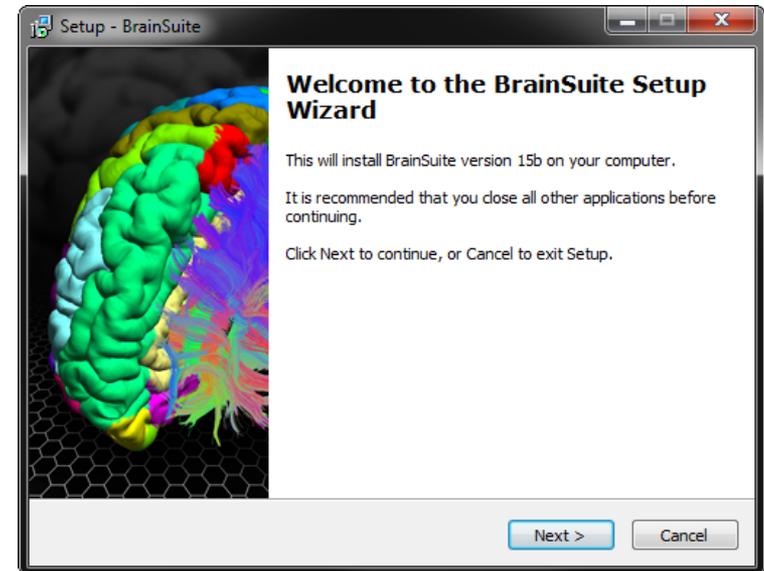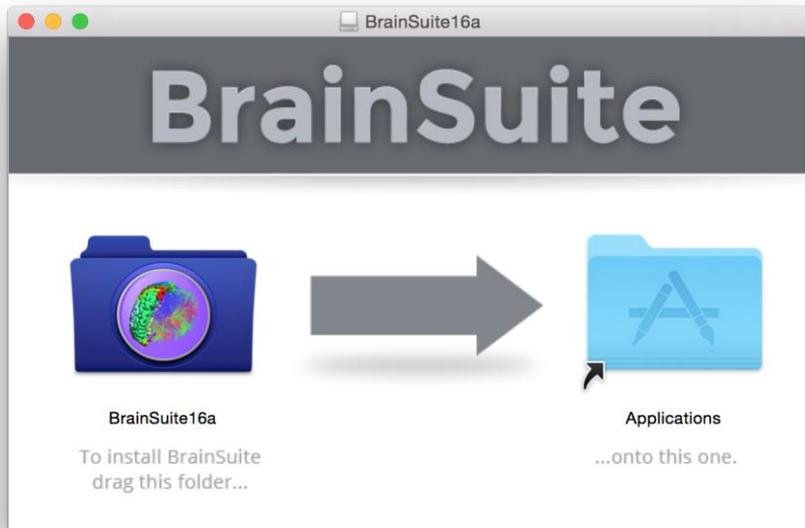# BrainSuite Workshop

Presented at the **UCLA Advanced Neuroimaging Summer Program**
14 July 2016

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BrainSuite Resources

- e-mail   support@brainsuite.org
- Main site   http://brainsuite.org
- Registration (forum/download)   http://brainsuite.org/register
- Download   http://brainsuite.org/download
- User forums   http://forums.brainsuite.org
- Tutorials   http://brainsuite.org/tutorials
- Additional utilities
                        http://brainsuite.org/processing/additional-tools

Installation

- Register and download at http://brainsuite.org
- Mac & Windows: open the installer
- Linux : gunzip/untar to your preferred install directory

Installation : Security
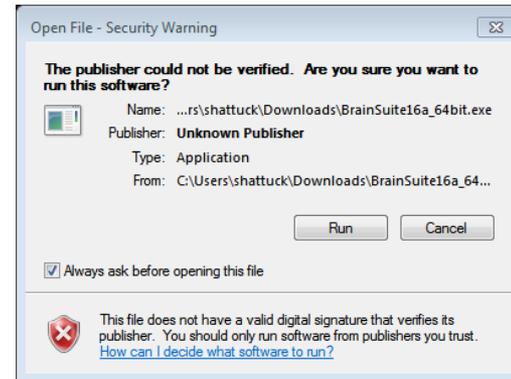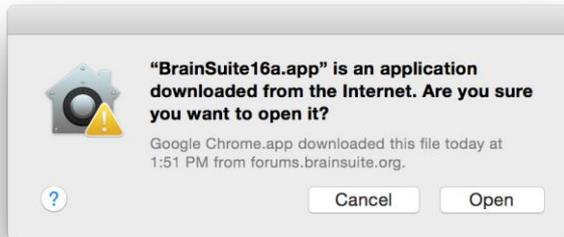
You may need to tell your OS that you trust BrainSuite.
- Mac
  - Navigate to /Applications/BrainSuite16a/brainsuite16a.app
  - Right-click and select "open".
  - Approve BrainSuite16a to run.
- Windows
  - Win7: approve it through the dialog box as above.
  - Other Windows versions may have different security procedures.

Installation : MCR

- SVReg and BDP require MATLAB 2015b or Compiler Runtime (MCR) 2015b
  - **Important: must be the 2015b Version!!!**
  - http://www.mathworks.com/products/compiler/mcr/

	Windows	Linux	Mac
R2015b (9.0)	64-bit	64-bit	Intel 64-bit

  - Links are also on the BrainSuite website.
  - MATLAB Runtime 9.0, for R2015b, is intended to work with MATLAB 8.6, which is also R2015b.
- Older versions of BrainSuite require MCR 2012b, which can be difficult to install on recent Mac OS versions.

Sample Data

NITP2016_BrainSuite_Tutorial

- contains several .bst files for running the examples in this tutorial

- **extraction** : MRI file for cortical surface extraction

- **structural** : contains SVReg outputs

- **diffusion** : contains output of the BDP commands

- **DNI-BCI_atlas** : examples of the DNI-BCI brain atlas

- **commandline** : scripts and data to run command line tools

This dataset was produced from the Beijing Enhanced data, Beijing Normal University, State Key Laboratory of Cognitive Neuroscience and Learning Enhanced Sample, which is available under a Creative Commons Attribution - Non-Commercial license (CC-BY). For more details please see:

http://fcon_1000.projects.nitrc.org/indi/retro/BeijingEnhanced.html

BrainSuite Filetypes

Orthogonal Views	
File extension	**Action**
.nii, .nii.gz	3D images in NIFTI format
.odf	List of image files use in ODF representation
.dfs	BrainSuite surface format
.dft	BrainSuite track format (diffusion tractography)
.dfc	BrainSuite curve format (for landmark delineation)
.xml	Label descriptions Spherical ROIs
.lut	Colormaps (plain text)
.bst	BrainSuite Study File

http://brainsuite.org/keyboard-shortcuts/

BrainSuite Keyboard Shortcuts

Main Window	
Ctrl Key Combos	**Action**
Ctrl + A	Autoscale images
Ctrl + B	Show previous surface (back)
Ctrl + F	Show next surface (forward)
Ctrl + L [upper case L]	Toggle ROI Labels
Ctrl + l [lower case L]	Toggle ROI Label Outlines
Ctrl + R	Toggle first overlay volume on/off
Ctrl + T	Toggle second overlay volume on/off
Ctrl + M [case sensitive]	Cycle mask mode
Ctrl + m [case sensitive]	Toggle Mask on/off
Ctrl + S	Toggle show surfaces
Ctrl + V	Toggle show volume slices in 3D view
Ctrl + X	Toggle show cursors
Ctrl + Z	Undo last paint action

Note that on a Mac you use the ⌘ key instead of Ctrl   http://brainsuite.org/keyboard-shortcuts/

BrainSuite Keyboard Shortcuts

Surface Display	
Key	**Action**
L	Toggle lighting for 3D view
G	Toggle tensor glyphs on/off
O	Toggle ODF glyphs on/off
F	Toggle fibers on/off
W	Toggle wire frame mode for surfaces
X	Cycle X-plane clipping (off, positive, negative)
Y	Cycle Y-plane clipping (off, positive, negative)
Z	Cycle Z-plane clipping (off, positive, negative)
h [case sensitive]	Reset clipping mode and position

http://brainsuite.org/keyboard-shortcuts/

BrainSuite Keyboard Shortcuts

Toolboxes	
Key	**Action**
I	Show Image Display Toolbox
S	Show Surface Display Toolbox
M	Show masking tool (Delineation Toolbox)
P	Show painter tool (Delineation Toolbox)
C	Show Curve Toolbox
D	Show Diffusion Toolbox

http://brainsuite.org/keyboard-shortcuts/

BrainSuite Keyboard Shortcuts

Image Display	
Key	**Action**
+	Zoom In
-	Zoom Out
*	Zoom Best Fit
/	Zoom to 1:1 (in smallest pixel dimension)

BrainSuite Keyboard Shortcuts

Connectivity Viewer	
Key	**Action**
1	Show Connectivity for Cortical Areas
2	Show Connectivity for Frontal Lobe
3	Show Connectivity for Parietal Lobe
4	Show Connectivity for Temporal Lobe
5	Show Connectivity for Occipital Lobe
6	Show Connectivity for Subcortical Areas
7	Show Connectivity for Brain Areas
8	Show Connectivity for All Labeled Regions (includes white matter, ventricles, etc).

BrainSuite Keyboard Shortcuts

Orthogonal Views	
Alt Key Combos	**Action**
Alt + 1	Rotate 3D view to xy view (axial, from superior)
Alt + 2	Rotate 3D view to xy view (axial, from inferior)
Alt + 3	Rotate 3D view to xz view (coronal, from posterior
Alt + 4	Rotate 3D view to xz view (coronal, from anterior)
Alt + 5	Rotate 3D view to yz view (sagittal, from right)
Alt + 6	Rotate 3D view to yz view (sagittal, from left)

1. MRI Brain Atlas Example
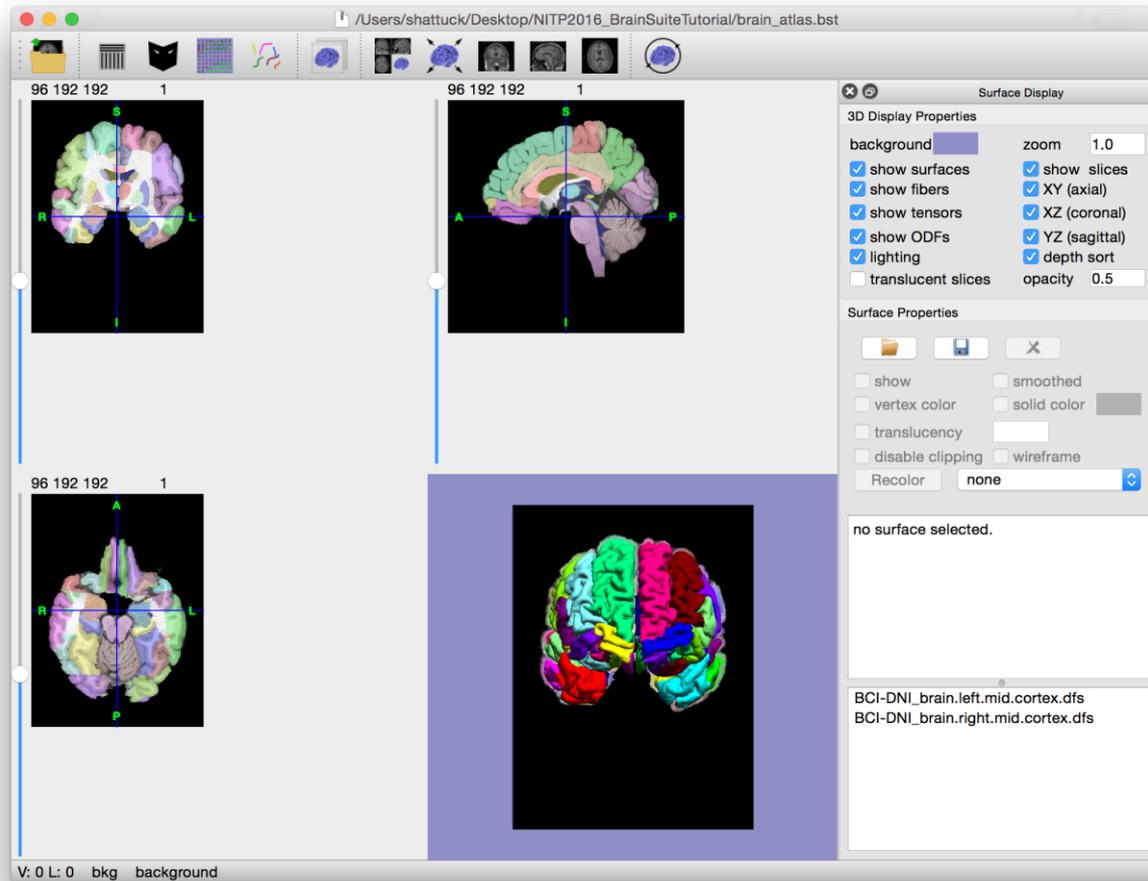
- From **brainsuite_atlas**, drag and drop **brain_atlas.bst** onto the GUI.
- Press ctrl-L/⌘-L and ctrl-S/⌘-S to hide the labels and surfaces.

1. MRI Brain Atlas Example
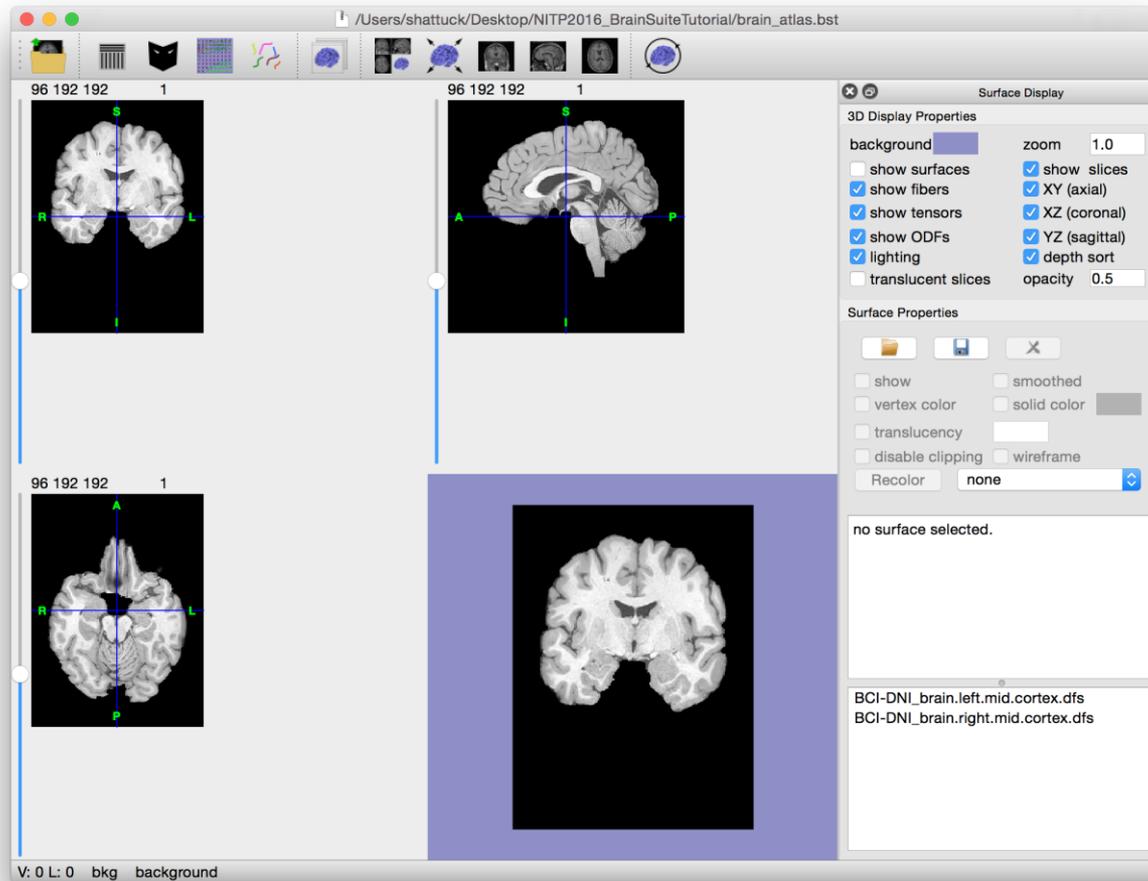
- From **brainsuite_atlas**, drag and drop **brain_atlas.bst** onto the GUI.
- Press ctrl-L/⌘-L and ctrl-S/⌘-S to hide the labels and surfaces.

1. MRI Brain Atlas Example
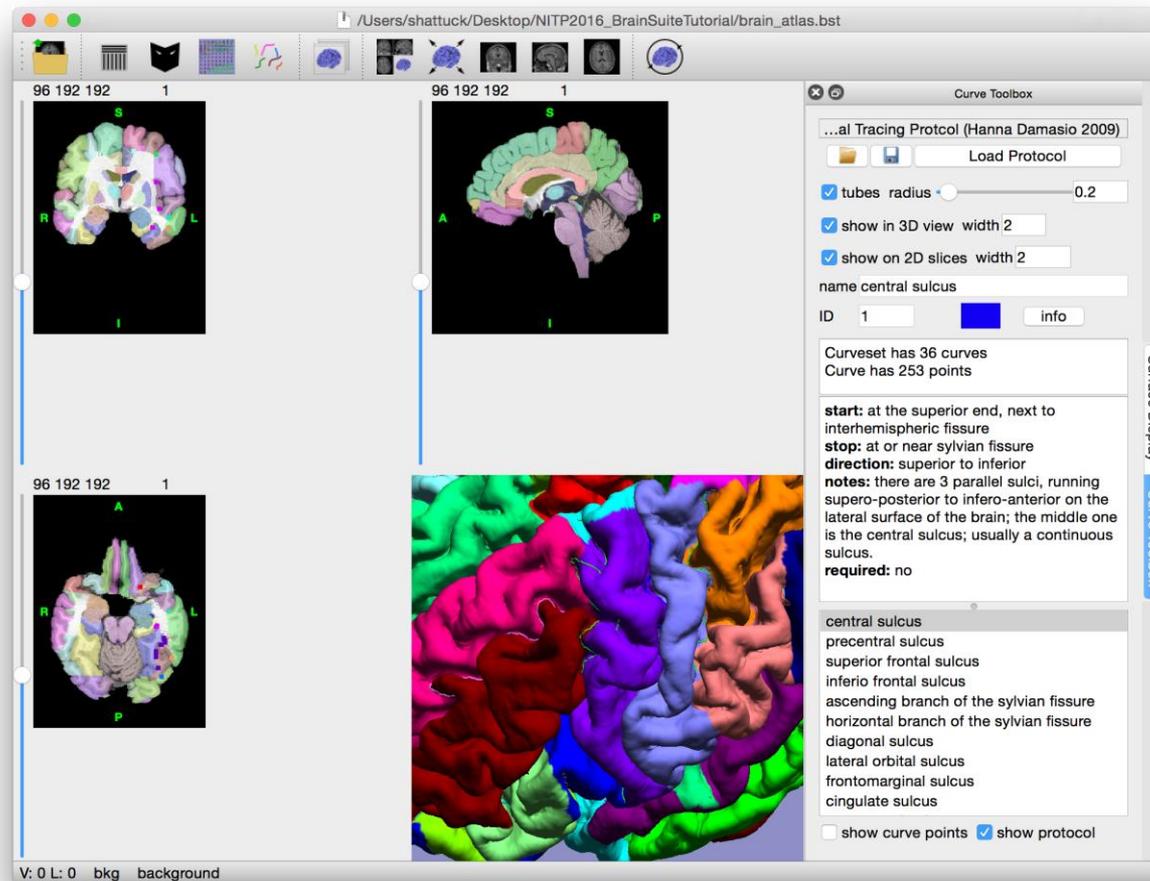
- Press ctrl-L/⌘-L and ctrl-S/⌘-S to restore the labels and surfaces.
- Drag & drop BCI-DNI_brain.left.all.dfc onto the GUI to see the sulcal curves.

2. Opening and Displaying an MRI

- Start BrainSuite
- Drag and drop the T1 image from the native space folder onto the interface

  structural/2523412.nii.gz

- Navigation:
  - Scrolling the sliders or click in the image windows
  - Click and drag the mouse in the 3D view to rotate the display
  - Ctrl+click/⌘+click to zoom*
- Press the 'I' key to open the Image Display Properties controller
  - Adjust the intensity ranges
  - Right-click to change colormaps
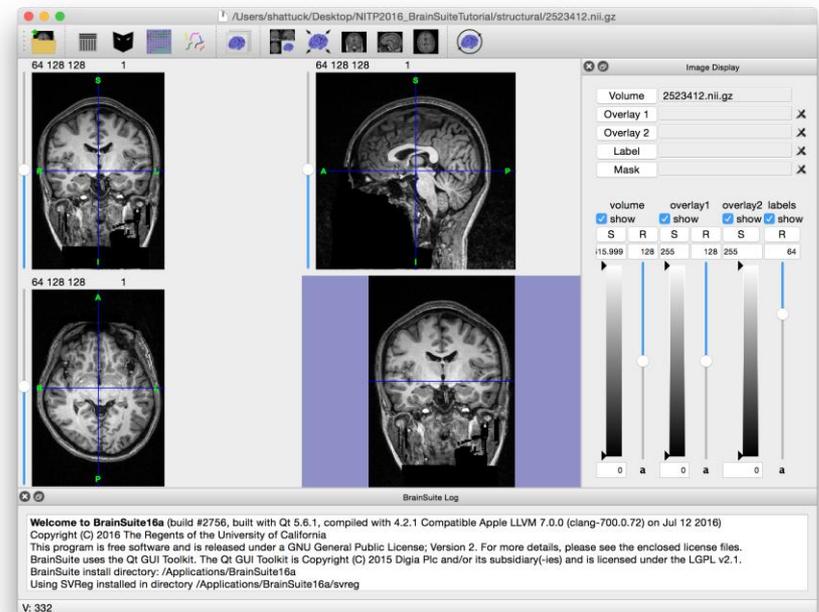
  *ctrl for Windows, ⌘ for Mac

3. Opening an Overlay

Load an overlay image

- Press the Overlay1 button
- Select the FA file:

diffusion/DTI/2523412.dwi.RAS.correct.FA.T1_coord.nii.gz

- Adjust the first alpha slider to change the blending of the two images
- Change the colormap of the overlay
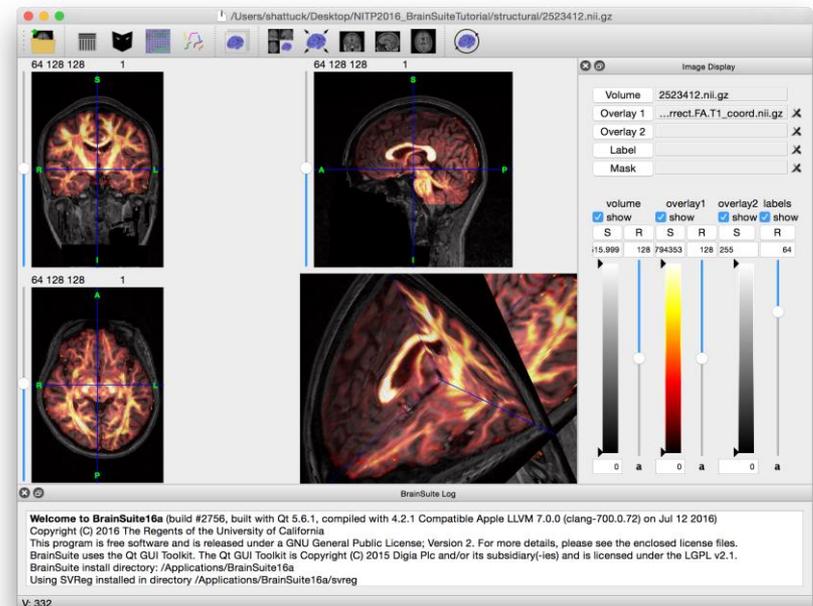
4. Mask and Surface Tools

- Open the T1 image as the primary volume
- Open the display properties and adjust the lower intensity range
- Press 'M' to open the mask tool
- Adjust the slider under Threshold, and see the mask boundary change.
- This will create a new mask as the slider moves.
- Set the value to 256.
- Press the 'Make Surface' button (you may need to enlarge the BrainSuite window to see this button)
- Press ctrl+V/⌘+V to hide the slices in the 3D view
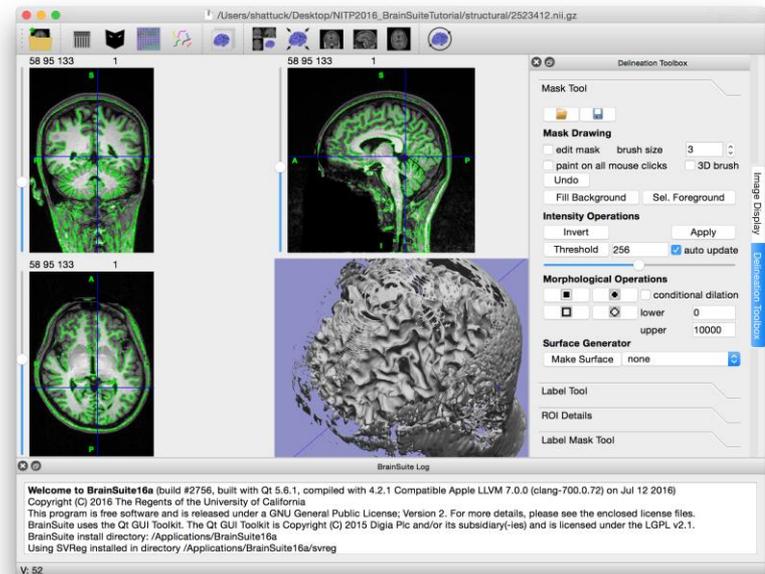
5. Working with Labels

- Load data from the structural directory
  - Load 2523412.nii.gz
  - Load 2523412.svreg.label.nii.gz as a Label image
- Each color corresponds to a different anatomical area as defined by BrainSuite
- Click the mouse on a labeled area, and the label is shown in the status bar.
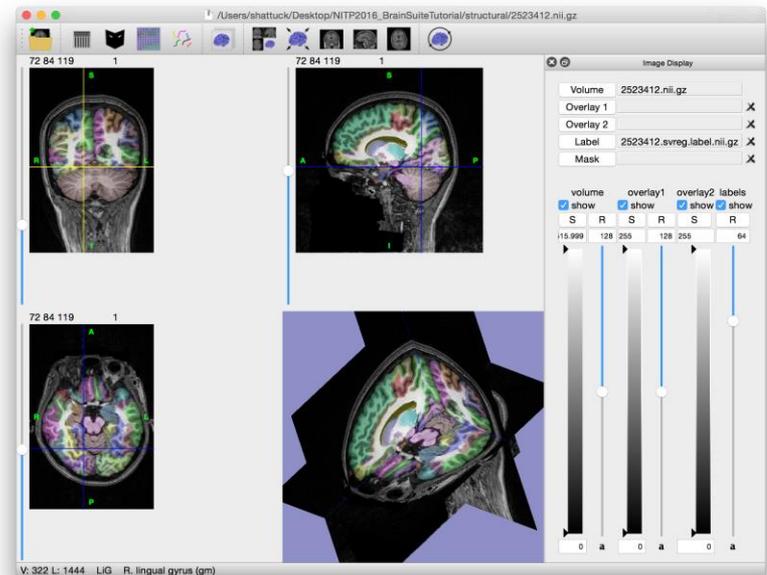
6. Working with Surfaces

- From the structural folder, drag and drop the file
  2523412.left.mid.cortex.svreg.dfs
  onto BrainSuite

- Properties of the different surfaces can be adjusted
  - Show or hide
  - Wireframe mode
  - Translucency

- Recolor based on different properties
  - Volumetric labeling
 - Curvature
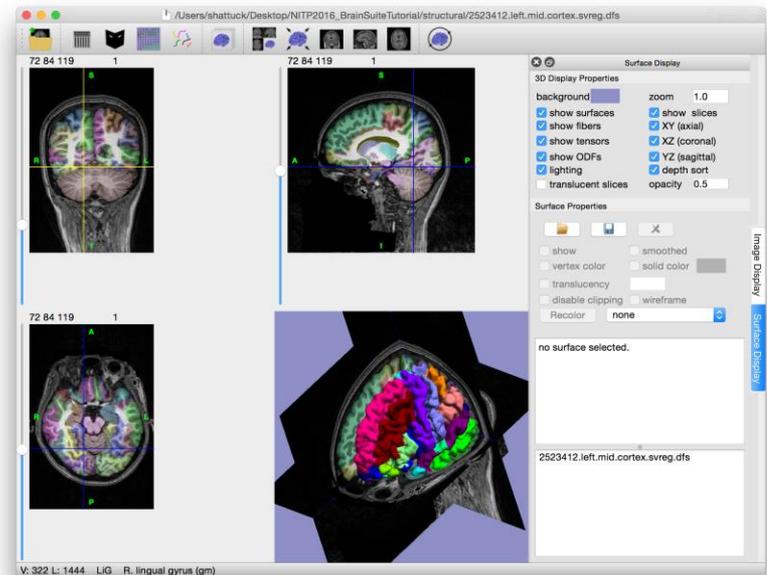
7. Extracting a Brain Surface

- Load the T1 image from the **extraction** folder* or drag brainsuite_extraction.bst onto BrainSuite.

- Open "Cortex -> Cortical Surface Extraction Sequence"

- Change the Skull Stripping parameters as follows:
  - Diffusion constant: 30
  - Edge constant: 0.80
  - These values will be automatically loaded if you use the .bst file
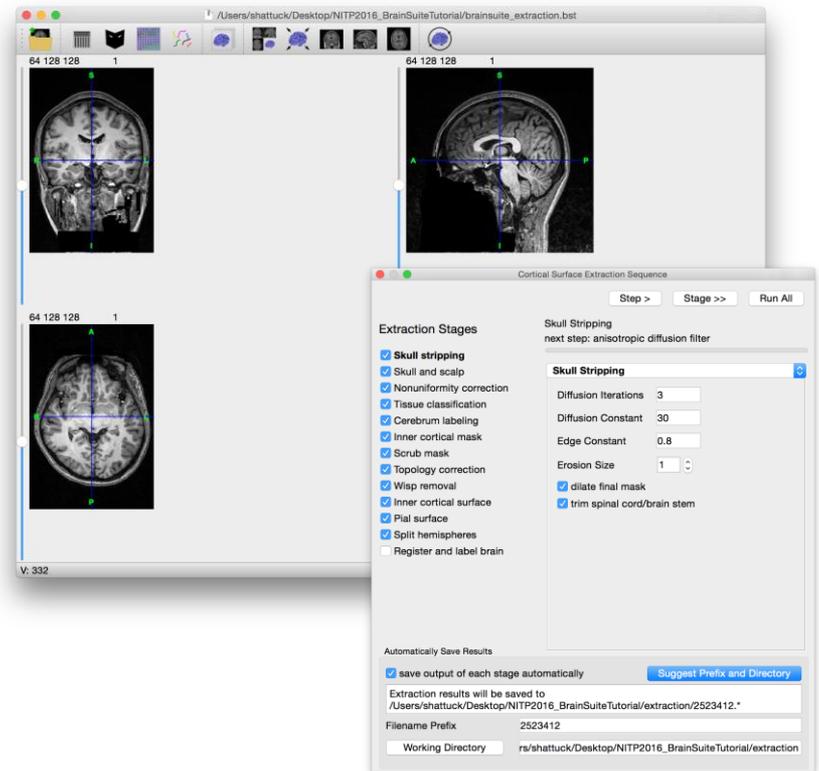
*By default, BrainSuite's extraction dialog will write files to the same directory as the input image, so be sure to use the extraction folder rather than the structural folder, which contains pre-processed data.

7. Extracting a Brain Surface

- Step through the Skull Stripping Stage
- Uncheck "Skull and Scalp"
- Continue stepping through each stage, observing the outputs
- **Stop after you've finished producing the inner cortical surface**
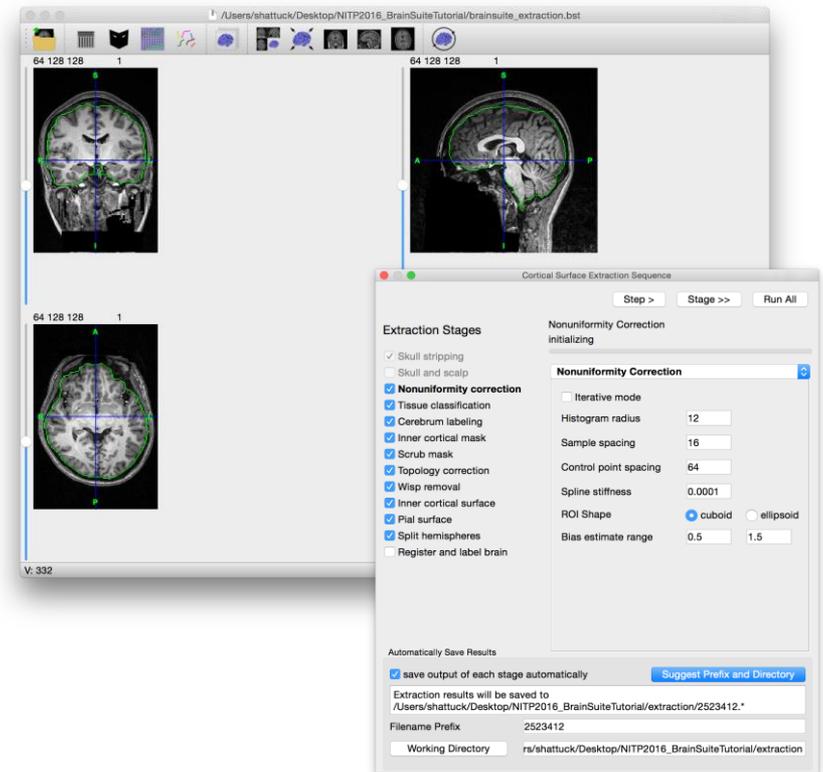
7. Extracting a Brain Surface

- At this point, you have produced an inner cortical surface mesh.

- The next step will produce the pial surface, which can take 5-10 minutes.
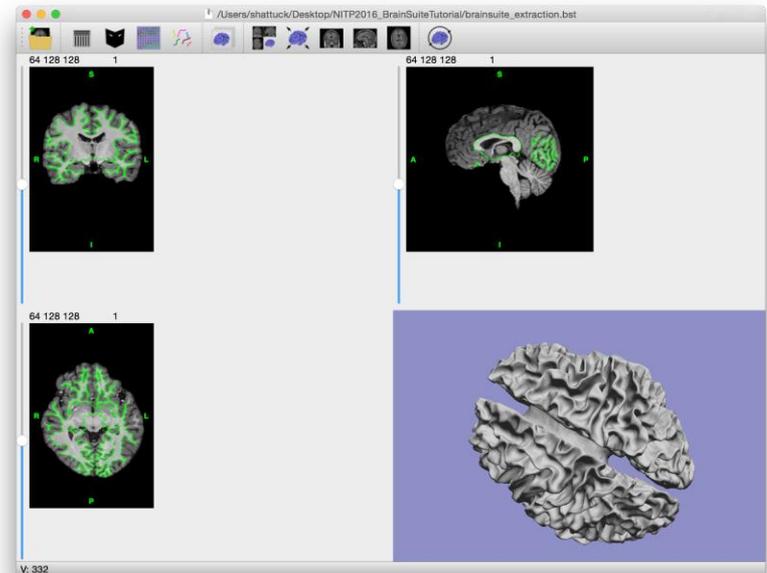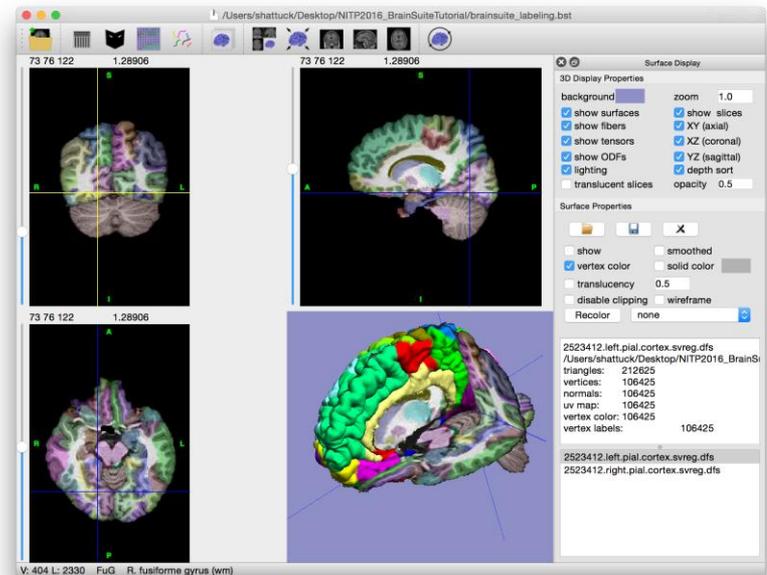
8. Automated SVReg Labeling

- **Drop brainsuite_labeling.bst onto BrainSuite**
- Hide one of the surfaces
- Scroll to different positions in the volume and observe the boundaries of the labels
- Open the Label Painter tool (press 'P')
  - Can be used to edit the labels
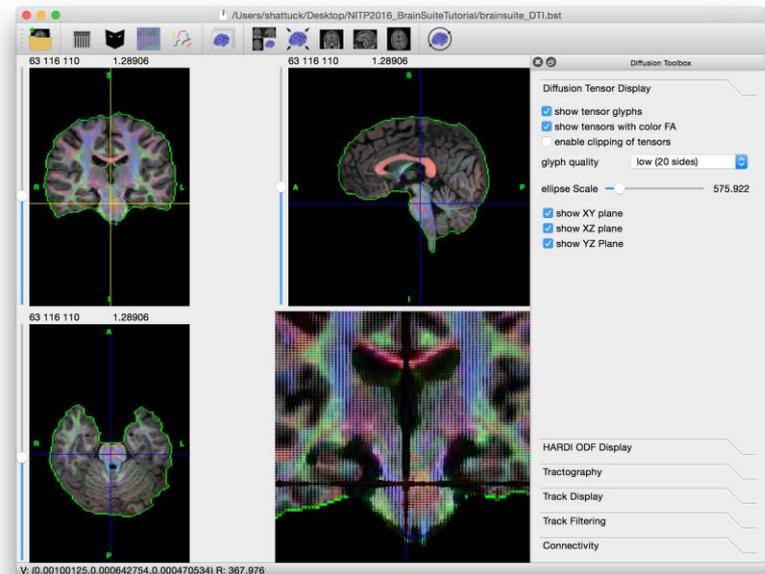 - Can calculate total volume of different labeled structures
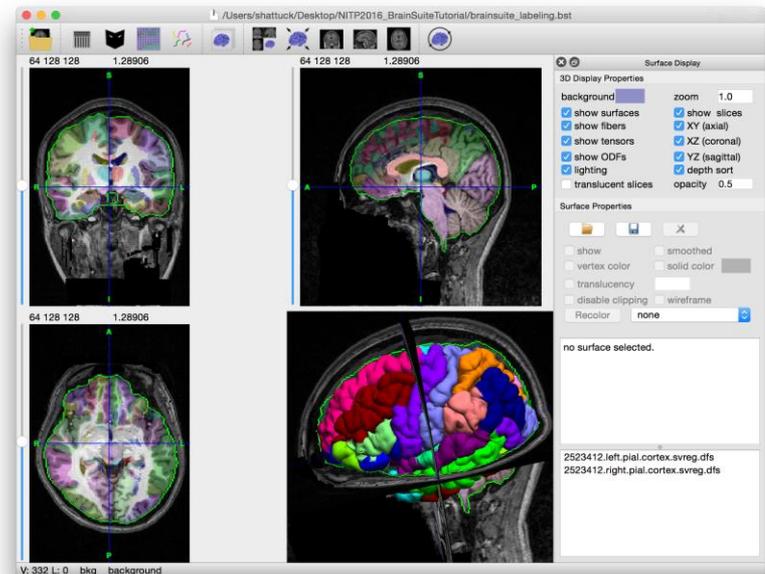
8. Automated SVReg Labeling

- Drop brainsuite_labeling.bst onto BrainSuite
- **Hide one of the surfaces**
- Scroll to different positions in the volume and observe the boundaries of the labels
- Open the Label Painter tool (press 'P')
  - Can be used to edit the labels
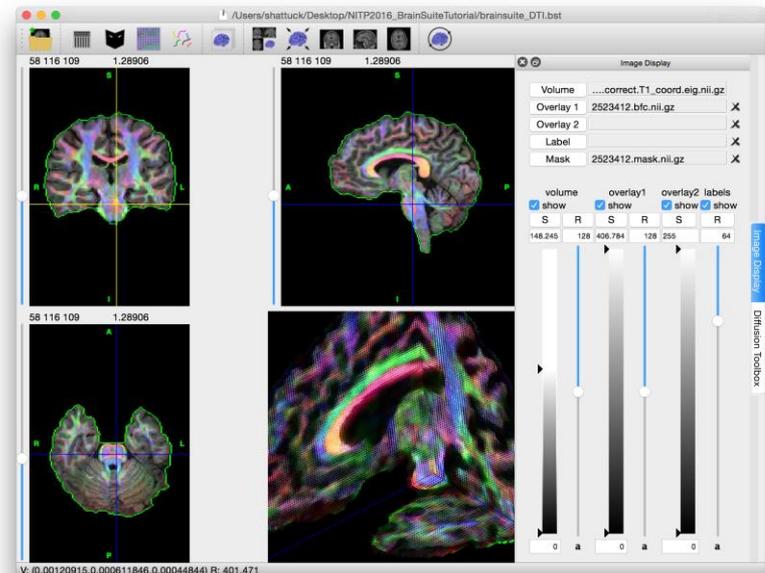 - Can calculate total volume of different labeled structures

9. DTI Data

- **Drop brainsuite_DTI.bst onto BrainSuite**
- Adjust the image display parameters ('I') to increase the brightness.
- Scroll through the volume and observe some of the structure that is made visible by the DTI
  - Hide the volume slices (ctrl+V/⌘+V)
  - Make the surface display full view
  - Zoom into the image
  - In the diffusion toolbox ('D'), adjust the size of the diffusion glyphs
- You can also load the structural scan as an overlay to observe the different modalities.
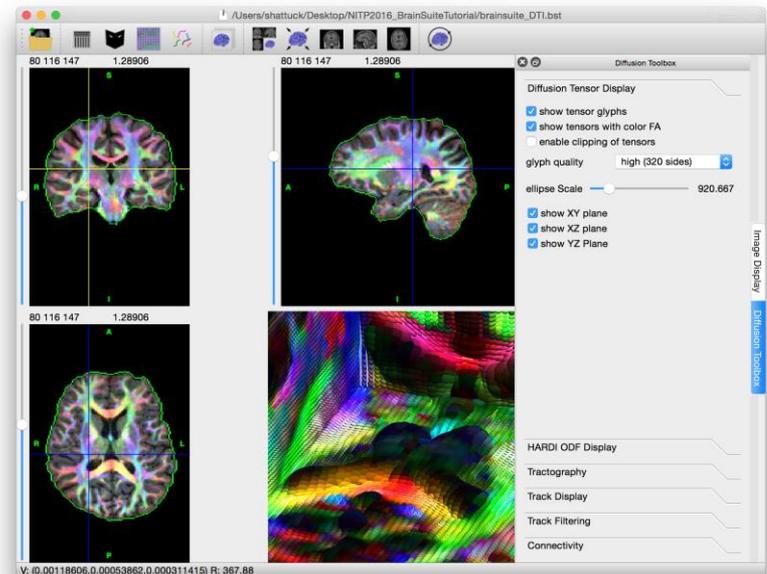
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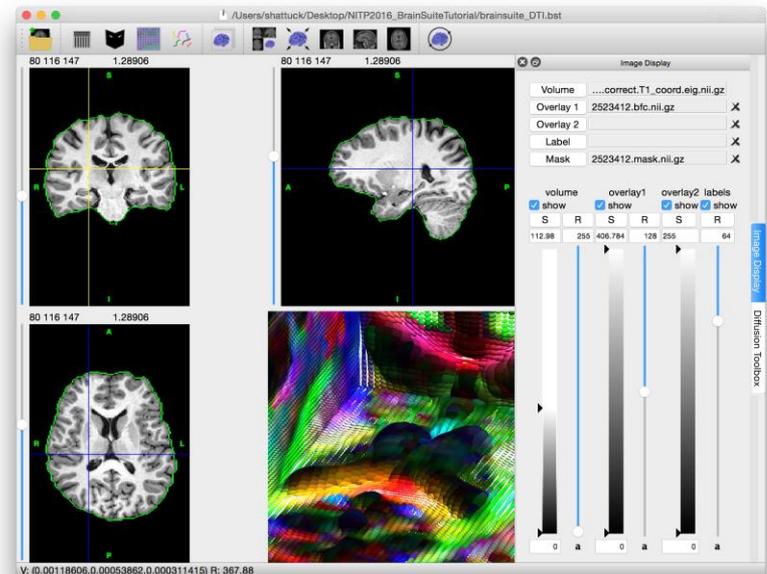
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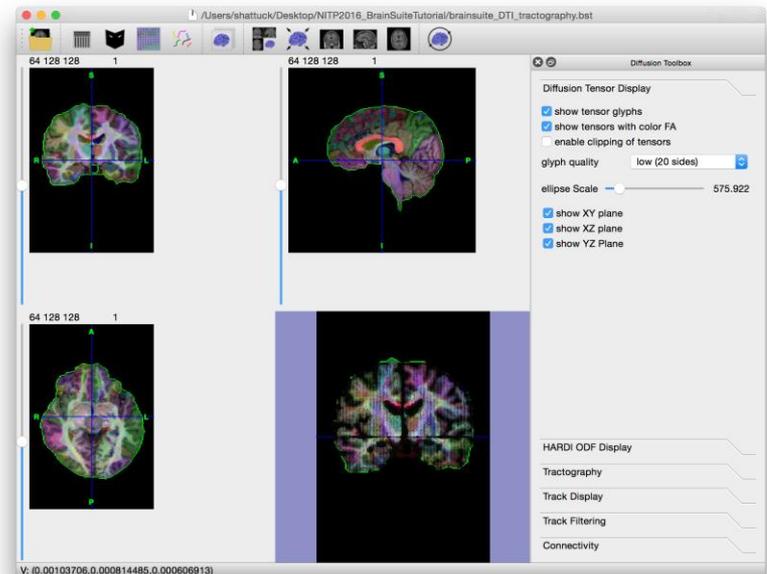
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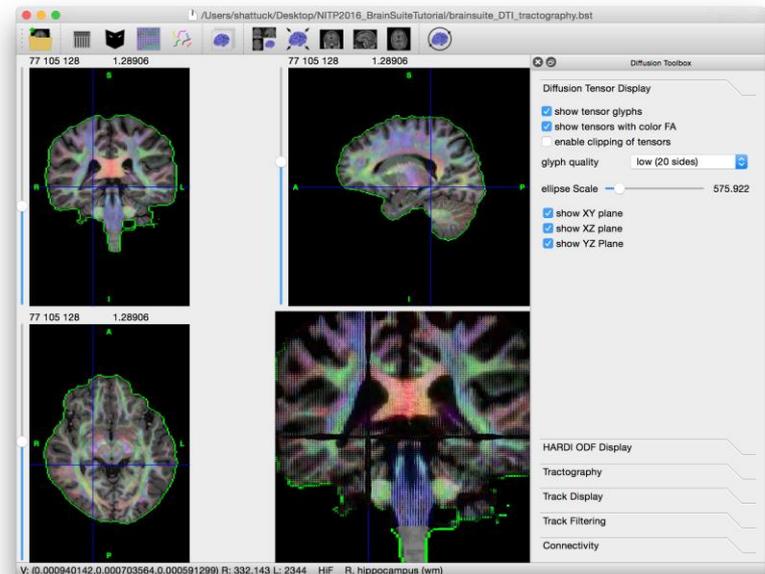
10. DTI Tractography

- **Drop brainsuite_DTI_tractography.bst onto BrainSuite**
- Adjust the display
  - Hide the labels (ctrl+L/⌘+L)
  - Zoom in on the 3D view
- In the diffusion toolbox ('D'):
  - Open the tractography tab
  - Change FA threshold to 0.25
  - Change track seeding to 0.5
  - Change angle threshold to 30
  - Press 'Compute Tracks'
- Explore the tracks using the interface
  - Cut planes (x/y/z keys)
  - Fibers on/off ('F')
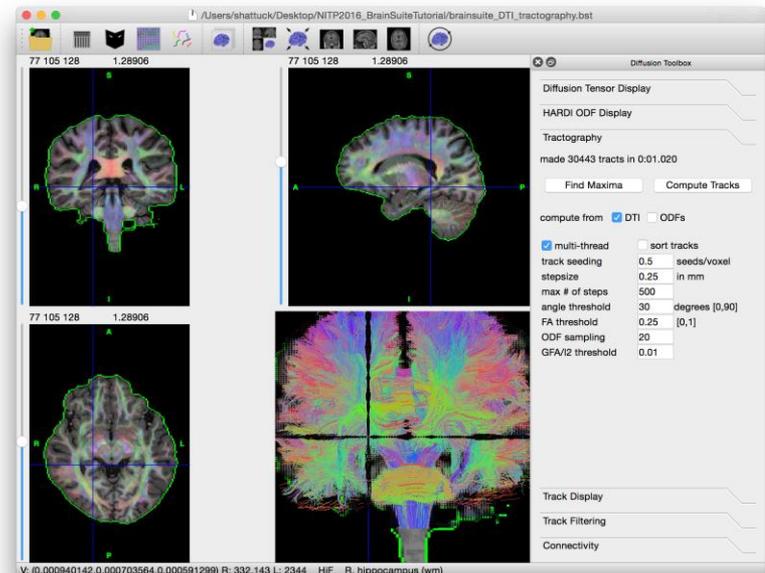 - Tensors glyphs on/off ('G')

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  - Hide the labels (ctrl+L/⌘+L)
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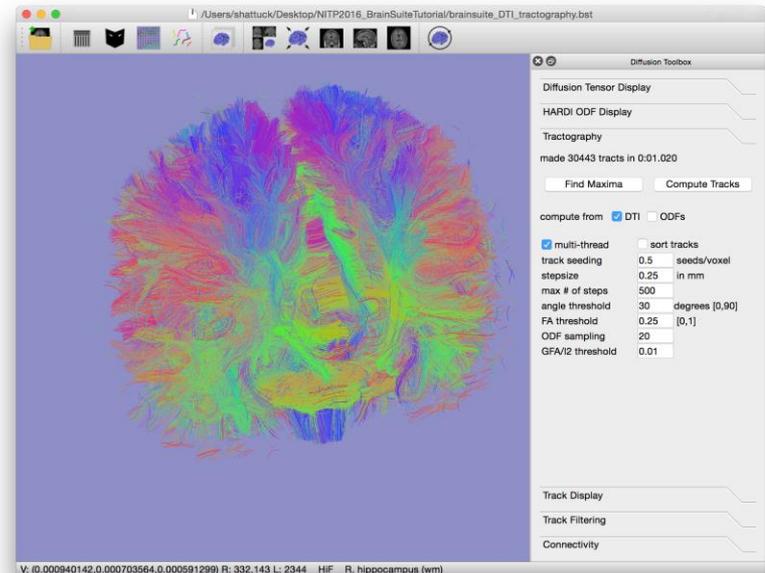 - Tensors glyphs on/off ('G')

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  - Tensors glyphs on/off ('G')
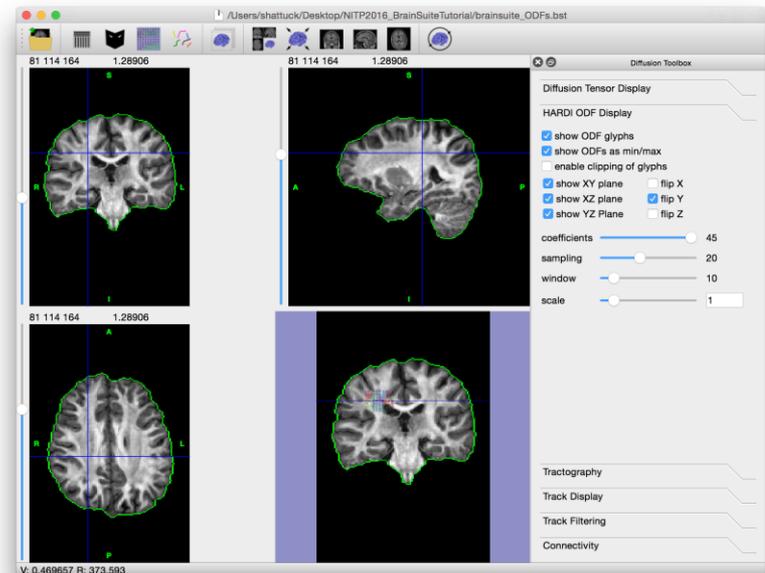
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  - Change FA threshold to 0.25
  - Change track seeding to 0.5
  - Change angle threshold to 30
  - Press 'Compute Tracks'
- **Explore the tracks using the interface**
  - Cut planes (x/y/z keys)
  - Fibers on/off ('F')
  - Tensors glyphs on/off ('G')

11. ODF Data

- **Drop brainsuite_ODFs.bst onto BrainSuite**

- Zoom in on the 3D view

- In the diffusion toolbox (press 'D'):
  - Show only the X-Z plane
  - Increase the window size to cover more of the slice
  - Scroll through the image and observe the ODF glyphs, particularly in the region of crossing fibers.
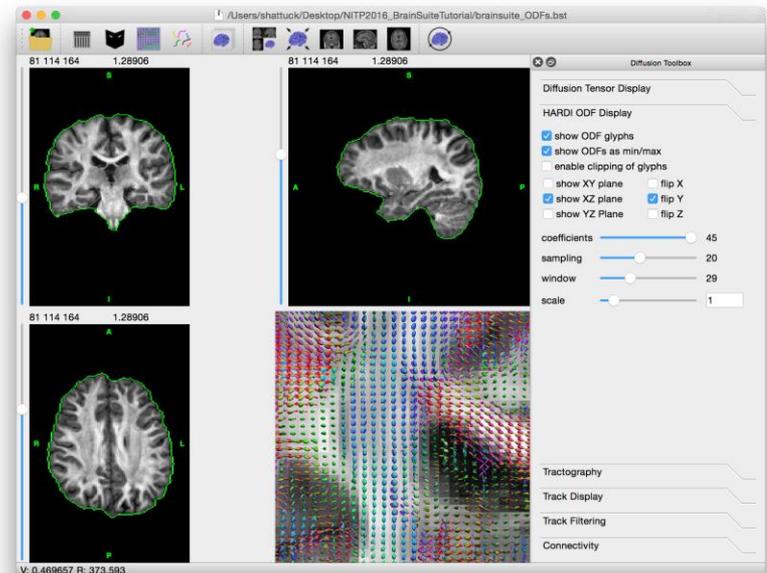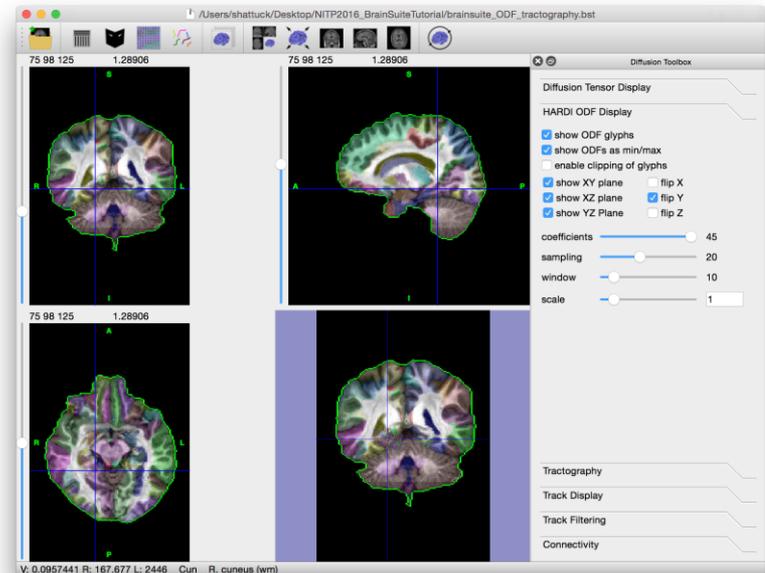
11. ODF Data

- Drop brainsuite_ODFs.bst onto BrainSuite

- Zoom in on the 3D view

- **In the diffusion toolbox (press 'D'):**

  - Show only the X-Z plane

  - Increase the window size to cover more of the slice

  - Scroll through the image and observe the ODF glyphs, particularly in the region of crossing fibers.

12. ODF Tracks

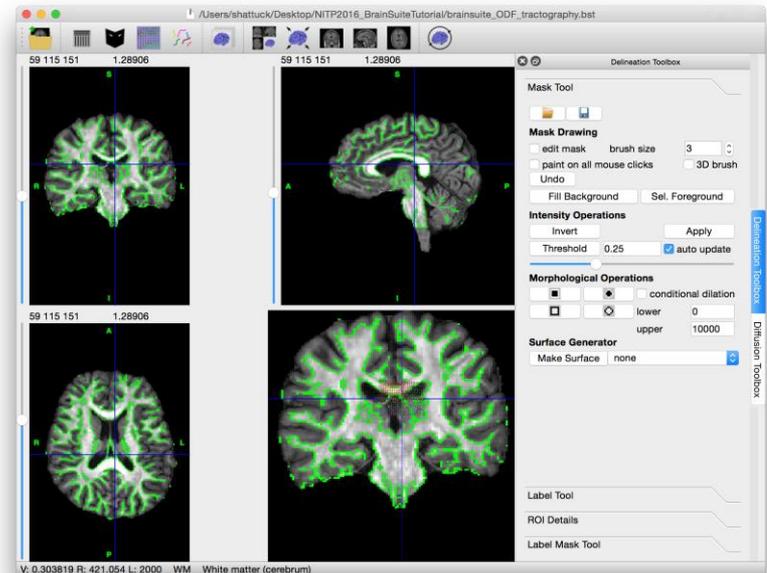This exercise requires a computer with a 64-bit operating system and at least 4GB of RAM

- **Drop brainsuite_ODF_tractography.bst onto BrainSuite**
- Zoom in on the 3D view
- Hide the labels (ctrl+L/⌘+L)
- Open the Mask Tool ('M'):
  - Change the threshold to 0.25
  - Press the threshold button
- Open Diffusion Toolbox ('D'):
  - Open the tractography tab
  - Change track seeding to 0.5
  - Press 'Compute Tracks'
- Explore the tracks using the interface
  - Cut planes (x/y/z keys)
  - Fibers on/off ('F')
  - ODF glyphs on/off ('O')
  - Toggle the labels (ctrl+L/⌘+L)

12. ODF Tracks

- Drop brainsuite_ODF_tractography.bst onto BrainSuite
- Zoom in on the 3D view
- Hide the labels (ctrl+L/⌘+L)
- **Open the Mask Tool ('M'):**
  - Change the threshold to 0.25
  - Press the threshold button
- Open Diffusion Toolbox ('D'):
  - Open the tractography tab
  - Change track seeding to 0.5
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12. ODF Tracks
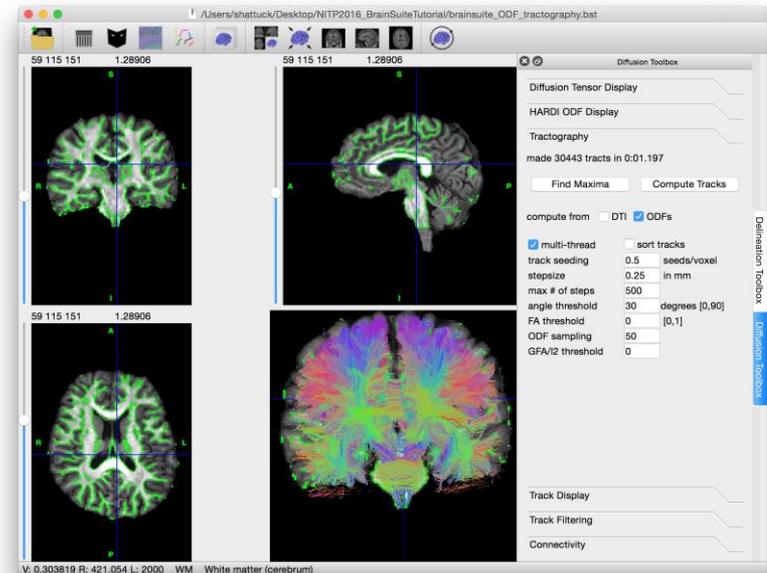
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- Zoom in on the 3D view
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  - Press the threshold button
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  - ODF glyphs on/off ('O')
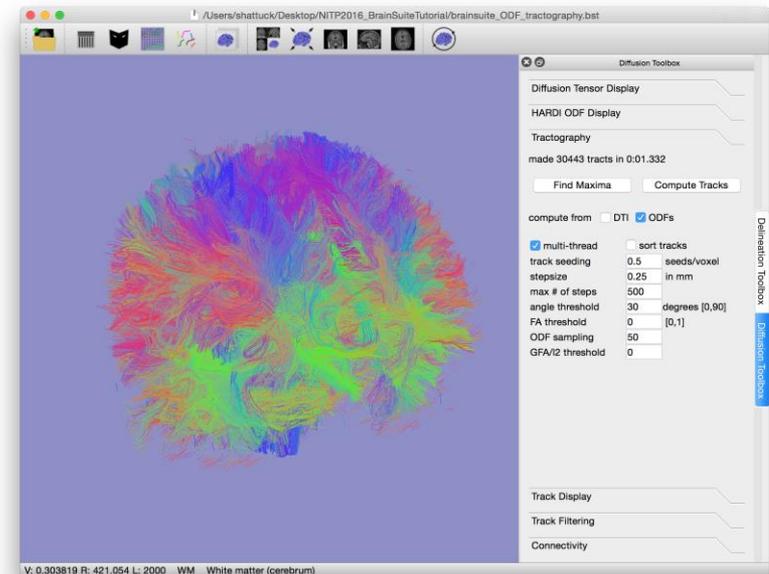 - Toggle the labels (ctrl+L/⌘+L)

12. ODF Tracks

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- Zoom in on the 3D view
- Hide the labels (ctrl+L/⌘+L)
- Open the Mask Tool ('M'):
  - Change the threshold to 0.25
  - Press the threshold button
- Open Diffusion Toolbox ('D'):
  - Open the tractography tab
  - Change track seeding to 0.5
  - Press 'Compute Tracks'
- **Explore the tracks using the interface**
  - Cut planes (x/y/z keys)
  - Fibers on/off ('F')
  - ODF glyphs on/off ('O')
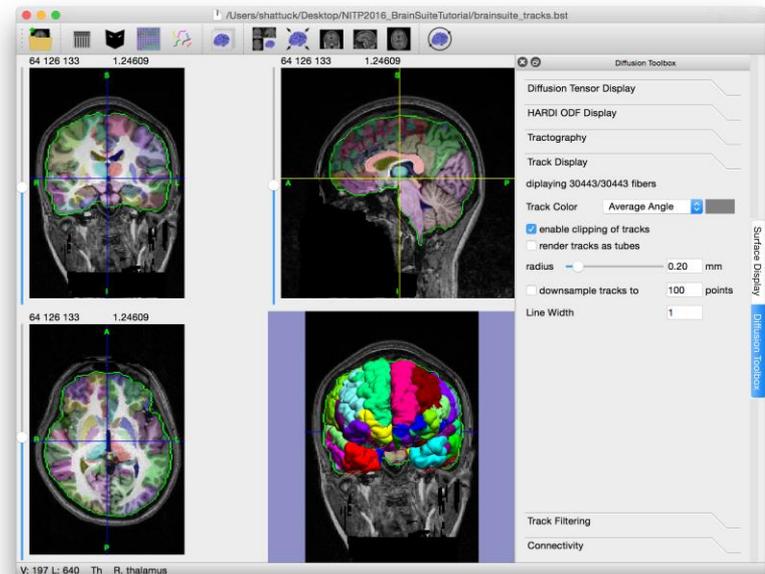 - Toggle the labels (ctrl+L/⌘+L)

13. Track Filtering

- **Drop brainsuite_tracks.bst onto BrainSuite**
- Adjust the display
  - Hide the surfaces (ctrl+S/⌘+S)
  - Hide the slices (ctrl+V/⌘+V)
  - Zoom in on the 3D view
- In the diffusion toolbox ('D'):
  - Open the Track Filtering tab
  - Adjust the length threshold to 10 and observe the spurious tracks disappear
- Explore the tracks using spherical ROIs
  - Press + to add a sphere at the current cursor position
  - Scroll through the image to see tracks connected to the sphere
  - Adjust the sphere radius to see larger regions
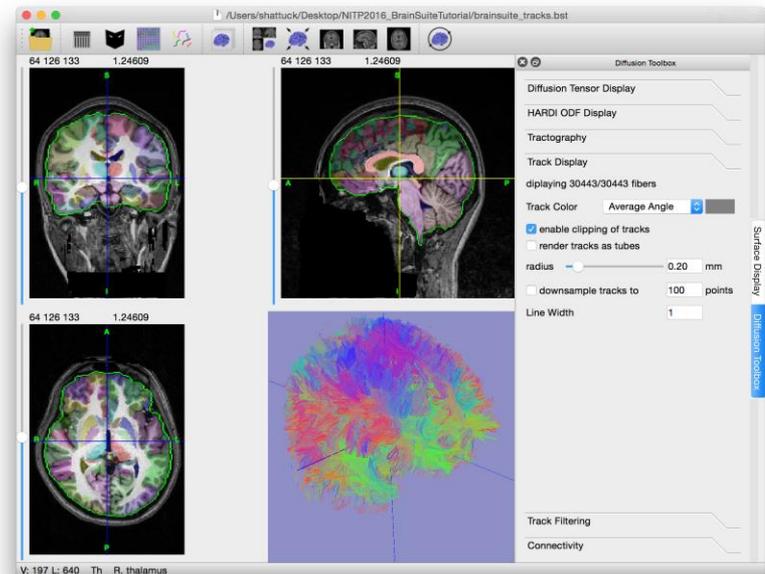 - Adjust other parameters (e.g., wireframe)

13. Track Filtering

- Drop brainsuite_tracks.bst onto BrainSuite
- **Adjust the display**
  - Hide the surfaces (ctrl+S/⌘+S)
  - Hide the slices (ctrl+V/⌘+V)
  - Zoom in on the 3D view
- In the diffusion toolbox ('D'):
  - Open the Track Filtering tab
  - Adjust the length threshold to 10 and observe the spurious tracks disappear
- Explore the tracks using spherical ROIs
  - Press + to add a sphere at the current cursor position
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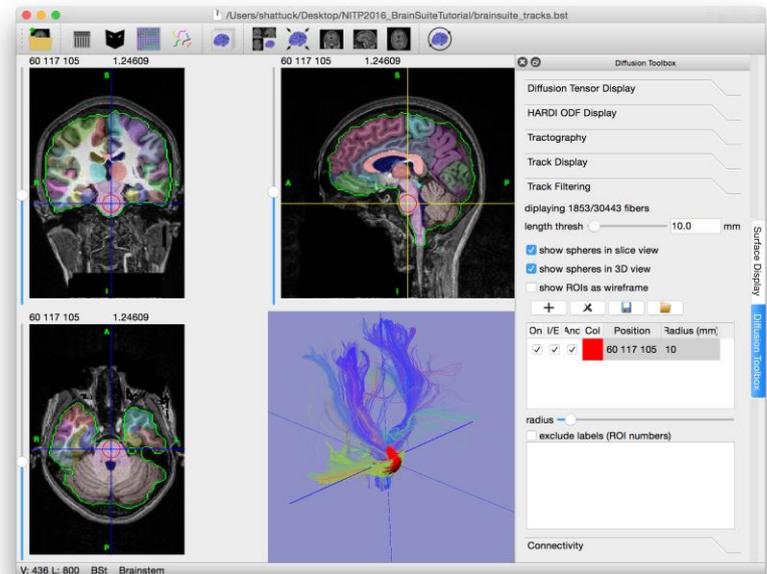 - Adjust other parameters (e.g., wireframe)

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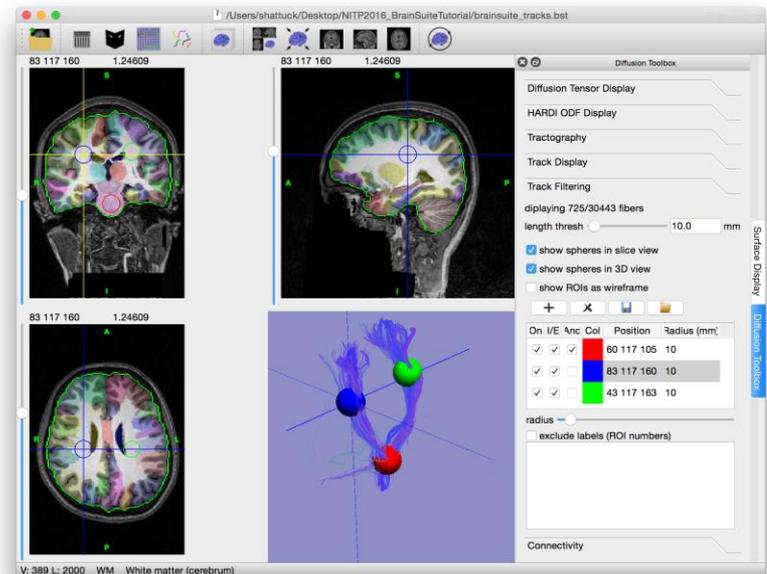 - Adjust other parameters (e.g., wireframe)

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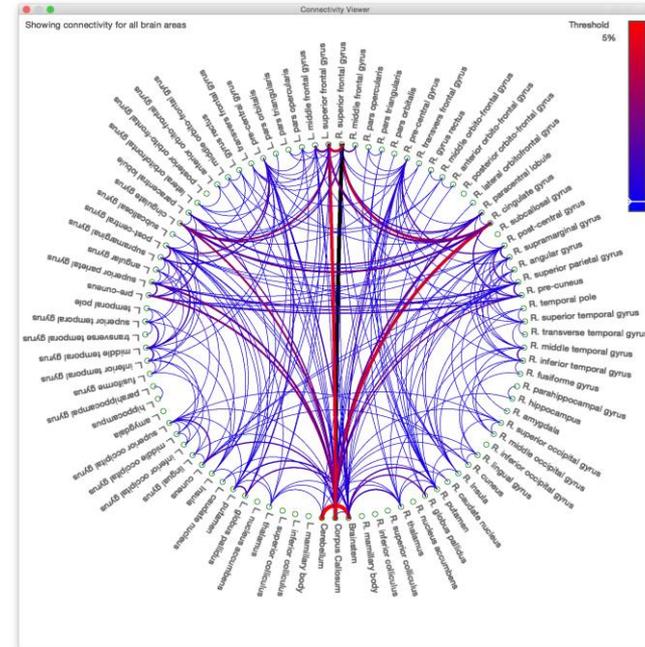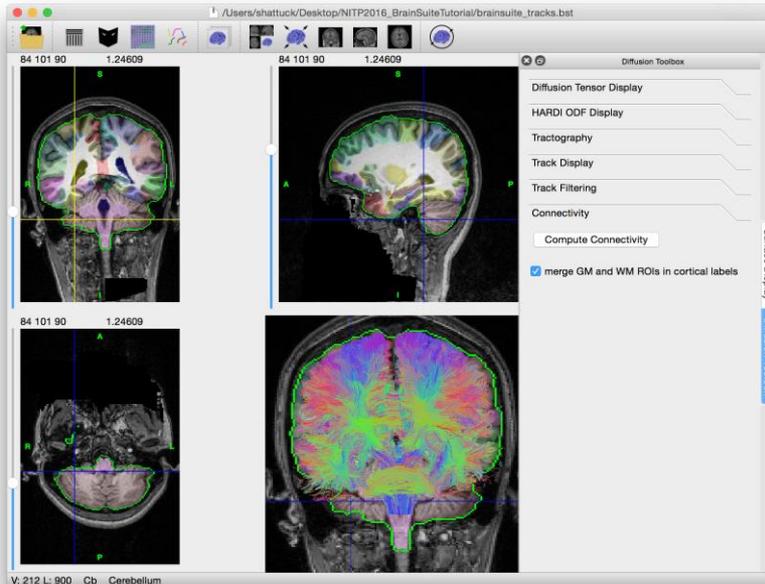 - Adjust other parameters (e.g., wireframe)

14. Connectivity

- **Load brainsuite_tracks.bst**
- **In the diffusion toolbox ('D'):**
  - Open the Connectivity tab
  - Press the 'Compute Connectivity' button
- The Connectivity Viewer allows you to explore connections between different ROIs
  - Select nodes along the wheel
  - ctrl+select to view connections between only 2 ROIs
  - shift+select to view multiple connections
  - Press 1,2,3,4 to observe different subsets (e.g., lobes)

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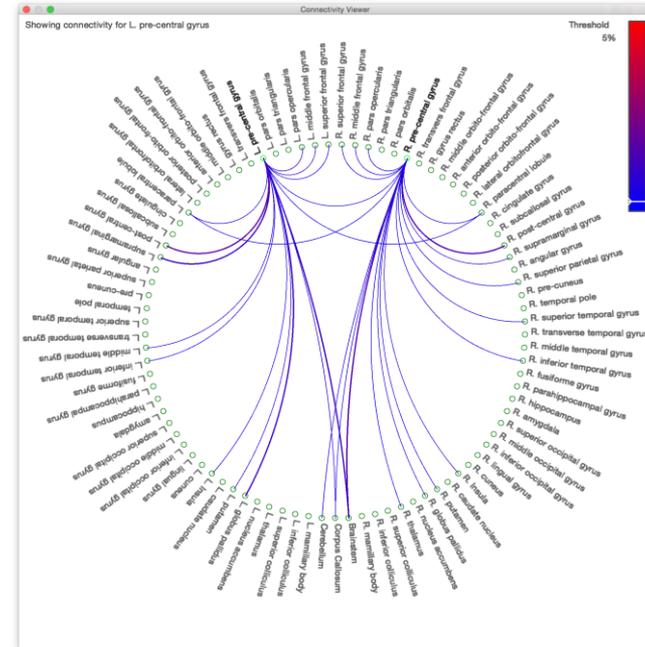 - shift+select to view multiple connections
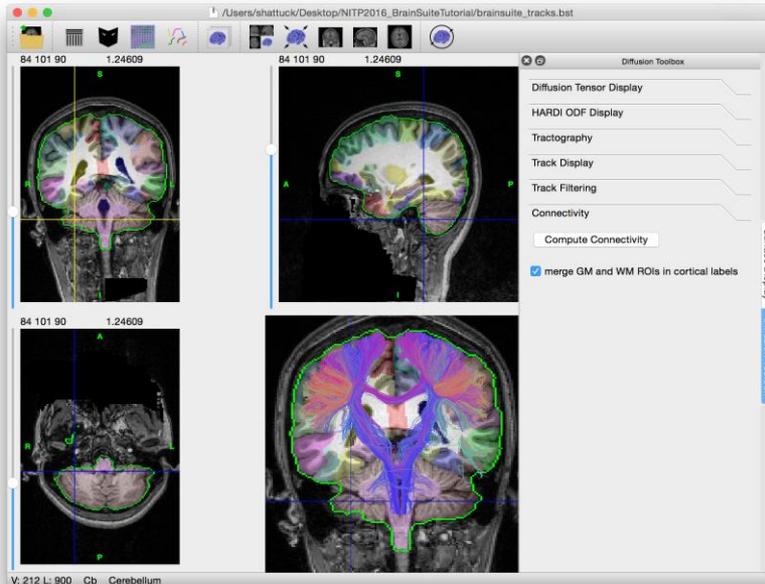 - Press 1,2,3,4 to observe different subsets (e.g., lobes)

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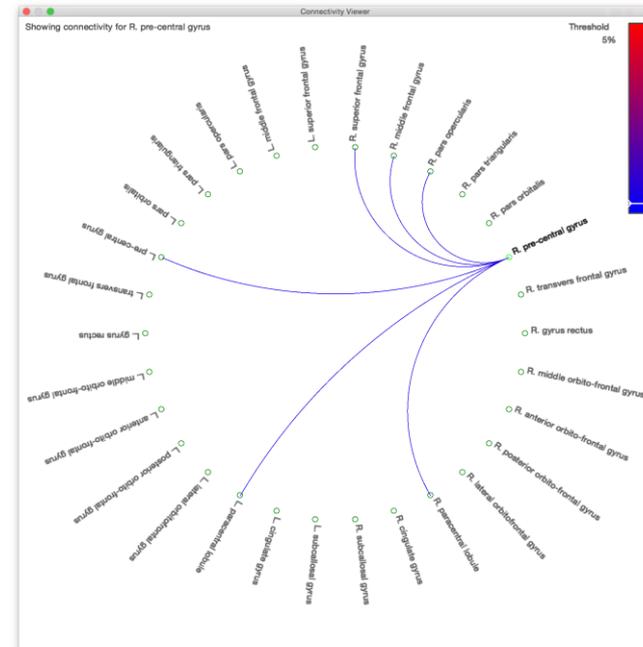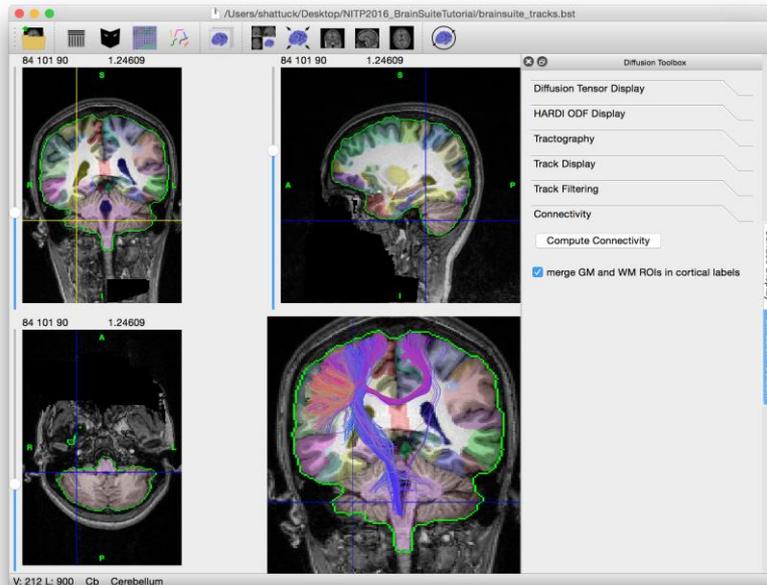   - Press 1,2,3,4 to observe different subsets (e.g., lobes)

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Command Line Extraction

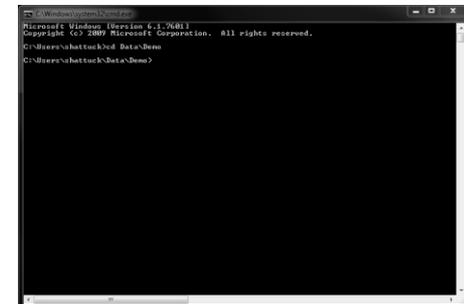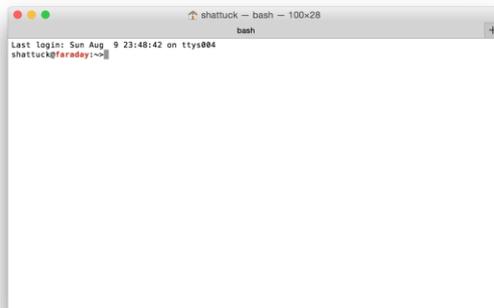Cortical Surface Extraction can also be run from the command line

Mac (similar for Linux):

`/Applications/BrainSuite16a/bin/cortical_extraction.sh 2523412.nii.gz`

Windows:

`"C:\Program Files\BrainSuite16a\bin\cortical_extraction.cmd" 2523412.nii.gz`

- The scripts will automatically read a file named BrainSuiteOptions if it exists in the current directory.
- The demo includes settings for the skull-stripping command.
- These commands are included as demo scripts in the extraction folder.
- Approximate run time on a 3.5GHz i7-3770k is **6 minutes**.

Command Line SVReg

Surface/Volume Registration can be run from the command line:

Mac (similar for Linux):

```
/Applications/BrainSuite16a/svreg/bin/svreg.sh 2523412 \
        /Applications/BrainSuite16a/svreg/BCI-DNI_brain_atlas/BCI-DNI_brain
```

Windows:

```
"C:\Program Files\BrainSuite16a\svreg\bin\svreg.exe" 2523412.nii.gz ^
        "C:\Program Files\BrainSuite16a\svreg\BCI-DNI_brain_atlas\BCI-DNI_brain"
```

n.b.: \ and ^ are line continuation characters for Mac/Linux and Windows, respectively.

- These commands are included as demo scripts in the extraction folder.
- Approximate run time on a 3.5GHz i7-3770k is **120 minutes**.

For additional usage flags, please see: http://brainsuite.org/processing/svreg/usage/

Command Line BDP

The BrainSuite Diffusion Pipeline is run from the command line:

Mac (similar for Linux):
```
/Applications/BrainSuite16a/bdp/bdp.sh 2523412.bfc.nii.gz --tensor –frt --fract \
        --nii 2523412.dwi.nii.gz -g 2523412.dwi.bvec -b 2523412.dwi.bval
```

Windows:
```
"C:\Program Files\BrainSuite16a\bdp\bdp.exe" 2523412.bfc.nii.gz --tensor –frt -fract ^
        --nii 2523412.dwi.nii.gz -g 2523412.dwi.bvec -b 2523412.dwi.bval
```

n.b.: \ and ^ are line continuation characters for Mac/Linux and Windows, respectively.

- These commands are included as demo scripts in the DWI folder.
- Approximate run time on a 3.5GHz i7-3770k is **22 minutes**.

For additional command line options, please see:
http://brainsuite.org/processing/diffusion/flags/

Command Line Thickness

Cortical Surface Thickness is run from the command line:

Mac (similar for Linux):

```
/Applications/BrainSuite16a/svreg/bin/thicknessPVC.sh 2523412
```

Windows:

```
"C:\Program Files\BrainSuite16a\svreg\bin\thicknessPVC.exe" 2523412
```

- These commands are included as demo scripts in the extraction folder.
- Approximate run time on an i7-3770k is **20 minutes**.