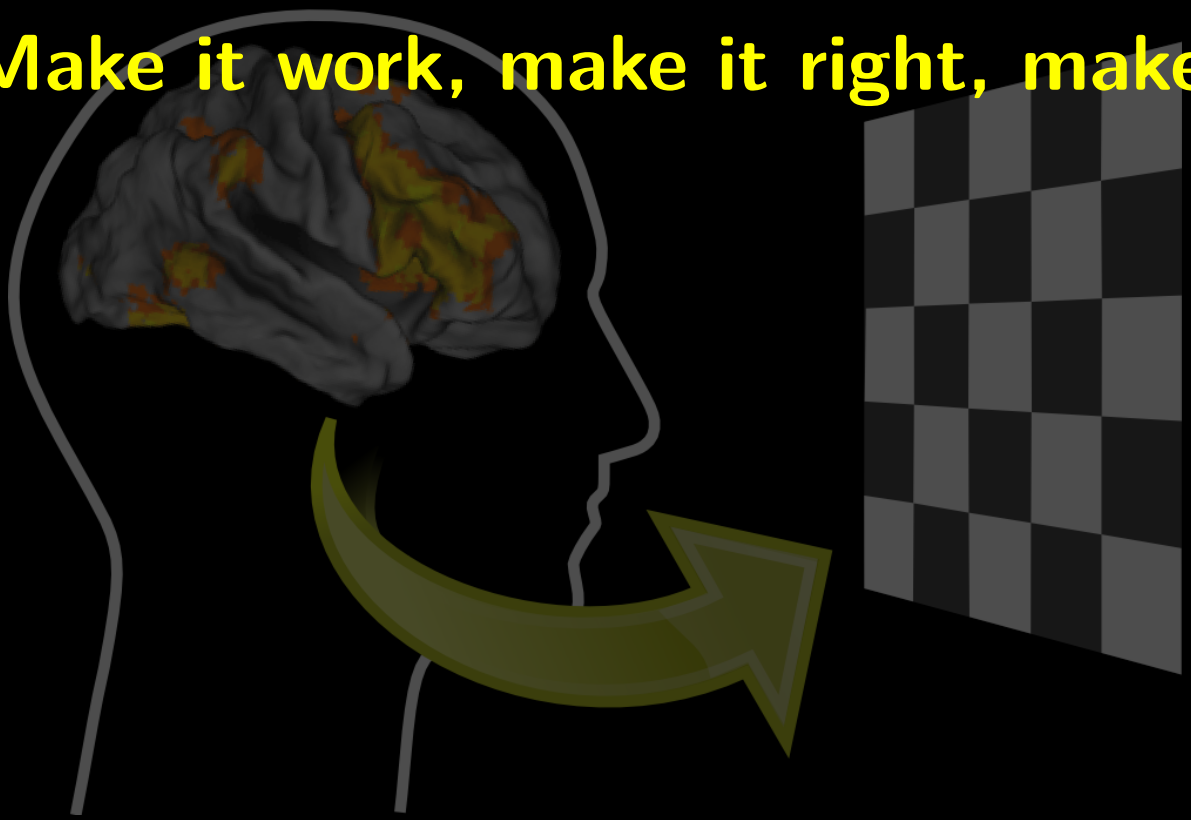
*"if it's not **open and verifiable by others**, it's not science, or engineering..."*

Stodden, 2010

6 years ago ... back to the future

Visual image reconstruction from human brain activity
[Miyawaki, *et al.* (2008)]

Make it work, make it right, make it boring



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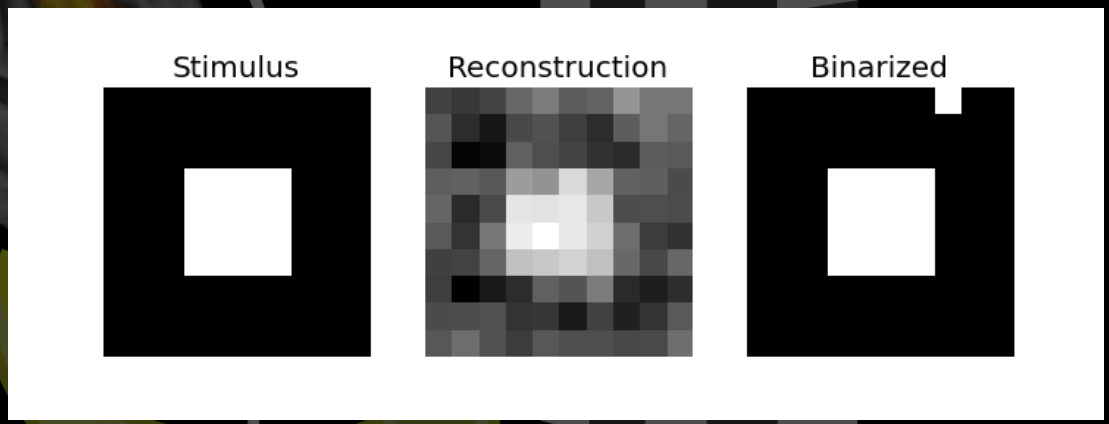


`http://nilearn.github.io/auto_examples/plot_miyawaki_reconstruction.html`

Code, data, ... just works™

`http://nilearn.github.io`

3 Nilearn: making learning for neuroimaging routine

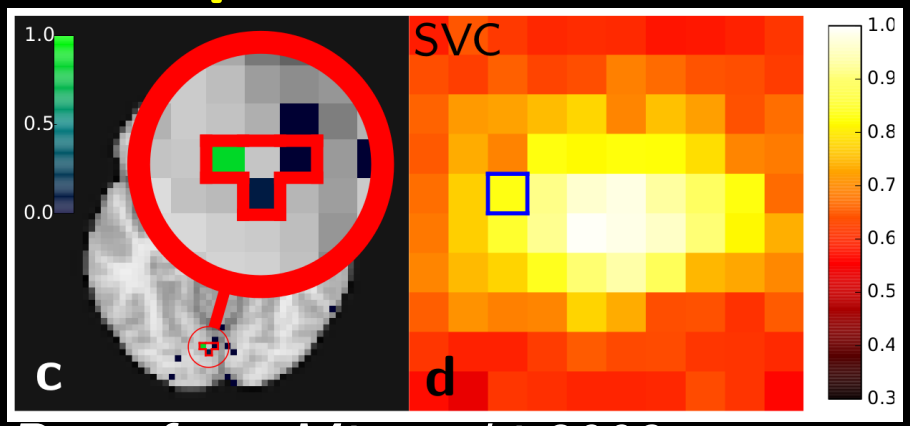
Project scope

CDS-funded

Machine learning for neuroimaging:
make using scikit-learn on neuroimaging easy

The target user base is small

Examples in the docs



Data from Miyawaki 2008

- Run out of the box, downloading **open data**
- Produce a clear figure

Routine, simple, reproduction of papers

3 Challenges we have to solve

- Getting the data

  Struggle for open data

- Massaging the data for machine-learning

  Very simple signal processing

- Documentation

  Users do not know what they need

- Output + visualization of results

  Putting it in application terms

- Getting the data

```
files = datasets.fetch_haxby()
```

Caching of the downloads

Resume of partial downloads

3 Nilearn in practice

- Getting the data

```
files = datasets.fetch_haxby()
```

- Massaging the data for machine-learning

```
masker = NiftiMasker(mask_img='mask.nii',
    standardize=True)
data = masker.fit_transform('fmri.nii')
```

Filenames to data matrix (memory-efficient I/O)

Common preprocessing steps included

3 Nilearn in practice

- Getting the data

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- Massaging the data for machine-learning

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- Learning with scikit-learn

```
estimator.fit(data, labels)
```

That's easy!

3 Nilearn in practice

- Getting the data

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- Output

```
plot_stat_map(masker.inverse_transform(
    estimator.weights_))
```

3 Nilearn in practice

- Getting the data

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- Massaging the data for machine-learning

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- Learning with sc

```
estimator.fi
```

Demo

Brain reading @ home

- Output

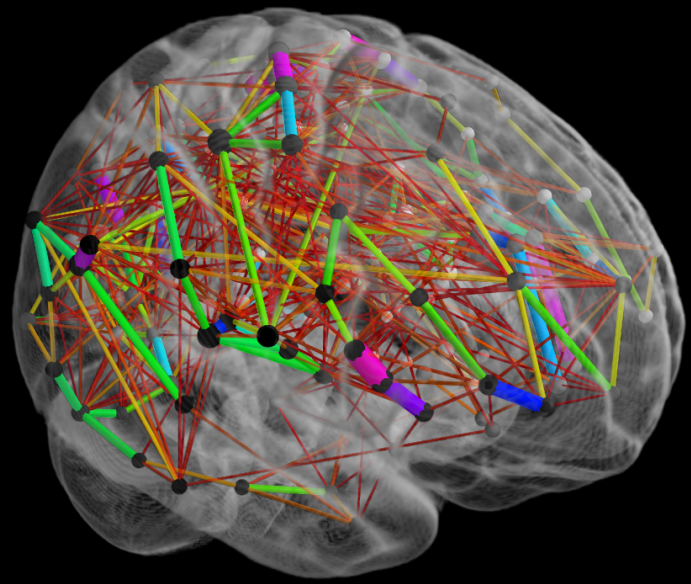
```
plot_stat_map(masker.inverse_transform(
    estimator.weights_))
```

3 There is more

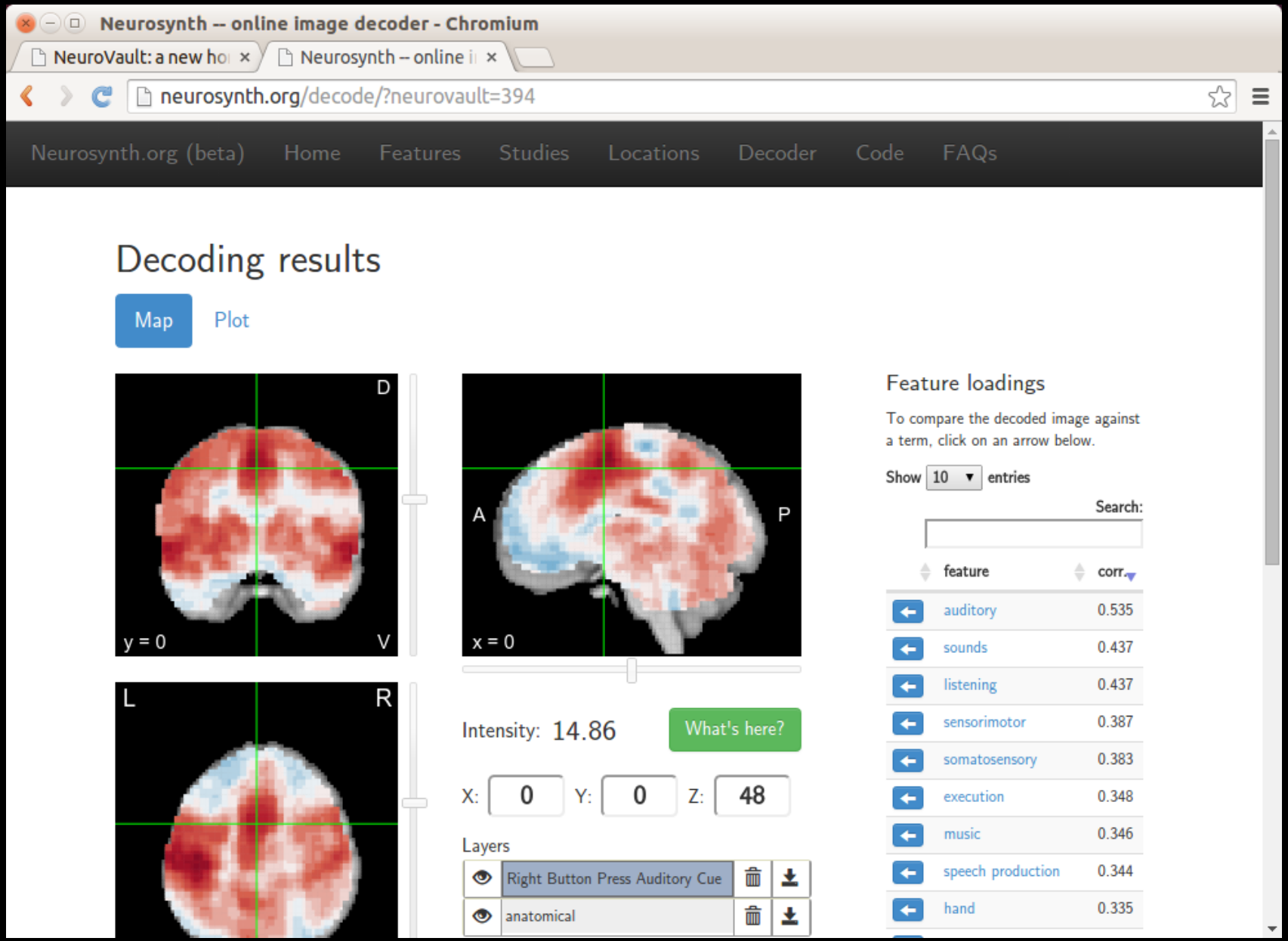
- Domain-specific brain-reading algorithm
  Image-penalties on linear models

- Unsupervised dictionary-learning
  Brain regions from uncontrolled mental activity

- Graph learning
  "Connectome": who talks to who

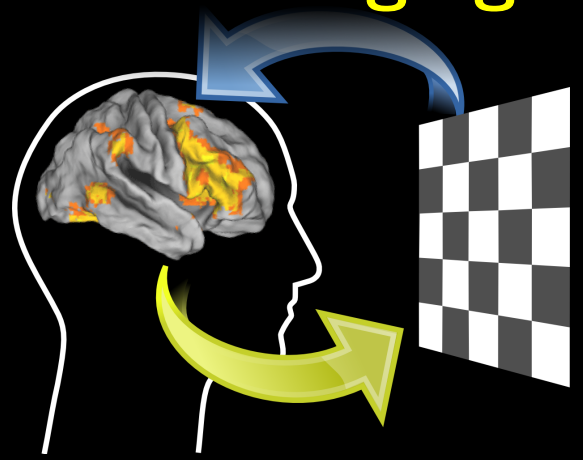


3 NeuroSynth + Neurovault: web brain reading



Nilearn: Machine learning for brain imaging

- Medical and cognitive science applications
- Learning problems, but not only about prediction error



Reaching domain scientists

First challenge: get the user to do simple tasks

Useful for methods research

lowers the bar to test methods on new data

@GaelVaroquaux