

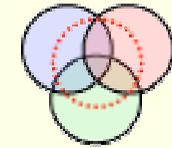


**Department of
Veterans Affairs**



**VAMCA: A toolbox for
the visualization and
metaanalysis of
functional organization
of the cortex using an
anatomical database**

P076



Mind & Brain
at UC Davis



VirginiaTech

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Abstract

The MatLab toolbox VAMCA (Visualization And Meta-analysis on Cortical Anatomy) [1] provides surface-based visualization of cortical functional activations published as stereotaxic coordinates (nitrc.org/projects/vamca). VAMCA uses a database of cortices from 60 healthy subjects to locate activations on a standardized cortical surface by extending the technique of multi-fiducial mapping [2] in order to perform meta-analyses.

Non-parametric statistical tests are provided for determining (a) whether two groups of foci are in the same cortical location; (b) the extent of overlap of the two groups' foci.

Here we apply the toolbox to analyze extra-striate visual functional areas.

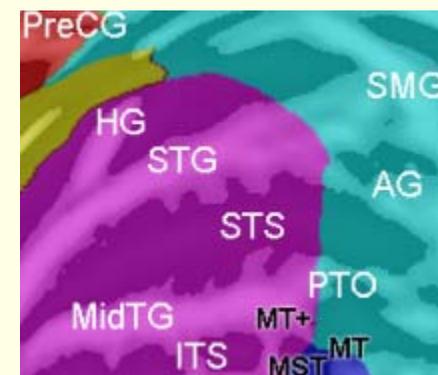
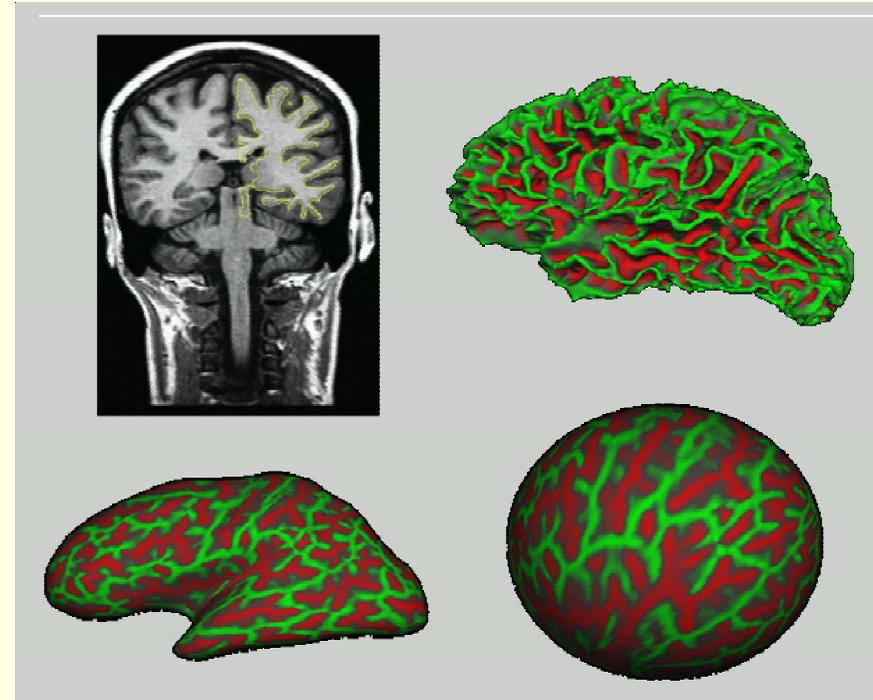
We also introduce and describe a simple-to-implement VAMCA email service for processing stereotaxic coordinates.

VAMCA Cortical Database

Subject database: Brain T1 anatomical data from young (18-48 y.o.) healthy RH subjects: 60 right-handed (33 male).

Processing: FreeSurfer [3] renders cortical surfaces and registers them to a cortical mean sphere. SPM5 segments and normalizes the T1 images to MNI-152 space using affine coregistration.

Multi-fiducial map database: 60 normalized 2D cortical surface space \leftrightarrow 3D MNI space maps.



**Standardized
Cortical
Cartographic Flat
Maps with labels**

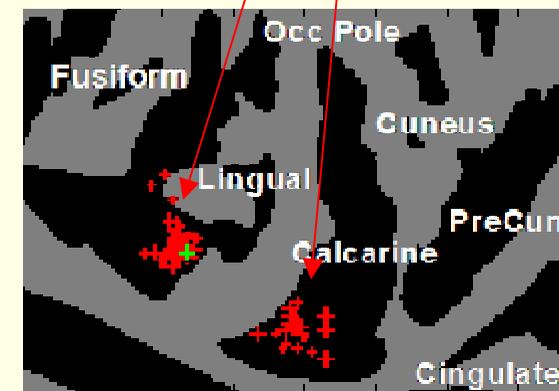
Mapping a stereotaxic location to the cortical surface

Stereotaxic coordinates in text files are processed in MatLab. An occipital lobe Talairach coordinate is circled.

The MNI to cortical surface maps are used to locate the closest location on all 60 surfaces (**red**) for each coordinate.

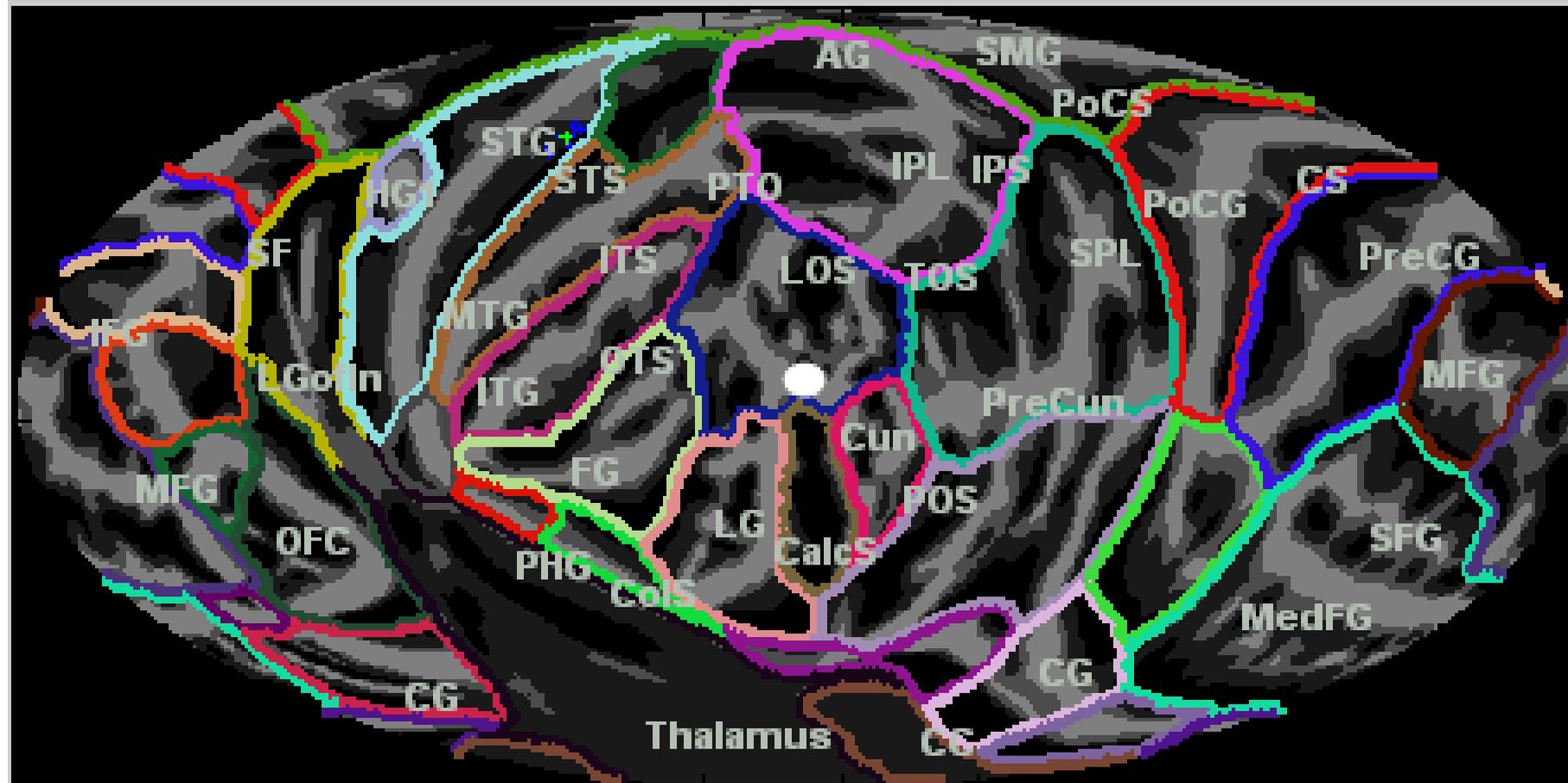
The 2D median location of the 60 surface locations is identified (**green**) and used for further processing.

TAL	-24.0	-54.0	-4.0	0.2
TAL	-40.0	26.0	24.0	0.2
TAL	-28.0	-6.0	40.0	0.2
TAL	36.0	-6.0	40.0	0.2
TAL	-36.0	-58.0	44.0	0.2
TAL	-37.0	18.0	18.0	1.0



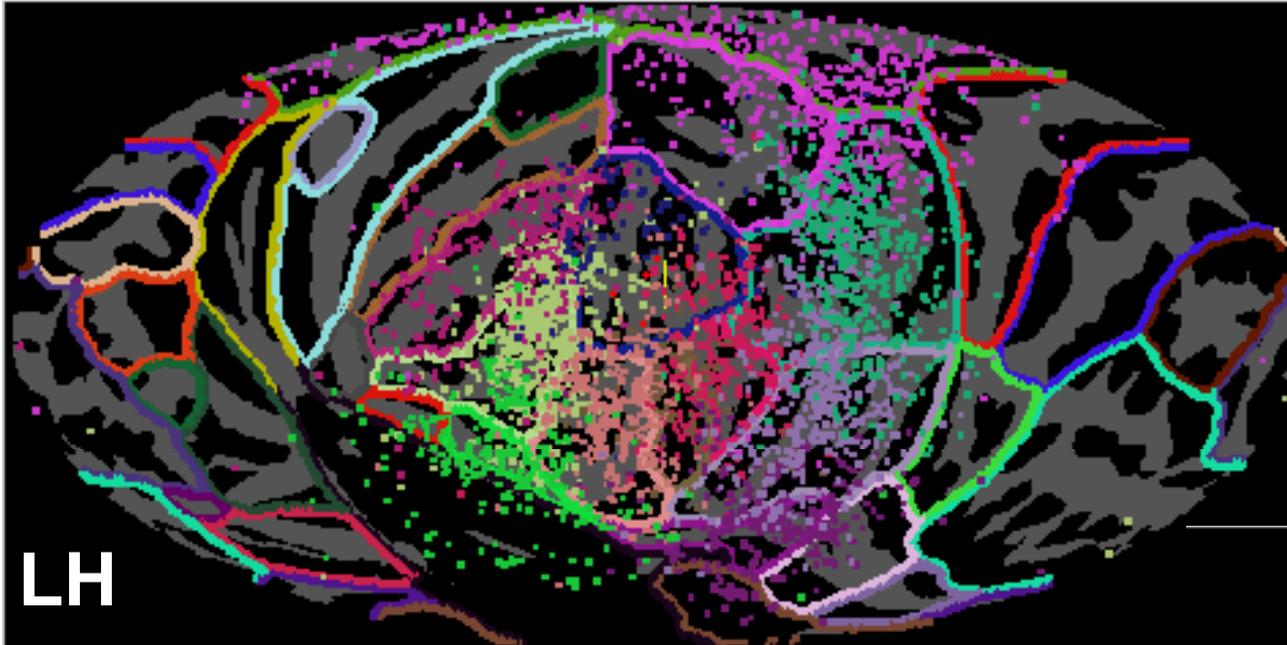
Cortical Surface Map Parcels

Display of 34 FreeSurfer generated parcels [4] on a flat map centered on the occipital pole (white circle) with the calcarine sulcus below it.

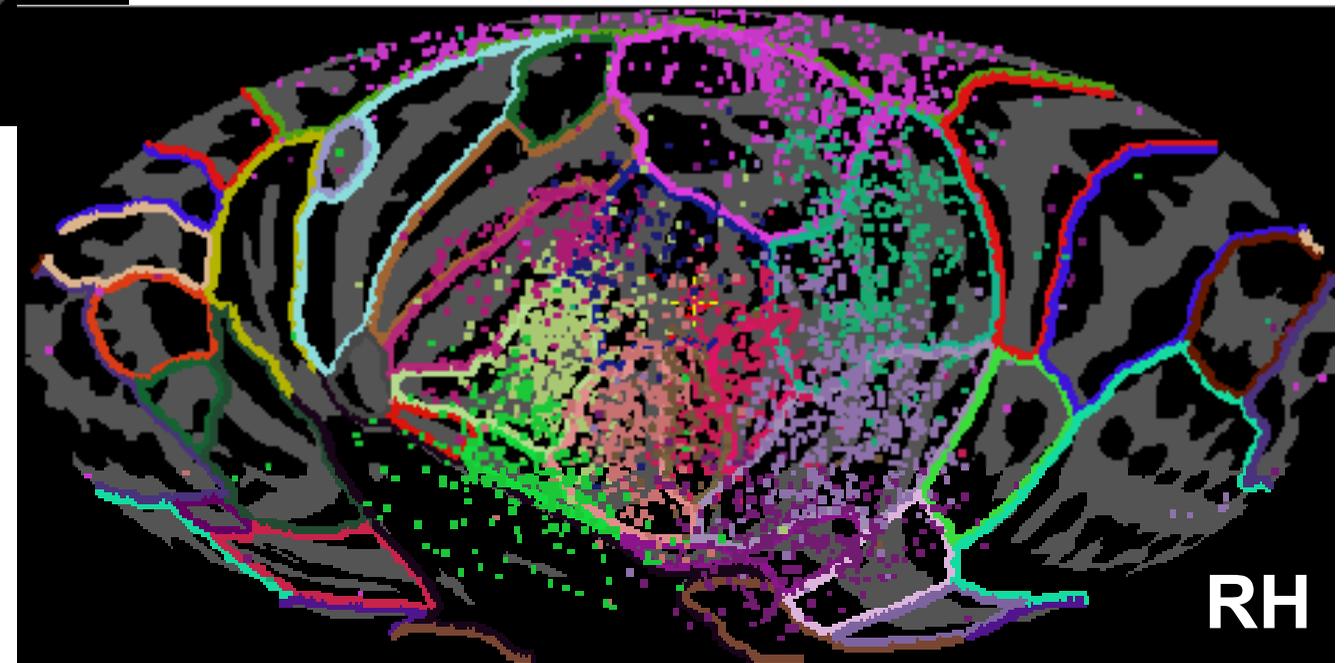


Inf Temporal, Fusiform, Parahippocampal, Lingual, Calcarine, Cuneus, Precuneus, LOS, Sup Parietal, Inf Parietal, Posterior Cingulate

Cortical Surface Mapping Accuracy



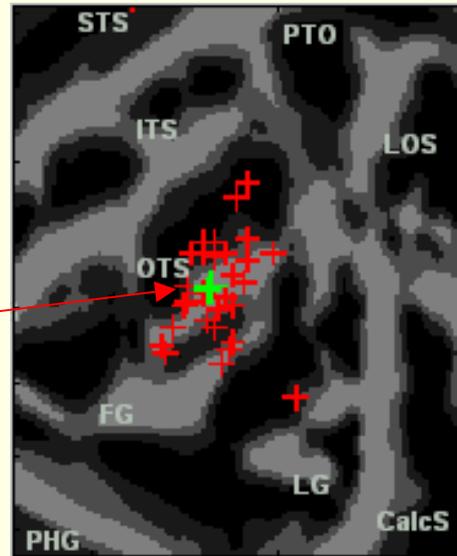
Display of 6909 SumsDB [5] posterior cortex coordinates labeled by paper authors as belonging to the ROIs outlined in the same color.



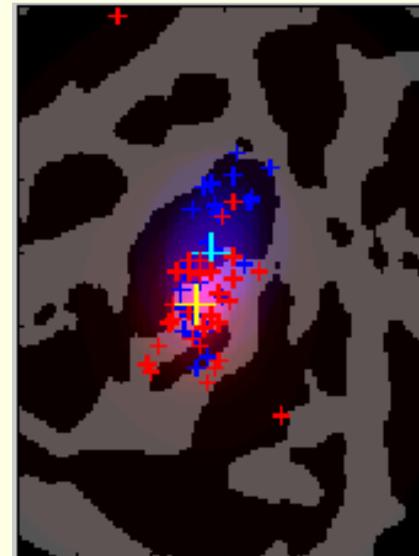
Similarly, fMRI simulations show that mean cortical reconstruction accuracy is ~ 4 to 10 mm.

Meta-analyzing the location of two groups of points on the cortex

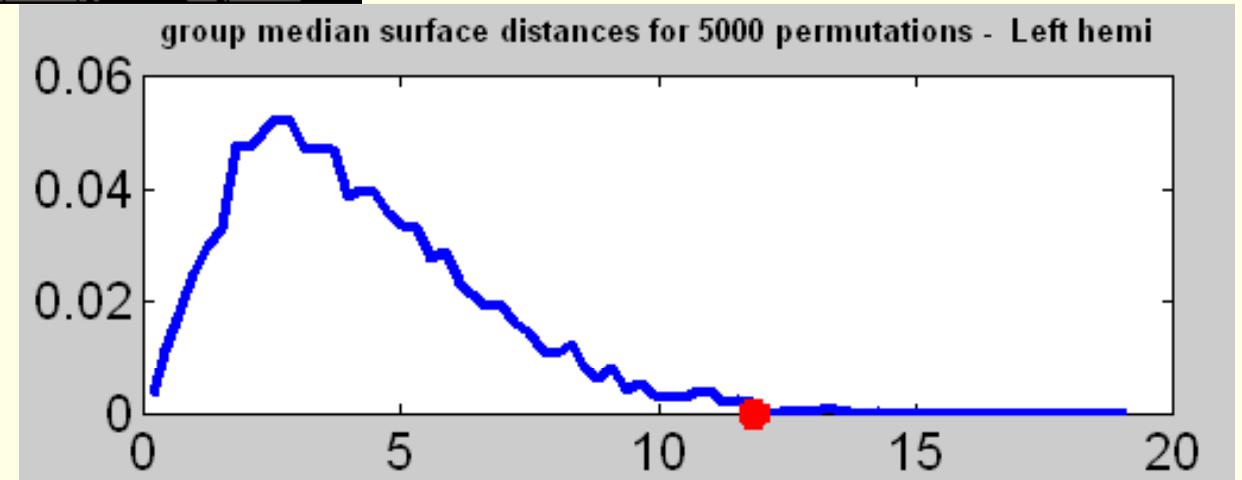
Compiled FFA coordinates (Berman *NI*, 2010) [6] in red with green as centroid of whole group.



Compared to Visual Word Form Area coordinates (Jobard, *NI*, 2003) [6] in blue, with cyan as group centroid (yellow for FFA).



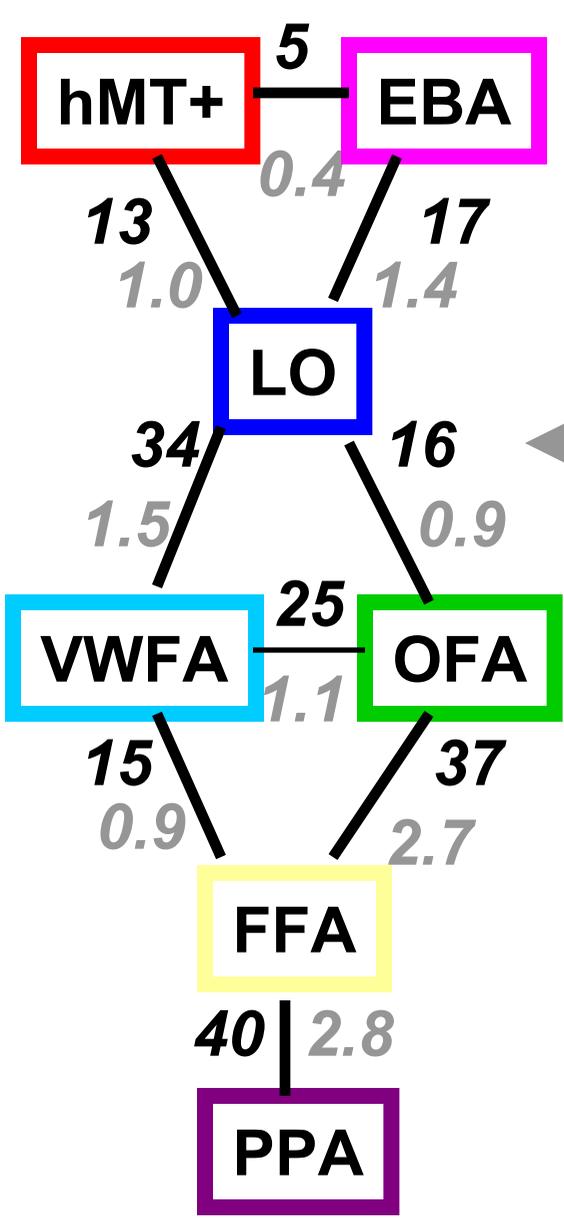
Test if the inter-group surface distance in mm between centroids (*) is high compared to distances (---) after permuting group membership.



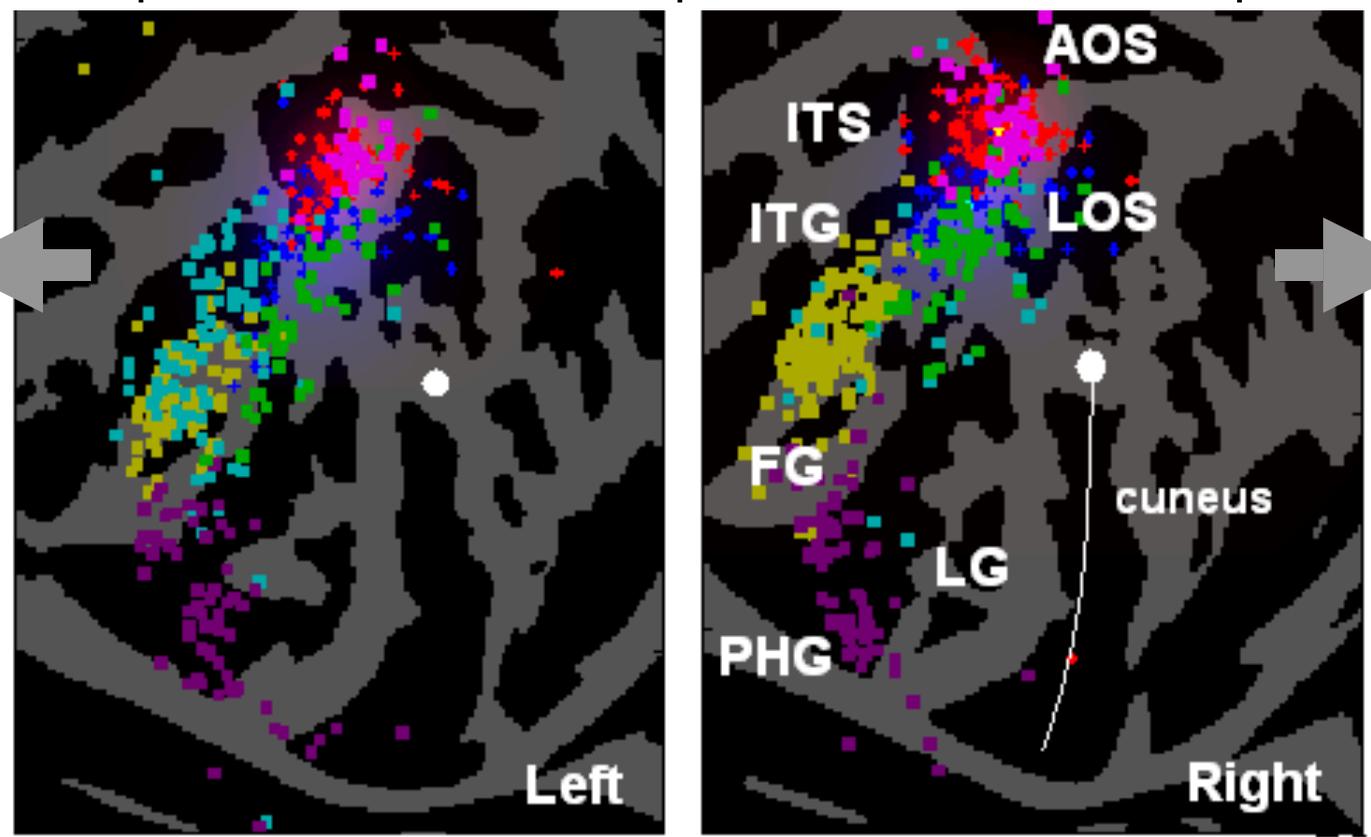
Mapping Ventral Extrastriate Visual Stimulus Selective Regions (SSR)

SSR	Papers	Experiments	Coordinates	Subjects
FFA: face vs --- (fusiform)	153	165	283	2068
PPA: place/scene/house vs. ---	57	64	140	789
VWFA: visual words vs ---	58	60	109	762
hMT+: motion vs stationary	80	84	160	949
LO: objects vs scrambled	72	73	142	843
EBA: headless bodies vs ---	28	32	66	431
OFA: face vs --- (occipital)	60	64	111	835

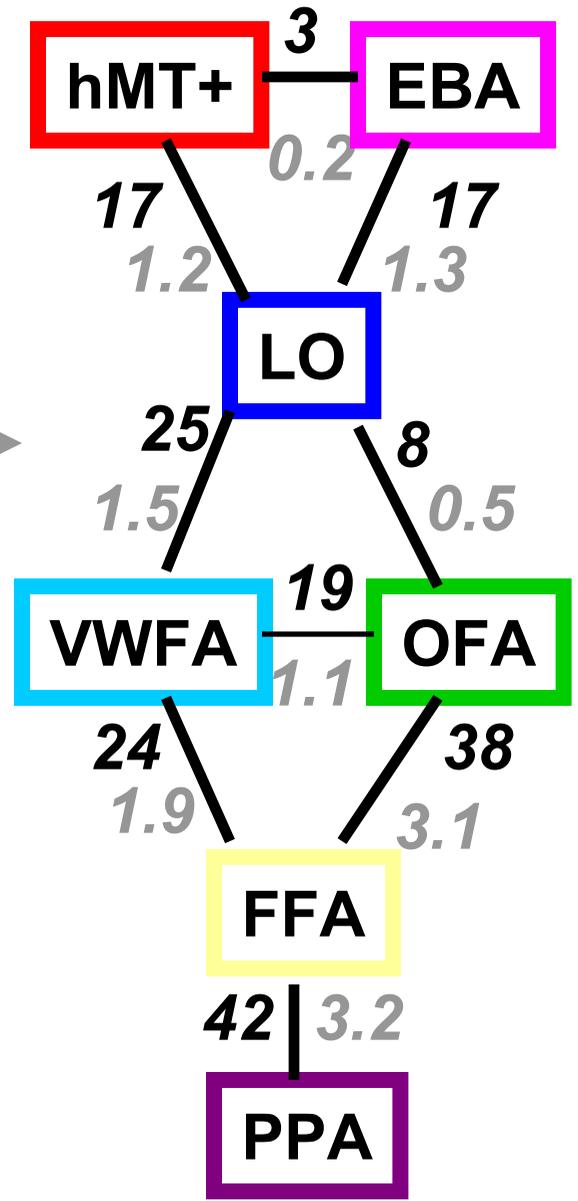
Papers were searched within Google Scholar using the “localizer” keyword along with relevant anatomical and stimulus terms.



Circle and line: occipital pole and calcarine. LG, lingual; FG, fusiform; PHG, parahippocampal; ITG/S, inferior temporal; LOS, lateral occipital; AOS, anterior occipital.

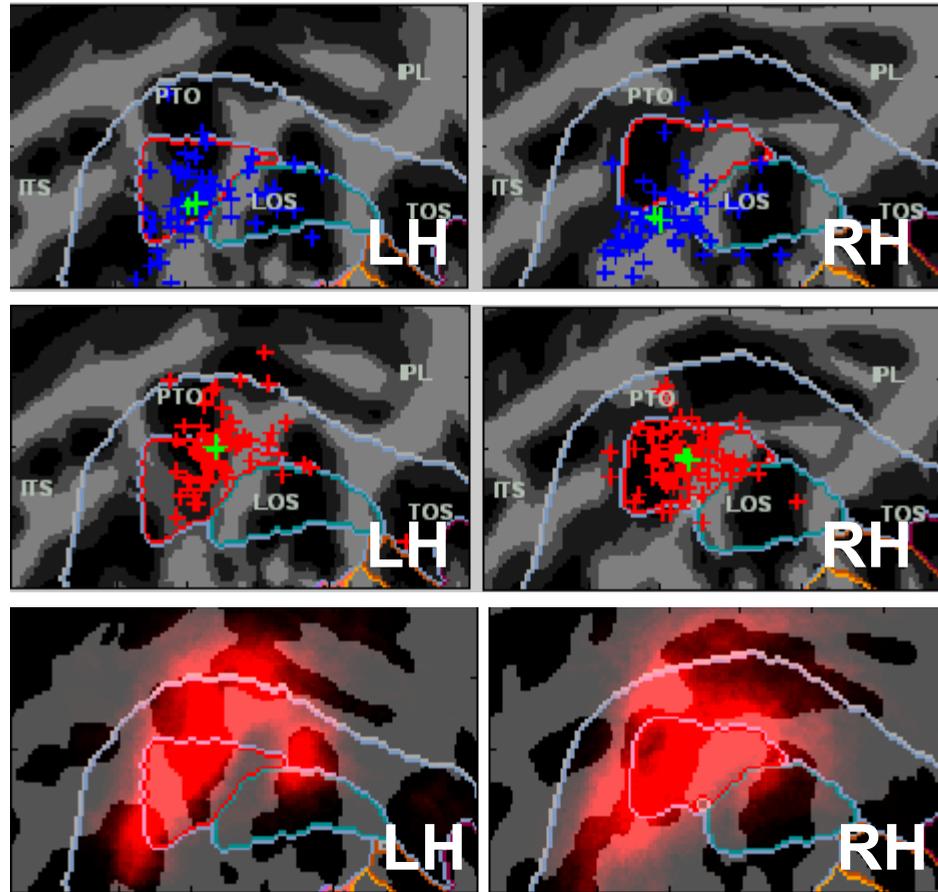


PPA FFA VWFA OFA LO hMT+ EBA

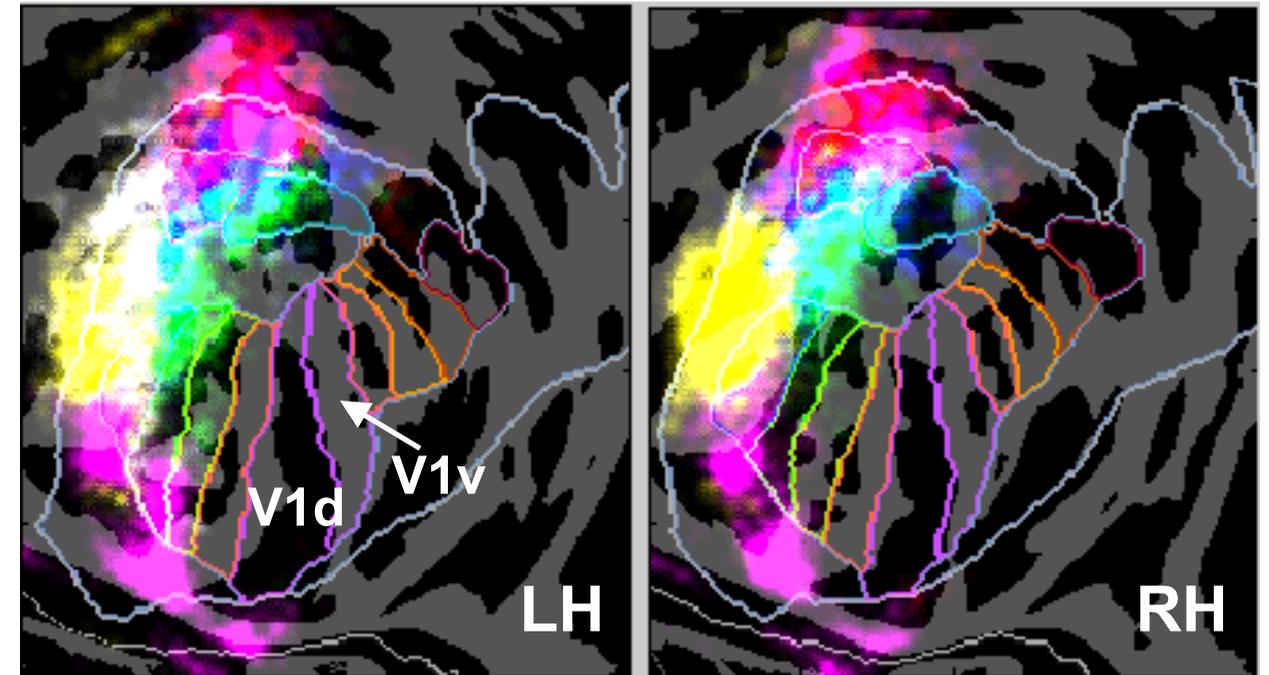


Distances in mm between SSR centroids; robust d' overlap measures in \sim mean/std dev units.

$$\text{Robust } d' = \frac{0.675 \cdot \text{Centroid Distance}}{\text{Median Absolute Deviation}}$$



Maps of SSRs **LO** (top) and **hMT+** (middle) as compared to the PALS-12 [2] same ROIs outlined. Bottom shows location of V5 mapped from cytoarchitectonic data [7].

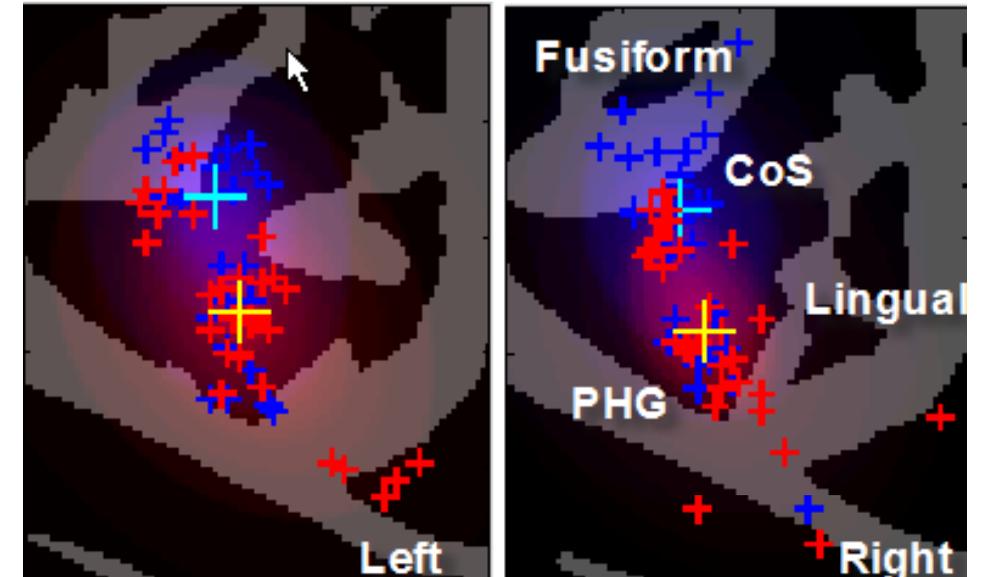
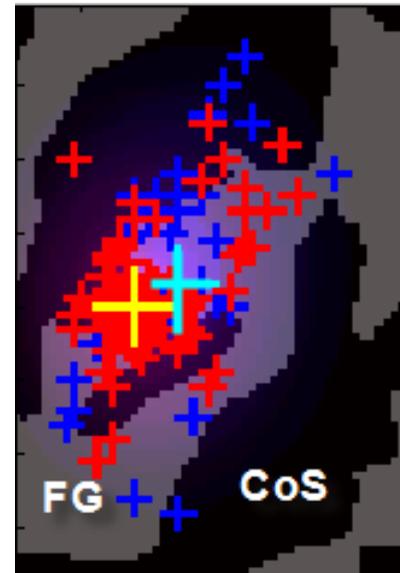


Clouds of individual surface locations for the SSRs using a winner-take-all maximal “density”: **PPA**, **FFA**, **VWFA**, **OFA**, **LO**, **MT**, and **EBA** with PALS-12 [2] visuotopy ROIs outlined.

Localizer Contrast Variations

The specific localizer used may matter.

FFA **passive viewing (+)** vs. FFA **task-engaged (+)** groups separated by 6 mm and $d'=0.5$ in the left hemisphere (only 3 mm and $d'=0.3$ in RH).



PPA **house (+)** vs. PPA **scene (+)** groups separated by 15 mm and $d'=0.9$ in both hemispheres

However, the following localizer differences appear to be inconsequential:

FFA: If the foil to faces was objects or scrambled faces ($d'=0.2-0.3$).

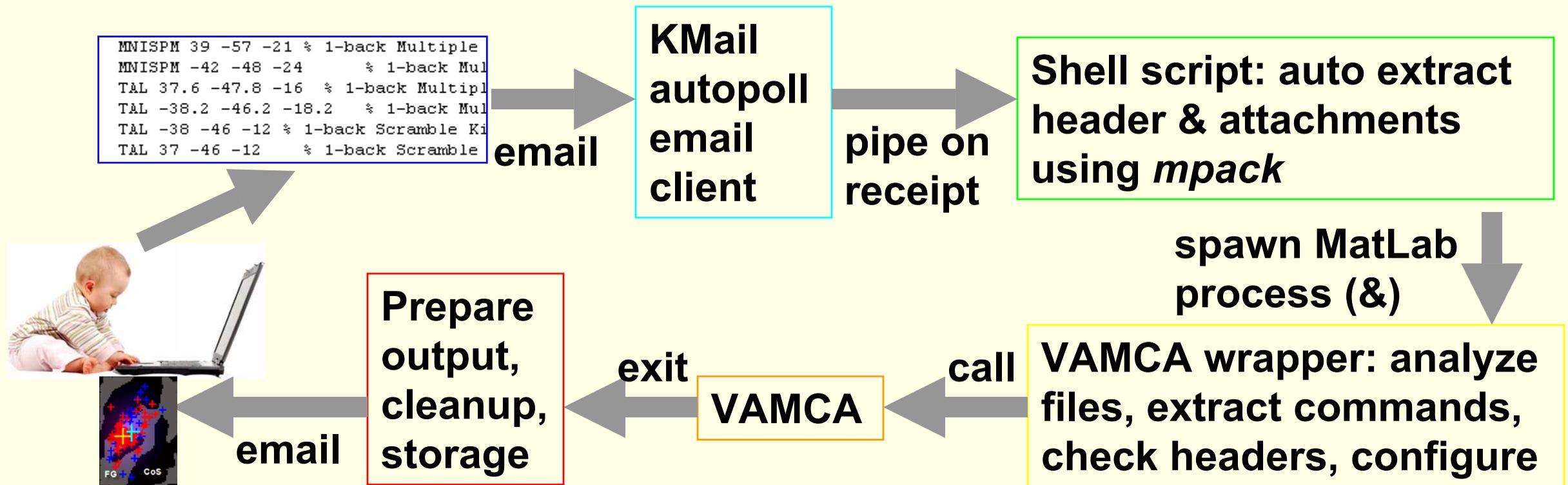
FFA&PPA: How many categories of foil objects were used ($d'=0.1-0.2$).

OFA&PPA: If subjects were passively viewing or doing a task ($d'=0.1-0.3$).

VAMCA Email Service

VAMCA.hcnlab@ebire.org hosts a VAMCA meta-analysis service. Text files with stereotaxic coordinates as attachments or in the email body are processed and returned with output text files and graphics.

System configuration is simple and extensible:



Considerations:

- **No web service to setup and program, just install *mpack*, customize two short scripts, and configure an ordinary email client.**
- **Scientific software runs in native language & form – not limited to using the languages available on a web server.**
- **Good for low-bandwidth/high-computation/large-fixed-database applications, and where a few minutes of return delay is acceptable.**
- **Can be setup behind strong firewalls where servers are not permitted.**
- **Can be implemented on multiple machines as needed – competitive polling of email account (with email deletion on receipt) distributes load.**
- **Important to use try...catch code to email back error types upon failure.**

Acknowledgements

We would like to thank Kimmo Alho for ideas and encouragement and And Turken and Bill Yund for many discussions.

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- [1] Herron et al., OHBM 2009, San Francisco, www.ebire.org/hcnlab
- [2] van Essen, Neuroimage, 28:635-662, 2005, sumsdb.wustl.edu
- [3] Dale, et al, Neuroimage, 9:179-194, 1999, surfer.nmr.mgh.harvard.edu
- [4] Desikan et al, Neuroimage 31, 968-980, 2006.
- [5] Reid & van Essen, sumsdb.wustl.edu/sums/studycollectionlib.do?list=listAll
- [6] Berman et al, NI, 50, 2010; Jobard et al, NI, 20, 2003.
- [7] Wilms et al, Anat Embryol, 210, 2005.

