Technical Guide 1

Labeling and Measuring Brain Components in Talairach Space

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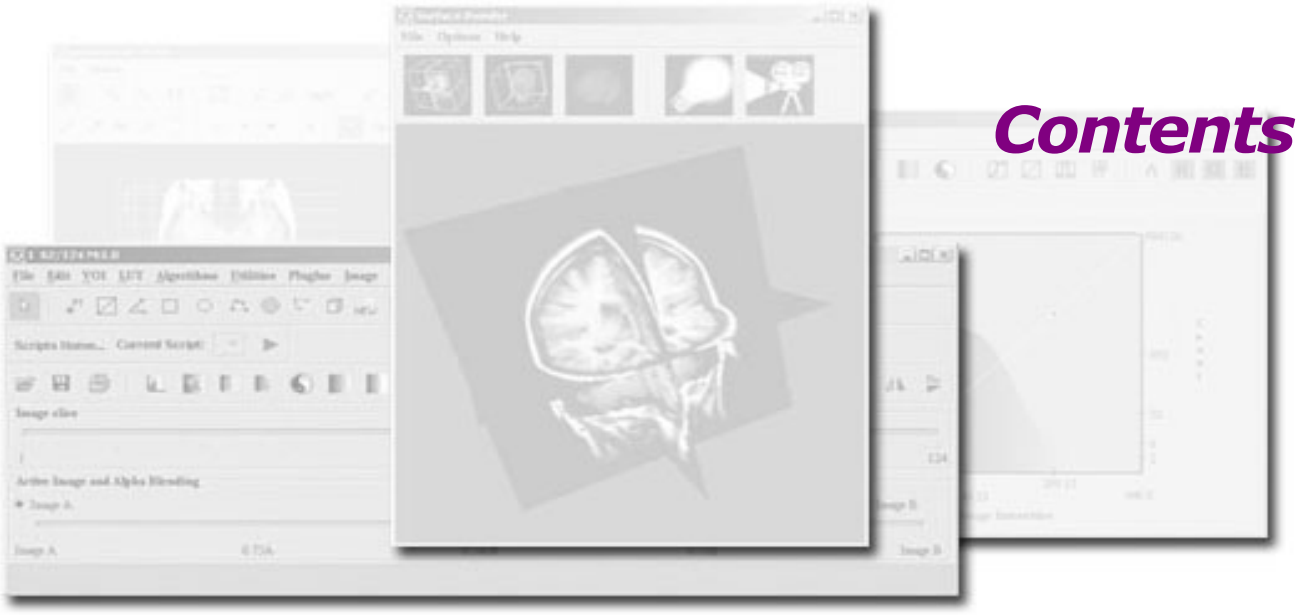
If you have a feature idea, send an email to wishlist@mipav.cit.nih.gov.



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1 Introducing Talairach Space

In this chapter . . .

Designed specifically for medical researchers, MIPAV concentrates on providing those researchers with the tools needed to do their work. It reads image files of many different formats and allows images to be displayed and measured using the most meaningful method to achieve research goals. MIPAV's flexibility becomes apparent when its capabilities are expanded and fine tuned through the development of plug-in programs that tailor solutions to meet specific requirements.

Using MIPAV to display, label, and measure brain components in Talairach space demonstrates both: MIPAV's native ability to display and measure brain images in Talairach space and the tailoring provided through the Talairach Transformation wizard and the FANTASM (Fuzzy and Noise Tolerant Adaptive Segmentation Method) plug-in programs, developed by the Johns Hopkins University.

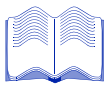
Background

In 1988 Jean Talairach and Pierre Tournoux developed a three-dimensional proportional grid system that can be used to identify and measure brains from any number of patients despite the variability of brain sizes and proportions. The premise of the system is that brain components that cannot be seen or identified can be defined in relation to other anatomic cerebral structures. In the Talairach system, the anterior commissure (AC) and posterior commissure (PC) are the structures from which the system of reference is developed.

The Talairach system establishes the maximal dimensions of the brain in three planes of space: *x, y*. and *z*:

- *AC-PC line (X axis)*—A horizontal line running through the anterior and posterior commissures.
- *VCA line (verticofrontal line, or Y axis)*—A vertical line passing through the anterior commissure
- *Midline (Z axis)*—A line forming the interhemispheric sagittal plane

Often referred to as the "origin," the anterior commissure is commonly used to describe structures. For example, a structure is described as "AC + 13 mm" for the frontal lobe or "AC - 35 mm" for the occipital pole. These descriptions assume that the anterior commissure is in the positive direction. However, the Talairach system does not use positive and negative directions. Instead, it labels quadrants according to number and letters (Figure 1A). The AC-PC line defines the horizontal plane, the VCA line defines the vertical plane, and the midline defines the depth plane. Because the anterior commissure and posterior commissure do not occur in the same axial slice, reslicing is necessary to put the brain into Talairach space.



Jean Talairach and Pierre Tournoux, *Co-Planar Stereotaxic Atlas of the Human Brain*, Thieme Medical Publishers, New York, 1988.

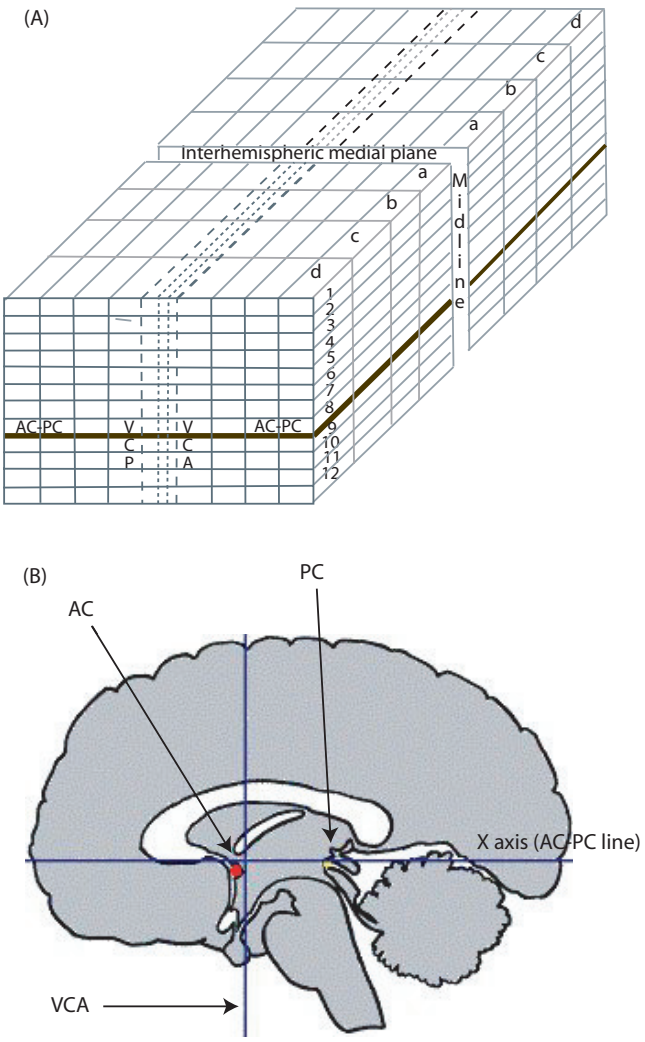


Figure 1. Talairach space: (A) Quadrants labeled by number and letters and (B) horizontal, vertical, and depth planes

This technical guide explains how to install and use two plug-in programs—the Talairach Transformation wizard and FANTASM—and MIPAV to:

- Create the *x, y,* and *z* planes of space in an image of a brain
- Transfer Talairach labels to an image of a brain
- Measure brain components in Talairach space

Talairach Transformation wizard

The Talairach Transformation wizard is a plug-in program for MIPAV that performs a semimanual transformation of image datasets of the brain to Talairach (stereotaxic) coordinates, providing atlas-based labeling. The Talairach coordinates allow researchers to easily identify subregions of the brain and measure their volume. It includes labels for 148 different substructures of the brain at various scales, obtained from the Talairach Daemon database, along with a set of volumetric images of the labels.

FANTASM

The FANTASM plug-in program is a different version of the Fuzzy C-mean algorithm for segmenting 2D and 3D images. It incorporates a spatial constraint that requires neighboring pixels to be similar and reduces the noise effect obtained with the Fuzzy C-mean algorithm. It can deal with outliers. Plans for a future version of FANTASM incorporates inhomogeneity correction.

References

ICBM atlas created by the International Consortium on Brain Mapping (ICBM), automatic (http://www.loni.ucla.edu/ICBM/ICBM_BrainTemplate.html).

Jean Talairach and Pierre Tournoux, *Co-Planar Stereotaxic Atlas of the Human Brain*, Thieme Medical Publishers, New York, 1988.

Neva Chernizasky, *Medical Imaging: Orientation*, Paper prepared for Matthew McAuliiffe, Ph.D. Center for Information Technology, National Institutes of Health, August 31, 2001.

Dzung L. Pham, "Spatial Models for Fuzzy Clustering," *Computer Vision and Image Understanding*, vol. 84, pp. 285-297, 2001.

P. L. Bazin, M. McAuliffe, W. Gandler, and D. L. Pham. "Free Software Tools for Atlas-based Volumetric Neuroimage Analysis," *Proceedings of the SPIE Medical Imaging 2005 Conference*, The International Society for Optical Engineering (SPIE), Bellingham, Washington, 2005.

2 Installing the Talairach Transformation Wizard, FANTASM, and Talairach Atlas

In this chapter . . .

To label and measure brains in Talairach space in MIPAV, you first need to download and install the following:

- **Talairach Transformation wizard**—A plug-in program that allows the transformation of images in and out of Talairach space.
- **Fuzzy and Noise Tolerant Adaptive Segmentation Method (FANTASM)**—A plug-in program.
- **Talairach atlas**—The Talairach atlas is not a plug-in program but a collection of VOIs especially designed to identify brain components using the Talairach atlas. During the procedure of transforming brains into Talairach space, you use the atlas by navigating to the directory in which the atlas is stored and then opening and applying the desired VOIs.

To install the Talairach Transformation wizard, FANTASM, and the Talairach Atlas

1. Go to the Laboratory of Medical Image Computing Software (MedIC) web site at Johns Hopkins University (Figure 2 on page 7):

   http://medic.rad.jhu.edu/download/public/

2. Download the following two MIPAV plug-in programs:
   - Talairach Transformation wizard
   - FANTASM

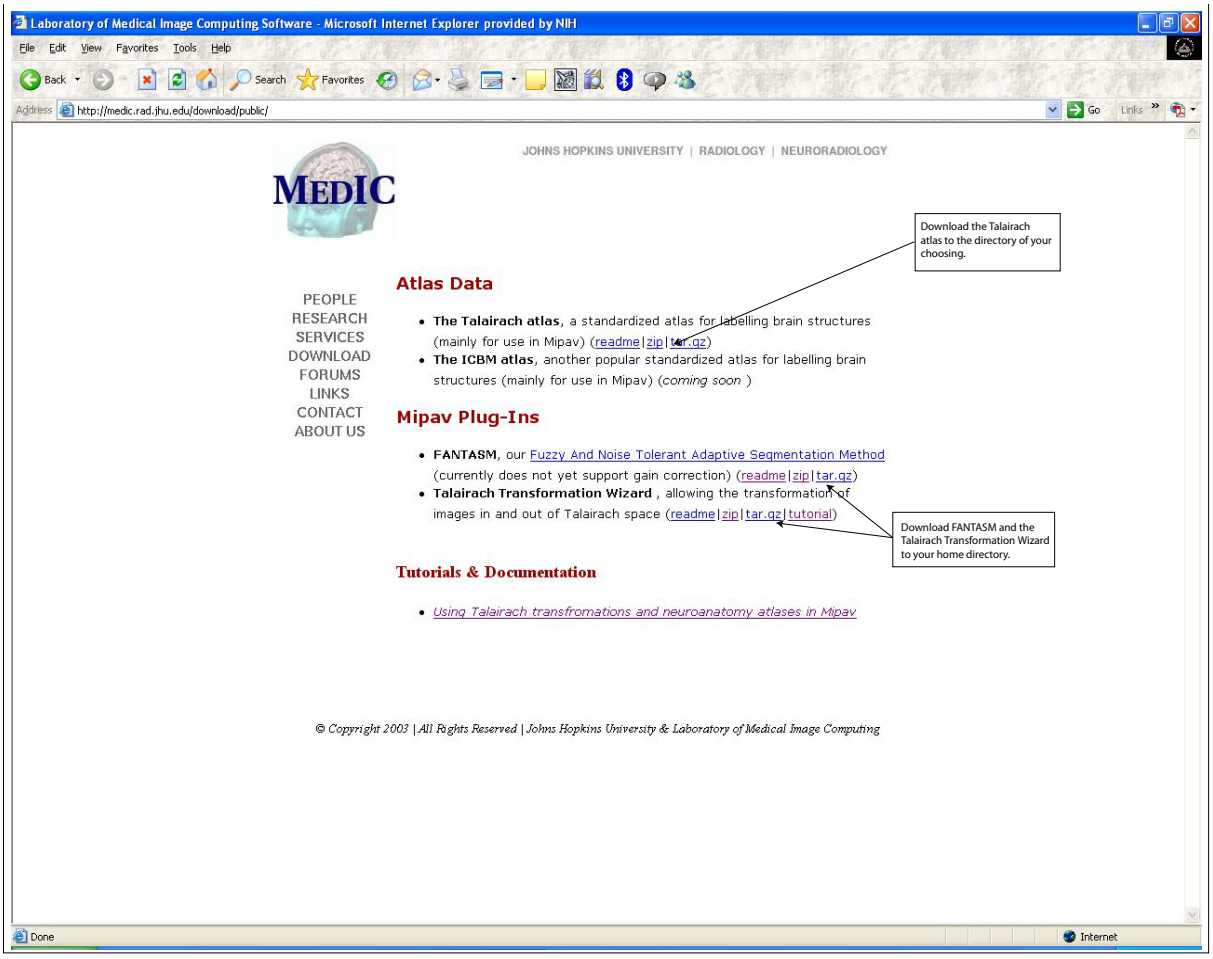


Figure 2. MedIC web site at Johns Hopkins University

3 Download the Talairach atlas.

4 Create a MIPAV plug-ins folder in your user or home directory.

5 Extract the files from the zip or tar files for the Talairach Transformation wizard and FANTASM plug-in programs and the Talairach atlas into your user or home directory:

Windows

`c:\Documents and Settings\<your user ID>\mipav\plugins`

Unix

`/user/<your user ID>/mipav/plugins`

Example: If the user ID for John Smith is smithj, then the user directory would be the following: `c:\Documents and Settings\smithj\mipav\plugins`. In Unix the home directory would be `/home/smithj/mipav/plugins`.

6 Extract the Talairach atlas files into either your home (mipav\plugins) directory or in any other directory on your workstation.

7 Start MIPAV. The initial MIPAV window opens.

8 Open an image. The expanded MIPAV opens. Notice that the PlugIn menu now includes the following commands:

- Algorithms > FANTASM
- Algorithms > TalairachTransform

Figure 3. PlugIns menu with FANTASM and TalairachTransform commands

Note: Because the Talairach atlas is not a plug-in program, it does **not** apppear on the PlugIns menu. You gain access to it later in this procedure by opening a VOI using VOI > Open VOI and navigating to the directory in which it is stored.

To participate in MedIC forums

1. Go to the Forums page at the Laboratory of Medical Image Computing Software (MedIC) web site at Johns Hopkins University (Figure 4 on page 9):

   http://medic.rad.jhu.edu/forums/

2. Browse the forums or register as a member and sign in.

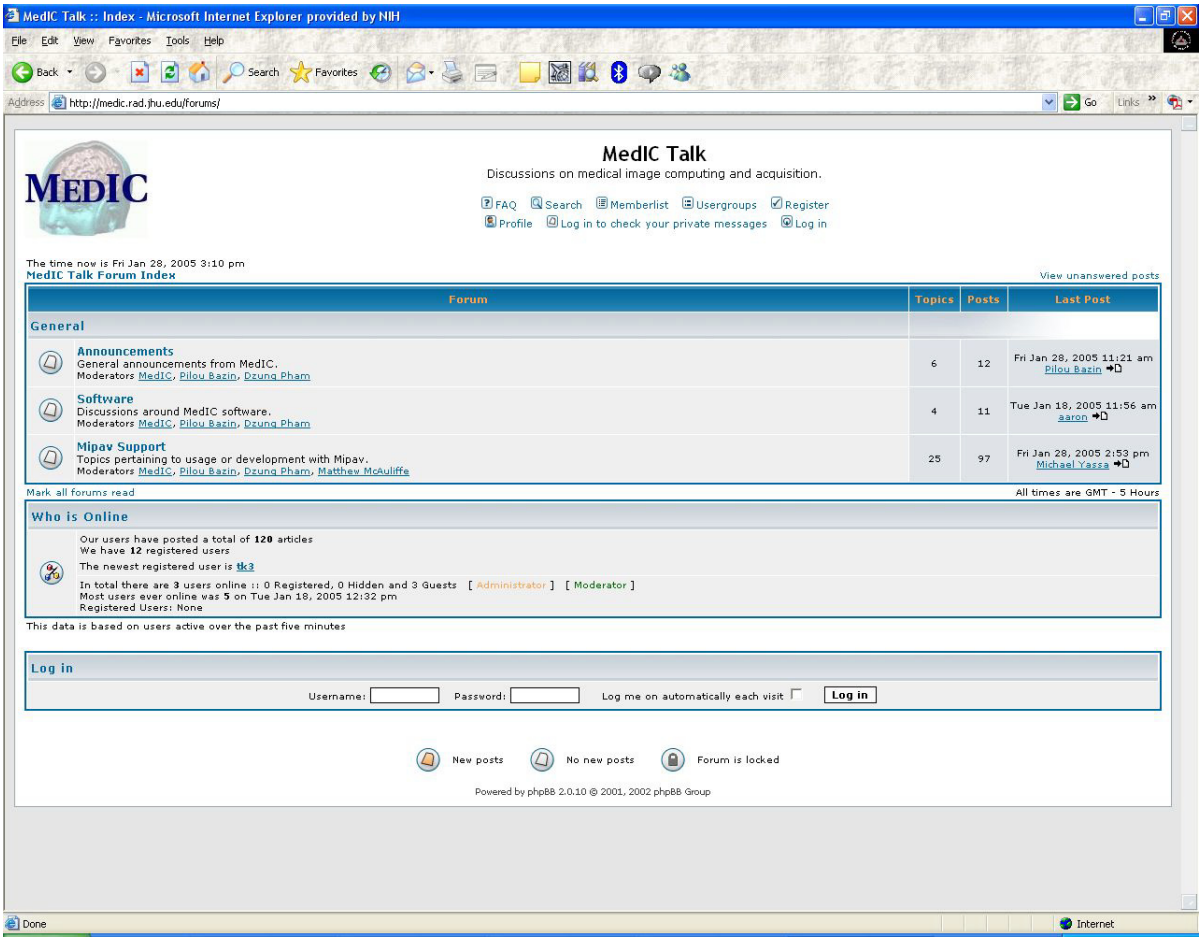


Figure 4. Forums page for the MedIC web site at Johns Hopkins University

3 Labeling and Measuring Brain Components in Talairach Space

In this chapter . . .

Figure 5 shows the six tasks involved in labeling and measuring brain components in Talairach space. After you complete the six tasks, you can also view the Talairach image in the triplanar window, where the Talairach grid and markers can be displayed on the image.

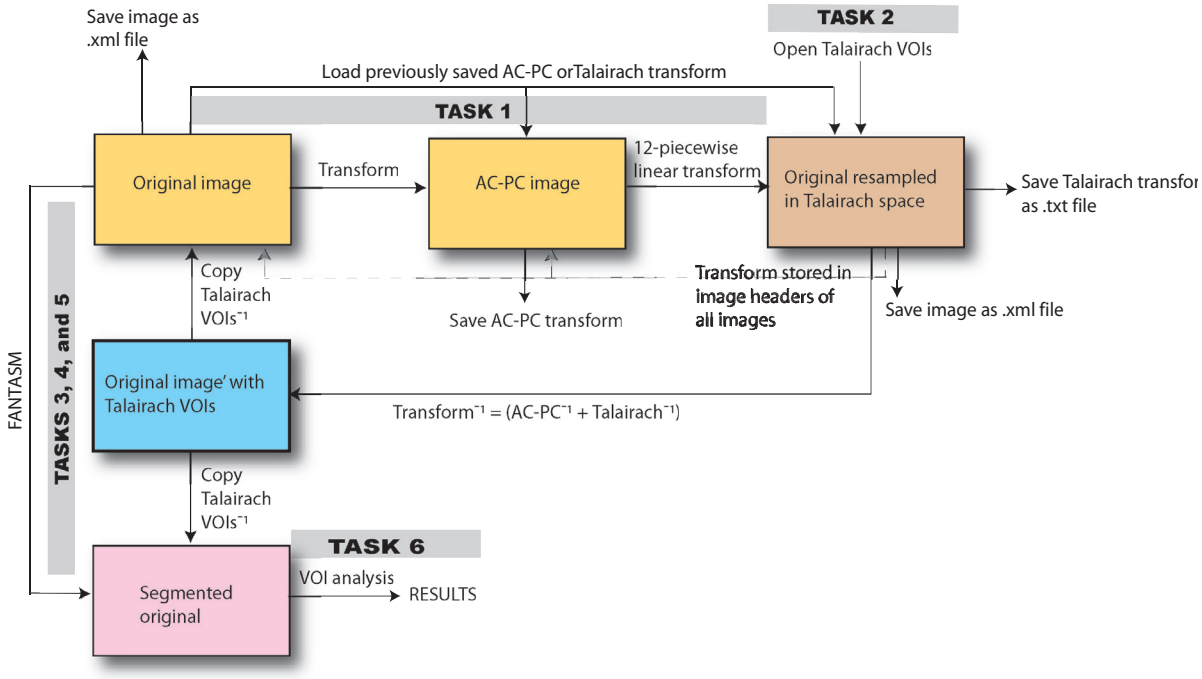


Figure 5. A functional diagram of the process of putting brain components in Talairach space

Task 1, Performing a semimanual transformation on datasets to the Talairach coordinate system

Transforming, or converting, datasets into Talairach space provides scientists with the ability to identify important structures within the standard brain. The Talairach atlas is as much a reference system as it is a coordinate system.

The main steps involved in transforming a dataset into the Talairach coordinate system are:

1. Performing anterior commissure and posterior commissure (AC-PC) alignment on page 12
2. Transform the AC-PC image to Talairach alignment on page 30

Performing AC-PC alignment

In the Talairach system the anterior commissure is often referred as the "origin," because it is the origin of the Talairach grid. In this first semimanual task, you need to identify and set five separate landmark points, beginning with the anterior commissure. Setting these points aligns the anterior commissure and posterior commissure that forms the basis of the Talairach grid. The landmark points, shown in Figure 6, are:

- **AC superior edge**—Top middle of anterior commissure
- **AC posterior margin**—Rear middle of posterior commissure
- **PC inferior edge**—Bottom middle of posterior commissure
- **First midsagittal point**—Some point in the midsagittal plane; abbreviated as SG1
- **Another midsagittal point**—Some other point in the midsagittal plane; abbreviated as SG2

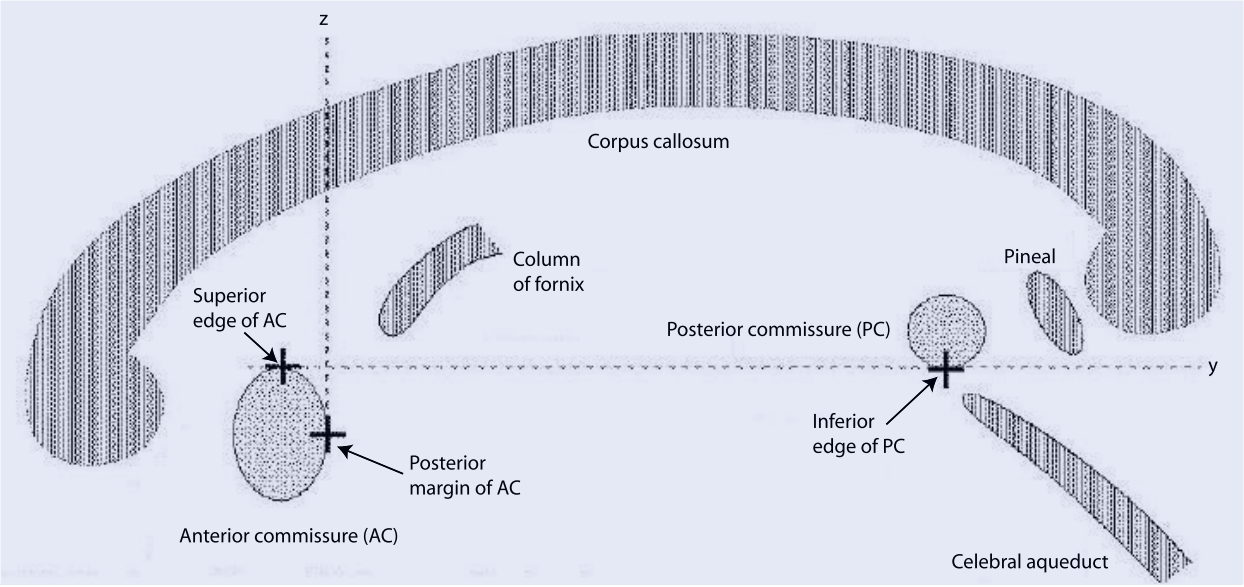


Figure 6. Landmark points used to perform AC-PC alignment

When you've set these points, the Talairach grid is formed from these axes (refer to Figure 7):

- **Y axis**—Anterior commissure and posterior commissure.
- **Z axis**—The longitudinal (interhemispheric or midsagittal) fissure is aligned to the *yz* plane, thus defining the *z* axis.
- **X axis**—The right-left axis perpendicular to the *y* and *z* axes.

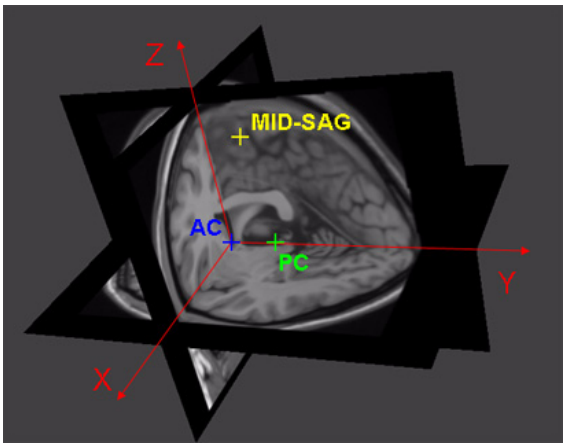


Figure 7. The *x, y,* and *z* planes in an image after AC-PC alignment

To perform AC-PC alignment

1 Open an image of the brain (Figure 8) that you want to put into Talairach space.

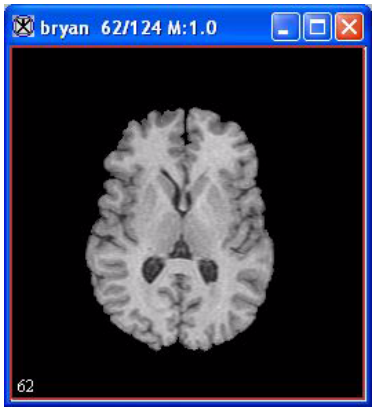


Figure 8. An image of a brain to be put in Talairach space

2 Select Image > Attributes > Edit Attributes. The Image Attributes dialog box opens.

3 Click Resolutions. The Resolutions page (Figure 9) appears.

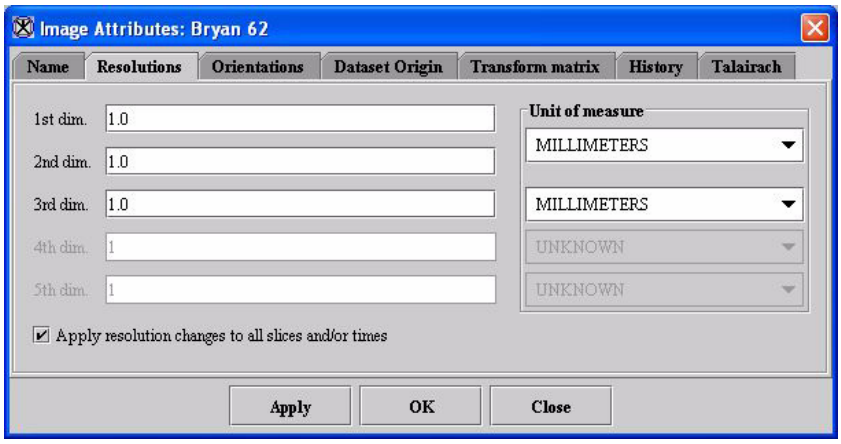


Figure 9. Resolutions page in the Image Attributes dialog box

4 Check the resolutions in 1st dim., 2nd dim., and 3rd dim to make sure they are correct, change them if they are incorrect, and click Apply.

5 Click Orientation. The Orientation page (Figure 10) appears.

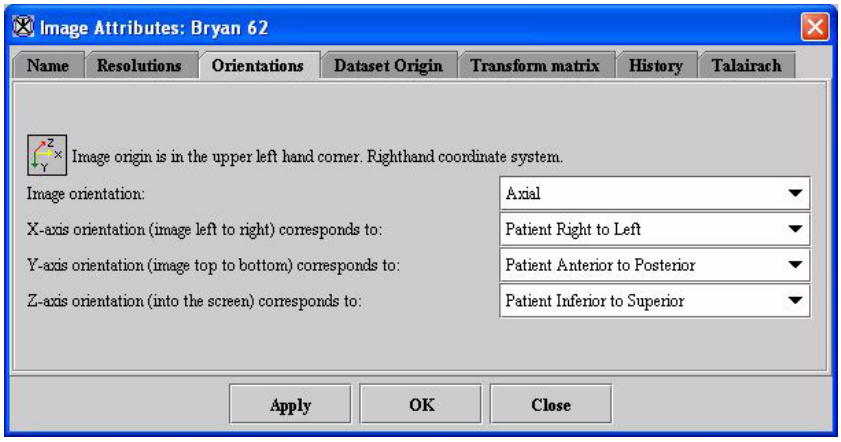


Figure 10. Orientations page in the Image Attributes dialog box

6 Check the orientation of the image to make sure it is correct.

Caution: Classical alignment problems that occur with images are that resolutions and orientation for the original image are not set properly.

7 Do one of the following:

- If the orientation is correct, go to the next step.
- If the orientation is incorrect:
  - Make the necessary changes.
  - Click Apply to apply the changes immediately.

8 Click Talairach. The Talairach page (Figure 11) appears.

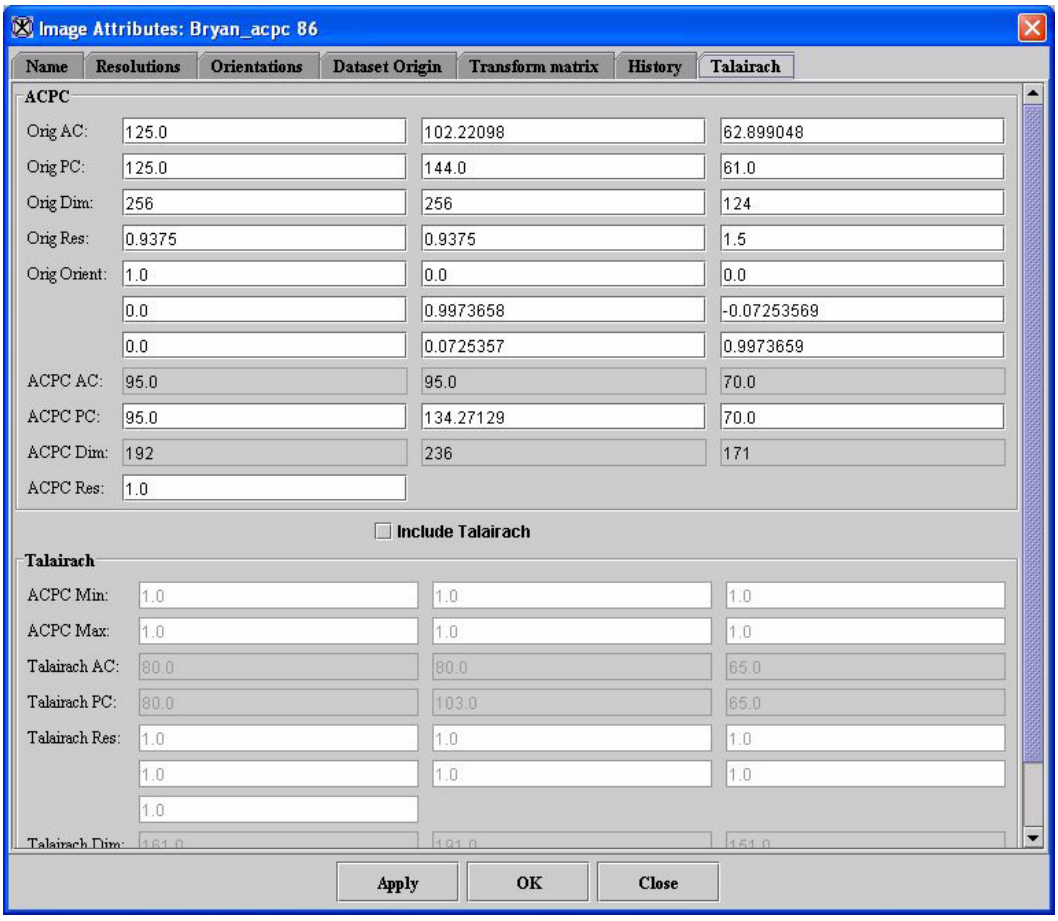


Figure 11. Talairach page in the Image Attributes dialog box as it appears *before* mapping the image to AC-PC or Talairach space

9 Scroll down the window and notice that "1.0" or "1" appears in all of the fields in the ACPC group and the Talairach group. This data should change as a result of performing, first, the ACPC transformation on the image and, second, the Talairach transformation.

10 Select Plug-Ins > Algorithms > TalairachTransform (Figure 12).

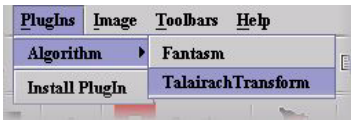


Figure 12. TalairachTransform command on the PlugIns menu

The Talairach Transform dialog box (Figure 13) opens.

ACPC	Transforms the original image of a brain into an AC-PC aligned image in which the anterior and posterior commisures in the brain are set on a horizontal line. When you click this button, the Create AC-PC Image dialog box opens.
Talairach	Transforms the AC-PC image of the brain into a Talairach-aligned image. When you click this button, the Create Talairach Image dialog box opens.
Load	Loads a previously saved AC-PC or Talairach transform into the original image. When you click this button, either the Load Talairach Transform File or the Load AC-PC Transform dialog box opens.
Save	Saves the AC-PC or the Talairach transform to a .txt file. When you click this button, the Save AC-PC Transform File or Save Talairach Transform dialog box opens.

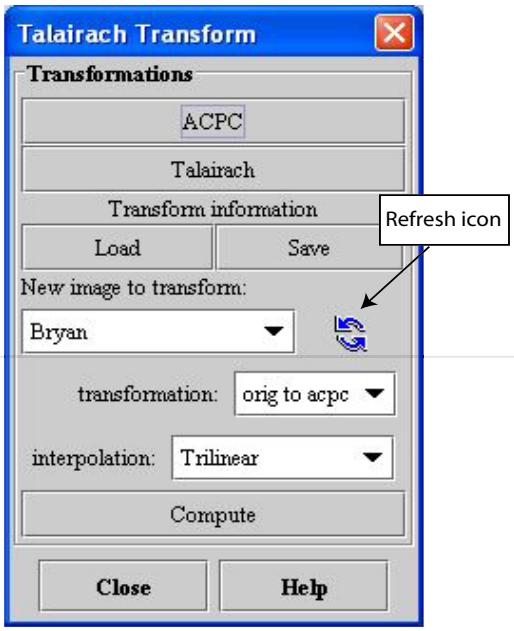


Figure 13. Talairach Transform dialog box

New image to transform	Displays a list of the original image and, if you click Refresh, any AC-PC or Talairach images that are currently open.	
Refresh	Refreshes the list of images in the New image to transform list to reflect any AC-PC or Talairach images that are currently open.	
Transformation	**Orig to AC-PC**	Transforms the original image to the AC-PC image. You choose this item to copy information from the original image to the AC-PC image.
	Orig to Tlrc	Transforms the original image to the Talairach image. You choose this item to copy information from the original image to the Talairach image.
	ACPC to Tlrc	Transforms the AC-PC image to the Talairach image. You choose this item to copy information from the AC-PC image to the Talairach image.
	Tlrc to AC-PC	Transforms the Talairach image to the AC-PC image. You choose this item to copy information from the Talairach image to the AC-PC image.
	Tlrc to orig	Transforms the Talairach image to the original image. You choose this item to copy information from the Talairach image to the original image.
	AC-PC to orig	Transforms the AC-PC image to the original image. You choose this item to copy information from the AC-PC image to the original image.
Interpolation	Indicates the method of interpolation to use when creating AC-PC or Talairach images. The default interpolation method is trilinear. However, you can choose any of the following interpolation methods, which are listed in order of complexity and amount of time required: • Nearest neighbor • Trilinear • Bspline 3rd order • Bspline 4th order • Cubic Lagrangian • Quintic Lagrangian • Heptic Lagrangian • Windowed sinc	
Compute	Transforms the new image according to the transformation chosen in Transformation. When you click Compute, the Talairach plugin stores the AC-PC and Talairach transform information in the image headers. To view this information, select the image and then select Image > Attributes > View header.	
Close	Closes the Talairach Transform dialog box and quits the Talairach plugin.	
Help	Displays online help for this dialog box.	

Figure 13. Talairach Transform dialog box (continued)

11 Click AC-PC at the top of the Talairach Transform dialog box. The following occurs:

- The image appears in a triplanar view (Figure 14).
- The Create AC-PC Image dialog box (Figure 14) opens on top of the triplanar view.

Note: If the image appears squeezed or otherwise out of alignment, you need to make sure that the resolutions on the Resolutions page of the Image Attributes window are correct.

The Create AC-PC Image dialog box (Figure 14) lists five landmark points that you need to locate and mark in the image. Table 1 lists these points and their approximate location in the image. “Guide to Finding Landmark Points” on page 20 illustrates the location of the points.

Tip: To create the AC-PC image, you may need to magnify  the image a couple of times, particularly for locating the AC superior edge, AC posterior margin, and PC inferior edge (refer to Figure 17 on page 22).

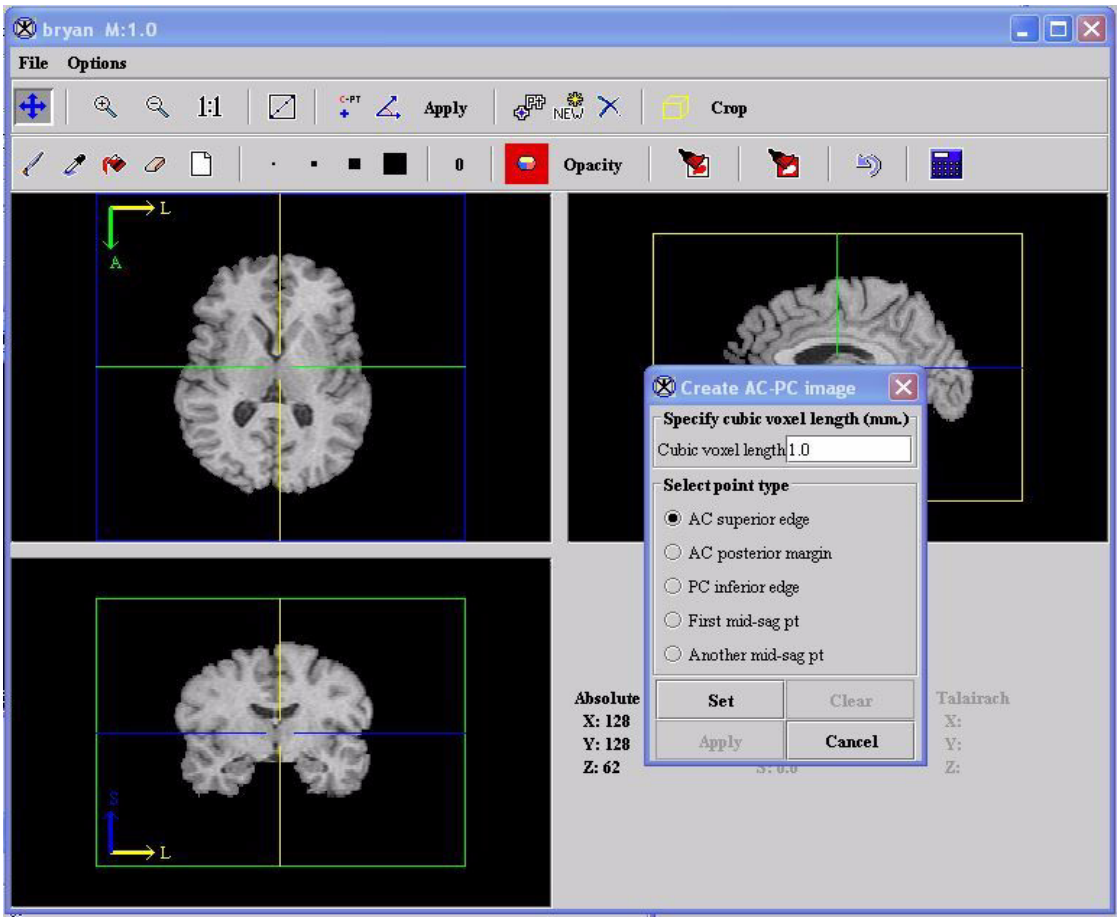


Figure 14. The Create AC-PC Image dialog box on top of the triplanar view of the image

Table 1. Landmark points needed to perform AC-PC alignment

Symbol used on image			
Abbreviation	**Color**	**Landmark points**	**Location in image**
ACS	Red	AC superior edge	Top middle of anterior commisure
ACP	Orange	AC posterior margin	Rear middle of anterior commissure
PC	Yellow	PC interior edge	Bottom middle of posterior commisure
MS1	Aqua	First midsagittal point	Some point in the midsagittal plane
MS2	Yellow	Second midsagittal point	Another point in the midsagittal plane

Guide to Finding Landmark Points

First Goal

Mark the top middle and rear middle of the anterior commisure.

In the sagittal image—Look for the anterior commisure at the bottom level of the corpus collosum, below the fornix.

In the coronal view—Look for the "mustache."

In the axial view—Look for the interhemispheric connection.

Second Goal

Mark the inferior edge of the posterior commissure.

Unfortunately, the posterior commissure doesn't show up well at 1-mm resolution. However, it is always at the top of the cerebral aqueduct, which usually shows up well.

If you can't see the posterior commissure, find the midsagittal location just at the top of the cerebral aqueduct and mark it as the PC inferior edge.

Final Goal

Mark two midsagittal points (SG1 and SG2), which are above the corpus callosum.

The two planes of AC-SC-SG1 and AC-PC-SG2 must be no more than 2 degrees apart. In practice, good candidates for SG1 and SG2 are often far from AC and PC and close to each other.

The following diagram shows where the points are located. An image in a triplanar view in which the image was magnified twice appears in Figure 17 on page 22.

To find the landmark points, it is extremely helpful to have a high-quality image of the anterior and posterior commissures.

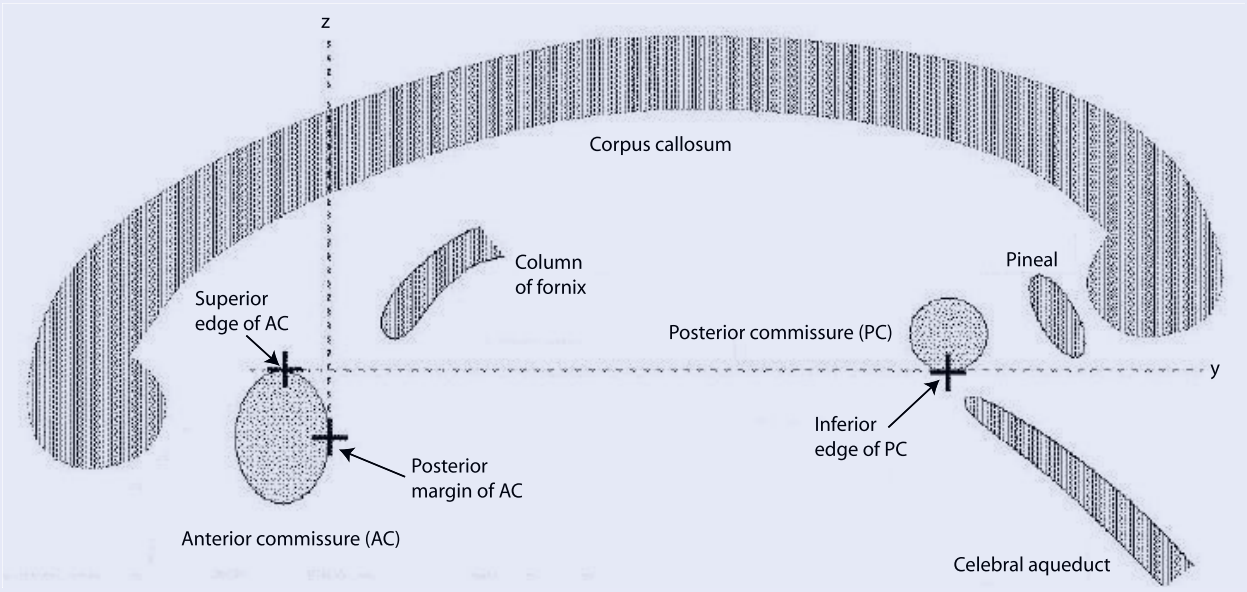


Figure 15. Landmark points used to perform AC-PC alignment

12 Set the scale of the image in Cubic voxel length. Make sure this scale matches the entries in step 4.

13 Select AC superior edge in the Create AC-PC Image dialog box (Figure 16).

14 Go to the triplanar image and locate the AC superior edge on the sagittal view of the image. Place the crosshair marker directly over the top middle of the anterior commisure.

15 Click Set on the Create AC-PC Image dialog box (Figure 16). A red marker labeled ACS appears on the point you indicated.

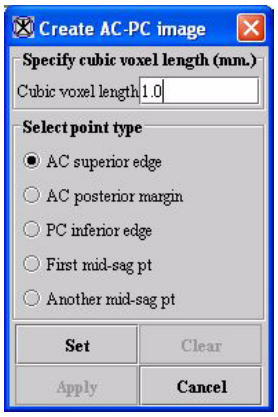


Figure 16. Create AC-PC Image dialog box

16 Select, locate, and set each of the remaining landmark points consecutively in the Create AC-PC Image dialog box. Refer to Table 1 on page 19, “Guide to Finding Landmark Points” on page 20, and Figure 17 on page 22 for directions on how to locate the individual points.

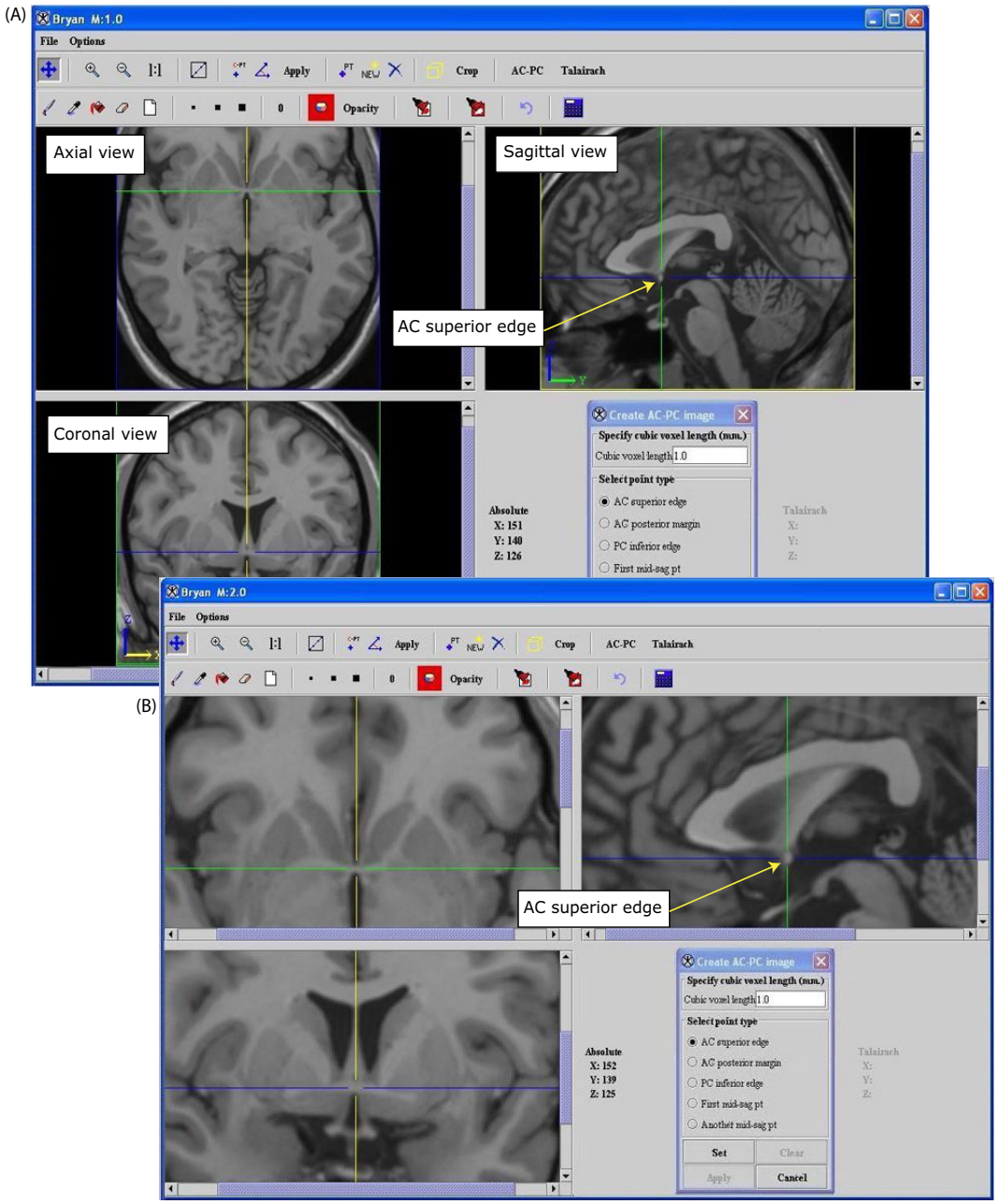


Figure 17. Finding landmark points: (A) AC superior edge in original image, (B) AC superior edge in magnified image, (C) PC inferior edge in original image, and (D) PC inferior edge in magnified image

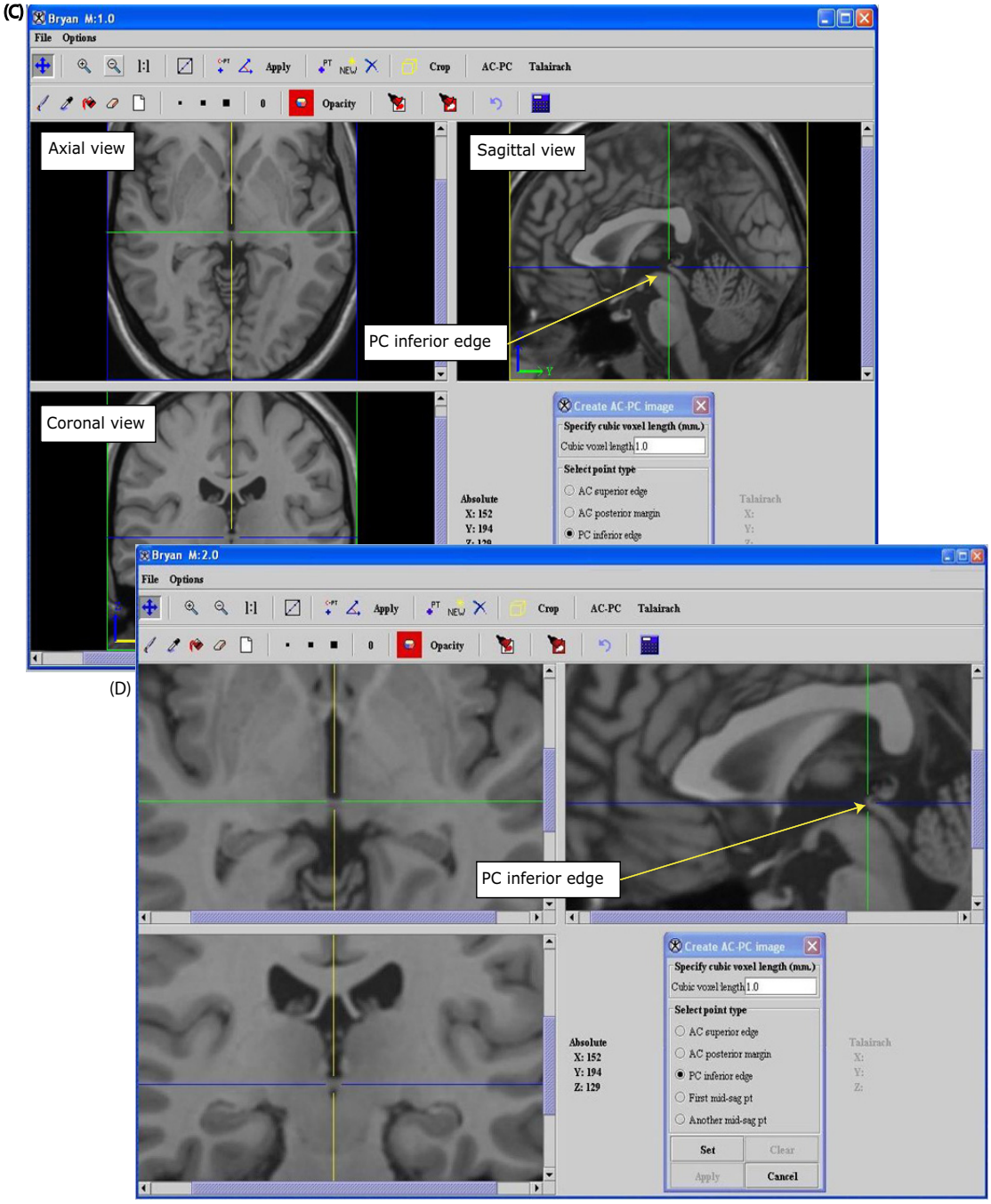


Figure 17. Finding landmark points: (A) AC superior edge in original image, (B) AC superior edge in magnified image, (C) PC inferior edge in original image, and (D) PC inferior edge in magnified image (continued)

Note: If you need to erase a landmark point that you've already set, select the point in the image. Return to the Create AC-PC Image dialog box and select the radio button for the point you want to delete. For example, to delete the AC posterior margin, select that radio button. Then click Clear (the Clear button only becomes available when you've completed the preceding instructions correctly).

17 Return to the Create AC-PC Image dialog box (Figure 18) when all landmark points are marked, and click Apply.

Tip: The Apply button only becomes available when all of the landmark points are correctly selected and set. A point is correctly set when the settings you chose appear to the right of each point (Figure 18).

A progress message appears, and then the image produced from the settings you specified appears in a new image window. The result is an AC-PC aligned image (Figure 20).

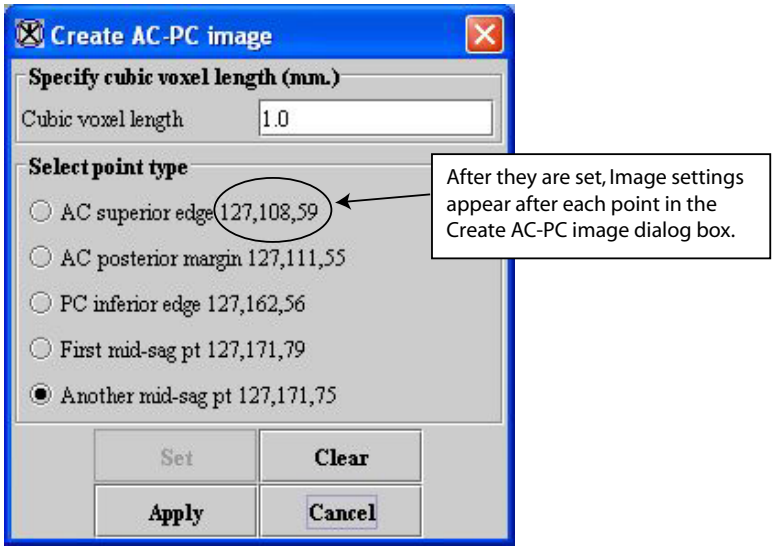


Figure 18. Create AC-PC Image dialog box with settings for each of the landmark points

18 Click to refresh the list of images in New image to transform. The transformed image, whose title is the name of the original image followed by *_acpc*, appears in the list (Figure 19).

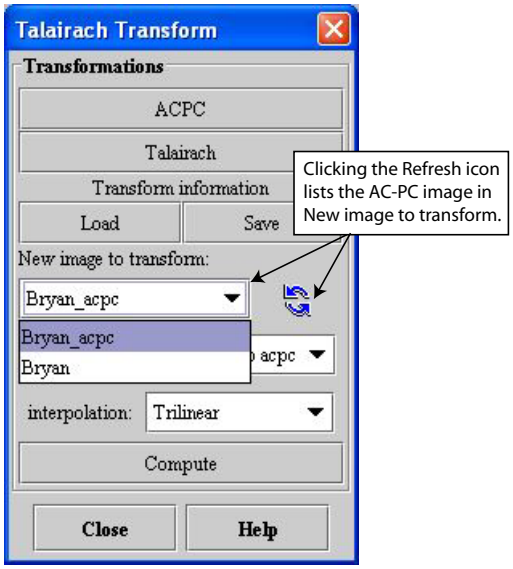
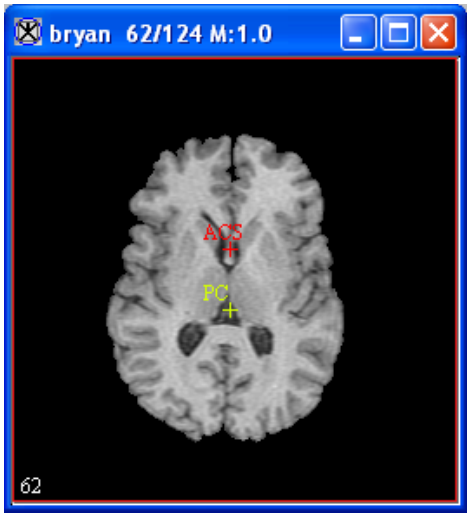


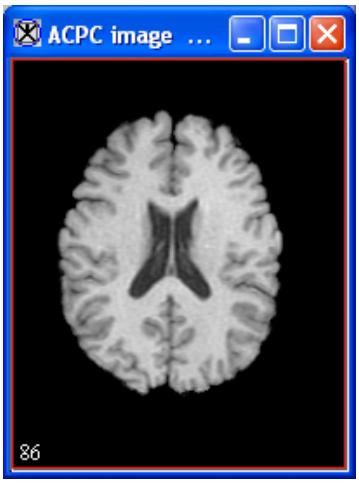
Figure 19. The New image to transform box after clicking the Refresh icon

Note: The slice of the AC-PC image that displays may differ from the slice shown in the original image. By default, the AC-PC image appears at its center slice.

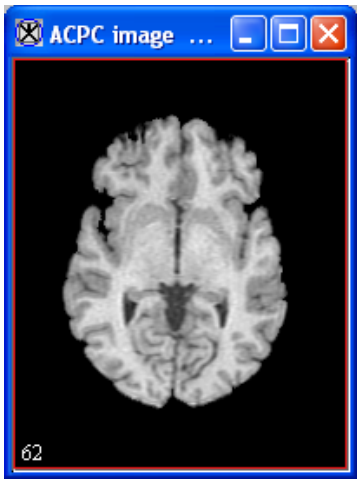
You may now want to save the AC-PC transform. If somehow you are interrupted in the procedure of transforming a brain image into Talairach space, saving the transform prevents your having to perform AC-PC alignment again.



(A) Original image of brain with landmark points marked



(B) AC-PC image of brain showing, by default, the center slice



(C) AC-PC image of the brain showing the same slice as the original image

Figure 20. A comparison of (a) the original brain with marked landmark points and (B) the image after AC-PC alignment showing, by default, the center slice and (C) image after AC-PC alignment showing same slice as the original image

To save the AC-PC transform (recommended)

1. Click Save in the Talairach Transform dialog box. The Save Talairach Transform File dialog box (Figure 21) opens.
2. Navigate to the directory in which you want to save the transform.
3. Type the file name for the transform and the extension **.txt**.

Note: The AC-PC transform file is a text document that can be read with any text editor, such as Microsoft Notepad.

4. Click Save. MIPAV saves the AC-PC transform to the folder you specified.

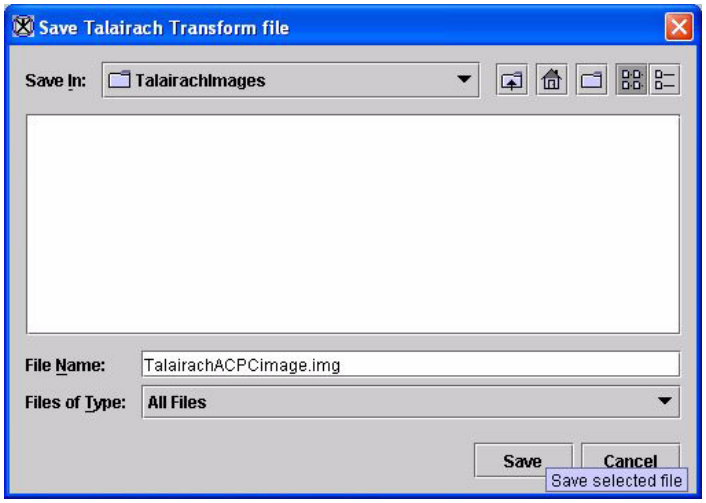


Figure 21. Save Talairach Transform dialog box

5 Type the file name for the transform and the extension **.txt**.

Note: The AC-PC transform file is a text document that can be read with any text editor, such as Microsoft Notepad.

6 Click Save. MIPAV saves the AC-PC transform to the folder you specified.

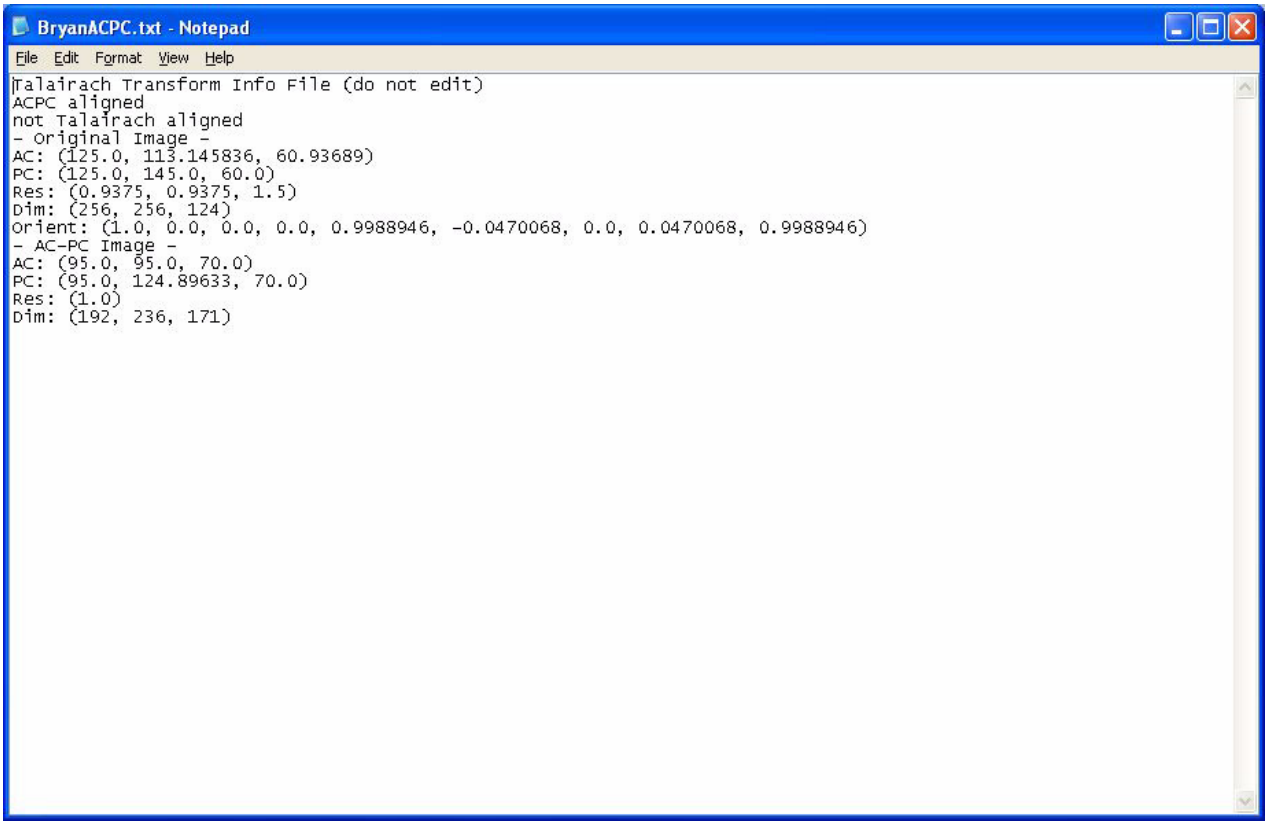


Figure 22. An example of an AC-PC transform file, which is a text file

To resolve errors

An error may occur if there is a 2-percent angular difference between the planes defined by AC-PC-MS1 and AC-PC-MS2. To resolve it, the ideal way is to align perfectly the MS1 and MS2 points on the midsagittal plane: using well-defined planes (choosing MS1 and MS2 far from the AC-PC line, one rather on the front and one on the back of the brain). If that fails, there is still the much less reliable method to have both MS points close to each other, so they define about the same plane.

To view the AC-PC settings for the AC-PC transformed image

1. Select the AC-PC transformed image that you just created.
2. Select Image > Attributes > Edit Attributes. The Image Attributes dialog box opens.

3 Click Talairach. The Talairach page appears.

4 Enlarge the Image Attributes dialog box (Figure 23) to show all of the fields in the dialog box.

Now that you have performed the AC-PC transformation on the image, the settings appear in the AC-PC group. However, because you have not yet performed the Talairach transformation on the image, the settings for the fields in the Talairach group still remain "1.0".

5 Click Close. The Image Attributes dialog box closes.

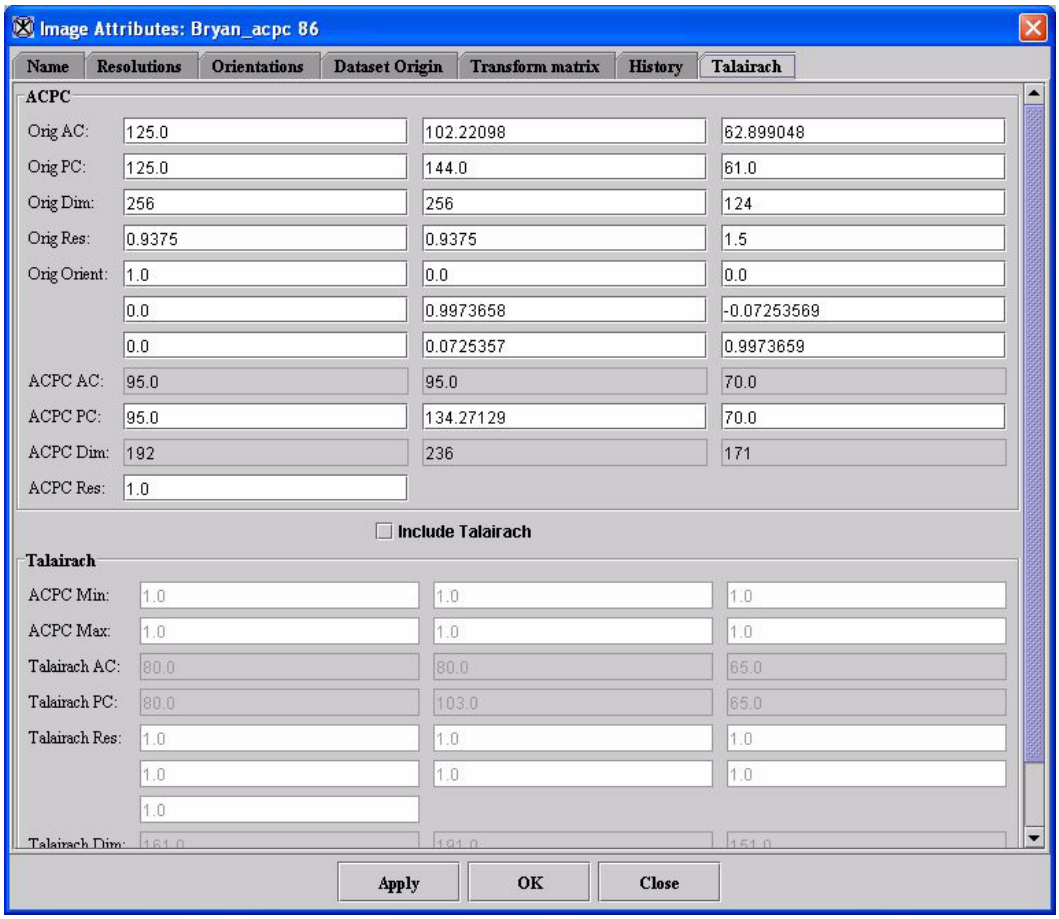


Figure 23. Enlarged Image Attributes dialog box showing AC-PC settings but no Talairach settings

To load a previously saved AC-PC transform

1. Open the original image of the brain on which you performed AC-PC alignment.
2. Select Plug-Ins > Algorithms > TalairachTransform. The Talairach Transform dialog box opens.
3. Select the name of the original image in New image to transform.
4. Select acpc to orig. in Transformation.
5. Click Load. The Load Talairach Transform File dialog box opens.
6. Navigate to the directory in which you saved the AC-PC .txt file and select the file.
7. Click Open. A message appears on the Data page in the Outlook window saying that "transform data loaded from <path>."
8. Click Compute. A progress message appears, and then the image produced from the loaded AC-PC transform appears in a new image window. The result is an AC-PC aligned image.

Performing Talairach alignment

The AC-PC image that was generated now needs to be aligned in the Talairach coordinate system. Talairach alignment consists in scaling the brain to match its boundaries with those of the Talairach atlas. It is a 12 degrees of freedom, piece wise linear transform. It brings the AC, PC, and anterior, posterior, left, right, inferior, and superior boundaries of the brain to normalized positions (Figure 24 on page 31).

After the AC-PC image is generated, it is necessary to find the six most anterior, posterior, left, right, inferior, and superior points, or, alternatively, the bounding box enclosing the brain. These points, along with the AC-PC landmark points, define a set of 12 boxes. In each box independently, the image is scaled along the three dimensions of the Talairach coordinates. Continuity is guaranteed since the boxes share common faces.

Talairach alignment is nonlinear as it scales differently the 12 boxes. Any direct measurement in this coordinate system is irrelevant: voxels have a different resolution in different boxes. For this reason, it is important to have the ability to bring back any Talairach-aligned image into the original image or the AC-PC aligned coordinates.

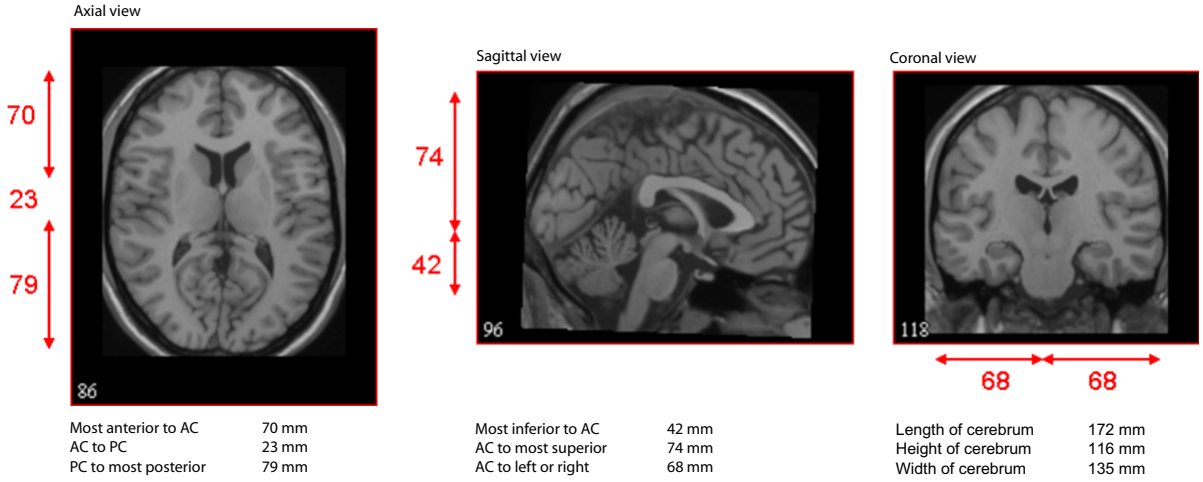


Figure 24. Performing 12-piece-wise linear transformation of the brain into Talairach alignment

To perform Talairach alignment

1. Select the AC-PC image in New image to transform box in the Talairach Transform dialog box (Figure 25).
2. Select Talairach. The Create Talairach Image dialog box (Figure 26 on page 33) appears on top of a triplanar view of the AC-PC image.

Tip: The goal at this point is to mark the limits of the brain: most anterior, most posterior, most superior, most inferior, most left, and most right points. The exact location of the points is not important as long as they bound the cerebrum.

3. Select Most anterior point in the Create Talairach Image dialog box.
4. Go to the triplanar view of the image. Select the point that is the most anterior point in the image. The important information is the position of the green line.
5. Click Set in the Create Talairach Image dialog box.
6. Repeat this procedure for the remaining points. When you finish setting the points, the Apply button becomes available.

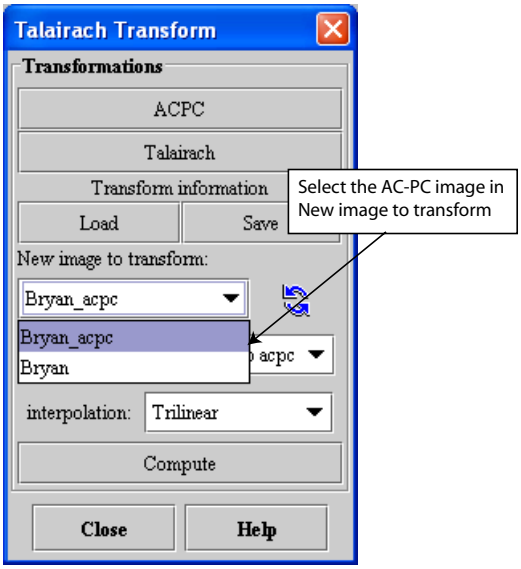


Figure 25. New image to transform box in the Talairach Transform dialog box

7 Click Apply. A status message appears during processing. When processing is complete, the Talairach aligned image (Figure 27) appears.

8 Click  to refresh the list of images in New image to transform. The transformed image, whose title is the name of the original image followed by *_acpc_Tlrc*, appears in the list (Figure 28 on page 34).

At this point, you may want to save the Talairach transform. Doing so eliminates the need to repeat the Talairach process for this dataset. If interruptions at this point prevent you from completing tasks 2 through 6, saving the transform allows you to resume where you left off.

The transform is saved as a text (.txt) file.

Note: You can use the Talairach transformation to bring other co-registered images into Talairach space and to send atlas information into the original image space.

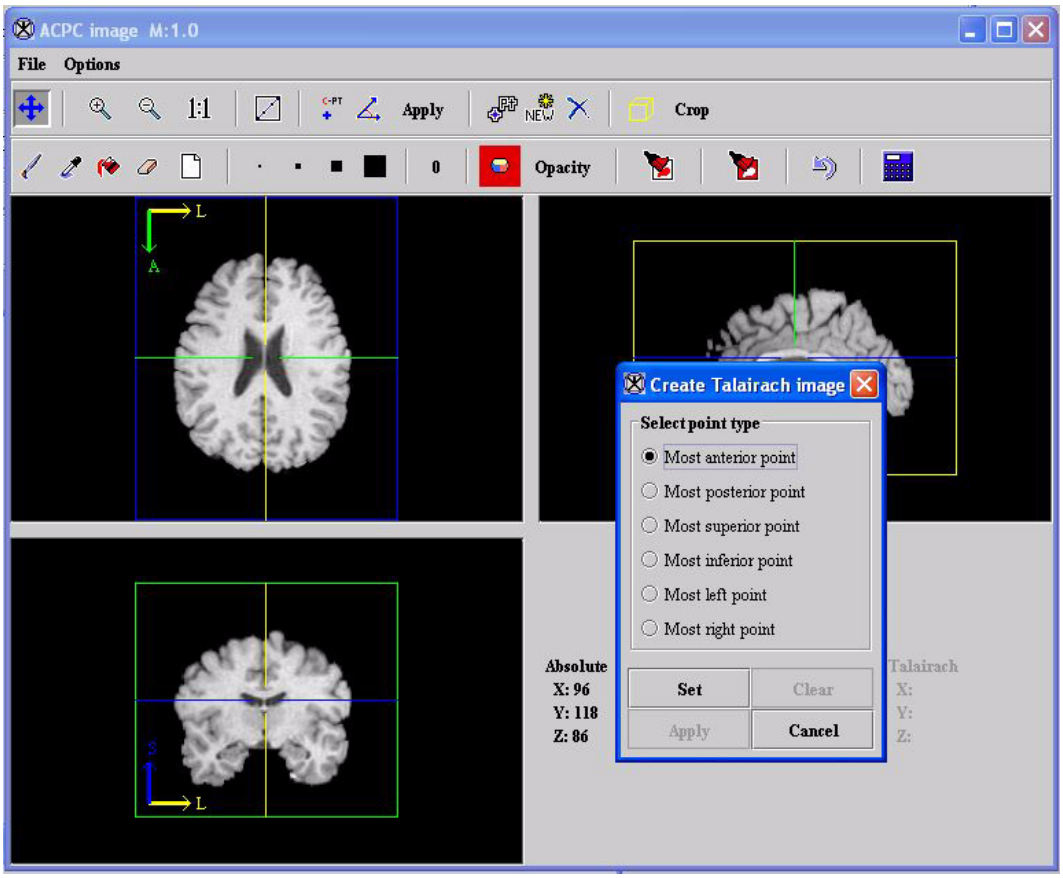


Figure 26. The Create Talairach Image dialog box on top of the triplanar view of the AC-PC image

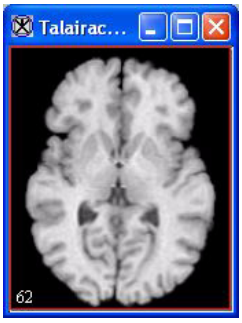


Figure 27. Talairach-aligned image

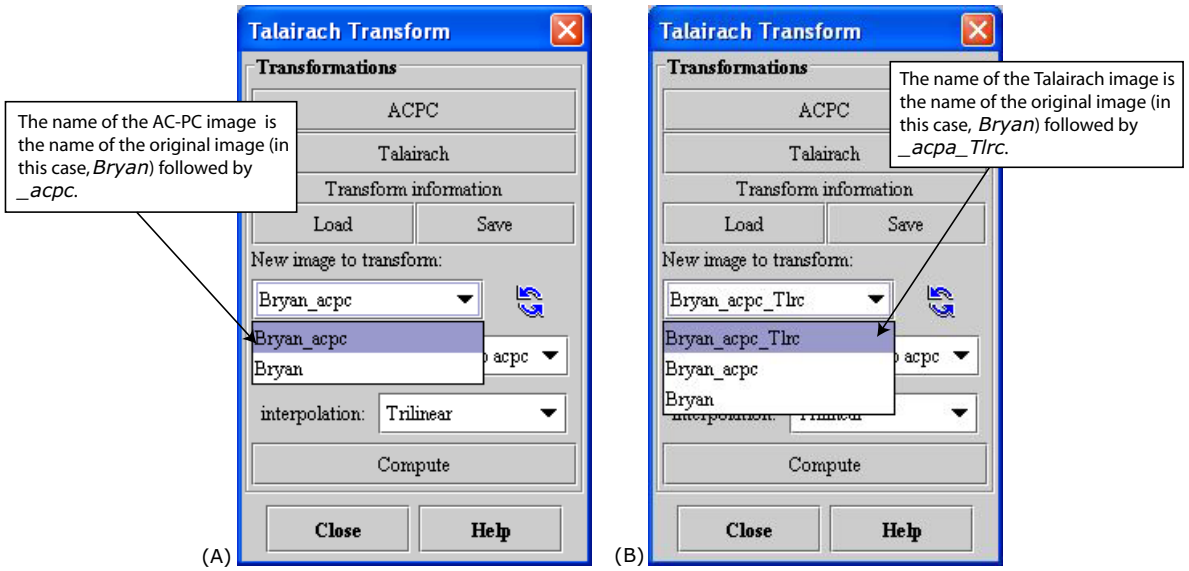


Figure 28. Labeling of AC-PC images and Talairach images

To save the Talairach transform (recommended)

1. Select the Talairach-aligned image that was generated.
2. Click Save in the Talairach Transform dialog box. The Save Talairach Transform File dialog box (Figure 21) opens.
3. Navigate to the directory in which you want to save the transform.
4. Type the file name for the transform and the extension **.txt**.
5. Click Save. The Talairach transform is saved in the folder you specified.

Note: The Talairach transform file is a text document that can be read with any text editor, such as Microsoft Notepad.

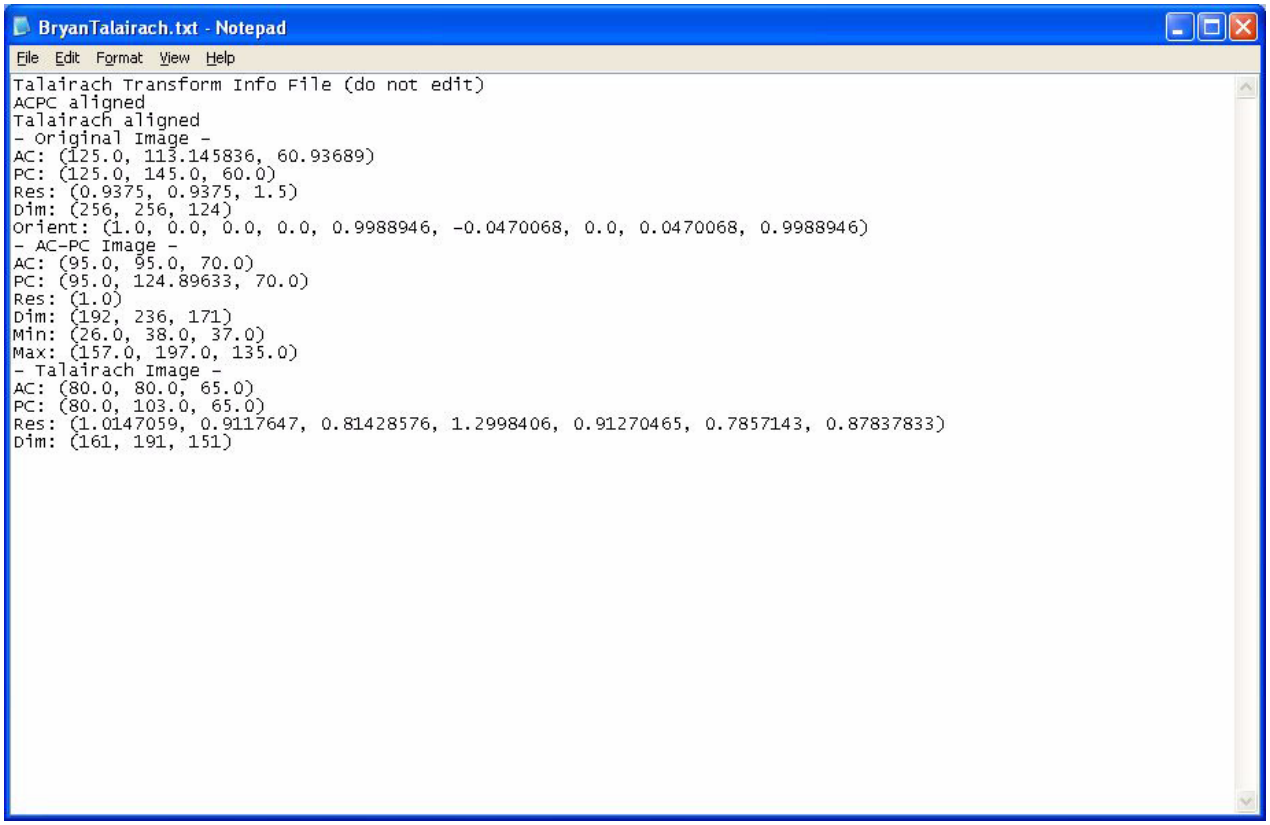


Figure 29. An example of a Talairach transform file, which is a text file

To view the Talairach settings for the Talairach-transformed image

1. Select the Talairach-transformed image.
2. Select Image > Attributes > Edit Attributes in the MIPAV window. The Image Attributes dialog box opens.
3. Click Talairach. The Talairach page appears.
4. Enlarge the Image Attributes dialog box (Figure 30) to show all of the fields in the dialog box.

   The settings in the Talairach group should now reflect the settings for the Talairach-transformed image. The Talairach page should also still show the settings for the AC-PC transformed image.
5. Click Close. The Image Attributes dialog box closes.

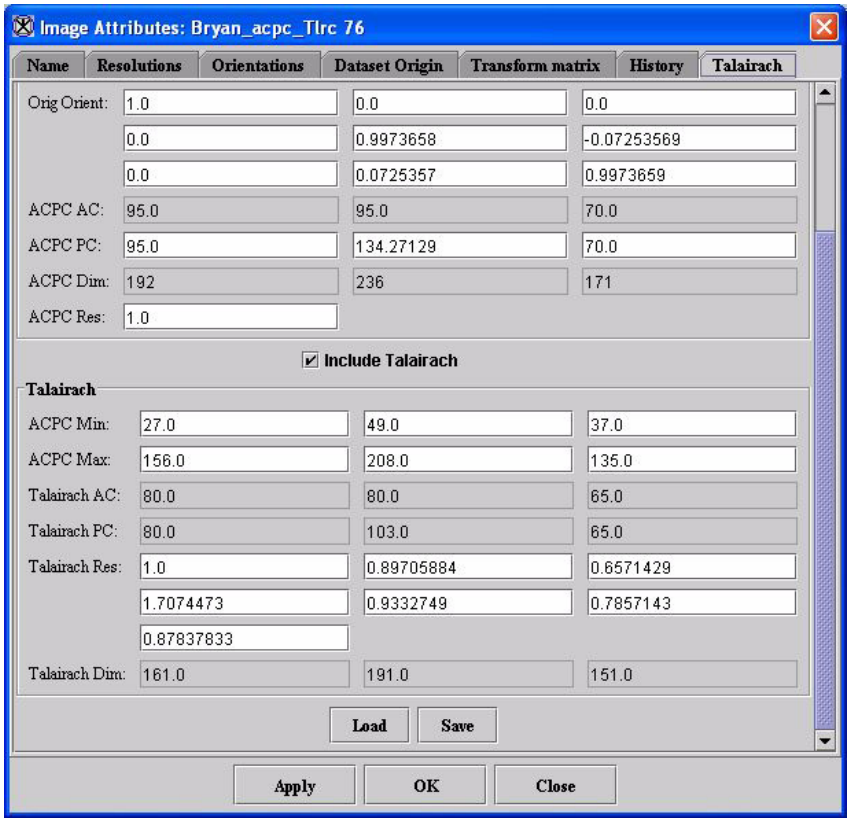


Figure 30. Image Attributes dialog box showing both the AC-PC settings and the Talairach settings

Task 2, Applying Talairach VOIs

The Talairach atlas includes five levels:

- **Talairach Level 1**—Main structures (left, right cerebrum, cerebellum, brain stem, and so on)
- **Talairach Level 2**—Lobes (temporal, frontal, parietal, posterior, occipital, limbic, anterior, midbrain, and so on)
- **Talairach Level 3**—Gyri (temporal, precentral, fusiform, thalamus, ventricles, and so on)
- **Talairach Level 4**—Matter (white matter, gray matter, CSF)
- **Talairach Level 5**—Brodmann areas (areas 1-47, hippocampus, putamen, and so on)

To apply Talairach VOIs

1. Select the Talairach-aligned image.
2. Click VOI > Open VOI in the MIPAV window. The Open VOI dialog box appears.
3. Navigate to the directory where you saved the Talairach atlas (Figure 31).
4. Click Talairach atlas folder (Figure 31A). The Talairach level folders open (Figure 31B).
5. Click one of the Talairach level folders that you want to use (Figure 31B). The folder opens showing all of the applicable VOIs for that level (Figure 31C).
6. Select one of the VOIs.
7. Click Open. The selected VOI appears on the Talairach-aligned image (Figure 32a).
8. Repeat steps 2–step 7 until all of the VOIs that you want to see are displayed on the image (Figure 32).

Note: The Talairach transformation deforms the brain. Measurements are not correct in Talairach space.

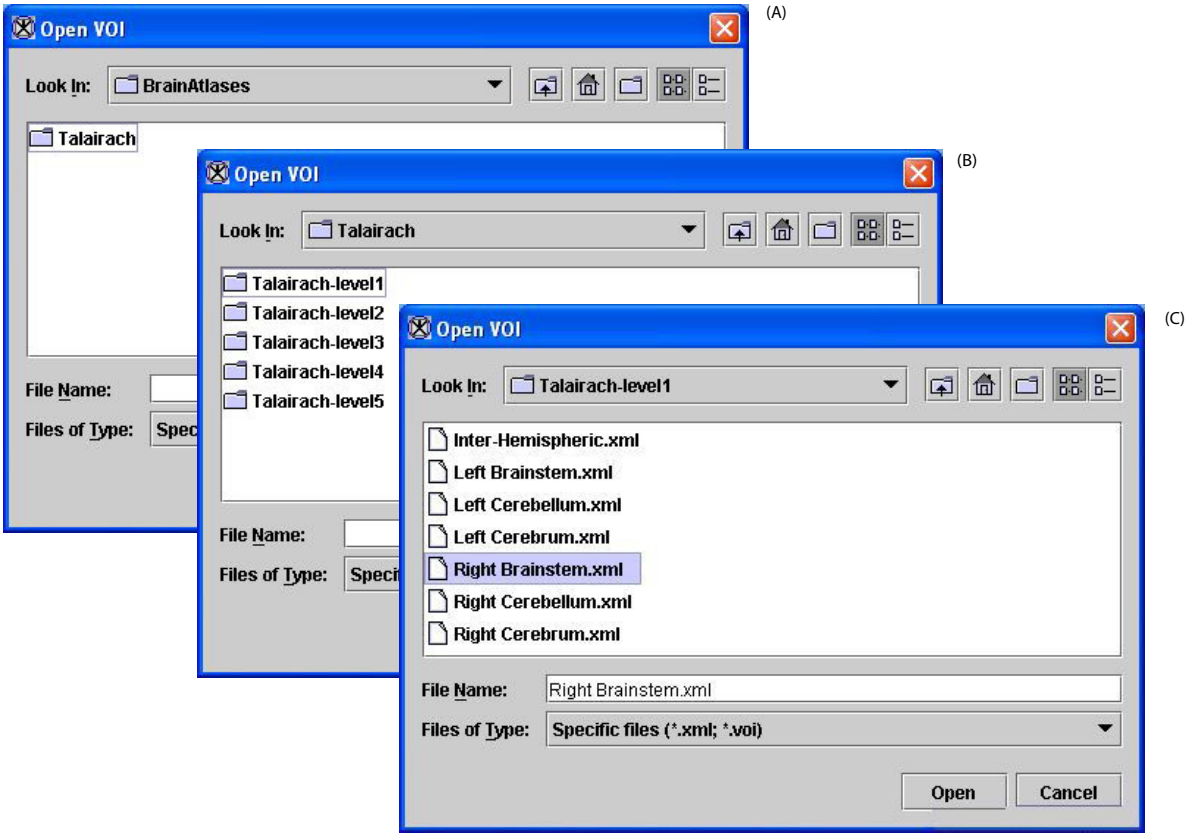
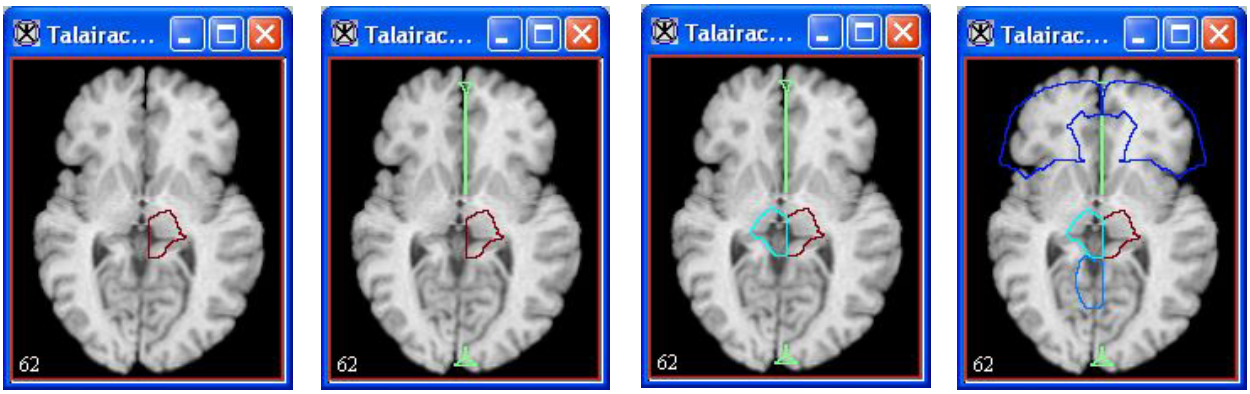


Figure 31. Navigating to the correct Talairach folder: (A) the Talairach folder; (B) the five levels of Talairach folders, and (C) the VOIs in the Talairach level 1 folder



(A) Right brainstem (burgundy)

(B) Right brainstem (burgundy) and Interhemispheric (green)

(C) Right brainstem (burgundy), interhemispheric (green), and left brainstem (turquoise)

(D) Right brainstem (burgundy), interhemispheric (green), left brainstem (turquoise), and left cerebellum (teal)

Figure 32. The sequence of images that results as you apply each desired VOI one at a time

You can add as few as one or as many VOIs as you want to appear on the image. Note that each VOI appears in a unique color.

Task 3, Segmenting the original image

You can segment the original image using either the FANTASM plug-in program or the Fuzzy C-Means algorithm. The FANTASM plug-in program, a different version of the Fuzzy C-Means algorithm, provides segmentation that is less sensitive to noise. This section provides directions for both:

- Using FANTASM to segment the image
- Using the Fuzzy C-Means algorithm to segment the image

To use the FANTASM plug-in program

1. Select the original image.
2. Select Plug-In > Algorithms > FANTASM. The FANTASM dialog box opens.

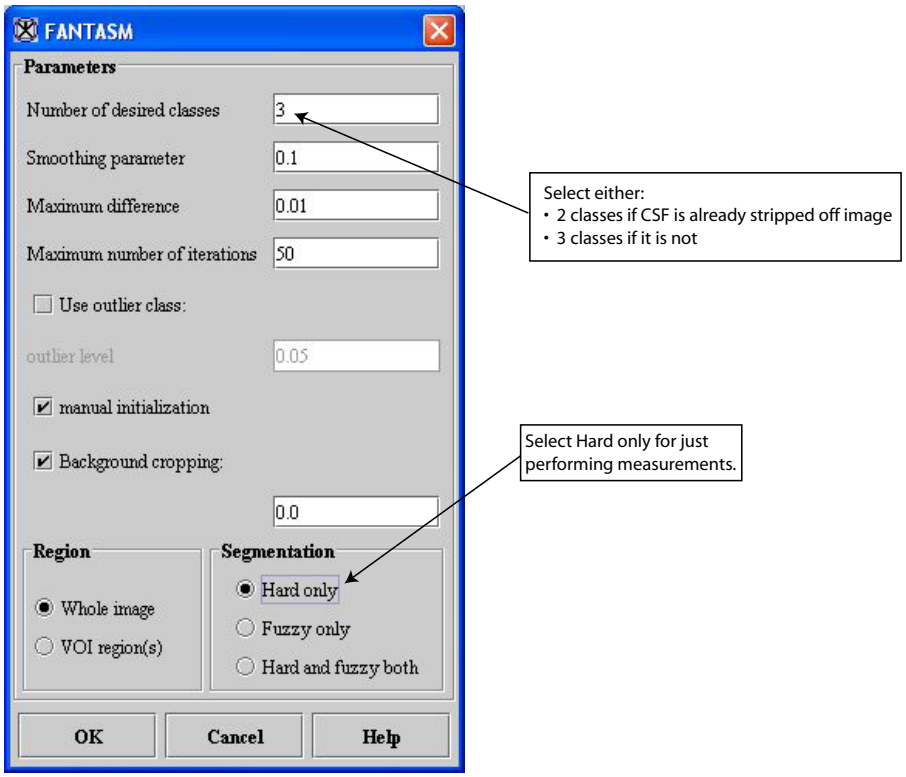


Figure 33. FANTASM dialog box

3 Complete the dialog box:

- In Number of desired classes, select either 2 classes if the CPF was stripped off the image previously or 3 classes if the CPF is still in the image.
- In Segmentation, select Hard only, which is the only segmentation needed for measurements.

4 Click OK. The Initial Centroids dialog box opens.

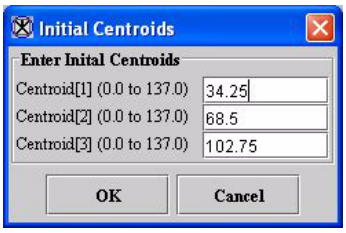


Figure 34. Initial Centroids dialog box

5 Click OK.

A series of progress messages appear, and data appears on the Data page in the Output window (Figure 35).

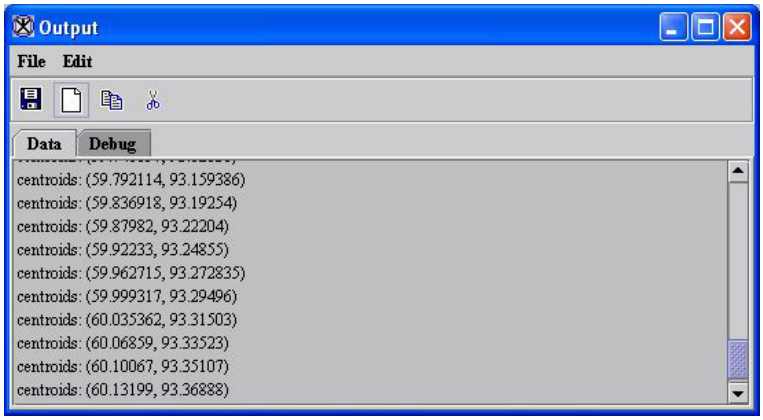


Figure 35. Data on the Data page in the Output window

In a few moments, processing completes, and an image appears (Figure 36A).

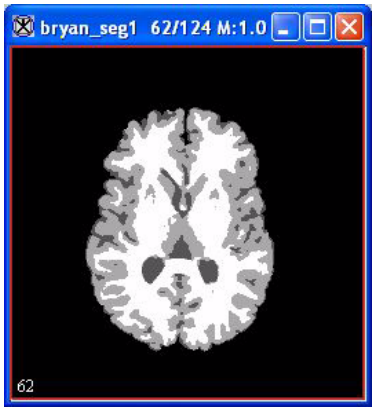


Figure 36. FANTASM image

To use the Fuzzy C-Means algorithm

1. Select the original image.
2. Select Algorithms > Fuzzy C-Means > Single Channel (Figure 37) in the MIPAV window.

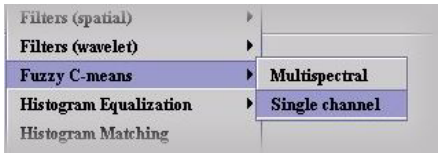


Figure 37. Fuzzy C-Means > Single Channel command on the Algorithms menu

The Fuzzy C-Means dialog box (Figure 38 on page 43) opens.

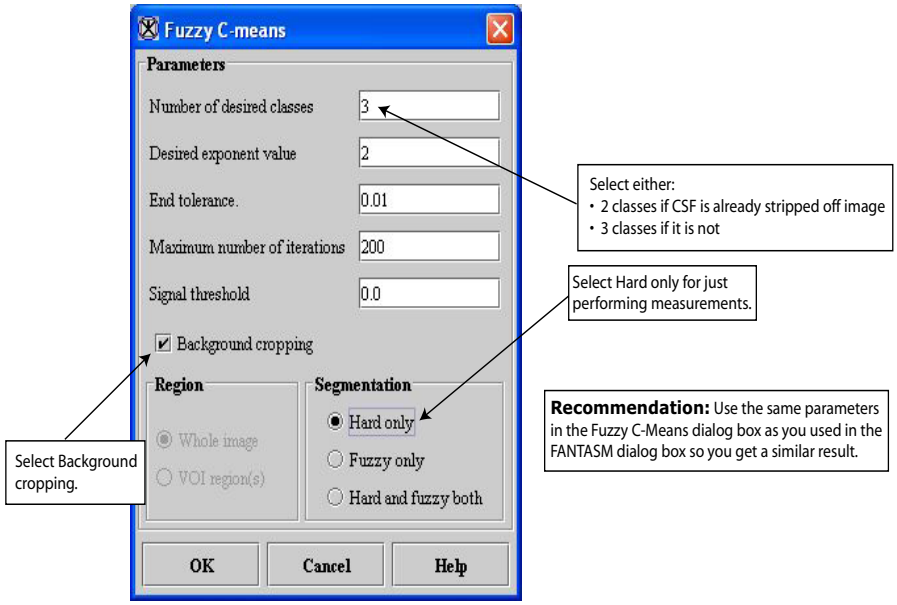


Figure 38. Fuzzy C-Means dialog box

3 Complete the dialog box:

- In Number of desired classes, select either 2 classes if the CPF was stripped off the image previously or 3 classes if the CPF is still in the image.
- In Segmentation, select Hard only, which is the only segmentation needed for measurements.

4 Click OK. The Initial Centroids dialog box (Figure 39) opens.

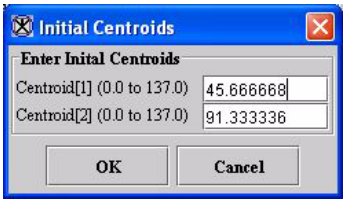


Figure 39. Initial Centroids dialog box

5 Click OK. A series of progress messages appear. In a few moments when processing completes:

- Data appears on the Data page in the Output window (Figure 40)

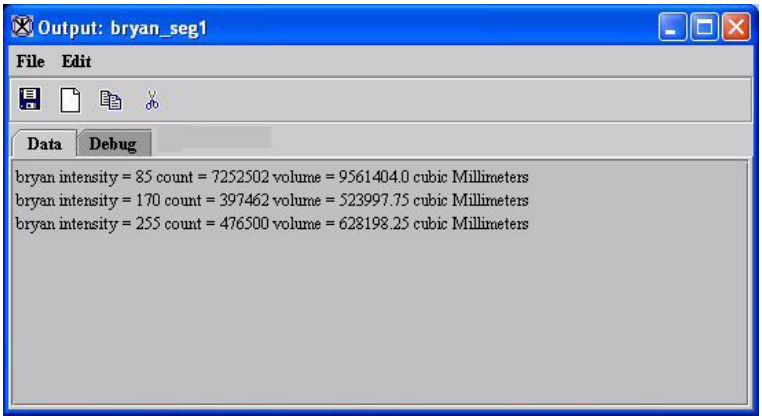


Figure 40. Data on the Data page in the Output window

- An image appears (Figure 41).

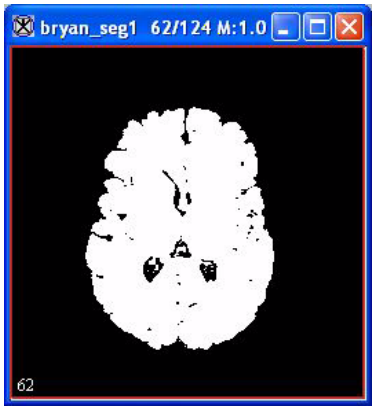


Figure 41. Image produced by using Fuzzy C-Means algorithm

Task 4, Transforming Talairach image and Talairach VOIs^{-1} to the original image

1. Select the Talairach image on which you added VOIs.
2. Go to the Talairach Transform dialog box (Figure 42).

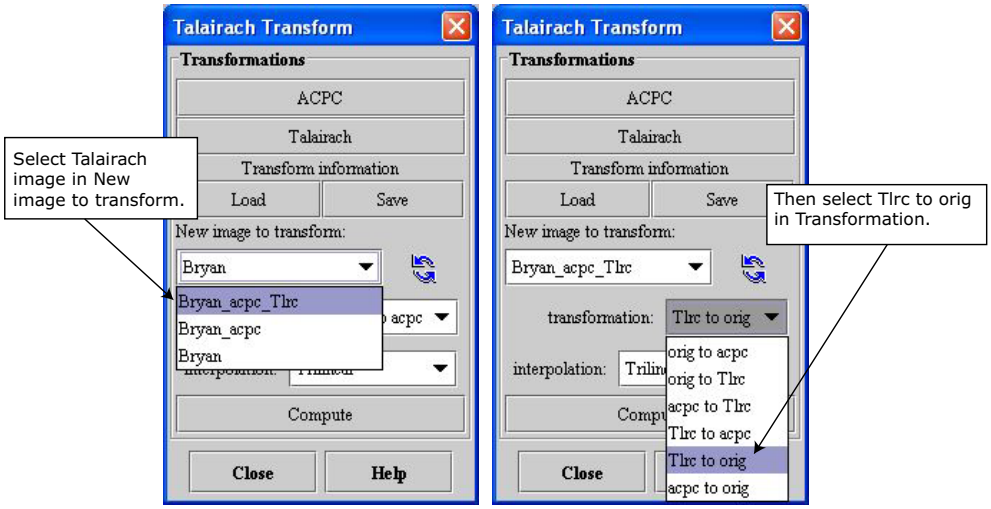


Figure 42. Transforming Talairach image and VOIs to a copy of the original image

3. Select Talairach image in the New image to transform list.
4. Select Tlrc to orig in the Transformation list.
5. Click Compute. A series of progress messages (Figure 43) appears. When the processing is complete, a copy of the original image with the VOI labels appears (Figure 44).

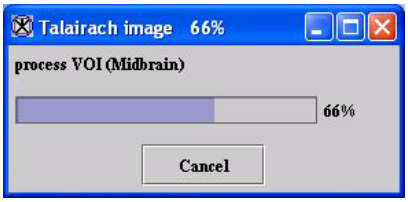


Figure 43. A progress message that appears when VOIs are transferred to the original image

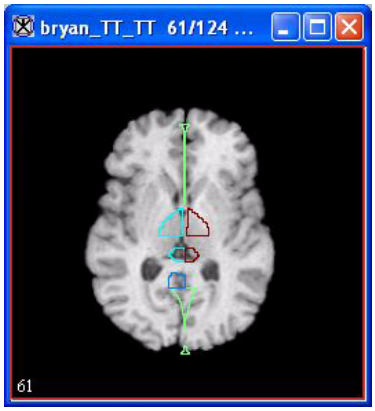


Figure 44. Copy of original image with Talairach transform and copied VOIs

Task 5, Copying Talairach VOIs^{-1} to segmented images

You can copy Talairach VOIs^{-1} to segmented images using one of two methods:

- **Copying and pasting VOIs**—Instead of saving and opening all of the VOIs, you use the keyboard to copy the VOIs from the Talairach image and then paste them on the segmented image.
- **Saving and opening VOIs**—In this procedure you first save all of the VOIs on the Talairach image and then open all of them on the segmented image. This method does provide a saved copy of the VOIs if, for some chance, they are needed again. However, saved copies take up space on the workstation or on storage media.

Tip: Generally, copying and pasting VOIs using the keyboard is the preferred method: it is faster and does not require space on the workstation or on storage media.

This section explains both methods.

Caution: Do not use the Group VOIs and Ungroup VOIs for this task.

To copy and paste VOIs using the keyboard

You can copy VOIs and contours individually, in groups, or in total. The following directions explain how to copy and paste all of the VOIs and their contours using the Ctrl and Shift keys and selecting VOIs with the mouse. For other keyboard and mouse combinations, refer to Table 2.

1. Select the Talairach image on which you applied VOIs (refer to “Task 2, Applying Talairach VOIs” on page 37).
2. Press and hold down Ctrl and Shift.
3. Select one of the VOIs in the Talairach image. MIPAV highlights the VOI in black.
4. Select another VOI. The product highlights that VOI in black.

5 Continue selecting VOIs until all of the VOIs are selected.

6 Select  on the VOI toolbar. Release the Ctrl and Shift keys.

7 Select the segmented image that was generated in "Task 3, Segmenting the original image" on page 40.

8 Select  on the VOI toolbar. MIPAV copies all of the VOIs that you selected

Note: You can also use Edit > Copy VOI instead of the copy icon and Edit > Paste VOI instead of the paste icon.

To save and open VOIs

1 Select the Talairach transformed version of the original image that was generated in the previous task.

2 Click VOI > Save All VOIs to. The Save dialog box opens.

3 Navigate to the directory in which you want to store the VOIs and click Save.

4 Select the segmented image generated in "Task 3, Segmenting the original image" on page 40.

5 Click VOI > Open All VOIs from. The Open dialog box opens.

6 Navigate to the directory in which you stored the VOIs, and click Open. The VOIs appear on the segmented image.

Table 2. Copying contours and VOIs using the keyboard

To select . . .	Then do this . . .
Only one contour in a VOI or a VOI in which there is only one contour	1.Select the Talairach image on which you applied VOIs (refer to "Task 2, Applying Talairach VOIs" on page 37). 2.Place the cursor over the contour or VOI and select it. MIPAV highlights the contour or VOI. 3.Select the image to which you want to place the contour or VOI (refer to "Task 3, Segmenting the original image" on page 40). 4.Select  , or select Edit > Paste VOI. The VOI appears on the image.
The entire VOI, including all of its contours	1.Select the Talairach image on which you applied VOIs (refer to "Task 2, Applying Talairach VOIs" on page 37). 2.Press and hold down Shift. 3.Place the cursor over any of the contours in a VOI and select it. MIPAV highlights the entire VOI, including all of its contours, in black. 4.Select  on the VOI toolbar. MIPAV copies the VOI. 5.Select the image to which you want to place the contour or VOI (refer to "Task 3, Segmenting the original image" on page 40). 6.Select  , or select Edit > Paste VOI. The VOI appears on the image.
Copy contours in different VOIs	1.Select the Talairach image on which you applied VOIs (refer to "Task 2, Applying Talairach VOIs" on page 37). 2.Press and hold down Ctrl. 3.Select a contour. MIPAV highlights the contour in black. 4.Select another contour in another VOI. 5.Continue selecting contours until all of the ones you want to copy are selected. 6.Select  on the VOI toolbar, or select Edit > Copy VOI. MIPAV copies the contours. 7.Select the segmented image to which you want to place the contours (refer to "Task 3, Segmenting the original image" on page 40). 8.Select  , or select Edit > Paste VOI. The contours appear on the image.

Table 2. Copying contours and VOIs using the keyboard (continued)

To select . . .	Then do this . . .
Copying more than one VOI, with all of their contours	1.Press and hold down Ctrl and Shift. 2.Select a VOI. MIPAV highlights the entire VOI, including all of its contours. 3.Select another VOI. Both this VOI and the first VOI are highlighted. 4.Repeat the previous step for as many VOIs as you want to copy. 5.Select  on the VOI toolbar. Release the Ctrl and Shift keys. 6.Select the segmented image that was generated in "Task 3, Segmenting the original image" on page 40. 7.Select  on the VOI toolbar. MIPAV copies all of the VOIs that you selected to the segmented image.

Task 6, Calculating statistics on VOIs

1. Select a segmented image that was produced in task 5.
2. Select VOI > Statistics Generator in the main MIPAV window. The Calculate Statistics on VOI Groups window opens and displays the VOI Selection page (Figure 45 on page 52).

   The VOI group list on the left of the window lists all of the VOIs that are in the image.
3. Make sure that the path and file name listed in VOI Statistic File Destination is correct. The path indicates where MIPAV should place the statistics file; the file name is the name of the statistics file.

   To change the path and file name, do either of the following:

   - Click Browse to navigate to the correct directory and file name.
   - Type the correct path and file name over the current path and file name.
4. Select the VOIs in the VOI group list on which you want to generate statistics (Figure 45).
5. Click the right arrow. MIPAV moves the selected VOIs to the list on the right (Figure 45).
6. Select the Statistics Options tab. The Statistics Options page (Figure 46 on page 52) opens.
7. Select the statistics that you want to be generated in Statistics to Calculate list.

   To select all of the statistics, click Select all.
8. Select Exclude pixels from calculation.
9. Change the value of Exclude Pixels from Between to Outside.

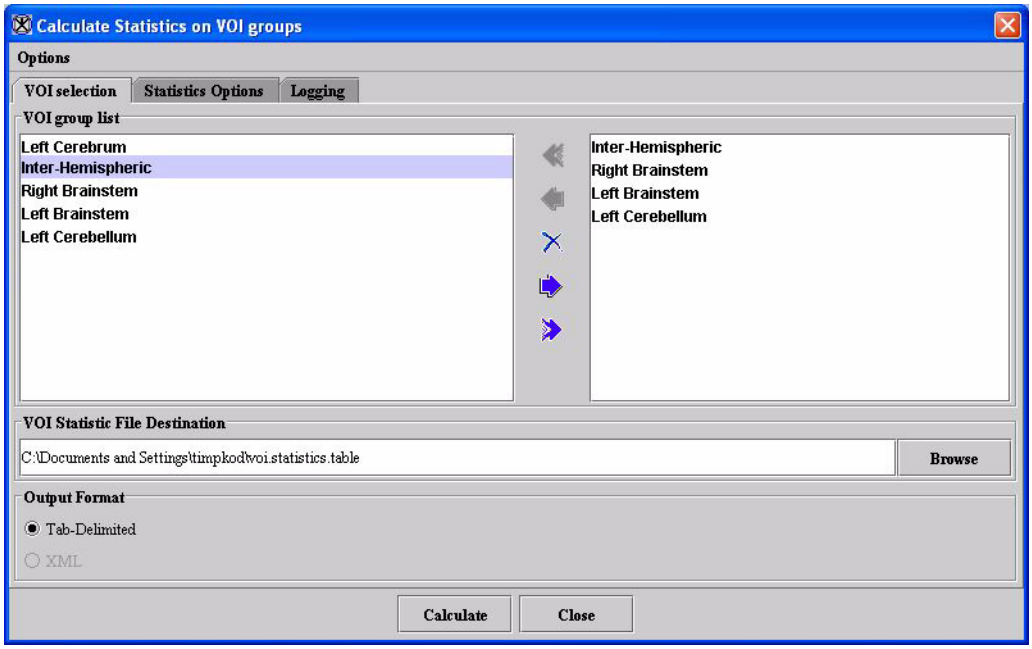


Figure 45. Calculate Statistics on VOI Groups window showing four VOIs that were moved to the right list

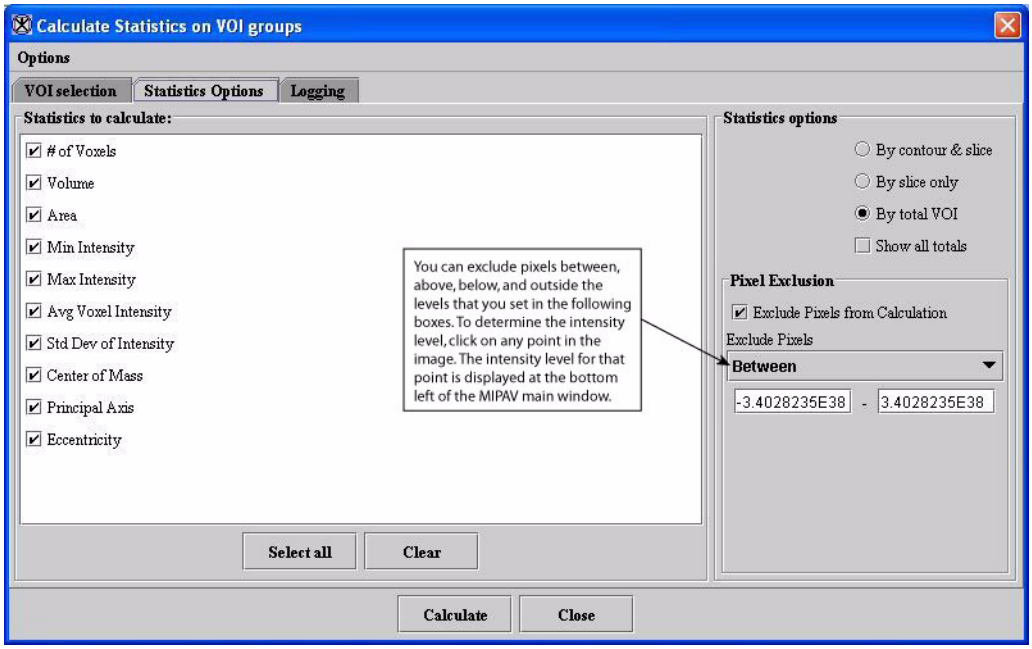


Figure 46. Statistics Options page in the Calculate Statistics on VOI Groups window

10 Insert the range of pixels that you want to exclude in the boxes.

To check the intensity level of the pixels in the image, click on any point within one of the VOIs (Figure 47). MIPAV displays the intensity level at that point on the left bottom of the MIPAV main window.

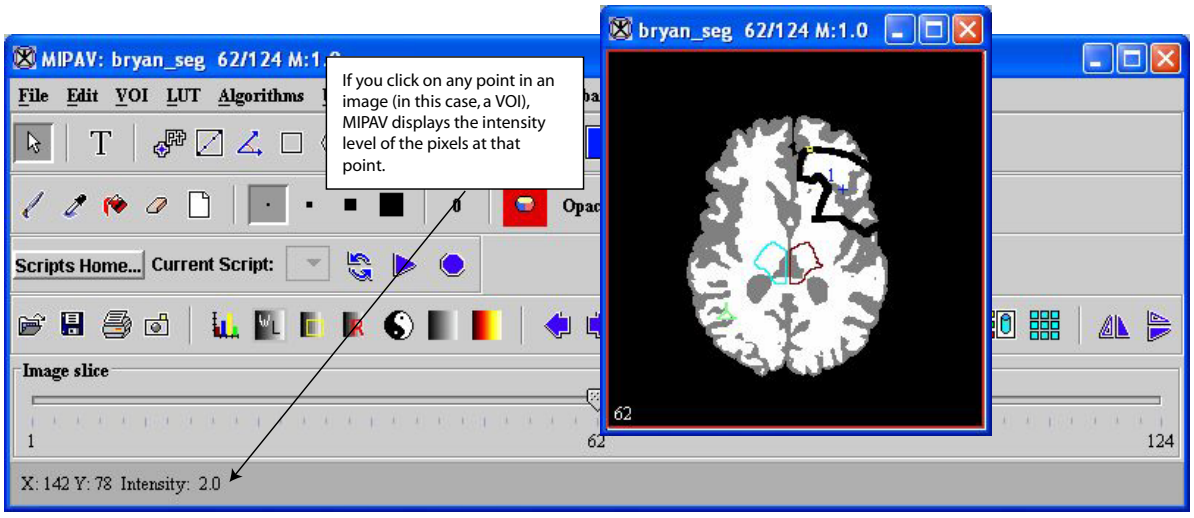


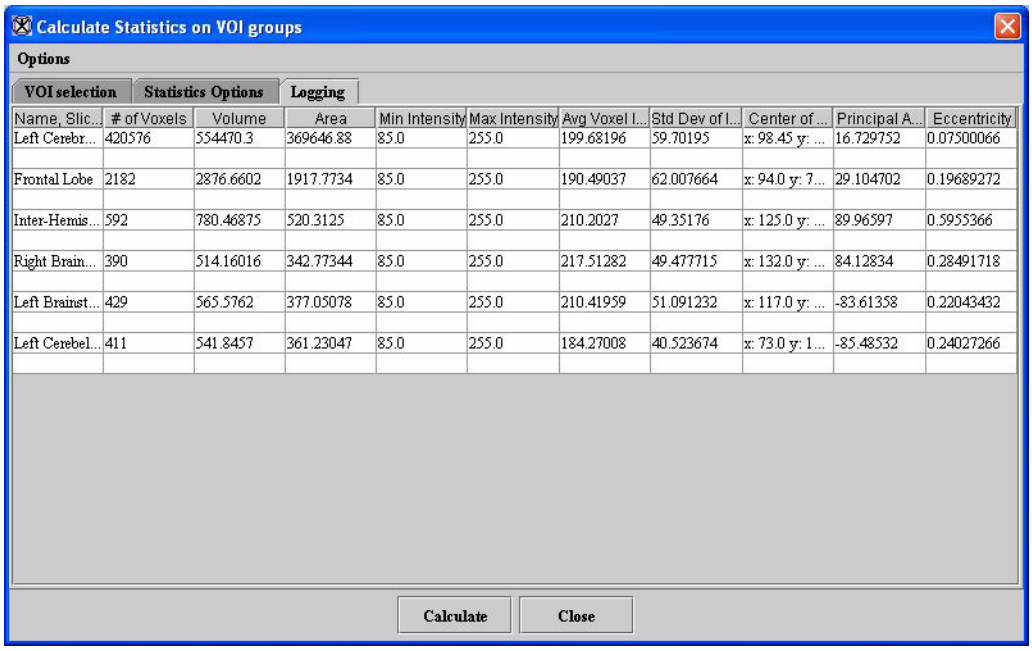
Figure 47. Finding the intensity level

Example: If the intensity level of the gray matter is 2, exclude pixels outside the range 1.5-2.5 or 1.9-2.1.

11 Click Calculate.

The Logging page (Figure 48 on page 54) opens showing a table of the statistics.

Note: If a message appears asking you whether to overwrite the file, refer to "Overwriting the VOI Statistics File" on page 54.



Name, Slic...	# of Voxels	Volume	Area	Min Intensity	Max Intensity	Avg Voxel I...	Std Dev of I...	Center of ...	Principal A...	Eccentricity
Left Cerebr...	420576	554470.3	369646.88	85.0	255.0	199.68196	59.70195	x: 98.45 y: ...	16.729752	0.07500066
Frontal Lobe	2182	2876.6602	1917.7734	85.0	255.0	190.49037	62.007664	x: 94.0 y: 7...	29.104702	0.19689272
Inter-Hemis...	592	780.46875	520.3125	85.0	255.0	210.2027	49.35176	x: 125.0 y: ...	89.96597	0.5955366
Right Brain...	390	514.16016	342.77344	85.0	255.0	217.51282	49.477715	x: 132.0 y: ...	84.12834	0.28491718
Left Brainst...	429	565.5762	377.05078	85.0	255.0	210.41959	51.091232	x: 117.0 y: ...	-83.61358	0.22043432
Left Cerebel...	411	541.8457	361.23047	85.0	255.0	184.27008	40.523674	x: 73.0 y: 1...	-85.48532	0.24027266

Figure 48. Logging page in the Calculate Statistics on VOI Groups window showing a table of the generated statistics

Overwriting the VOI Statistics File

If statistics were written to the statistics file in the past, a message may appear asking whether to overwrite the previous statistics table.

To overwrite the file, click Overwrite.

To cancel, click Cancel, and change the file name in VOI Statistic File Destination on the VOI Selection page.

To always overwrite the statistics file, either select Options > Overwrite file automatically or press Alt O.

To clear the Logging page, either select Options > Clear Log Window or press Alt C.

Viewing the Talairach grid on Talairach images

Once a Talairach image is generated, you can display the Talairach grid on top of the image in a triplanar view.

1. Open the Talairach image that you generated.
2. Select Image > Views > Triplanar, or click , the Triplanar icon in the MIPAV window. The triplanar view of the image appears.
3. Select Options > Show Talairach Grid in the triplanar window. The Talairach grid appears on each of the three images.
4. Select Options > Show Talairach Position in the triplanar window (Figure 49). The letters and numbers for the Talairach grid appear on the grid (Figure 50).

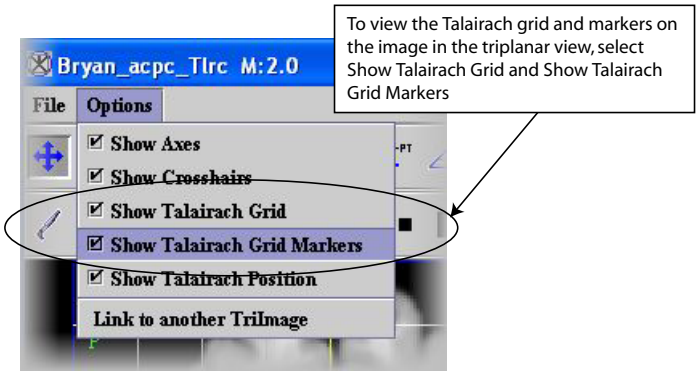


Figure 49. Talairach commands on the Options menu in the triplanar view

5. Close the triplanar window when finished.

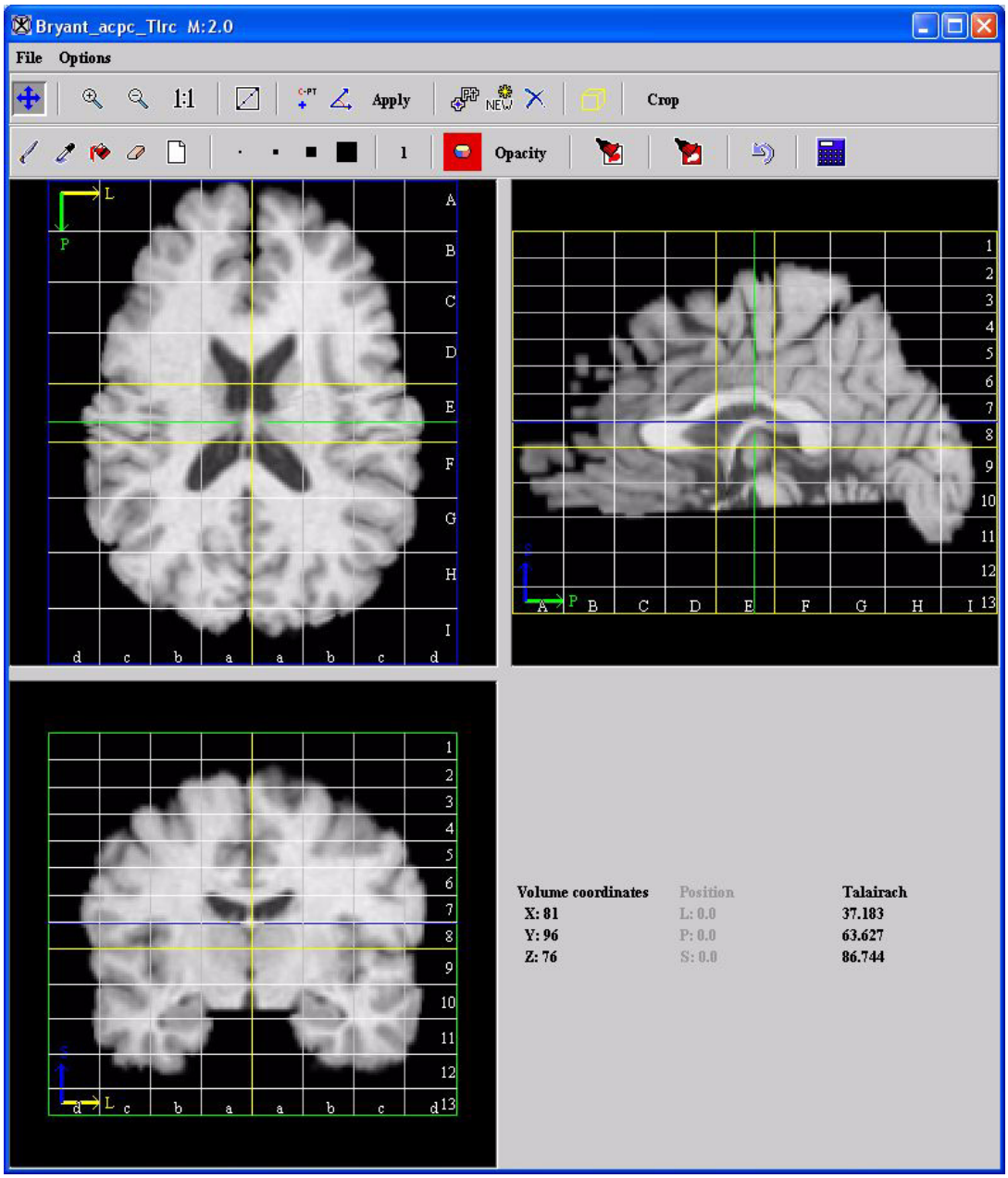


Figure 50. Triplanar view of the Talairach image overlaid with both the Talairach grid and Talairach position numbers and letter