Feature-Space Clustering for fMRI Meta-Analysis

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Human Brain Mapping : July 2001.

Scope

Exploratory data analysis
as a possible alternative to ***inferential analyses***

Generalize the existing methodologies for clustering raw time series:
for ***data reduction*** &
meta-analysis of *single-voxel* neuroimaging analyses.

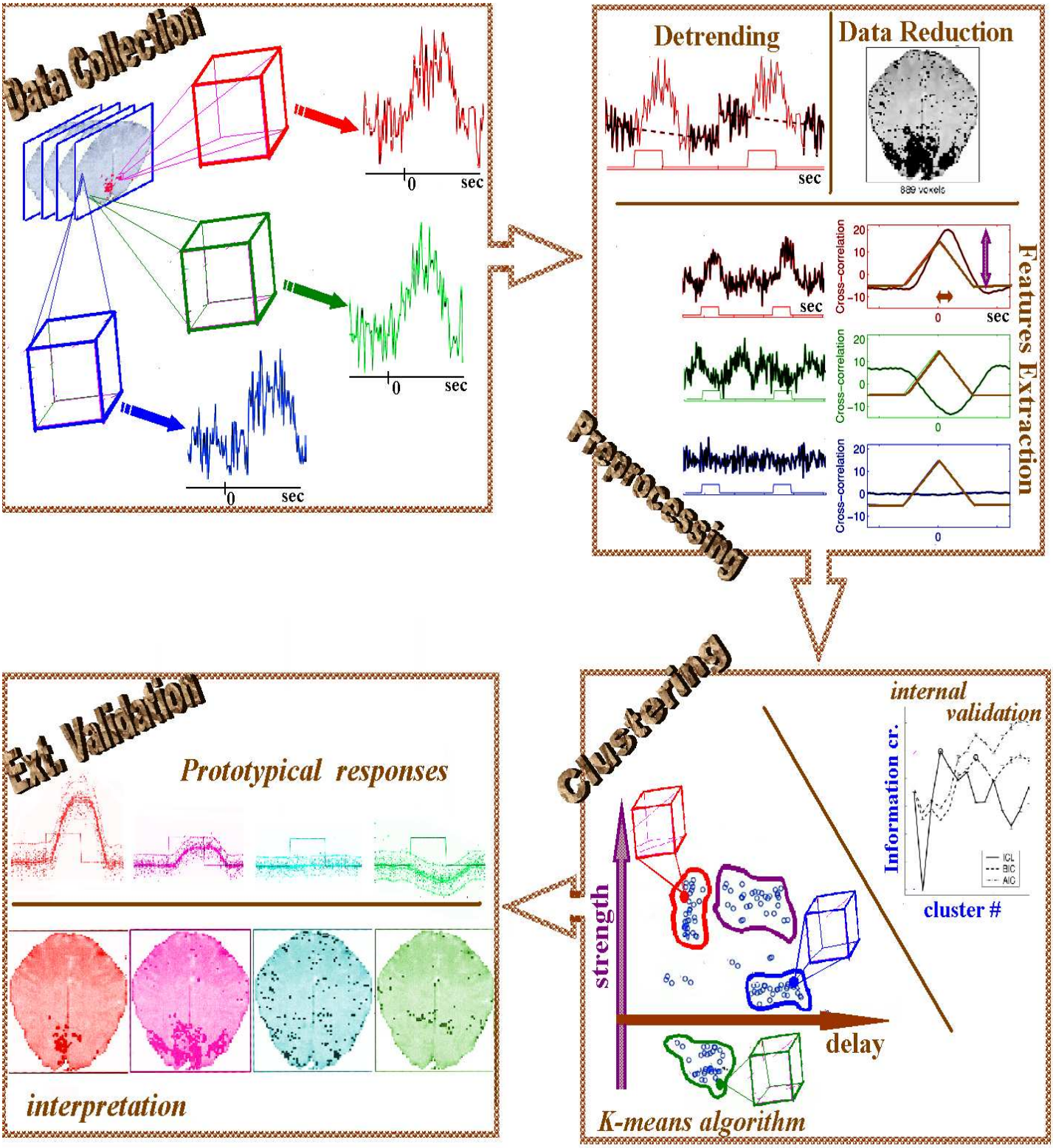
Baumgartner et al. *"Fuzzy clust. vs correlation analysis"* [Magn. Reson Imaging, 1998],

Tonini & Edelman. *"Functional Clustering in Neuroimaging Data"* [Neuroimage,1998]

Baune et al. *"Dynamical Cluster Analysis of cortical fMRI activation"* [Neuroimage, 2001]

Baumgartner et al. *"Assessing coactivation in fMR via MST"* [Neuroimage, 2001]

OUTLINE

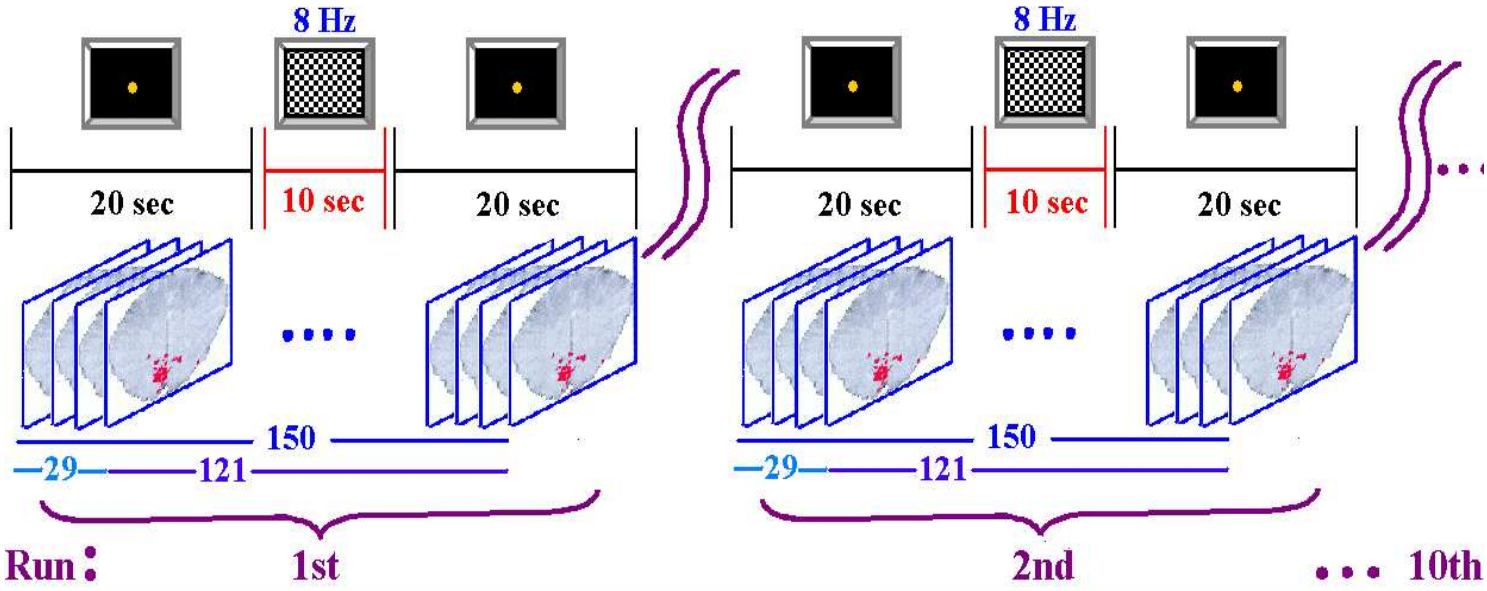

Data Collection
0
sec
Detrending
sec
Data Reduction
889 voxels
Features Extraction
Cross–correlation
Preprocessing
Clustering
internal validation
Information cr.
ICL
BIC
AIC
cluster #
strength
delay
K-means algorithm
Ext. Validation
Prototypical responses
interpretation

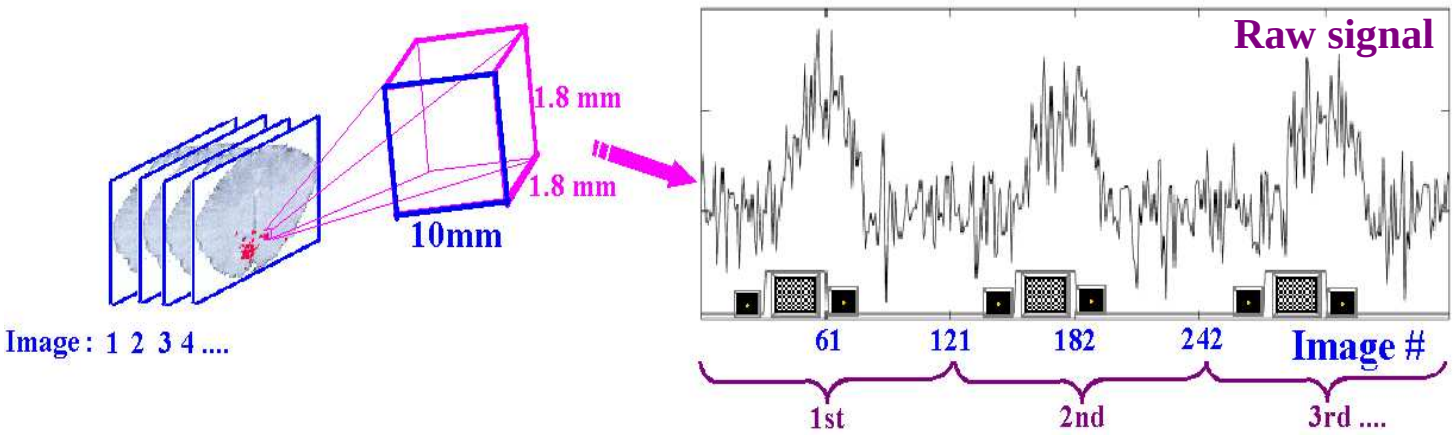
DATA

Images (128 x 128 pels) : FOV of 230 mm, 10mm slice thickness, were acquired in a para-axial orientation parallel to the ***calcarine sulcus***.

ROI was limited to a 68 x 82 2D voxel map (each voxel: 1.8 x 1.8 x 10 mm)

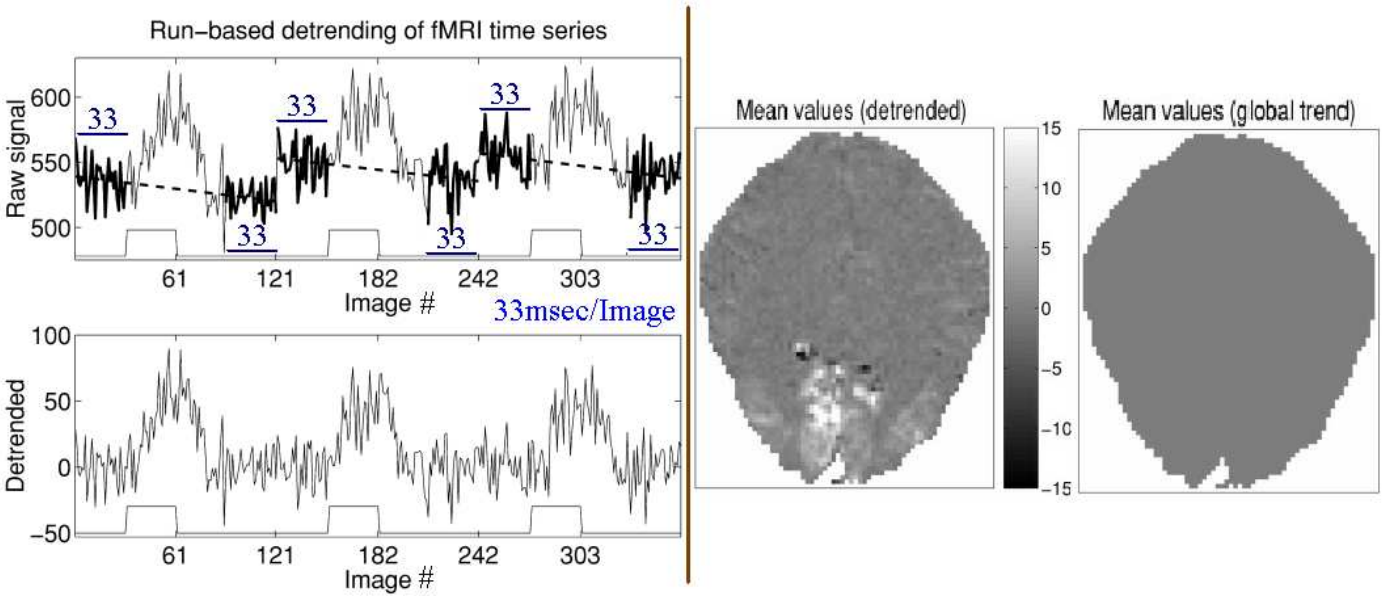
Visual paradigm: 20 sec of rest period (darkness / a light fixation dot),
10 sec of full-field checkerboard reversing at 8 Hz
20 sec of rest period





PREPROCESSING

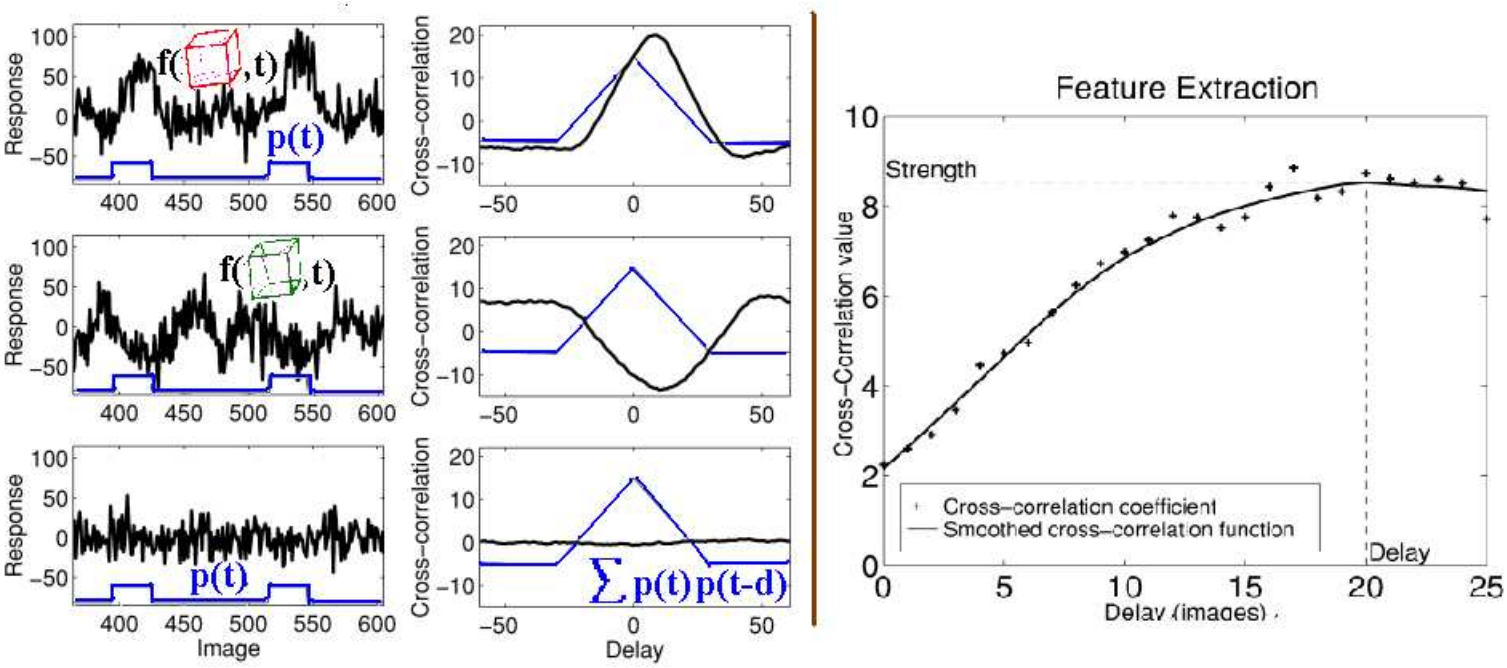
Detrending



Data reduction *(omnibus F test)*

Features extraction from cross-correlation

between the *Raw signal* f(x,y,z,t) and *the paradigm* p(t)



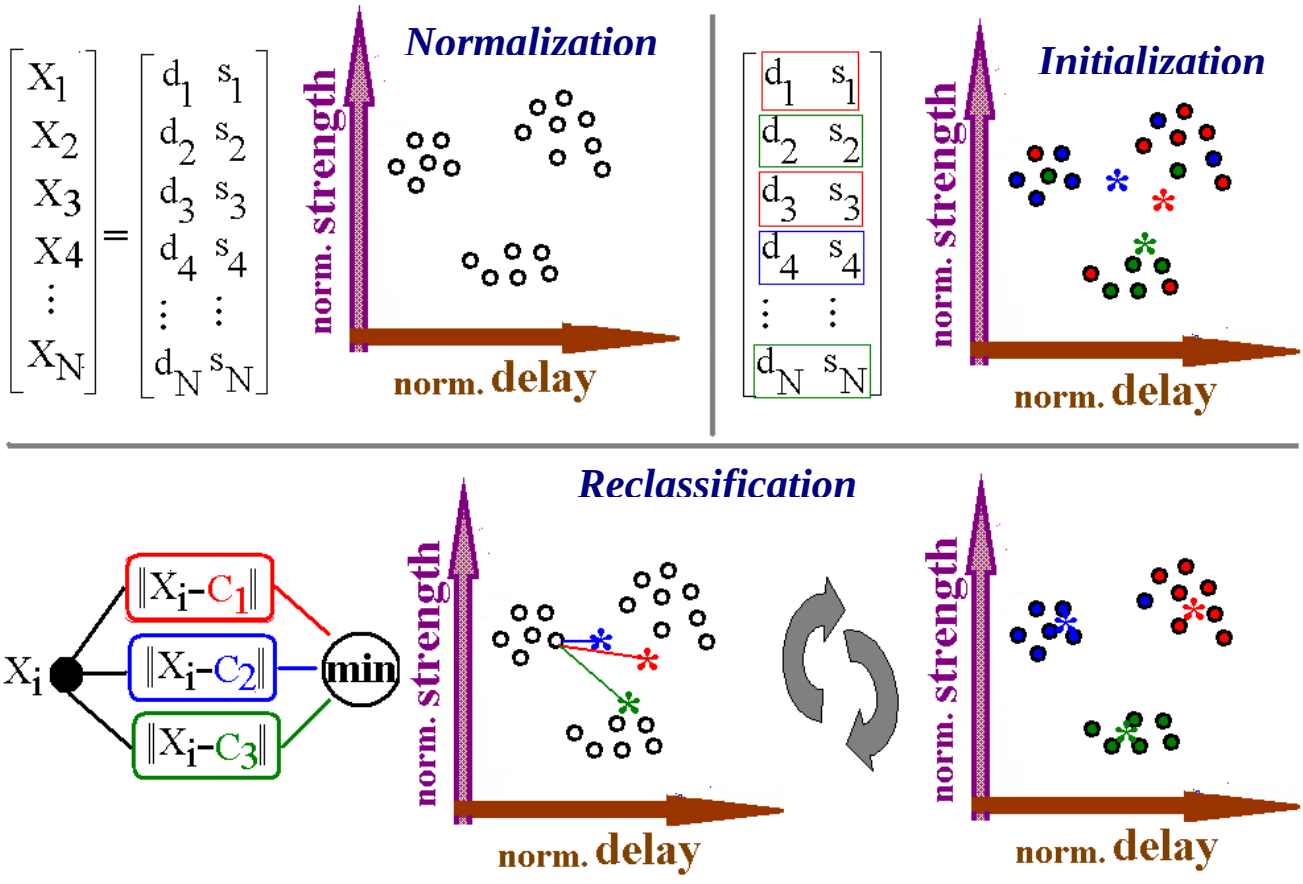
Features extraction for *Metaclustering*

fusion of attributes from standard voxelwise analyses:

- standard Student t test (rest   VS activation) : ***- t statistic***
- Kolmogorov – Smirnov test : ***- d statistic***
- Correlation with the paradigm (delayed 7 sec) : ***- r coefficient***
- FIR filter model, fitted on the fMRI signal :
  - std of the fitted signal
  - delay estimated from the FIR filter
- Gamma filter model, fitted on the fMRI signal :
  - strength parameter from the fitted signal
  - delay estimated from filter

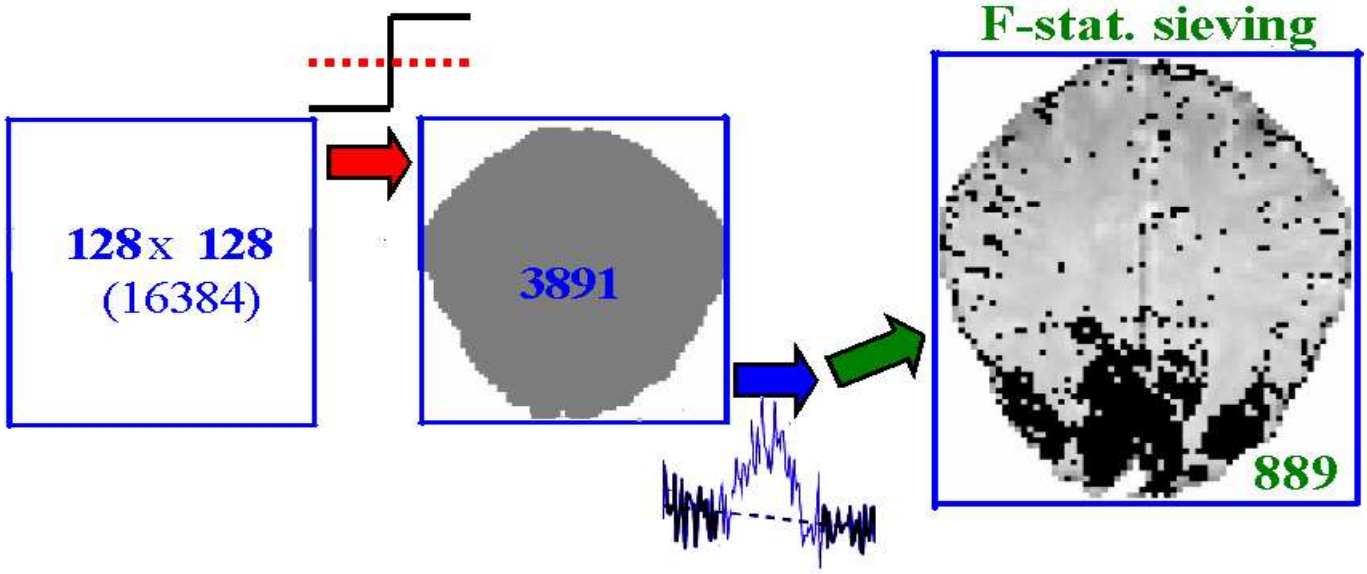
CLUSTERING

K-means Algorithm

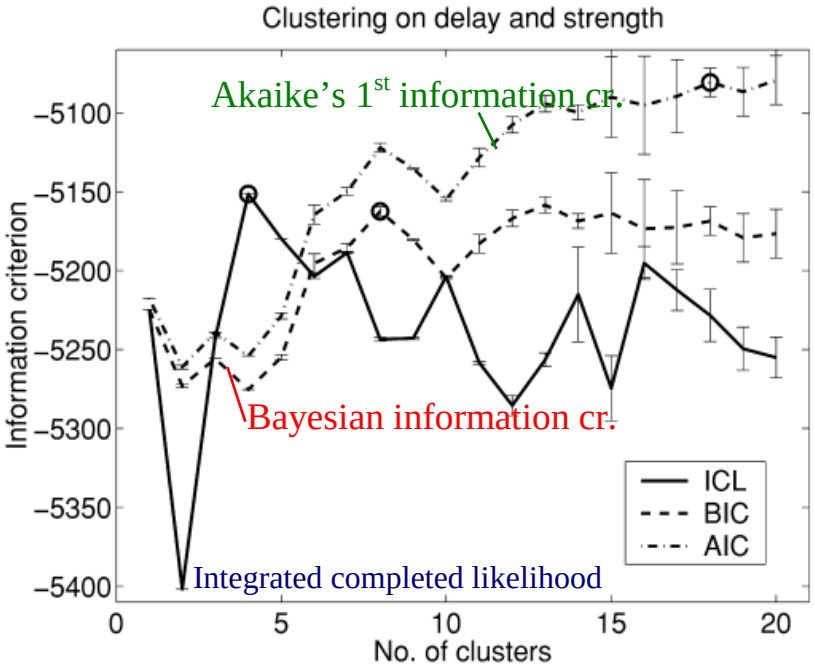


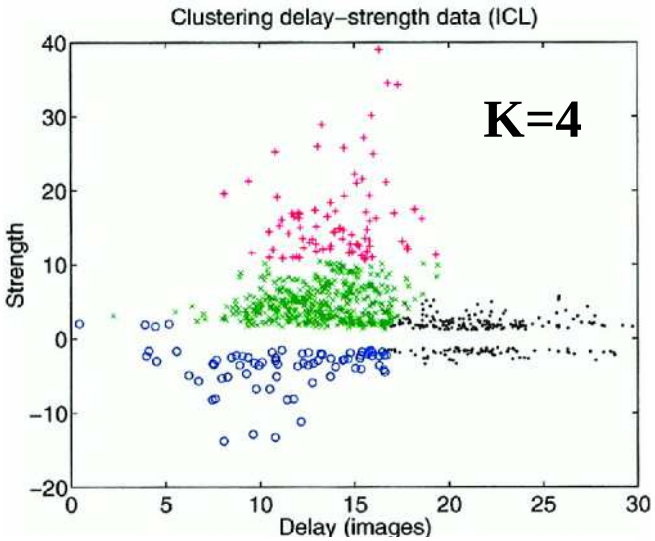
RESULTS

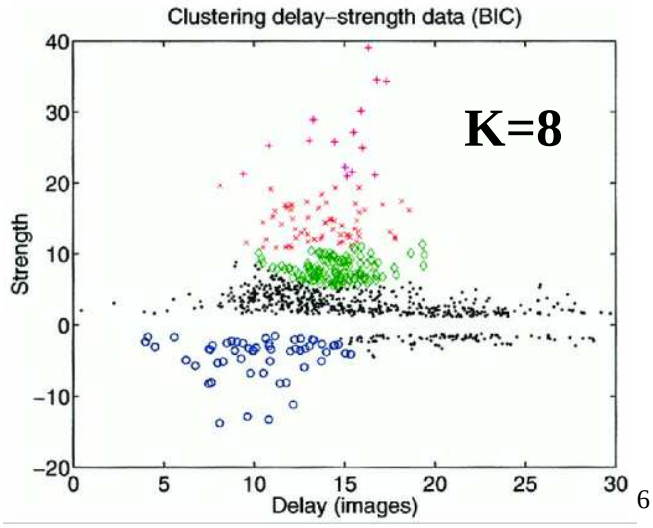
Preprocessing

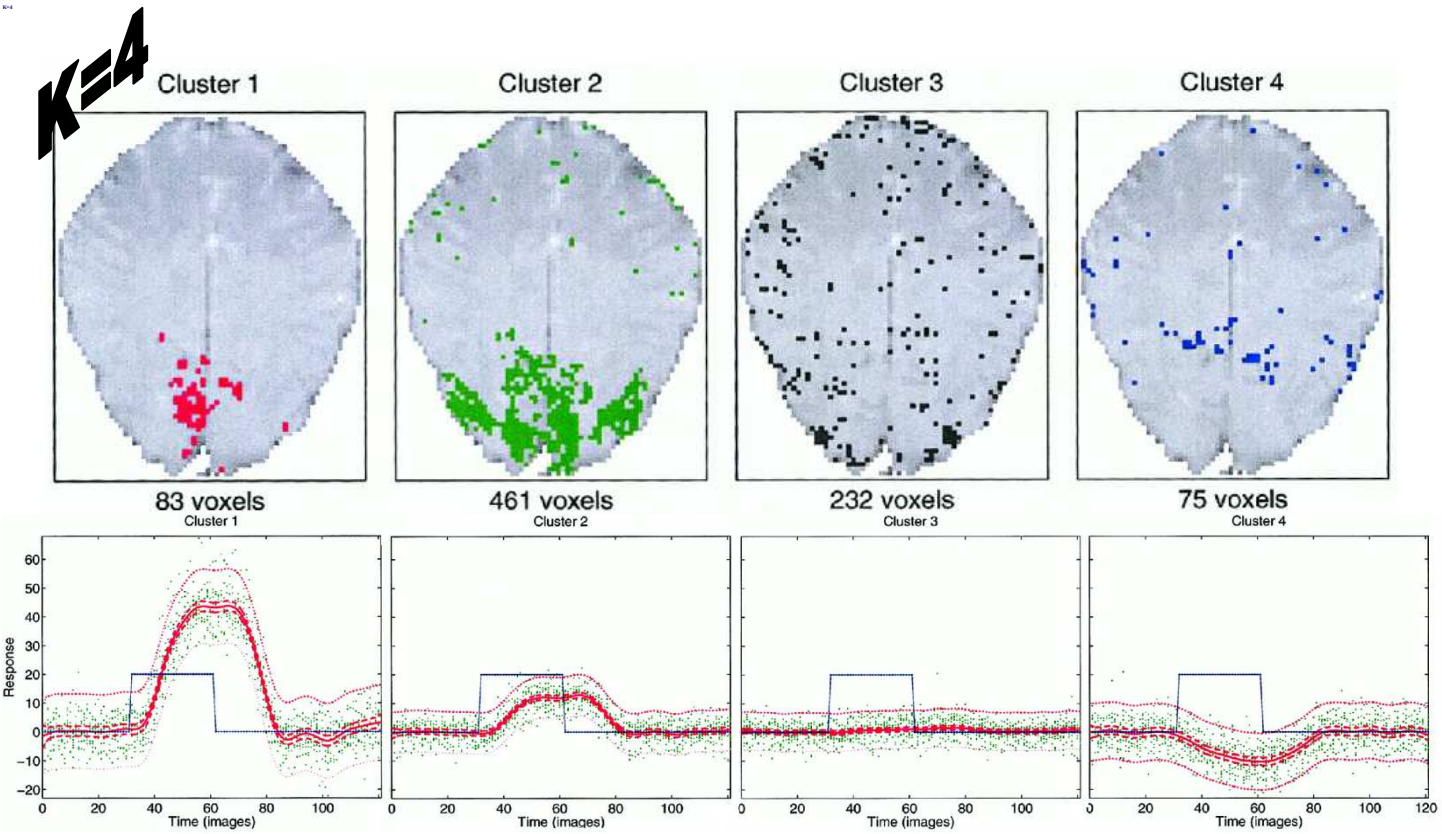


Clustering on delay and strength

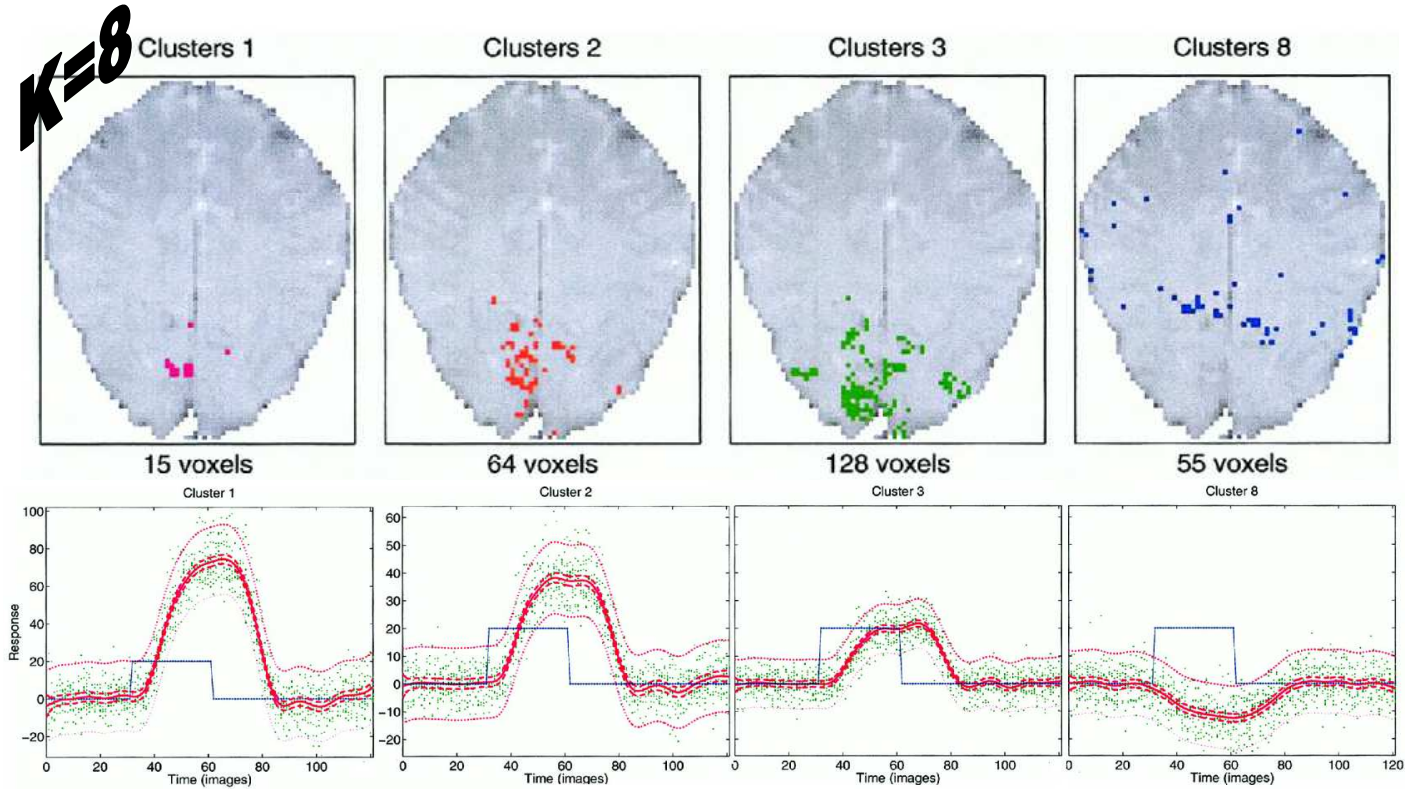








❶ The data in clusters 1, 2 & 4 display very significant activations of various strength.
❷ The delay to 90% of maximum activation is 6.5, 6.2, 6.8 sec
❸ There is a significant undershoot in cluster 1 around images 85-105.

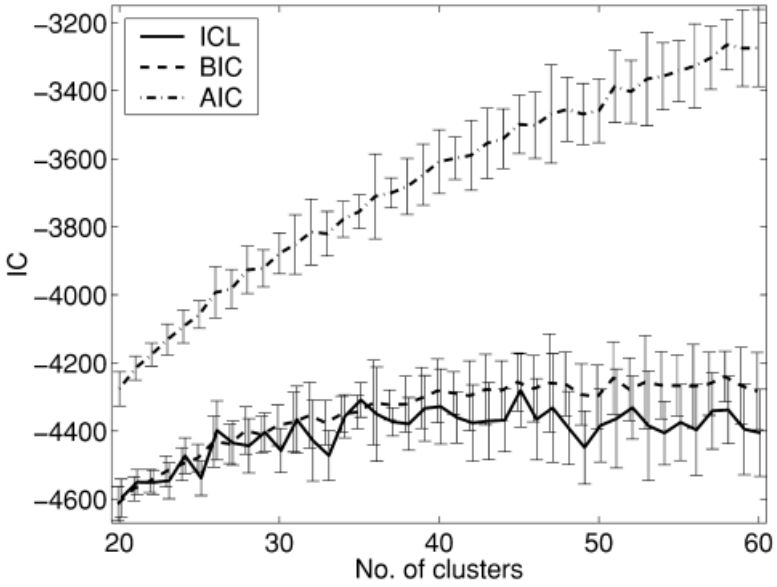


❶ 4 out of 8 resulting clusters display some kind of activation.
❷ The 3rd cluster shows lateral activation in two smaller areas that correspond to V5
❸ The delays for the negative activation are 1-1.5 sec sorter

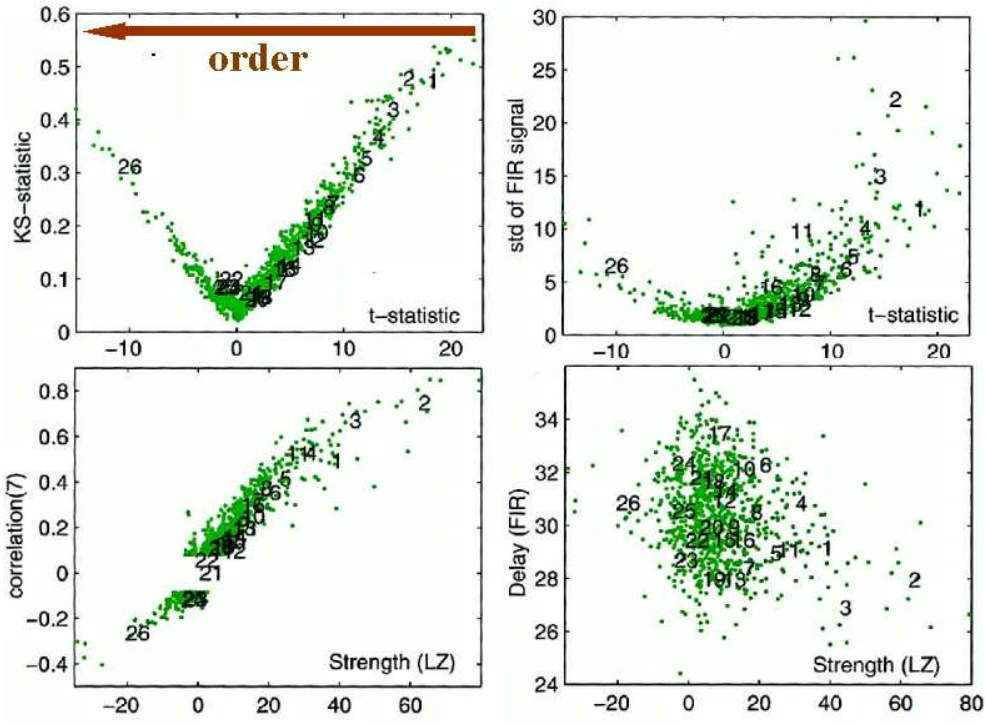
than the delays for the positive activation.

➲ ***Meta clustering*** in the 7D feature-space

Selected K=26

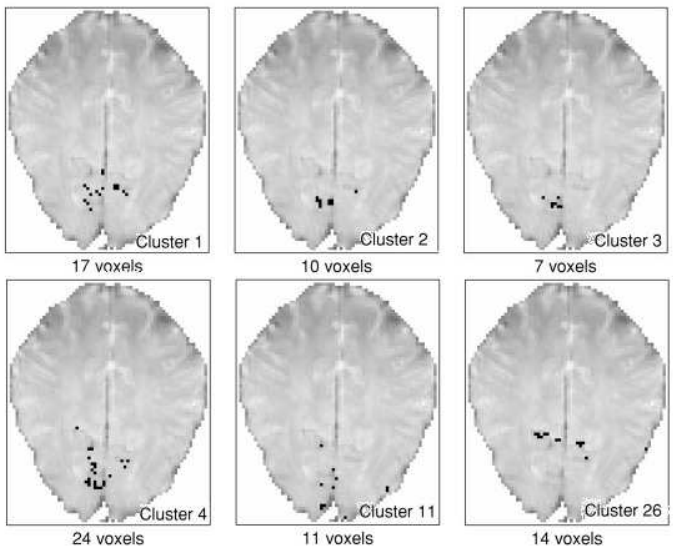


The projection of CA on 2D plots, as a means to compare the different features

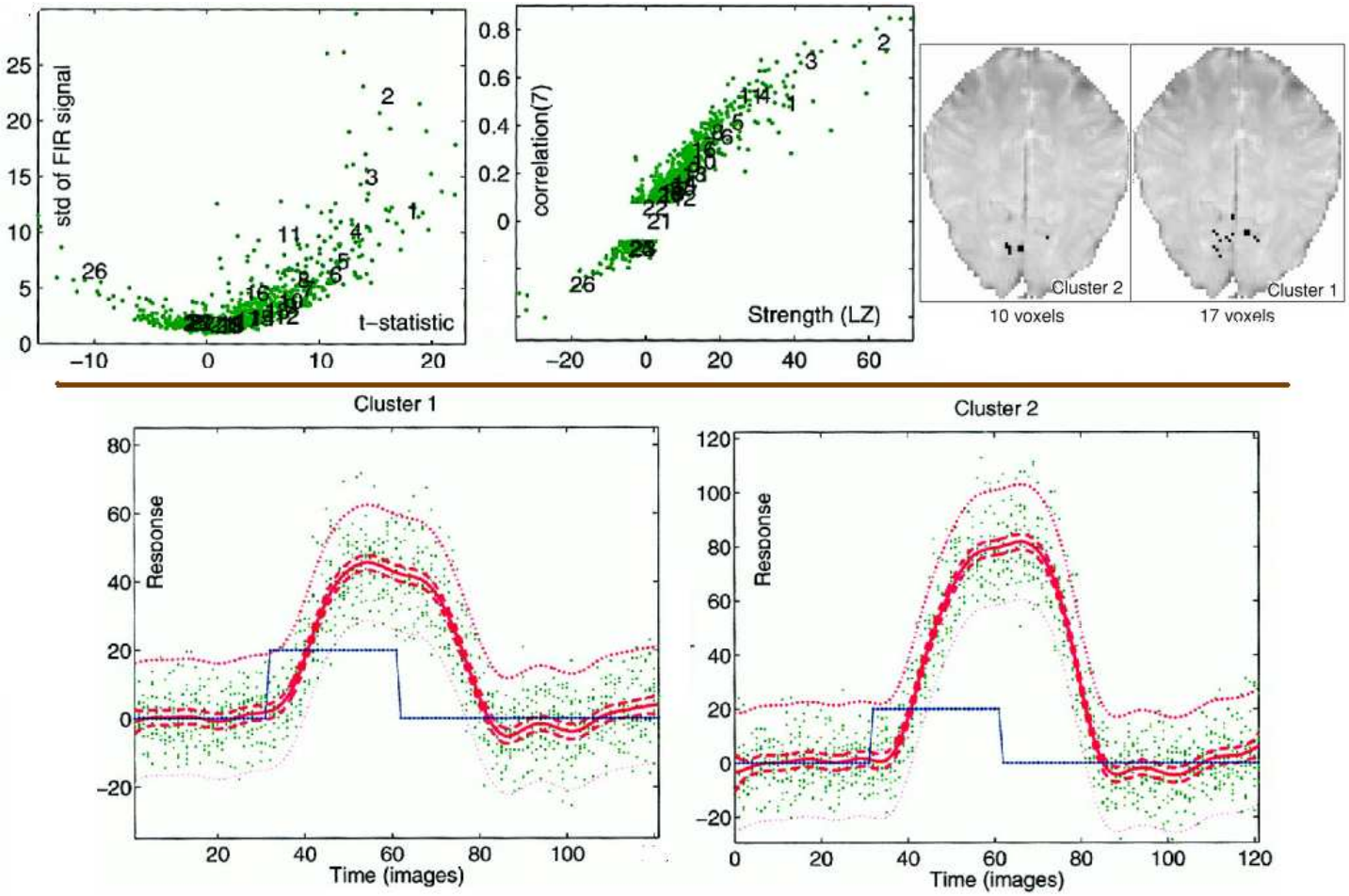


The ordering of clusters according to each feature to access the consensus in the features

e.g. FIR-std assigns similar rank to cluster with positive-negative activation (t-stat. based [1] vs [26])

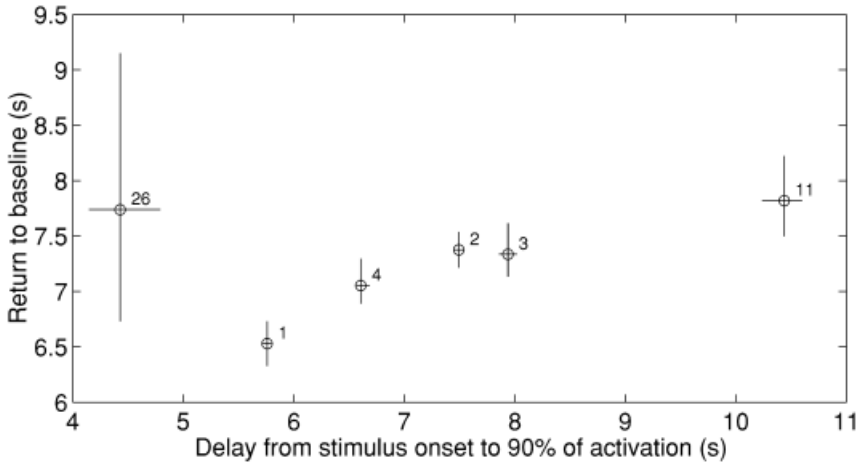


conventional SPMs criticism



t-stat. & KS-stat. rely heavily on a square wave design.

Timing of the haemodynamic response.



CONCLUSIONS

- **Existense of voxel-groups characterized by negative pattern of activation.**
- **No evidence for *"Initial dip"***
- **Parsimonious description of the Data**
- **Complementary information revealed by the plethora of different approaches for voxel-based analysis**

Discussion

① Theoretical considerations
(metric / convergence / K-means modeling limitations etc.)

② Fusion of neuroimaging modalities
Anatomical vs Functional clustering (anat.MRI & fMRI)

③ Time-series Clustering
for exploring/testing putative Temporal-Coding schemes

Friedrich & Laurent ***"Dynamic Optimization of Odor Represenation"***, **Science, vol 291, Feb 2001**