

Matthew Brett

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EDUCATION

Royal London Hospital Bachelor of medicine and surgery	1987–1990
Cambridge University Open entrance scholarship BA 2.i; Experimental psychology	1984–1987

WORK HISTORY

University of California, Berkeley Associate researcher at the Brain Imaging Center	2008–present
MRC Cognition and Brain Sciences Unit, Cambridge Senior investigator scientist	2005–2008
University of California, Berkeley Associate specialist in psychology; advised by Rich Ivry	2003–2005
MRC Cognition and Brain Sciences Unit, Cambridge Research associate in psychology; advised by John Duncan	1999–2003
MRC Cyclotron Unit, Hammersmith Hospital / Physiology Laboratory, Oxford Research registrar in neurology; advised by David Brooks (London) and John Stein (Oxford)	1996–1999
Radcliffe Infirmary, Oxford Neurology registrar	1995–1999
National Hospital for Neurology, London Neurology senior house officer	1994–1995
St Bartholemew's Hospital, London Senior house officer in medicine	1992–1994
Addenbrooke's Hospital, Cambridge Senior house officer in neurosciences	1992
Royal London Hospital House officer in medicine	1991
Princess Alexandra Hospital, Harlow House officer in surgery	1990

RESEARCH METRICS ¹

Citations: 11267
h-index: 32
i10-index: 39

¹From <https://scholar.google.com/citations?user=q12RP7AAAAAJ> as of Jan 22, 2017

NEUROLOGY

Neurology qualifications

National training number in neurology (UK) 1996
Member of the Royal College of Physicians (UK) 1994

Neurology teaching

Oxford University 1994–1995
Supervision of medical students in neuroanatomy

Neurology articles

Brett, Matthew and Sallie Baxendale (2001). "Motherhood and memory: a review." In: *Psychoneuroendocrinology* 26.4, pp. 339–362.

Brett, M., M. R. Persey, M. M. Reilly, T. Revesz, D. R. Booth, S. E. Booth, P. N. Hawkins, M. B. Pepys, and J. A. Morgan-Hughes (1999a). "Transthyretin Leu12Pro is associated with systemic, neuropathic and leptomeningeal amyloidosis." In: *Brain* 122 (Pt 2), pp. 183–190.

Brett, M., R. Greenwood, J. Powell, and P. Morris (1995). "Late functional recovery with a novel community rehabilitation programme after herpes simplex encephalitis". In: *Clinical Rehabilitation* 9.3, pp. 267–270. ISSN: 0269-2155. DOI: 10.1177/026921559500900315.

Chesser, Alistair and Matthew Brett (1989). "Clinical teaching in context: a factor analysis of student ratings. Research in Medical Education Conference (RIME)". In: *Proceedings of the twenty-eighth annual conference. Washington: Association of American Medical Colleges.*

COGNITIVE AND MOTOR NEUROSCIENCE

Neuroscience awards

British brain and spine foundation training fellowship 1996–1999

Neuroscience teaching

Cambridge University 2007–2008
Supervision in undergraduate neuroscience for Jesus College

Neuroscience research supervision

MRC Cognition and Brain Sciences Unit, Cambridge 2007–2008
Member of the Graduate Committee

Cambridge University BA final year projects 2007–2008
Final year undergraduate projects in experimental psychology by Sam Burnand and Rich Armstrong. Projects on functional MRI of response selection. Both projects graded as first class

Cambridge University PhD 2001–2004
Jessica Grahn: *The functional anatomy of musical beat perception*. Jessica is an associate professor in the Brain and Mind Institute, Western University, Ontario

Cambridge University PhD 2000–2004
Katja Osswald: *The role of SMA and basal ganglia in motor learning, mechanisms of apraxia and methods of functional MRI analysis*. Katja is an associate lecturer at the department of psychology in York and an NHS clinical psychologist

Neuroscience articles

- Rodriguez Rodriguez, Valia, Russell Thompson, Mark Stokes, Matthew Brett, Indira Alvarez, Mitchell Valdes-Sosa, and John Duncan (2012). "Absence of face-specific cortical activity in the complete absence of awareness: Converging evidence from functional magnetic resonance imaging and event-related potentials". In: *Journal of Cognitive Neuroscience* 24.2, pp. 396–415.
- Grahn, Jessica A and Matthew Brett (2009). "Impairment of beat-based rhythm discrimination in Parkinson's disease." In: *Cortex* 45.1, pp. 54–61. DOI: 10.1016/j.cortex.2008.01.005.
- Grahn, Jessica A and Matthew Brett (2007). "Rhythm and beat perception in motor areas of the brain." In: *J Cogn Neurosci* 19.5, pp. 893–906. DOI: 10.1162/jocn.2007.19.5.893.
- Spencer, Rebecca M C, Timothy Verstynen, Matthew Brett, and Richard Ivry (2007). "Cerebellar activation during discrete and not continuous timed movements: an fMRI study." In: *Neuroimage* 36.2, pp. 378–387. DOI: 10.1016/j.neuroimage.2007.03.009.
- Dove, Anja, Matthew Brett, Rhodri Cusack, and Adrian M Owen (2006). "Dissociable contributions of the mid-ventrolateral frontal cortex and the medial temporal lobe system to human memory." In: *Neuroimage* 31.4, pp. 1790–1801. DOI: 10.1016/j.neuroimage.2006.02.035.
- Graham, Kim S, Andy C H Lee, Matthew Brett, and Karalyn Patterson (2003). "The neural basis of autobiographical and semantic memory: new evidence from three PET studies." In: *Cogn Affect Behav Neurosci* 3.3, pp. 234–254.
- Kellenbach, Marion L, Matthew Brett, and Karalyn Patterson (2003). "Actions speak louder than functions: the importance of manipulability and action in tool representation." In: *J Cogn Neurosci* 15.1, pp. 30–46. DOI: 10.1162/089892903321107800.
- Kellenbach, Marion L., Matthew Brett, and Karalyn Patterson (2001). "Large, colorful, or noisy? Attribute- and modality-specific activations during retrieval of perceptual attribute knowledge." In: *Cogn Affect Behav Neurosci* 1.3, pp. 207–221.

Neuroscience abstracts

- Osswald, Katja, John Duncan, Gordon D. Logan, and Matthew Brett (2002). "Automatic response selection – functional imaging of practice effects". In: *Abstract Viewer/Itinerary Planner*. Washington, DC: Society for Neuroscience. Program No. 163.2. Online.
- Dove, Anje, James B. Rowe, Matthew Brett, and Adrian M. Owen (2001). "Neural correlates of passive and active encoding and retrieval: A 3T fMRI study". In: *NeuroImage* 13.6, S660.
- Brett, Matthew, John F. Stein, and David J. Brooks (1998). "The role of the lateral premotor cortex in conditional and imitated praxis". In: *NeuroImage* 9, S987.
- Brett, Matthew, I. Harry Jenkins, John F. Stein, and David J. Brooks (1997). "Movement selection without preparation does not activate the SMA". In: *NeuroImage* 5, S269.

IMAGING METHODS AND STATISTICS

Methods leadership

Increasing true findings in imaging

2005–present

Author of the first (to my knowledge) fully reproducible imaging analysis (Aston *et al* 2006). Piloted and implemented new teaching methods designed to increase the quality and efficiency of scientific computing practice in imaging and statistics (see Methods Teaching)

Development strategy

2005–present

Standard imaging software uses languages unsuitable for large projects (MATLAB, C) and / or scientific developers (C, C++). This makes large projects stagnate, discourages scientist developers,

and encourages uncritical application of software recipes. Identified Python as the future standard for scientific development, and started long-term project to develop open international projects for imaging analysis in Python (see Computing leadership, Selected software).

Methods reporting 2008
One of six authors on the standard guidelines for reporting an fMRI study (Poldrack *et al* 2008).

Hypothesis testing 2001–present
Much initial research followed the emphasis of imaging software on exploratory analysis rather than testing anatomical hypotheses. Implemented small volume correction methods for SPM software, and wrote MarsBaR – a widely used region-of-interest analysis toolbox for SPM (see Selected software). With Rebecca Saxe, Nancy Kanwisher, advocated region-of-interest methods (Saxe *et al* 2006).

Understanding imaging statistics 1996–present
It is common for researchers to find it difficult to relate the statistics they have been taught to the statistics implemented in neuroimaging software. Wrote a series of popular online tutorials mixing code and mathematics to describe imaging statistics in standard terms, including smoothing, the general linear model and random field theory (see selected tutorials).

Methods teaching

University of California, Berkeley 2016
Lead instructor for Berkeley post-graduate course “PSYCH 214 – functional MRI methods” <https://bic-berkeley.github.io/psych-214-fall-2016>

University of California, Berkeley 2013–present
Organizer, designer and main teacher for “practical neuroimaging” post-graduate course – combines teaching of concepts behind imaging analysis with training in scientific computing

University of California, Berkeley 2015
Co-taught with Jarrod Millman. Undergraduate and masters statistics course on “Reproducible and collaborative statistical data science”

University of California, Berkeley 2015–present
Organizer: imaging analysis discussion group

University of California, Berkeley 2008–present
Lecturer on functional MRI spatial processing and statistics for post-graduate “Functional MRI methodology seminar”

Stanford University 2013
Lecturer at the “fMRI data analysis workshop”

University of California, Berkeley 2008–2011
Speaker for post-graduate “Neuroimaging seminar series”

San Francisco 2009
Lecturer on FMRI Software Library course, speaking on “Experimental design”

MRC Cognition and Brain Sciences Unit, Cambridge 1999–2003, 2005–2008
Organizer (1999–2003) and regular speaker at “Imaging interest group” seminar series

MRC Cognition and Brain Sciences Unit, Cambridge 2007
Lecturer for short course on SPM

Human Brain Mapping conference 2004, 2006, 2007
Lecturer for introductory training course on functional MRI

Oslo, Norway 2005
Co-organized and co-taught with Ansgar Furst. 4-day course on fMRI analysis using SPM software

Yale 2005
Faculty for course on anatomical and functional MRI analysis using SPM

Paris, France 2000–2003
Lecturer on statistics and spatial processing for functional imaging analysis course

Melbourne, Australia 2001
Only teacher of 9 hours of lectures and 5 hours of practical sessions on functional MRI analysis using SPM software

Methods research supervision

Cambridge University post-doctoral research 2002–2006
Ferath Kherif, working on multivariate statistics for clustering and diagnostics of functional imaging data. Ferath is a principal investigator at the Laboratory of Research in Neuroimaging, Lausanne, Switzerland

Cambridge University post-doctoral research 2001–2002
Alexandre Andrade, on brain surface-based functional MRI statistics, coherence analysis. Alexandre is assistant professor at the Physics Department of the Faculty of Sciences of the University of Lisbon

Selected methods tutorials

Brett, Matthew (2016). *Fourier without the e^i* . URL: http://matthew-brett.github.io/teaching/fourier_no_ei.html.

Brett, Matthew (2015a). *Convolution*. URL: http://matthew-brett.github.io/teaching/on_convolution.html.

Brett, Matthew (2015b). *Introducing principal components analysis*. URL: http://matthew-brett.github.io/teaching/pca_introduction.html.

Brett, Matthew (2015c). *Notes on the Bonferroni threshold*. URL: http://matthew-brett.github.io/teaching/bonferroni_correction.html.

Brett, Matthew (2015d). *Thresholding with the false discovery rate*. URL: <http://matthew-brett.github.io/teaching/fdr.html>.

Brett, Matthew (2014). *Coordinate systems and affines*. URL: http://nipy.org/nibabel/coordinate_systems.html.

Brett, Matthew (2013a). *Introducing the general linear model*. URL: http://matthew-brett.github.io/teaching/glm_intro.html.

Brett, Matthew (2013b). *Notes on "Why most published research findings are false"*. URL: http://matthew-brett.github.io/teaching/ioannidis_2005.html.

Brett, Matthew (2013c). *Thresholding with random field theory*. URL: http://matthew-brett.github.io/teaching/random_fields.html.

Brett, Matthew (2012b). *What is an R formula? Python / R notebook*. URL: http://perrin.dynevor.org/exploring_r_formula.html.

Brett, Matthew (1999–2003). *Introduction to SPM statistics - MATLAB*. URL: <http://imaging.mrc-cbu.cam.ac.uk/imaging/PrinciplesStatistics>.

- Brett, Matthew (1998–2003). *An introduction to smoothing - MATLAB*. URL: <http://imaging.mrc-cbu.cam.ac.uk/imaging/PrinciplesSmoothing>.
- Brett, Matthew (1998-2003a). *Small volume correction using the theory of random fields- MATLAB*. URL: <http://imaging.mrc-cbu.cam.ac.uk/imaging/SmallVolumeCorrection>.
- Brett, Matthew (1998-2003b). *Thresholding with random fields - MATLAB*. URL: <http://imaging.mrc-cbu.cam.ac.uk/imaging/PrinciplesRandomFields>.

Methods articles

- Garyfallidis, Eleftherios, Matthew Brett, Marta M. Correia, Guy B. Williams, and Ian Nimmo-Smith (2012). “QuickBundles, a method for tractography simplification”. In: *Frontiers in Neuroscience* 6, p. 175.
- Poline, Jean-Baptiste and Matthew Brett (2012). “The general linear model and fMRI: Does love last forever?” In: *NeuroImage* 62.2, pp. 871–880. DOI: 10.1016/j.neuroimage.2012.01.133.
- Schwarzbauer, Christian, Toralf Mildner, Wolfgang Heinke, Matthew Brett, and Ralf Deichmann (2010). “Dual echo EPI—the method of choice for fMRI in the presence of magnetic field inhomogeneities?” In: *Neuroimage* 49.1, pp. 316–326. DOI: 10.1016/j.neuroimage.2009.08.032.
- Poldrack, Russell A, Paul C Fletcher, Richard N Henson, Keith J Worsley, Matthew Brett, and Thomas E Nichols (2008). “Guidelines for reporting an fMRI study.” In: *Neuroimage* 40.2, pp. 409–414. DOI: 10.1016/j.neuroimage.2007.11.048.
- Brett, Matthew, William Penny, and Stefan Kiebel (2007). “Parametric procedures”. In: *Statistical Parametric Mapping: The Analysis of Functional Brain Images*. Ed. by Karl Friston, John Ashburner, Stefan Kiebel, Thomas Nichols, and William Penny. Elsevier, pp. 223–231.
- Aston, John A D, Federico E Turkheimer, and Matthew Brett (2006). “HBM functional imaging analysis contest data analysis in wavelet space.” In: *Hum Brain Mapp* 27.5, pp. 372–379. DOI: 10.1002/hbm.20244.
- Saxe, Rebecca, Matthew Brett, and Nancy Kanwisher (2006). “Divide and conquer: a defense of functional localizers.” In: *Neuroimage* 30.4, pp. 1088–96, 1088–96. DOI: 10.1016/j.neuroimage.2005.12.062.
- Nichols, Thomas, Matthew Brett, Jesper Andersson, Tor Wager, and Jean-Baptiste Poline (2005). “Valid conjunction inference with the minimum statistic.” In: *Neuroimage* 25.3, pp. 653–660. DOI: 10.1016/j.neuroimage.2004.12.005.
- Cusack, Rhodri, Matthew Brett, and Katja Osswald (2003). “An evaluation of the use of magnetic field maps to undistort echo-planar images.” In: *Neuroimage* 18.1, pp. 127–142.
- Kherif, Ferath, Jean-Baptiste Poline, Sébastien Mériaux, Habib Benali, Guillaume Flandin, and Matthew Brett (2003). “Group analysis in functional neuroimaging: selecting subjects using similarity measures.” In: *Neuroimage* 20.4, pp. 2197–2208.
- Brett, Matthew, Ingrid S Johnsrude, and Adrian M Owen (2002). “The problem of functional localization in the human brain.” In: *Nat Rev Neurosci* 3.3, pp. 243–249. DOI: 10.1038/nrn756.
- Hammers, Alexander, Matthias J Koeppe, Samantha L Free, Matthew Brett, Mark P Richardson, Claire Labbé, Vincent J Cunningham, David J Brooks, and John Duncan (2002). “Implementation and application of a brain template for multiple volumes of interest.” In: *Hum Brain Mapp* 15.3, pp. 165–174.
- Brett, Matthew, Alexander P Leff, Chris Rorden, and John Ashburner (2001b). “Spatial normalization of brain images with focal lesions using cost function masking.” In: *Neuroimage* 14.2, pp. 486–500. DOI: 10.1006/nimg.2001.0845.

- Gustard, Sharon, M Jalal Fadili, Emma J. Williams, L. D. Hall, T. Adrian Carpenter, Matthew Brett, and Ed T. Bullmore (2001). "Effect of slice orientation on reproducibility of fMRI motor activation at 3 Tesla." In: *Magn Reson Imaging* 19.10, pp. 1323–1331.
- Turkheimer, Federico, Matthew Brett, Dimitris Visvikis, and Vincent J. Cunningham (2001). "Statistical Estimation of PET Images in the Wavelet Domain". In: *Physiological imaging of the brain with PET*. Ed. by A. Gjedde. Academic Press, pp. 29–33. ISBN: 0122857518.
- Rorden, Chris and Matthew Brett (2000). "Stereotaxic display of brain lesions." In: *Behav Neurol* 12.4, pp. 191–200.
- Turkheimer, Federico E., Matthew Brett, John A D Aston, Alexander P. Leff, P. A. Sargent, Richard J. Wise, Paul M. Grasby, and Vincent J. Cunningham (2000). "Statistical modeling of positron emission tomography images in wavelet space." In: *J Cereb Blood Flow Metab* 20.11, pp. 1610–1618. DOI: 10.1097/00004647-200011000-00011.
- Turkheimer, Federico E., Matthew Brett, D. Visvikis, and Vincent J. Cunningham (1999). "Multiresolution analysis of emission tomography images in the wavelet domain." In: *J Cereb Blood Flow Metab* 19.11, pp. 1189–1208. DOI: 10.1097/00004647-199911000-00003.

Methods abstracts

- Garyfallidis, Eleftherios, Matthew Brett, Vassilis Tsiaras, George Vogiatzis, and Ian Nimmo-Smith (2010). "Identification of corresponding tracks in diffusion MRI tractographies". In: *Proceedings of the International Society for Magnetic Resonance in Medicine*. Vol. 18.
- Brett, Matthew, Ian Nimmo-Smith, Katja Osswald, and Ed T. Bullmore (2003). "Model fitting and power in fast event related designs". In: *NeuroImage* 19.2, abstract 791.
- Fadili, M. Jalal, Ed T. Bullmore, and Matthew Brett (2002). "Wavelet methods for characterising mono-and poly-fractal noise structures in shortish time series: an application to functional MRI". In: *Image Processing, 2001. Proceedings. 2001 International Conference on*. IEEE, pp. 225–228. ISBN: 0780367251.
- Brett, Matthew, Kalina Christoff, Rhodri Cusack, and Jack Lancaster (2001a). "Using the Talairach atlas with the MNI template". In: *Neuroimage* 13.6, S85.
- Johnsrude, Ingrid S., Rhodri Cusack, P. Morosan, Debbie Hall, Matthew Brett, Karl Zilles, and Richard S. J. Frackowiak (2001). "Cytoarchitectonic region-of-interest analysis of auditory imaging data". In: *NeuroImage* 13.6, S897.
- Brett, Matthew, Peter Bloomfield, David J. Brooks, John F. Stein, and Paul Grasby (1999b). "Scan order effects in PET activation studies are caused by motion artifact". In: *NeuroImage* 9, S56. ISSN: 1053-8119.

SCIENTIFIC COMPUTING

Computing leadership

Neuroimaging in Python project

2004–present

Co-founder (with Jarrod Millman) of the neuroimaging in Python project (NIPY) <http://nipy.org>. Co-author (with Jarrod Millman) of R01 grant to fund NIPY development (see below). Set NIPY community development standards including BSD code license, version control, continuous integration testing on all major platforms, automated reporting of code test coverage, formal code review. The NIPY organization <https://github.com/nipy> is now home to 12 neuroimaging code projects. Lead author and maintainer of nibabel and nipy software projects; third contributor by

code commits of dipy software project (see below). 99th centile personal ranking for scientific code impact by Depsy.org ²

Scientific Python

2004–present

Code contributor to all the main scientific Python packages, including numpy, scipy, matplotlib, Cython, statsmodels; organization member of projects numpy, scipy, matplotlib, scikit-image, Python-pillow, MacPython and the Python packaging authority.

Computing grants

NIH RO1 grant

2007–2010

Co-author (with Jarrod Millman) of NIH grant 5R01MH081909-02 “Continued development and maintenance of the Neuroimaging In Python project”

Selected scientific software

See <https://www.openhub.net/accounts/matthew-brett>

Dipy

2009–present

Python package for analysis of diffusion MRI data. Third-ranked developer by code commits. In total: project has 69 contributors; 43,806 lines of code; estimated 11 years of developer effort ³. 99th centile for research impact among all scientific R and Python projects ².

Nibabel

2007–present

Reads and writes standard neuroimaging file formats. Lead developer and maintainer. In total: 46 contributors; 28,473 lines of code; estimated 7 years of developer effort ⁴. 100th centile for research impact among all R, Python projects ².

Nipy

2006–present

Spatial processing and statistical analysis of functional MRI data. Lead developer and maintainer. In total: 59 contributors; 69,522 lines of code; estimated 18 years of developer effort ⁵. 97th centile for research impact among all R, Python projects ².

Phiwave

2004–2005

Wavelet analysis for spatial inference on functional imaging data. Lead developer and maintainer. 2 contributors; 5,367 lines of code; estimated estimated 2 years of effort ⁶.

MarsBaR

2003–present

Region of interest analysis for functional imaging data. Lead developer and maintainer. In total: 3 contributors; 22,166 lines of code; estimated 6 years of developer effort ⁷. MarsBaR abstract has been cited 2289 times as of January 2017.

Computing teaching

See also: teaching on imaging methods and statistics.

University of California, Berkeley

2016

Certified as instructor for Software Carpentry workshops ⁸

Havana, Cuba

2013

Invited speaker and teacher at the Latin-American summer school on Neuroinformatics, speaking on “The need and methods for reproducible science”

²See: <http://depsy.org> and *Nature* 2016: 529, 115–116

³<https://www.openhub.net/p/dipy>

⁴<https://www.openhub.net/p/nibabel>

⁵<https://www.openhub.net/p/nipy>

⁶<https://www.openhub.net/p/phiwave>

⁷<https://www.openhub.net/p/marsbar>

Selected computing tutorials

Brett, Matthew (2012a). *Floating point error*. URL: http://matthew-brett.github.io/teaching/floating_error.html.

Brett, Matthew (2012–2016). *The curious coder's guide to git*. URL: <https://matthew-brett.github.io/curious-git>.

Computing articles

Garyfallidis, Eleftherios, Matthew Brett, Bago Amirbekian, Ariel Rokem, Stéfan van der Walt, Maxime Descoteaux, and Ian Nimmo-Smith (2014). “Dipy, a library for the analysis of diffusion MRI data”. In: *Frontiers in Neuroinformatics* 8.8. DOI: 10.3389/fninf.2014.00008.

Millman, K. Jarrod and Matthew Brett (2007). “Analysis of functional magnetic resonance imaging in Python”. In: *Computing in Science & Engineering*, pp. 52–55. ISSN: 1521-9615.

Computing abstracts

Millman, K. Jarrod and Matthew Brett (2011). “Reproducible research for neuroimaging”. In: *Front. Neuroinform. Conference Abstract: 4th INCF Congress of Neuroinformatics*. doi: 10.3389/conf.fninf.Vol. 158.

Brett, Matthew, Jonathan Taylor, Chris Burns, K. Jarrod Millman, Fernando Perez, Alexis Roche, Bertrand Thirion, and Mark J. D’Esposito (2009). “NIPY: an open library and development framework for fMRI data analysis”. In: *NeuroImage* 47, S196. ISSN: 1053-8119.

Taylor, Jonathan E., Keith J. Worsley, Matthew Brett, Yann Cointepas, John D. Hunter, K. Jarrod Millman, Jean-Baptiste Poline, and Fernando Perez (2005). “BrainPy: an open source environment for the analysis and visualization of human brain data”. In: *Neuroimage* 26, p. 763.

Brett, Matthew, Jean-Luc Anton, Romain Valabregue, and Jean-Baptiste Poline (2002). “Region of interest analysis using an SPM toolbox”. In: *Neuroimage* 16.2, pp. 1140–1141.

REVIEWER

PLOS One, F1000, NeuroImage; Human Brain Mapping; Journal of Cognitive Neuroscience; Neuroscience Letters; Clinical Neurophysiology; Journal of Neuroimaging; the Journal of Clinical and Experimental Neuropsychology; Frontiers in Neuroinformatics; Computing in Science and Engineering; Frontiers in Brain Imaging Methods; Frontiers in Neuroanatomy.

⁸Software carpentry (<http://software-carpentry.org>) is an international project to teach scientists effective use of computing tools