



Applied NeuroDebian: Python in Neuroimaging

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Dartmouth College, USA

Munich, Germany 2012



The Vision

We (society) have the software platform. . .

- that works on all devices, operating systems, . . .
- that is guaranteed to be available for as long as we want, wherever we want
- that we can freely share with anyone
- that makes manual maintenance trivial, or superfluous
- so all software is available in a single environment
- so we can share our experience with colleagues
- so we can share data processing workflows easily
- so developers can focus their scarce resources

How do we get there?

Role model **debian**

- Origin of most active software distributions
- Vast archive of maintained software (≈ 30000 binary packages) – proven procedures
- Self-governed, “do-ocracy”, no need to earn money, going strong for 20 years



debian

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We ...

- Adopt standards and procedures
- Participate in the Debian project and integrate all research software
- Benefit from the work of thousands of *additional* developers
- Call it **NeuroDebian**, add fancy logo



NeuroDebian from a researcher's perspective

Install simple editor

```
apt-get install gedit
```

Install complex MRI analysis package

```
apt-get install fsl
```

Install software collection for psycho-physics

```
apt-get install science-psychophysics
```

Keep the whole system up-to-date

```
apt-get upgrade
```


Python in Neuroimaging (<http://www.nipy.org>)



Python in NeuroImaging



Find the community @ <http://www.nipy.org>

Stimuli Delivery

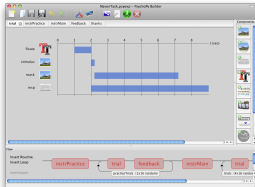
PsychoPy

<http://www.psychopy.org>



PsychoPy is an easy, precise, platform-independent package for stimulus presentation. Suitable for psychophysics, neuroimaging, and all areas of psychology.

- Huge variety of stimuli generated in real-time
- Cross-platform – run the same script on Linux, Win or OS X
- Flexible stimulus units (degrees, cm, or pixels)
- Code interface for those that like to program
- Builder interface for those that don't
- Input from keyboard, mouse, joystick or button boxes
- Multi-monitor support
- Automated monitor calibration (supported photometers)



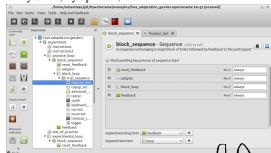
OpenSesame

<http://www.cogsci.nl/software/opensesame>



OpenSesame is a graphical experiment builder for the social sciences.

- A comprehensive and intuitive graphical user interface
- WYSIWYG drawing tools for creating visual stimuli
- Cross-platform
- Python scripting for complex tasks
- A plug-in framework
- Compatibility (through plug-ins) with commonly used devices: (e.g. Eyelink eye trackers, serial response boxes, Mantra object tracker)
- Compatibility with popular Python libraries: PsychoPy, PyGame, PyOpenGL, etc.



Data I/O

NiBabel

<http://nipy.org/nibabel>



NiBabel provides read and write access to some common medical and neuroimaging file formats, including: **ANALYZE** (plain, SPM99, SPM2), **GIFTI**, **NIFTI**, **MINC**, as well as **PAR/REC**. NiBabel is the successor of **PyNIFTI**. The various image format classes give full or selective access to header (meta) information and access to the image data is made available via NumPy arrays.

Analysis

BrainVISA

<http://brainvisa.info>



BrainVISA is an open-source, modular and customizable software platform built to host heterogeneous tools ded-

icated to neuroimaging research. It aims at helping researchers in developing new neuroimaging tools, sharing data and distributing their software.

- Databasing capabilities
- Massive computation facilities using Soma-workflow
- Open environment, with many toolboxes
- Specialized toolboxes for T1 MRI processing, sulci and gyri morphometry, diffusion imaging and fibers tracking, surface and structural analysis, 3D histology...
- Links with other software like SPM, FSL, FreeSurfer, or CIVET



D. Geffroy, D. Rivière, I. Denghien, N. Soudet, S. Laguitton, and Y. Coenepas. BrainVISA: a complete software platform for neuroimaging. In Python in Neuroscience workshop, Paris, Aug. 2011.

DiPy

<http://nipy.org/dipy>

DiPy
Diffusion Imaging in Python



DiPy is an international FOSS project for diffusion magnetic resonance imaging analysis. DiPy is multiplatform and will run under any standard operating system such as **Windows**, **Linux**, **Mac OS X**. Some of our **state-of-the-art** applications are:

- Reconstruction algorithms e.g. GQI, DTI
- Tractography generation algorithms e.g. EuDX
- Intelligent downsampling of tracks
- Ultra fast tractography clustering
- Resampling datasets with anisotropic voxels to isotropic
- Visualizing multiple brains simultaneously
- Finding track correspondence between different brains
- Warping tractographies into another (e.g. MNI) space
- Support of various file formats e.g. Trackvis or NIFTI



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<http://goo.gl/DXZXB>

<http://github.com/nipy/nipy-artwork>



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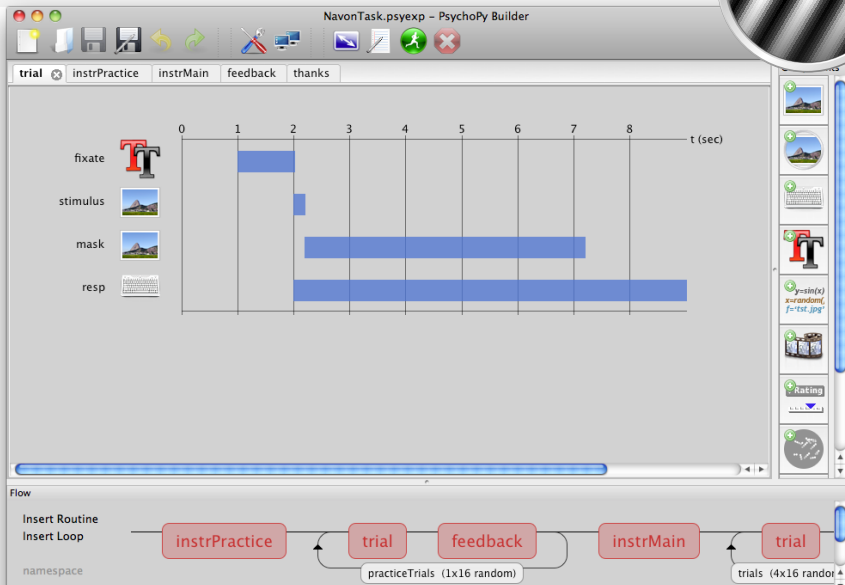


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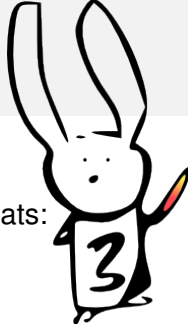
PsychoPy: Builder

<http://www.psychopy.org>



NiBabel

<http://nipy.org/nibabel>



NiBabel (successor of **PyNIfTI**) provides read and write access to some common medical and neuroimaging formats:

- **ANALYZE** (plain, SPM99, SPM2)
- **GIFTI**
- **NIfTI1**
- **MINC**
- **PAR/REC**
- **Freesurfer** volume/surface/spec

The various image format classes give full or selective access to header (meta) information and access to the image data is made available via NumPy arrays.

Handy tools...

NiBabel: Handy tools

<http://nipy.org/nibabel>



nib-dicomfs :
FUSE filesystem on top of a directory with DICOMs

nib-ls :
ls for neuroimaging data files

```
$> nib-ls -s nibabel/tests/data/*
nibabel/tests/data/0.dcm      failed
nibabel/tests/data/1.dcm      failed
nibabel/tests/data/analyze.hdr uint8 [ 91, 109, 91, 1] 2.00x2.00x2.00x0.00 *1.72e+03+0 error
nibabel/tests/data/example4d.nii.gz int16 [128, 96, 24, 2] 2.00x2.00x2.20x2000.00 #exts: 2 sform [229725] 2:1.2e+03
nibabel/tests/data/nifti1.hdr int16 [ 91, 109, 91] 2.00x2.00x2.00 error
nibabel/tests/data/test.mgz >f4 [ 3, 4, 5, 2] 3.74x3.74x3.74 [120] -2.4:2.5
nibabel/tests/data/tiny.mnc uint8 [ 10, 20, 20] 2.00x2.00x2.00 [4000] 0.21:0.75
nibabel/tests/data/tinypet.v failed
```

NIPY provides a rich suite of algorithms for pre-processing and analysis of neuroimaging data

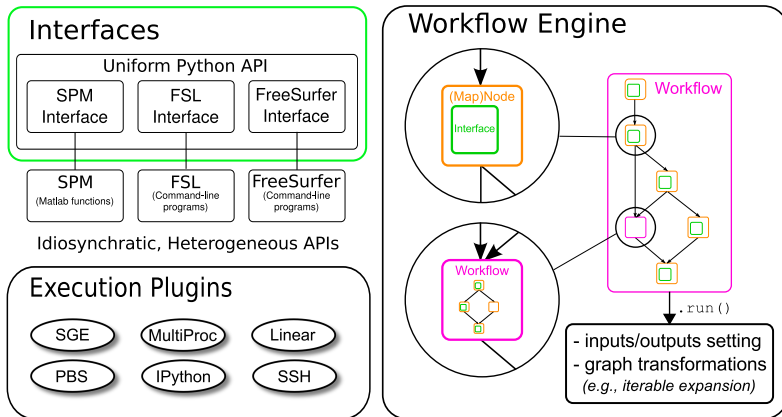
- General linear model (GLM) statistical analysis
- Combined slice time correction and motion correction
- General image registration routines with flexible cost functions, optimizers and resampling schemes
- Image segmentation
- Basic visualization of results in 2D and 3D
- Basic time series diagnostics
- Clustering and activation pattern analysis across subjects
- Reproducibility analysis for group studies

Nipype

<http://nipy.org/nipype>

Nipype allows you to

- interact with tools from different software packages (SPM, FSL, FreeSurfer, Camino, AFNI, Slicer)
- combine processing steps from different packages
- develop new workflows faster by reusing common steps from old ones
- process data faster by running in parallel
- make your research easily reproducible
- share your processing workflows with the community



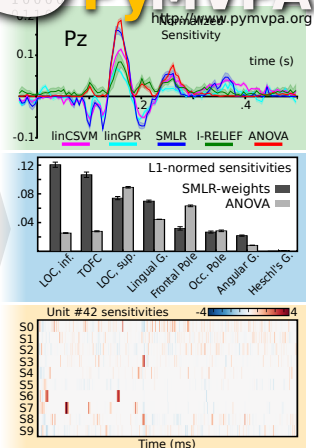
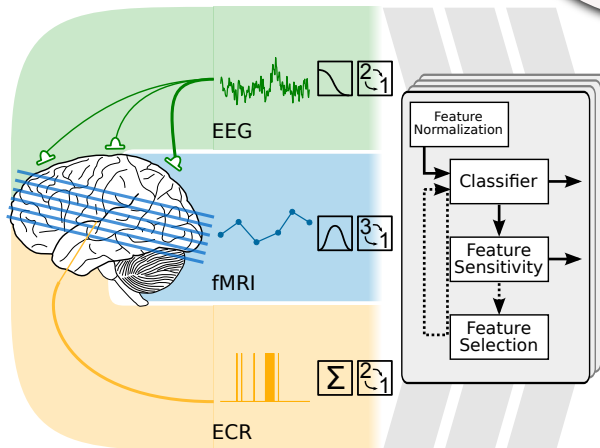


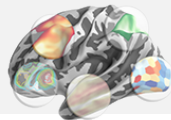
PyMVPA eases statistical learning analyses (or otherwise called Multivariate pattern analysis, MVPA) of large datasets, with an accent on neuroimaging.

- Easy I/O to Neuroimaging data (via NiBabel)
- Variety of machine learning methods (e.g. SVM, SMLR, kNN)
- Uniform interfaces to other toolkits (e.g. MDP, Shogun, Scikit-learn)
- Flexible Searchlight-ing
- Uber-Fast GNB/M1NN Searchlight-ing
- Hyperalignment (Haxby et al 2011, Neuron)

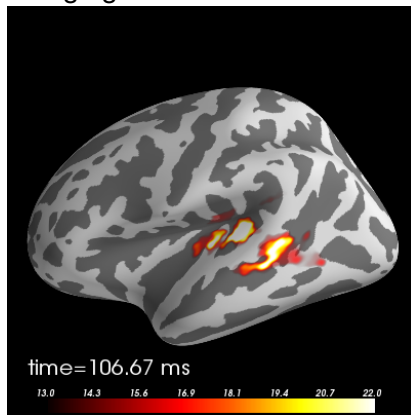
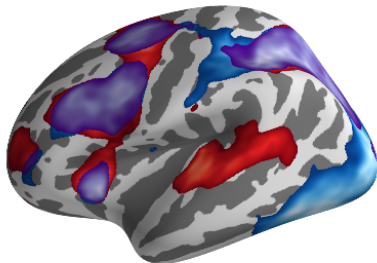
PyMVPA

http://www.py_mvpa.org





PySurfer is a module for visualization and interaction with cortical surface representations of neuroimaging data from Freesurfer.





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Python in Electrophysiology



Find the community @ <http://neuralensemble.org>

Data I/O

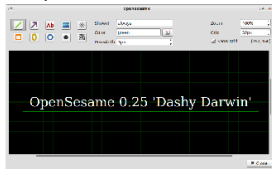
XXX

<http://example.org>



Brief description.

- The most interesting
- and
- methodology oriented
- features
- ideally with limited selection of citations



D. Geffroy, D. Rivière, I. Denghien, N. Souedet, S. Laguitton, and Y. Cointepas. BrainVISA: a complete software platform for neuroimaging. In Python in Neuroscience workshop, Paris, Aug. 2011.

Neuroshare Tools

<http://g-node.org/neuroshare-tools>

neuroshare

Neuroshare is a standardized API for accessing neurophysiology data stored in vendor-specific binary formats in a vendor-neutral way. The G-Node Neuroshare Tools provide libraries and utilities built on Neuroshare and Python to work with Neuroshare compatible files on various platforms.

- High-level Python library to access Neuroshare compatible data-files
- Automatically detects file types and loads the corresponding vendor library
- Support for GNU/Linux, MacOS X, and Windows
- Neuroshare-WineProxy enables the use of vendor libraries for Windows under GNU/Linux and MacOS X
- Comes with a tool to convert any data file supported by Neuroshare to the HDF5 format

Metadata Management

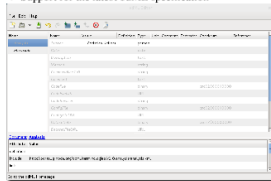
odML libraries & Editor

<http://www.g-node.org/odml/>



Use the open metadata Markup Language to annotate data with information about the stimulus, data acquisition, and experimental conditions.

- Developer friendly libraries for Python and Java
- Fully functional graphical editor for Linux, Windows, and MacOS X
- Support for the latest odML specification



Grewe J, Wachtler T, Benda J (2011) A bottom-up approach to data annotation in neurophysiology. Front. Neuroinform. 5:16. doi: 10.3389/fninf.2011.00016

Data Archiving

Experimentation Control

Analysis

Stimfit

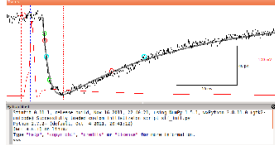
<http://www.stimfit.org>



Visualise and quantify electrophysiological data.

- With a focus on patch-clamp recordings
- Supports most standard patch-clamp file types
- Embedded Python shell
- Measure action potential, EPSC and EPSP kinetics
- Extract spontaneous and evoked events
- Successfully used in many publications for > 5 years

| Experiment | Stimulus | Stimulus | Stimulus | Stimulus | Stimulus |
|------------|----------|----------|----------|----------|----------|
| Adaptation | 2.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Stimulus | 2.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Stimulus | 2.000 | 1.000 | 1.000 | 1.000 | 1.000 |



Closed-loop Frameworks

Brain Download:

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ICANHASCHEEZBURGER.COM 🍕 🍔 🍌

Acknowledgements

Michael Hanke

FOSS developers of
Python, NumPy, SciPy,
Matplotlib, H5Py, Rpy,
Nipy, nibabel, ...
Inkscape, ...
Debian Community

James V. Haxby
Stephen J. Hanson

INCF

Dr. Yaroslav O. Halchenko
Dartmouth College, NH, USA
yoh@onerussian.com

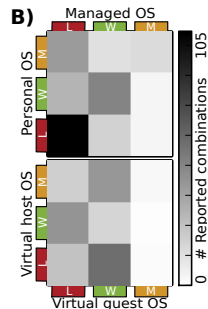
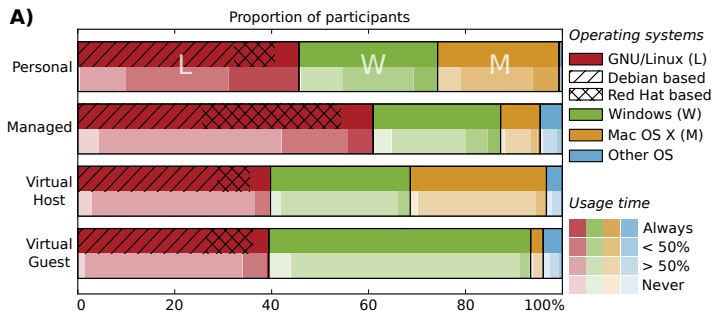
about the slides:
should become available at
© 2012
snake-brain © 2010
slide style

<http://neuro.debian.net>

Yaroslav O. Halchenko & artwork authors,
Arno Klein
inspired by Stefano Zacchiroli

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OS market share



Hanke & Halchenko, 2011, Front. Neuroinf.



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Open is not enough. Let's take the next step: An integrated, community-driven computing platform for neuroscience

Yaroslav O. Halchenko^{1, 2, 3} and Michael Hanke^{3, 4, 5*}

¹ Center for Cognitive Neuroscience, Dartmouth College, USA

² Department of Psychological and Brain Sciences, Dartmouth College, USA

³ Debian Project

⁴ Department of Experimental Psychology, Otto-von-Guericke-University, Germany

⁵ Center for Behavioral Brain Sciences, Germany

The last five years have seen dramatic improvements in the collaborative research infrastructure. A need for open research tools has been identified (Ince et al., 2012), and one solution has been clearing houses, such as the INCF Software Center[1], and the NITRC[2] portal, which facilitate efforts of peer-to-peer software and data sharing that were previously limited to only well-funded formal consortia (see Poline et al., 2012, for a recent summary of the status quo). However, collecting these resources into a centralized clearing-house addresses only one necessary aspect on the way to a sustainable software ecosystem for neuroscience – availability. Unfortunately it does not ensure ease of deployment, nor does it offer a sustainable model for long-term maintenance.

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