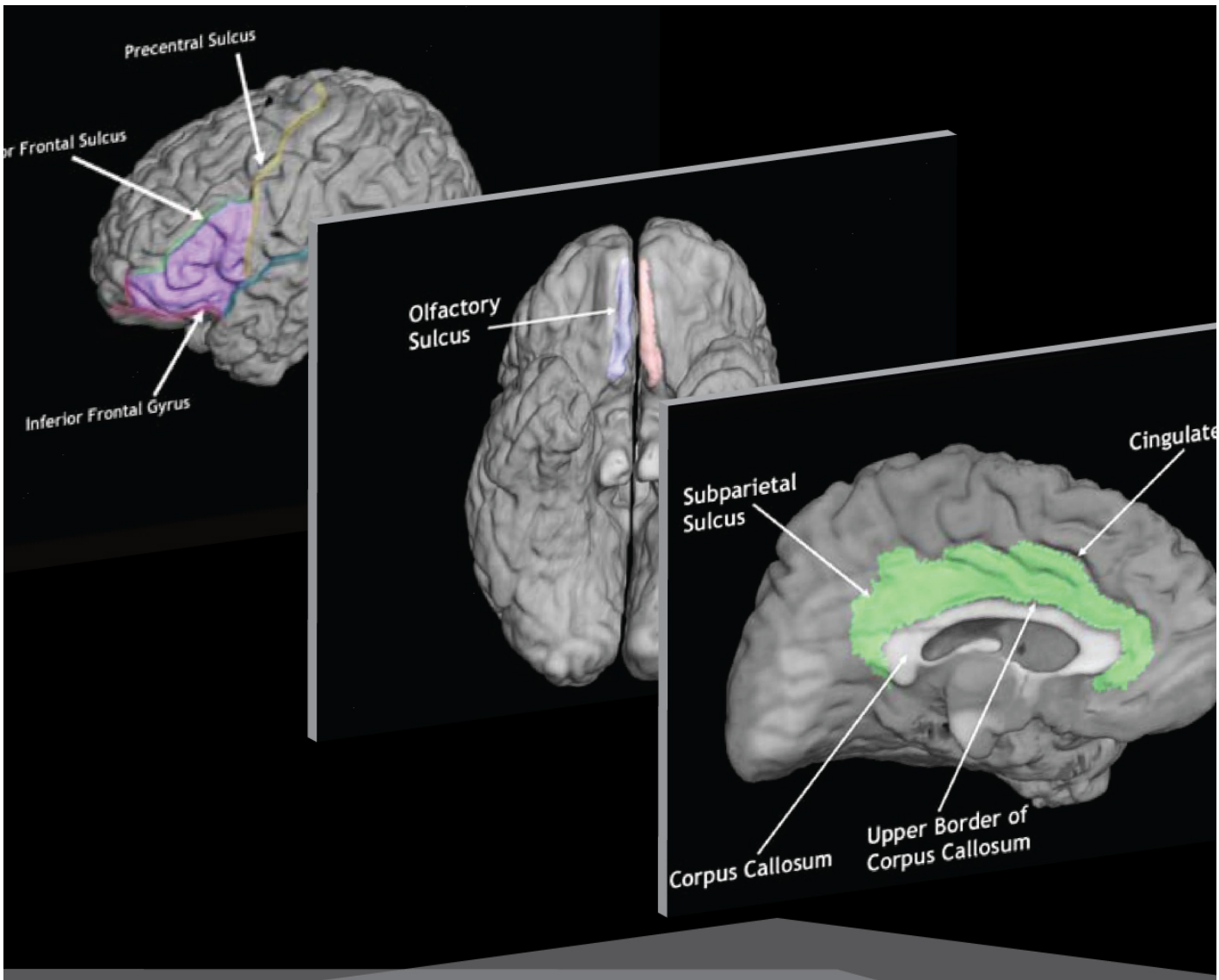


Delineation Protocols for the LONI Probabilistic Brain Atlas (LPBA40)

Supplement to the paper:
"Construction of a 3D Probabilistic Atlas of Human Cortical Structures" (NIMG-06-1395) submitted by Shattuck DW, Mirza M, Adisetiyo V, Hojatkashani C, Salamon G, Narr KL, Poldrack RA, Bilder RM, and Toga AW

This document contains the written protocols used to delineate anatomical structures for the LPBA40 atlas. The development of these protocols and the LPBA40 atlas are described in the paper "Construction of a 3D Probabilistic Atlas of Human Cortical Structures" (NIMG-06-1395) submitted by Shattuck DW, Mirza M, Adisetiyo V, Hojatkashani C, Salamon G, Narr KL, Poldrack RA, Bilder RM, and Toga AW.

An interactive version of these protocols can be found at the following website:

http://www.loni.ucla.edu/NCRR/protocols.aspx?id=722

Angular Gyrus

Step 1

The angular gyrus is located in the parietal lobe, posterior to the supramarginal gyrus and immediately anterior to the occipital lobe. Its anterior boundary is the Jensen sulcus and its posterior boundary is the occipital lobe. Its superior boundary is the intraparietal sulcus and its inferior boundary is the superior temporal sulcus. The inferior and posterior end of the angular gyrus should form a 'c' shape around the posterior end of the superior temporal sulcus (STS). (Fig. 1, Fig. 2)

Figures 1 & 2

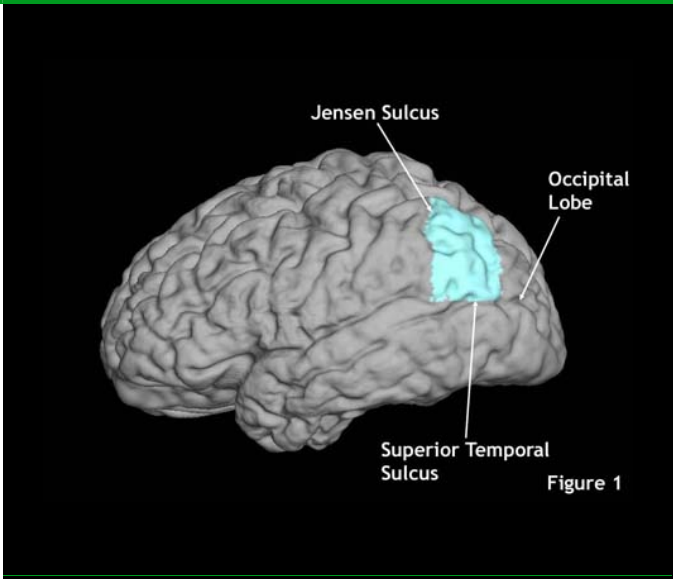


Figure 1

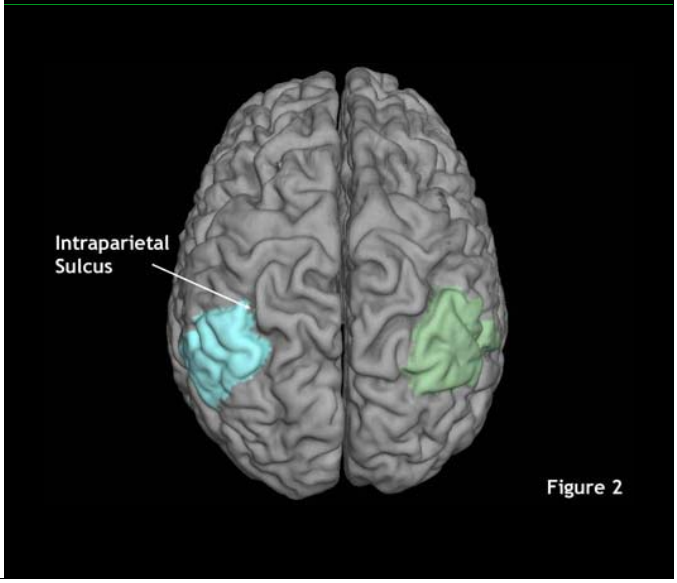


Figure 2

Angular Gyrus

Step 2

Before masking, it is important to eyeball the boundaries of the angular gyrus on a 3D object. Begin by finding the anterior boundary of the occipital lobe, by imagining a line between the occipital notch inferiorly and the parieto-occipital fissure superiorly. This line will serve as a posterior boundary for the angular gyrus (Fig. 3) . Secondly, find the STS's posterior boundary. The angular gyrus should form a 'c' shape around this boundary. Finally, find anterior boundary by locating the Jensen sulcus by locating the posterior ends of Sylvian fissure's middle segment and the STS. Draw an imaginary line from both these points up to the intraparietal sulcus. Between these two lines is the Jensen sulcus. (Fig. 4)

Figures 3 & 4

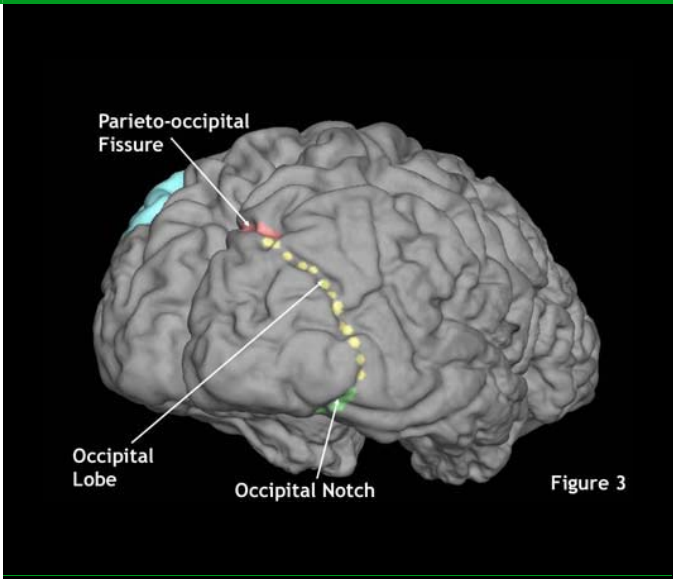
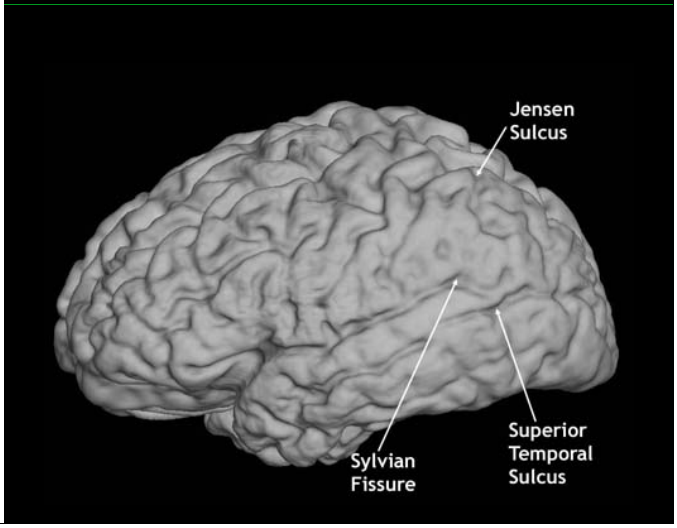


Figure 3

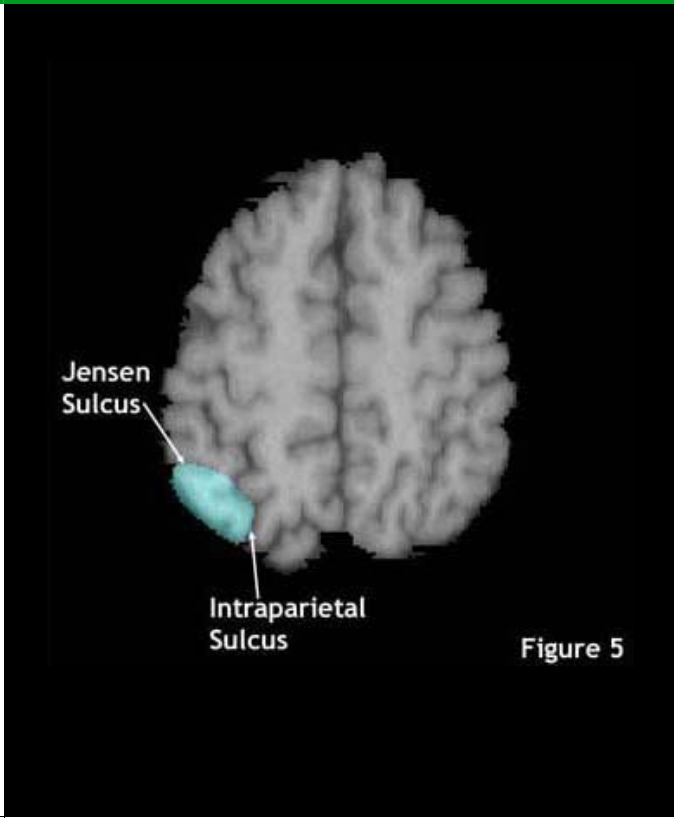


Angular Gyrus

Step 3

Masking of the angular gyrus is done in the axial view. Begin anteriorly, at a slice where the Jensen sulcus is clear. Mask the Jensen sulcus to its internal endpoint and draw a straight line down to the intraparietal sulcus. Follow the intraparietal sulcus to its lateral end, and fill in everything within these boundaries. (Fig. 5)

Figure 5

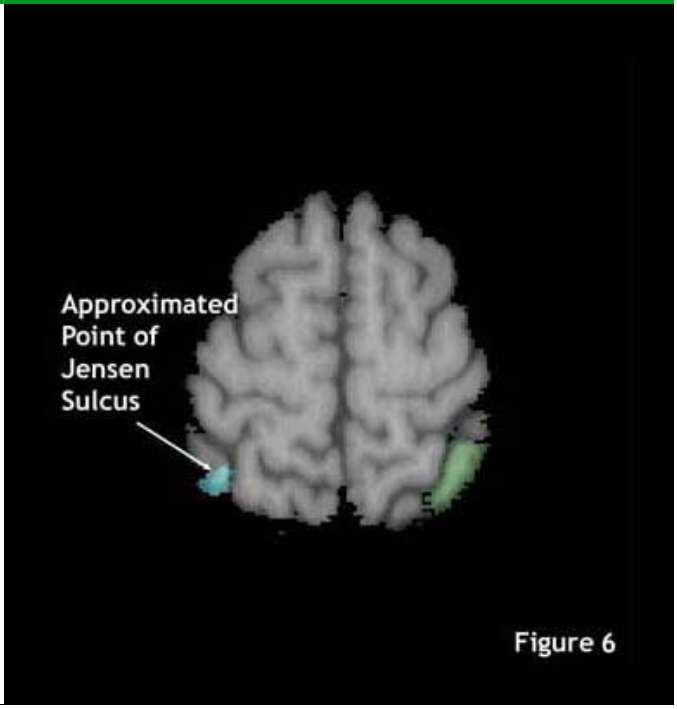


Angular Gyrus

Step 4

Continue step 3 to the superior end of the brain. If either sulcus becomes unclear, find the final slice at which it was last clear and approximate this point on all other slices. (Fig. 6)

Figure 6

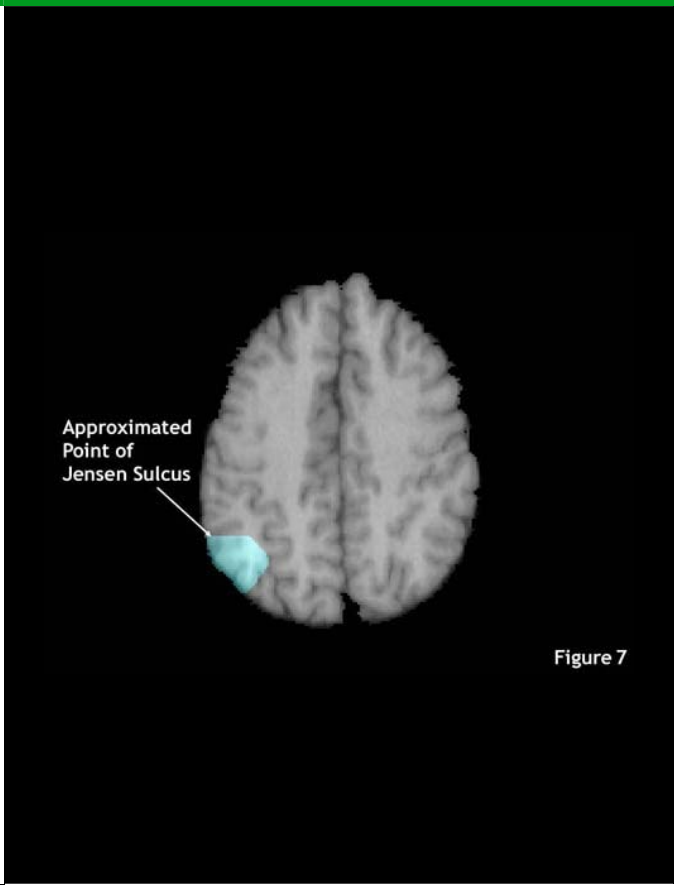


Angular Gyrus

Step 5

Once the angular gyrus is masked to the superior end of the brain, find the first slice that was masked, and continue step 3 inferiorly. Moving inferiorly, the Jensen sulcus will disappear. At this point, reference the last slice where the sulcus was clear and approximate its location on the following slices. On the 3d object, this will create a straight line from the end of the Jensen sulcus to the inferior end of the angular gyrus. In addition, the intrapareital sulcus may become unclear. When this happens, reference the predetermined boundary of the occipital lobe on the 3D object for the boundary and mask between these two approximated points. (Fig. 7)

Figure 7

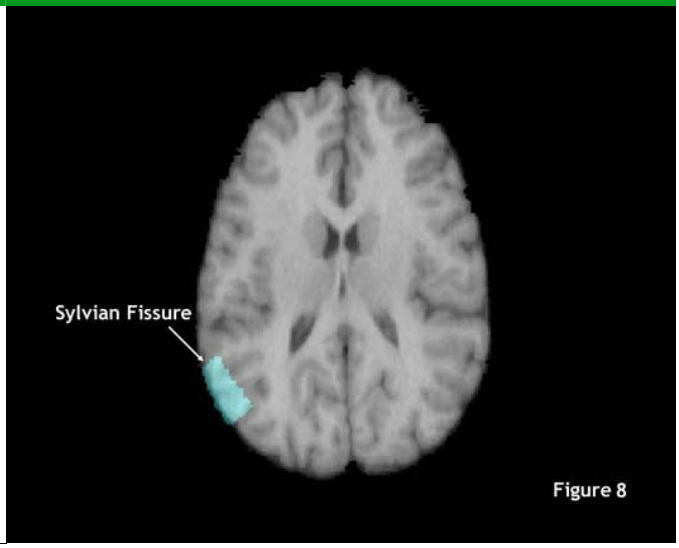


Angular Gyrus

Step 6

Moving inferiorly, the posterior segment of the Sylvian fissure will come into view. At this point, mask from the posterior segment of the Sylvian fissure to the approximated anterior boundary of the occipital lobe. Continue this step until reaching the STS. (Fig. 8)

Figure 8

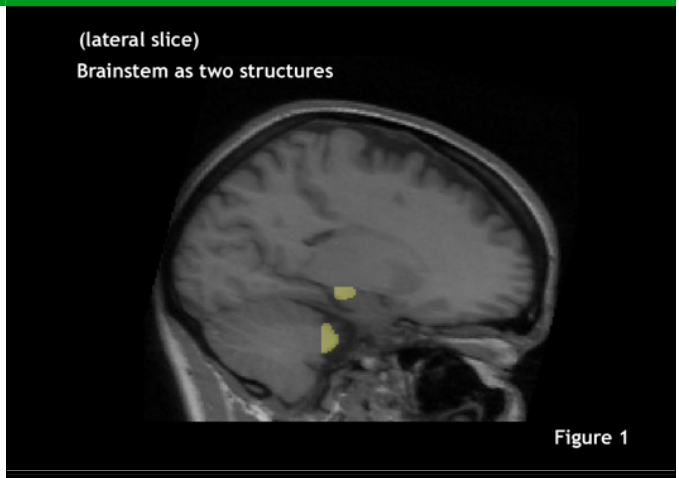


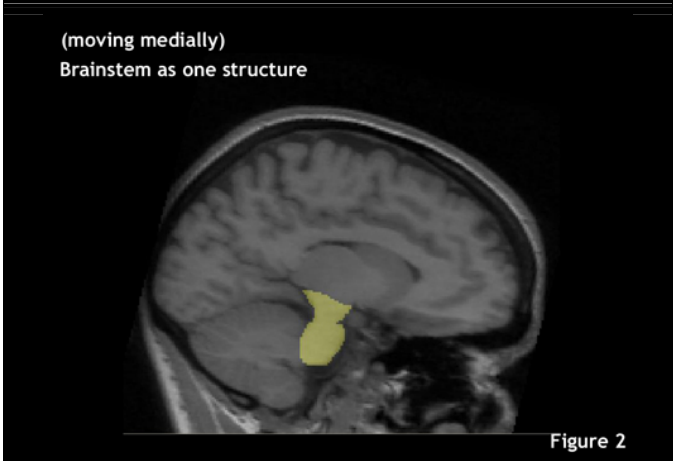
Brainstem

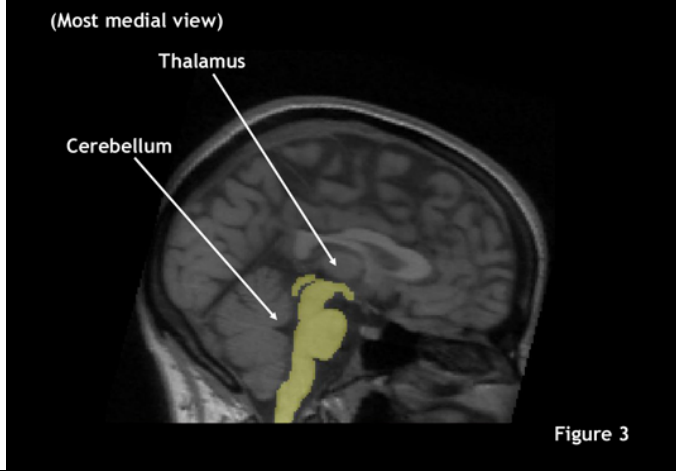
Step 1

The brainstem is the structure anterior to the cerebellum and inferior to the thalamus. It consists of the medulla oblongata, midbrain, and pons. In the sagittal view, the brainstem appears as two separate structures laterally but then fuse to form a single structures medially. (Fig. 1, Fig. 2, Fig. 3)

Figures 1 2 & 3







Brainstem

Step 2

Start in the sagittal view at the most lateral slice. Begin masking the brainstem when the lateral geniculate body appears and inferior to that as an anterior protrusion appears from the cerebellum. Trace the lateral geniculate body's inferior boundary and connect the superior ends of the inferior boundary by cutting straight across the ends. Mask everything within. Trace the anterior boundary of the anterior protrusion in the cerebellum then also connect the posterior ends by cutting across the ends. Mask everything within (Fig. 4). The two separate regions should begin to approach each other as the view becomes more medial (Fig. 5)

Figure 4 & 5

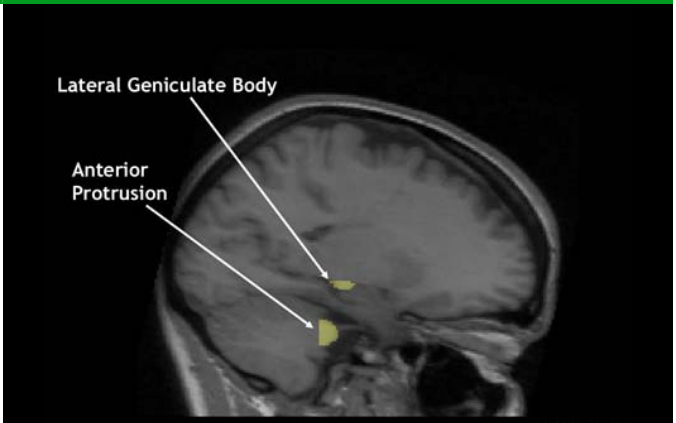


Figure 4

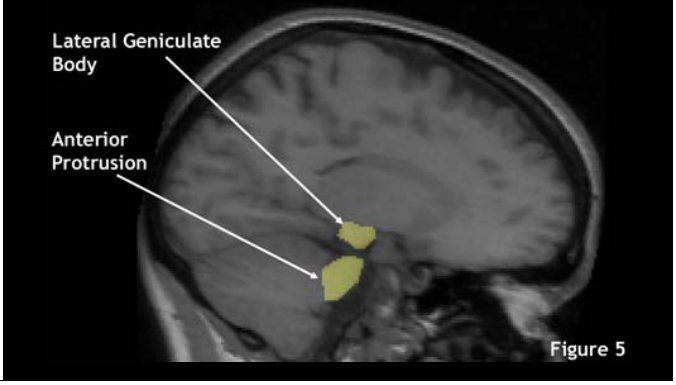


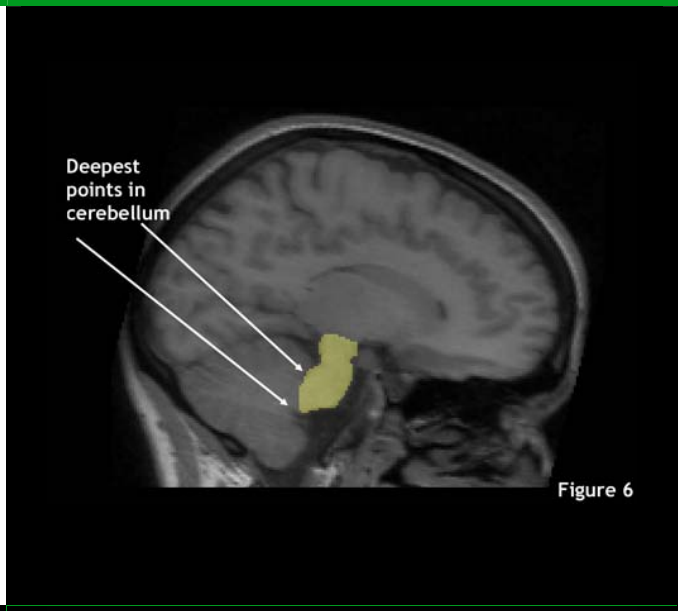
Figure 5

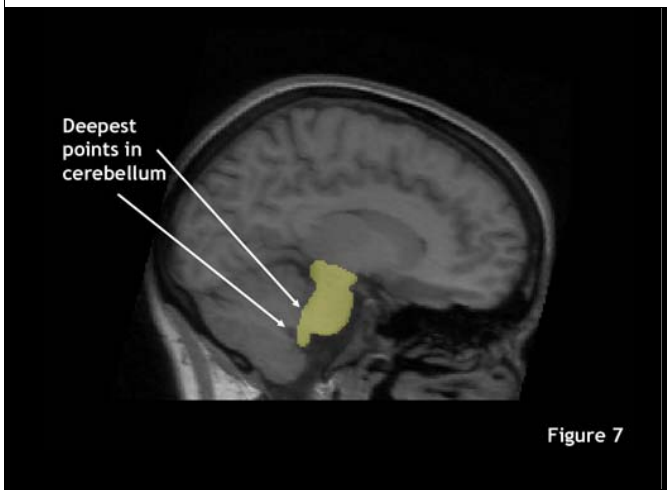
Brainstem

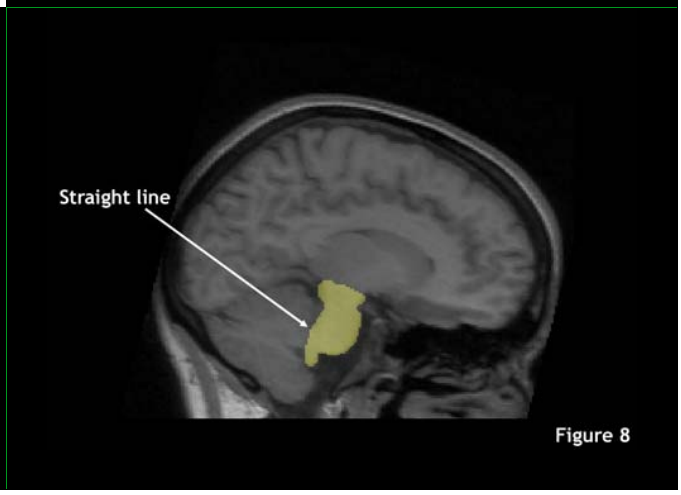
Step 3

As the two regions fuse, trace the outline of the brainstem into the deepest points allowed in the cerebellum and connect the two ends (Fig. 6, Fig. 7). Continue this until the brainstem's posterior boundary near the cerebellum can be defined as a straight line (Fig. 8). At this point, trace the boundary of the brainstem in its entirety. Note the brainstem is anterior to the fourth ventricle (Fig. 9, Fig. 10).

Figure 6 7 & 8

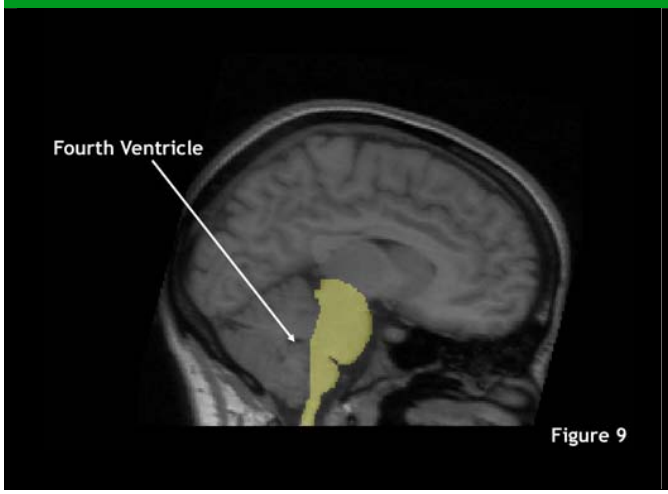


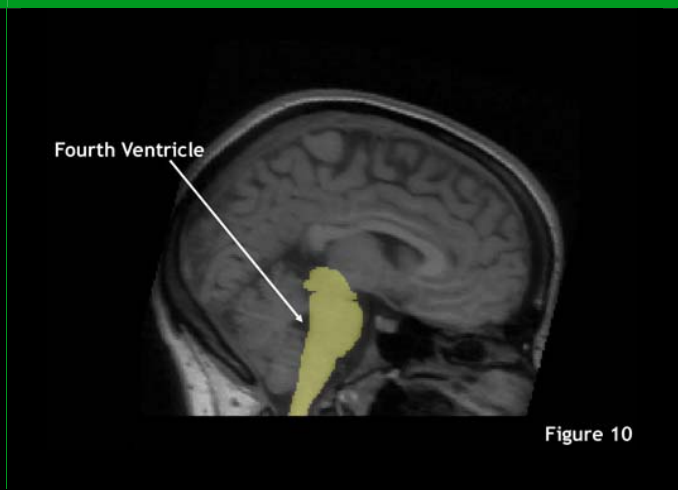




Step 3 (continued)

Figures 9 & 10

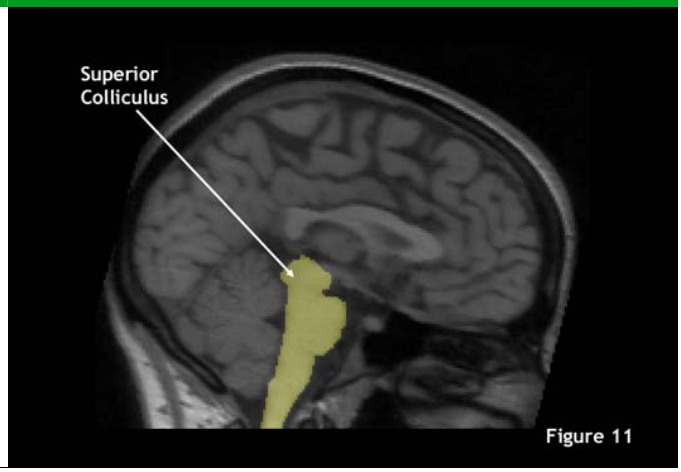




Step 4

As the brain stem extends inferiorly to the bottom of the image, begin to monitor the superior part of the brainstem for the superior colliculus. (Fig. 11)

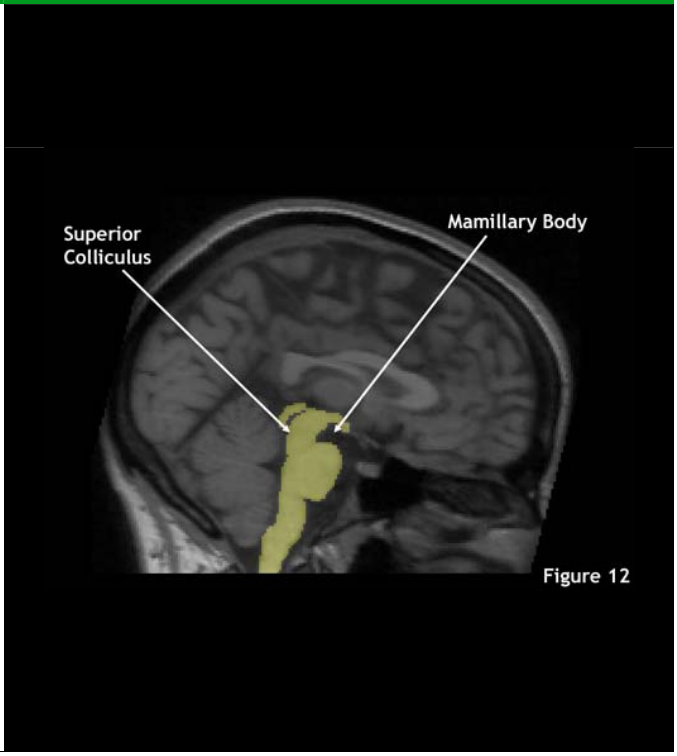
Figure 11



Step 5

Soon after the superior colliculus can be identified, take note of the separation between the main body of the brainstem and the superior colliculus and trace this distinction. Also, take note of the protrusion anterior to the superior colliculus, the mamillary body, and mask this area (Fig. 12).

Figure 12



Step 6

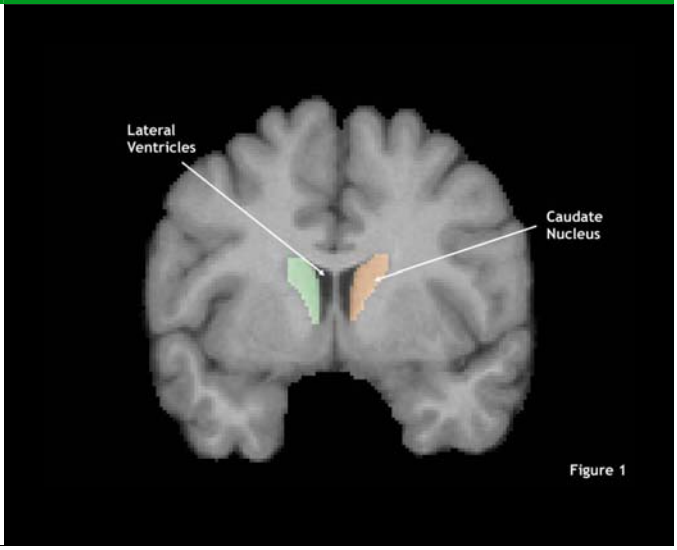
Follow steps 1-5 in reverse order for the left hemisphere (medial to lateral) until the lateral geniculate body and the anterior protrusion from the cerebellum cannot be distinguished as protrusions.

Caudate Nucleus

Step 1

The caudate nucleus is a predominately gray sub-cortical structure located lateral to the lateral ventricles. It generally takes on a butterfly-like shape. (Fig. 1)

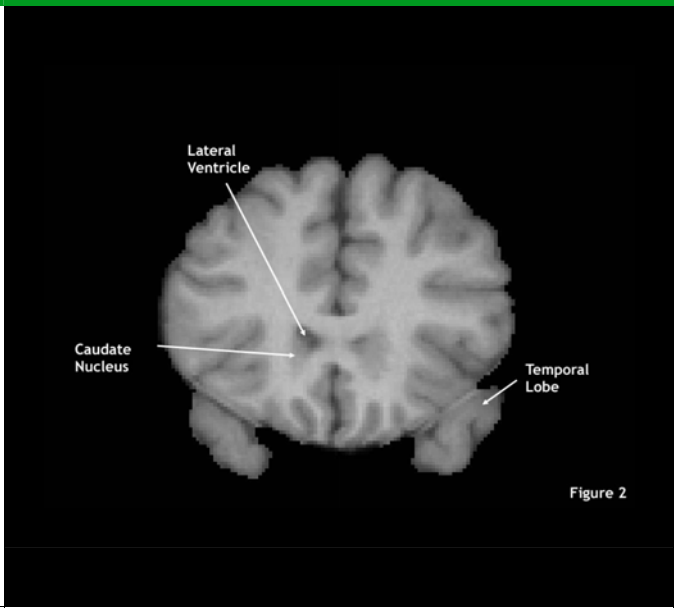
Figure 1



Step 2

Masking of the caudate nucleus is done in the coronal view. Moving from the anterior end of the brain to the posterior end, the temporal lobe will appear at the inferior aspect of the brain. At this point, begin to look for an area of gray matter inferior to the lateral ventricles. Mask the entire gray matter area being careful to exclude the ventricles. (Fig. 2)

Figure 2

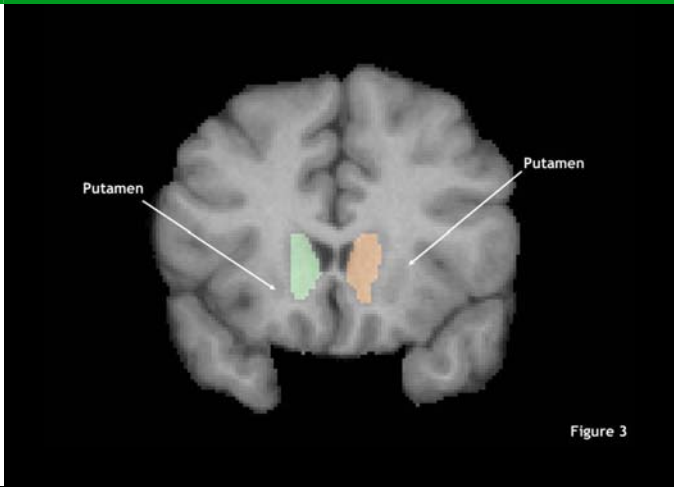


Caudate Nucleus

Step 3

Moving posteriorly the putamen will appear lateral to the caudate nucleus. Be careful to exclude the putamen. (Fig. 3)

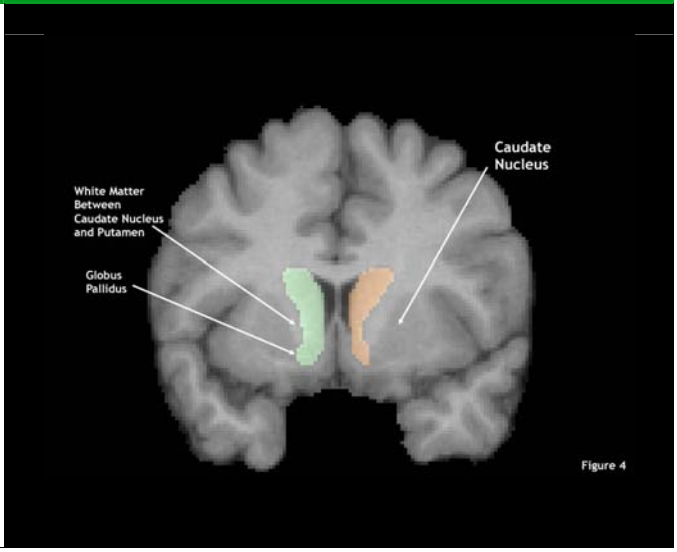
Figure 3



Step 4

Moving even further posterior the globus pallidus will appear. This creates a bridge between the caudate and the putamen. At this point mask the caudate nucleus as before stopping at a line straight down from the white matter separating the caudate and the putamen. As before, be careful to mask only the gray matter and exclude white matter. (Fig. 4)

Figure 4

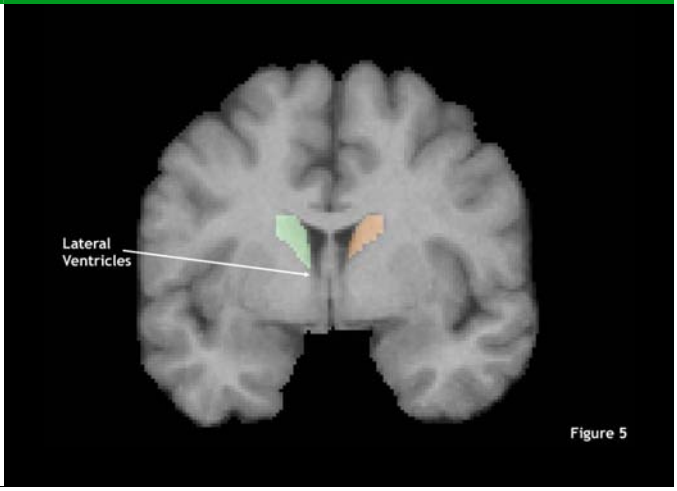


Caudate Nucleus

Step 5

When it is no longer possible to mask down to the globus pallidus without including the lateral ventricles, mask from the top of the caudate nucleus to the bottom of the lateral ventricles. (Fig. 5)

Figure 5

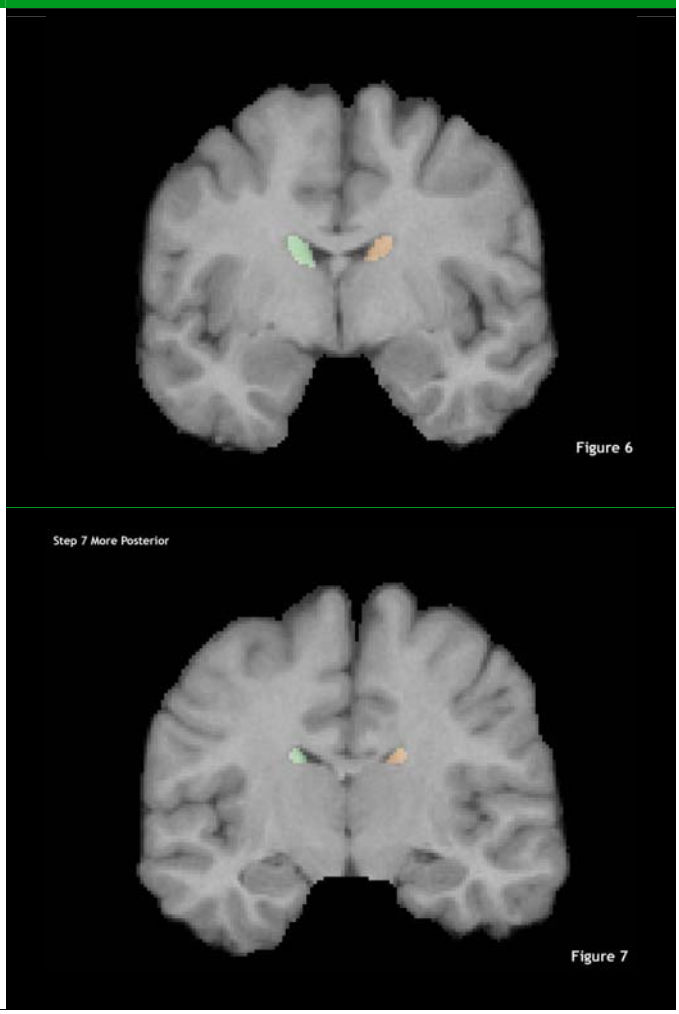


Caudate Nucleus

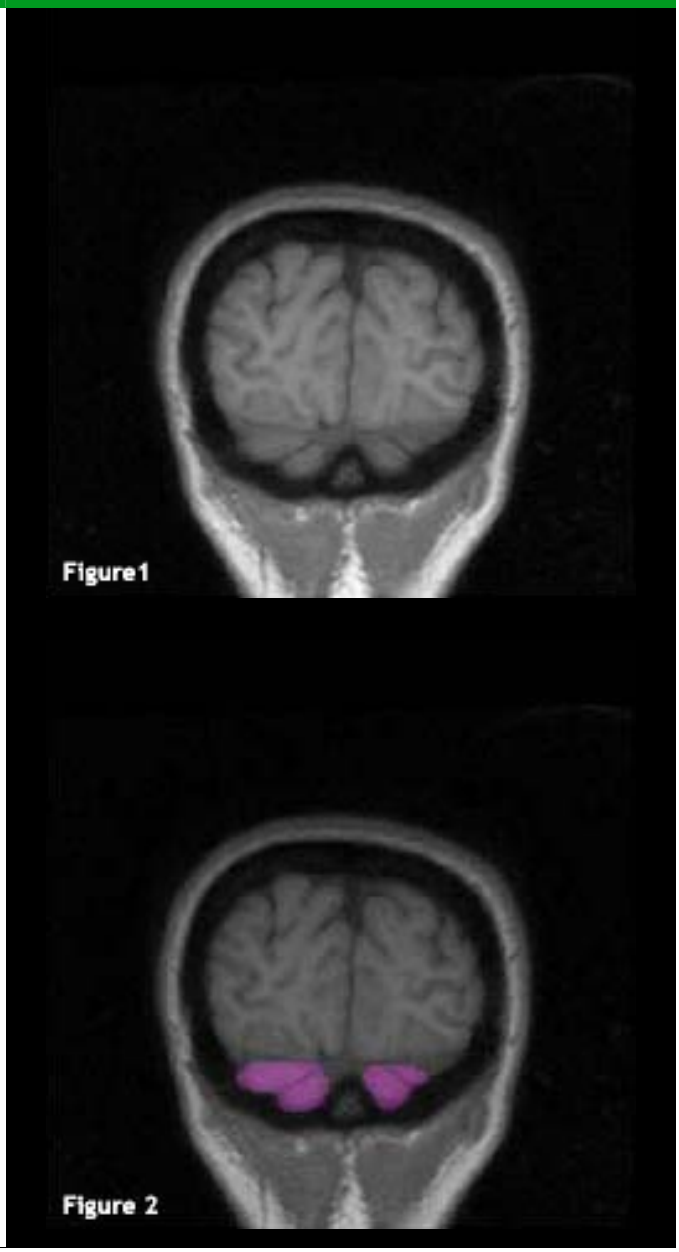
Step 6

The caudate nucleus will get smaller moving posteriorly. End masking once it is no longer visible. (Fig. 6, Fig. 7)

Figures 6 & 7



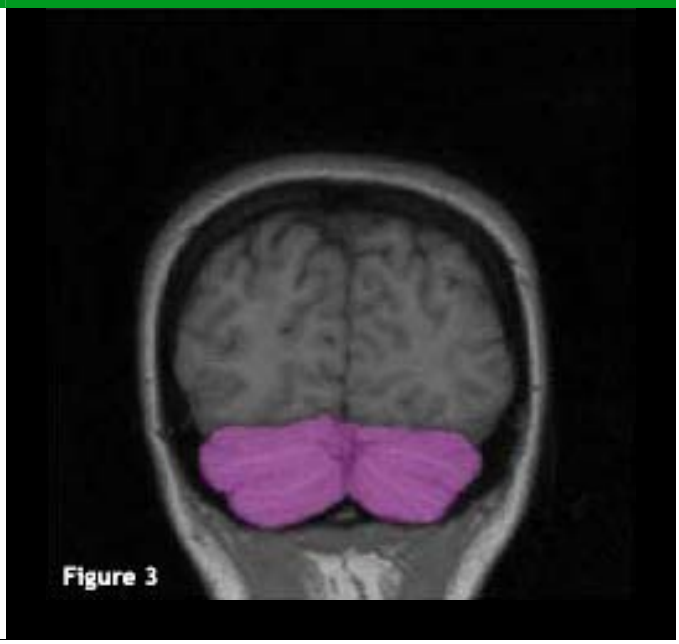
Cerebellum

Step 1	Figures 1 & 2
Find the most posterior plane in the coronal view. Begin masking the cerebellum once the cerebellum becomes visible inferior to the fissure separating the cerebellum from the cerebral cortex (Fig. 1, Fig. 2).	

Step 2

When the left and right hemispheres of the cerebellum merge, mask the cerebellum without a division (Fig. 3).

Figure 3



Step 3

Once the brain stem appears, follow the boundary of the cerebellum carefully to avoid including any part of the brain stem in the mask (Fig. 4).

Figure 4

Cerebellum

Step 4

The medulla of the brain stem fuses with the cerebellum at the superior cerebellar peduncle (Fig. 5). Reference the sagittal view to determine this boundary (Fig. 6). Exclude the IV ventricle from the mask.

Figures 5 & 6

Figure 5

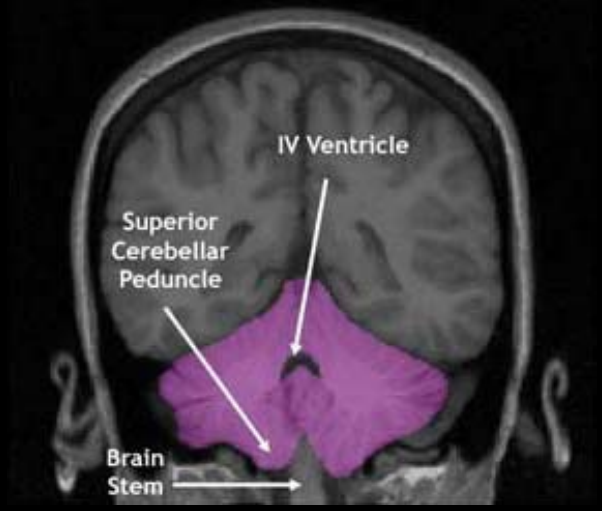
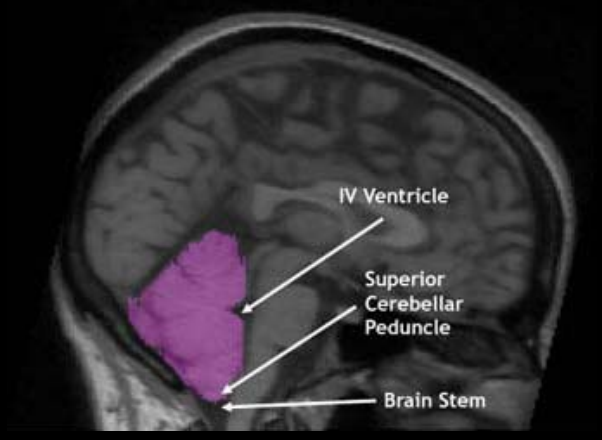


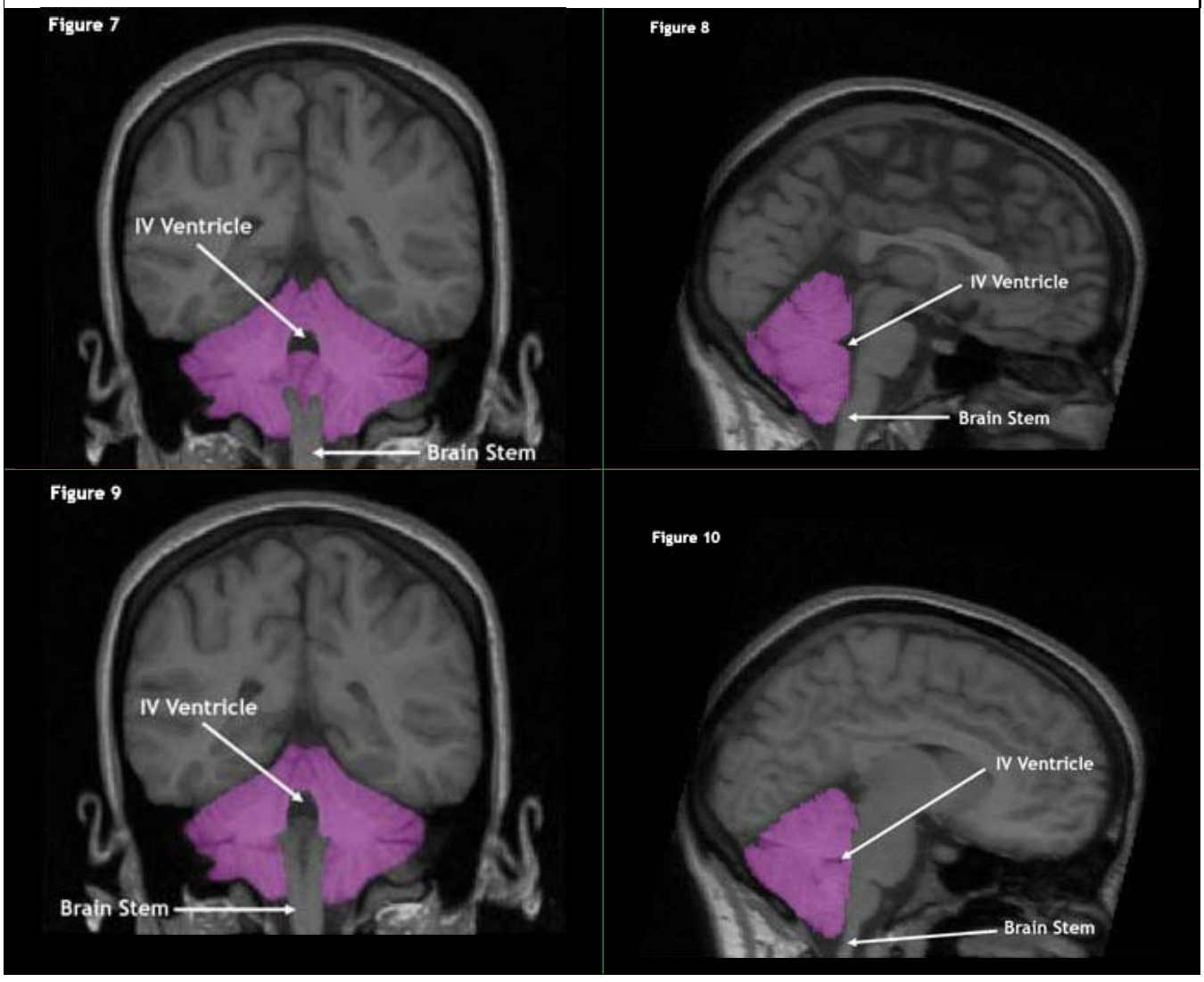
Figure 6



Step 5

Figures 7 8 9 & 10

Immediately posterior to the region shown in step 4, the brain stem begins to merge with the rest of the cerebellum. In this region, it is important to explicitly exclude any part of the brain stem from the mask. Frequently reference the sagittal view to determine which areas to mask. Fig. 7 and Fig. 9 show coronal views at various points in region, and Fig. 8 and Fig. 10 show the corresponding sagittal views.



Step 6

Once the brain stem has completely fused with the middle cerebellar peduncle, exclude the middle cerebellar peduncle, and brachium conjunctivum from the mask. (Fig. 11, Fig. 12).

Figures 11 & 12

Figure 11

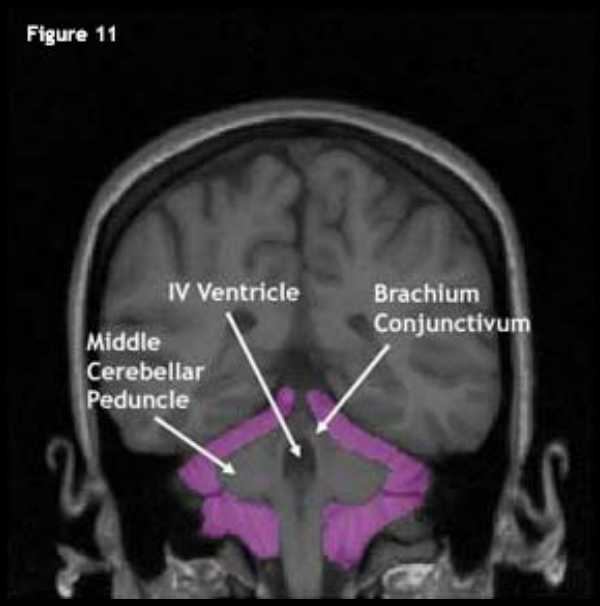
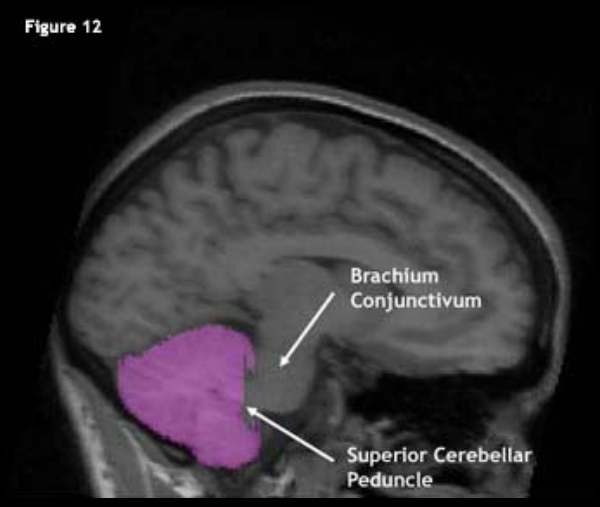


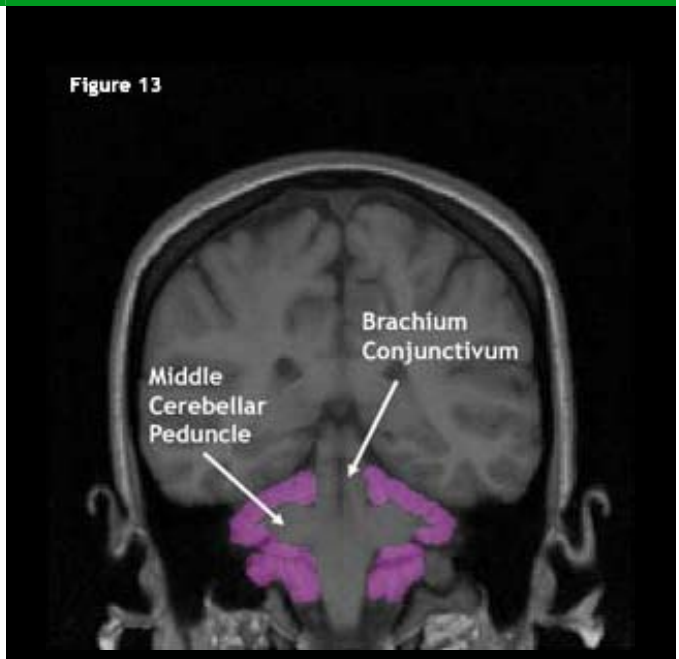
Figure 12

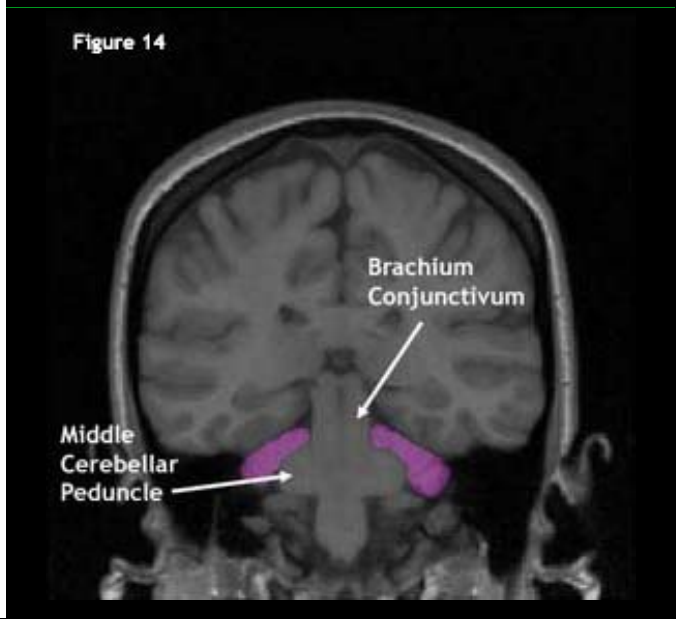


Step 7

Continue masking until the cerebellum until it is no longer visible (Fig. 13, Fig. 14).

Figures 13 & 14



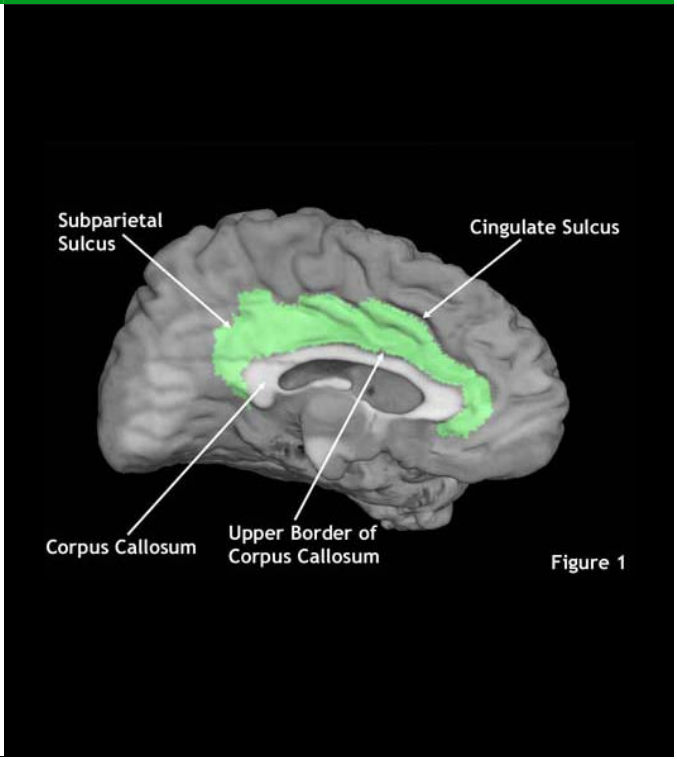


Cingulate Gyrus

Step 1

The cingulate gyrus is distinct from the frontal, parietal, occipital and temporal lobes. Anteriorly, its superior boundary is the cingulate sulcus. Posteriorly, its superior boundary is the subparietal sulcus. Its inferior boundary is the upper border of the corpus callosum. (Fig. 1)

Figure 1



Cingulate Gyrus

Step 2

Initially mask in the sagittal view in order to find the cingulate gyrus' superior and inferior boundaries. Locate a medial sagittal slice where the cingulate sulcus, subparietal sulcus and corpus callosum are most clearly defined. In this view, trace the cingulate sulcus from the point it connects to the corpus callosum to the point where it meets the subparietal sulcus. From that point, follow the subparietal sulcus to the point where the sulcus meets the corpus callosum and trace the upper boundary of the corpus callosum. Mask everything interior to these boundaries.

If any of the superior boundary sulci are interrupted, cut across any branching white matter to connect the interrupted sulcus. Tracing initially in the sagittal view defines not only the superior and inferior boundaries of the cingulated gyrus but indirectly defines the anterior and posterior boundaries.(Fig. 2, Fig. 3)

Figures 2 & 3

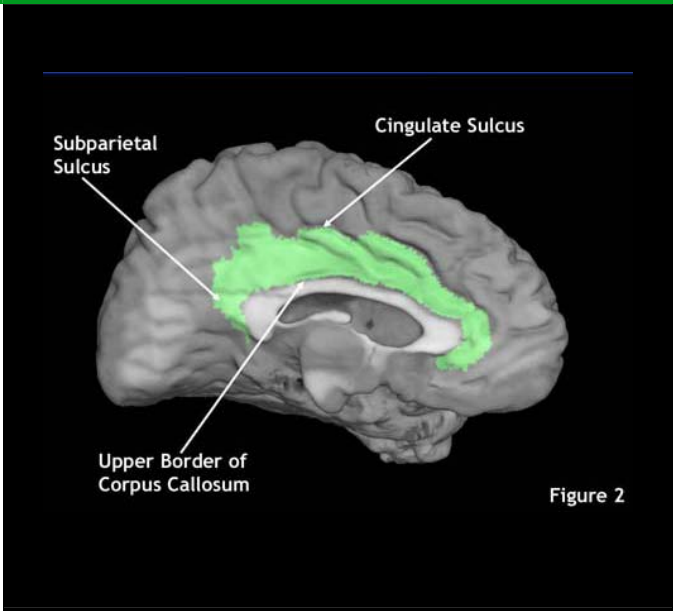


Figure 2

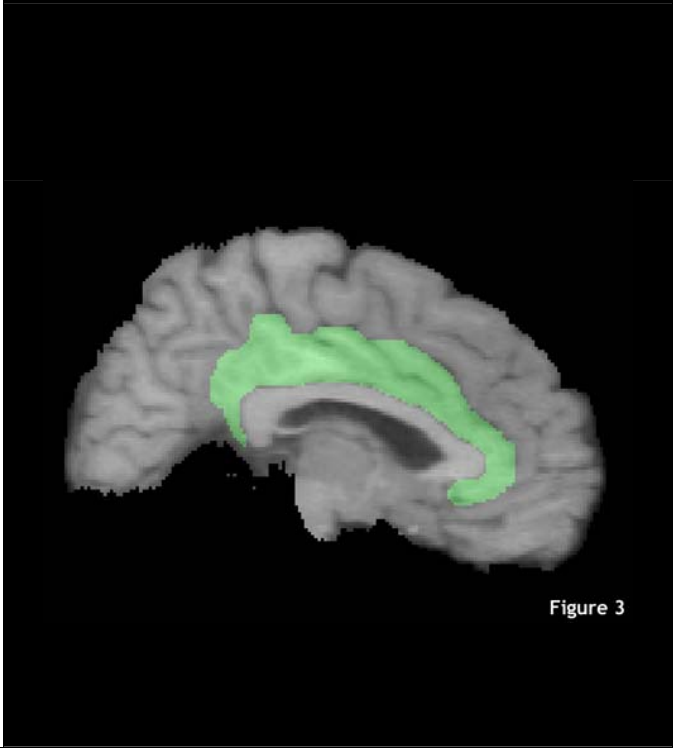


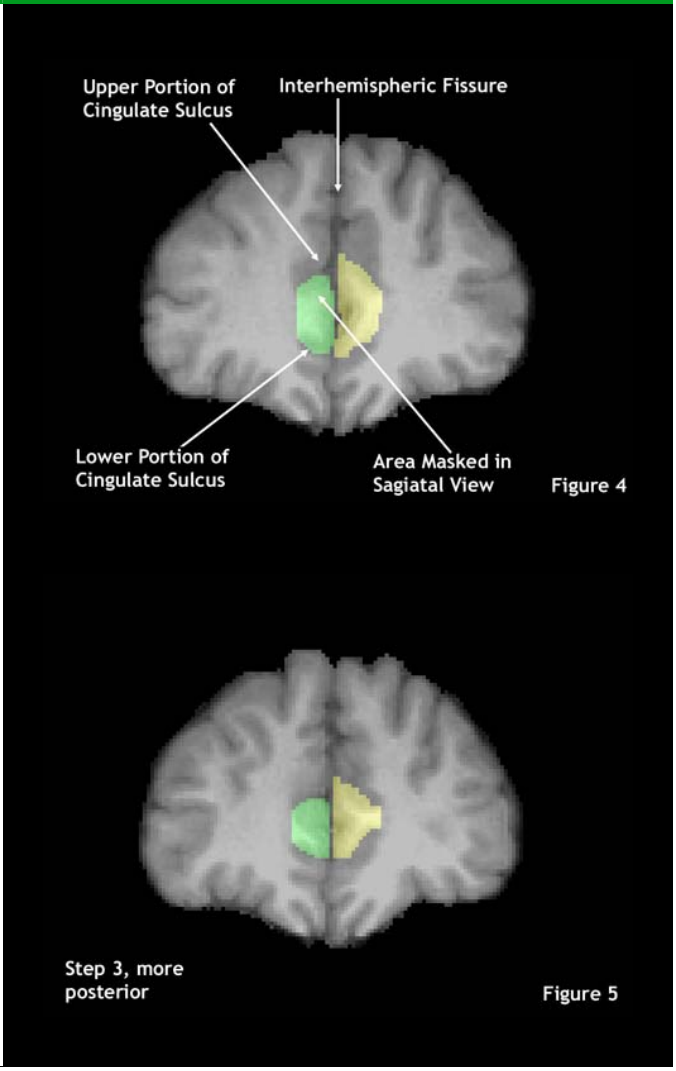
Figure 3

Cingulate Gyrus

Step 3

Once all boundaries are defined in the sagittal view, switch to the coronal view. Find the most anterior masked point as traced in the sagittal view. Use the masked area, which should span the area between the cingulate sulcus' upper and lower portions, to approximate the height of the cingulate gyrus. Trace the upper portion of the cingulate sulcus to its internal end, and trace down to the internal end of the lower portion of the cingulate sulcus. Trace the entire lower cingulated sulcus toward the interhemispheric fissure and trace the interhemispheric fissure to connect the two portions of the cingulate sulcus. Mask everything within these boundaries. (Fig. 4, Fig. 5)

Figures 4 & 5



Cingulate Gyrus

Step 4

Once the corpus callosum appears, trace the cingulate sulcus' upper portion to the upper boundary of the corpus callosum. Trace the cingulate sulcus' lower portion to the lower boundary of the corpus callosum. When connecting the ends of two different boundaries, try to trace a straight line. Mask everything within these boundaries. (Fig. 6, Fig. 7)

Figures 6 & 7

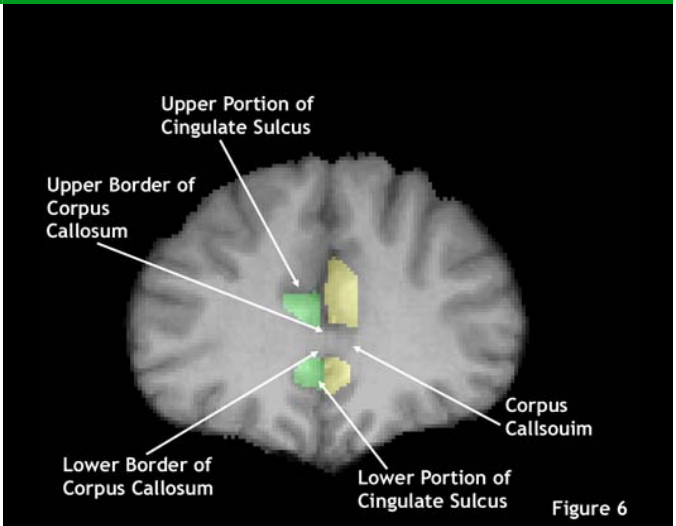


Figure 6

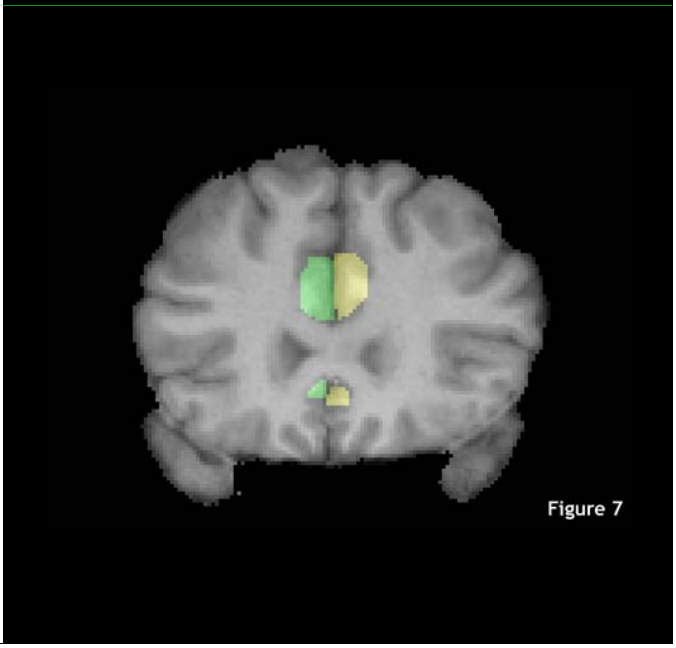


Figure 7

Cingulate Gyrus

Step 5

When the cingulate sulcus' lower portion is no longer visible, only mask the upper portion of the cingulate sulcus to the upper border of the corpus callosum. Use the previously masked area from the sagittal view as a guide for height. (Fig. 8, Fig. 9)

Figures 8 & 9

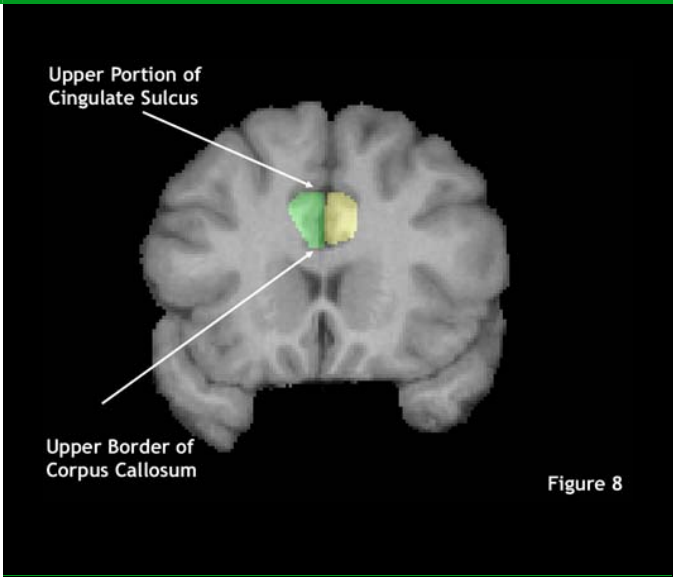


Figure 8

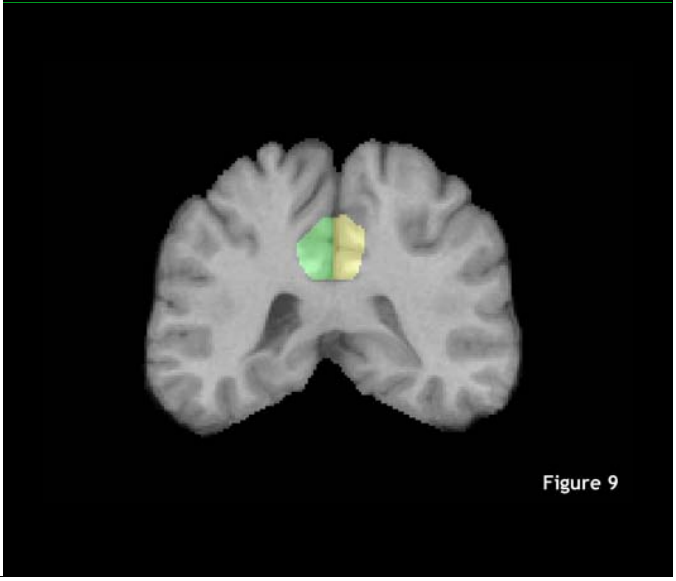


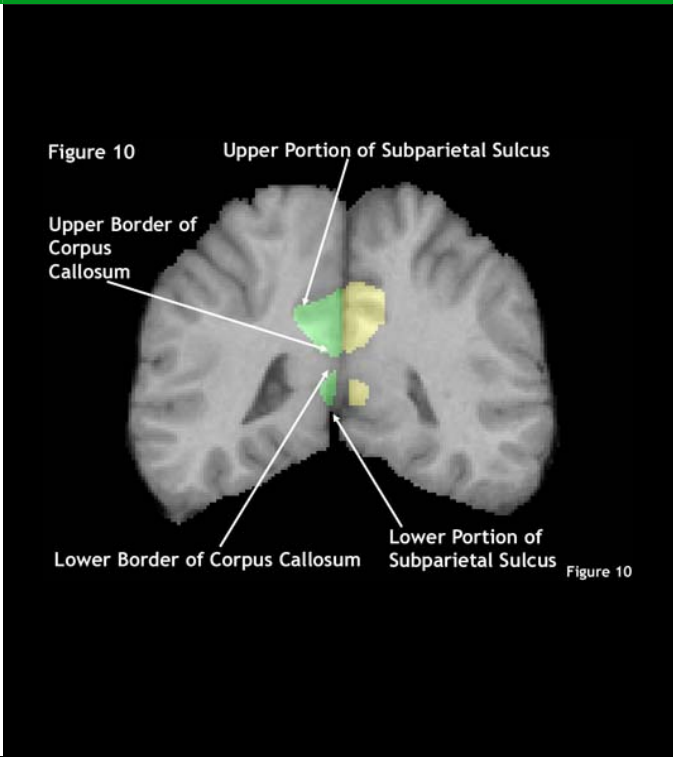
Figure 9

Cingulate Gyrus

Step 6

Moving posteriorly, the cingulate gyrus will once again show up as two separate regions. Trace the subparietal sulcus' upper portion to the upper border of the corpus callosum. Trace the subparietal sulcus' lower portion to the lower border of the corpus callosum. If the subparietal sulcus' upper or lower portion is not clear, refer to the previously masked area from the sagittal view to define areas to be masked. (Fig. 10)

Figure 10



Cingulate Gyrus

Step 7

Eventually, the cingulate gyrus' two portions merge. Use the area previously masked area in the sagittal view as a guide. Trace the subparietal sulcus' upper portion to its internal end and cut to the subparietal sulcus' lower portion. Continue this step until reaching the last posterior labeled region as masked in the sagittal view. (Fig. 11, Fig. 12)

Figures 11 & 12

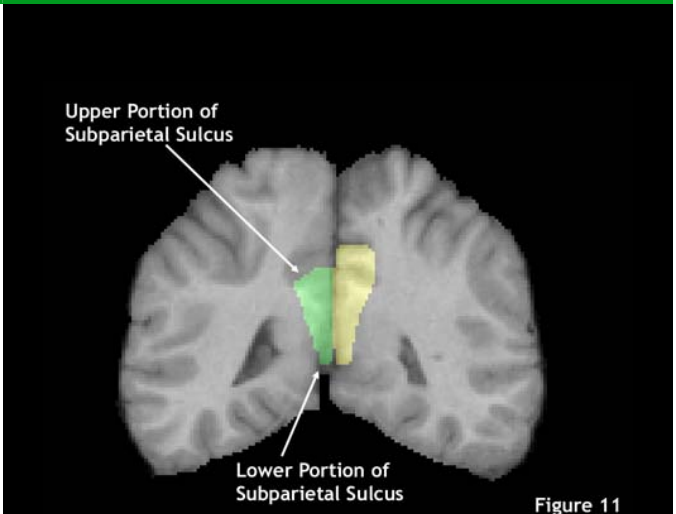


Figure 11

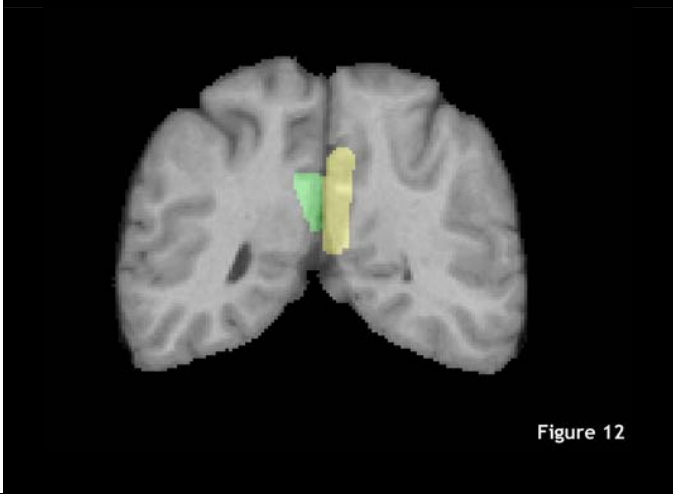


Figure 12

Cuneus

Step 1

The cuneus is the medial aspect of the occipital lobe. It is defined inferiorly by the calcarine fissure, which divides the occipital lobe horizontally. The superior and anterior boundary of the cuneus is the parieto-occipital fissure, which separates the occipital lobe from the parietal lobe, running diagonally from the most superior part of the occipital lobe in an inferior/ anterior direction. (Fig. 1, Fig. 2, Fig.3)

Figures 1 2 & 3

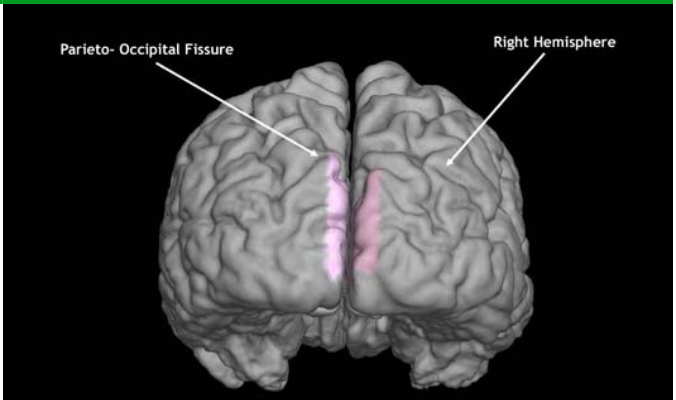


Figure 1: Posterior View

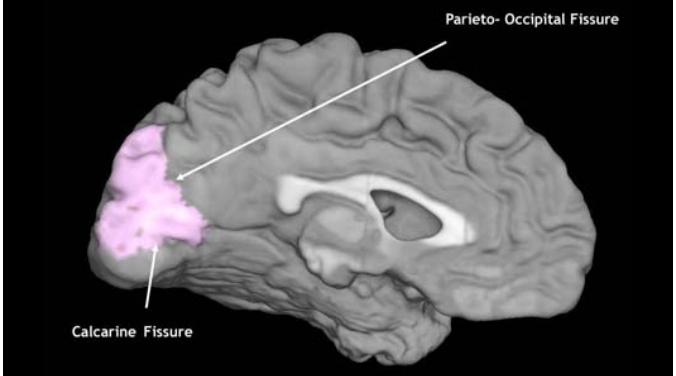


Figure 2: Left Hemisphere

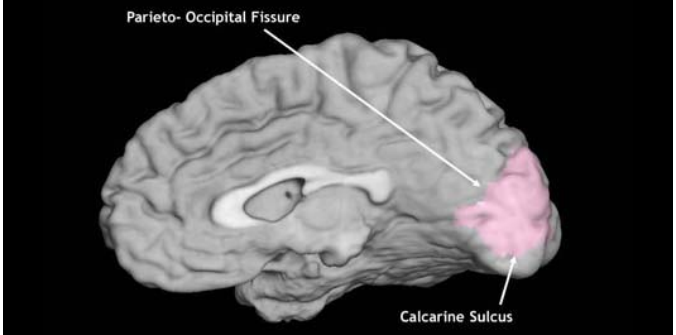


Figure 3: Right Hemisphere

Cuneus

Step 2

To define the boundaries initially, mask first in the sagittal view. Go to a mid-sagittal slice where the parieto-occipital fissure and the calcarine sulcus are easily identified. Mask the parieto-occipital fissure to its inferior endpoint and mask a straight line to the anterior endpoint of the calcarine sulcus. Follow the calcarine sulcus to the posterior end of the brain. If it does not connect to the posterior end of the brain, connect it to the next highest sulcus. Mask everything within these boundaries. (Fig. 4)

Figures 4

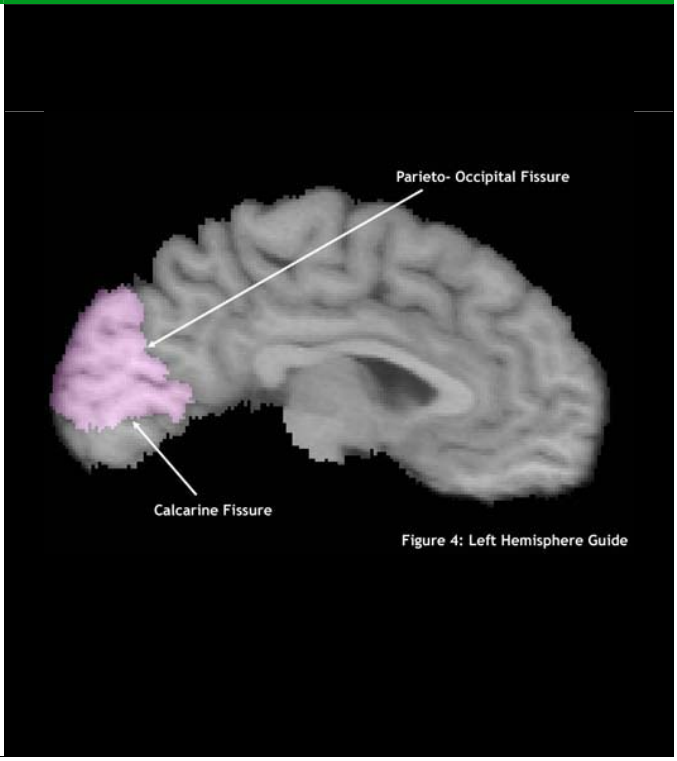


Figure 4: Left Hemisphere Guide

Cuneus

Step 3

Once a guide has been set up, switch to the axial view. Start superiorly, where the gyrus as masked in the sagittal view first appears. To define the lateral boundary of the gyrus, move slightly (5-6 slices) inferiorly from this initial slice, and label everything medial to the first sulcus interior to the longitudinal fissure, using the height identified from the preexisting label. Continue to label the all slides superior to that and inferior as well at the same defined thickness. (Fig. 5, Fig. 6)

Figures 5 & 6

Figure 5: Coronal View of Guide

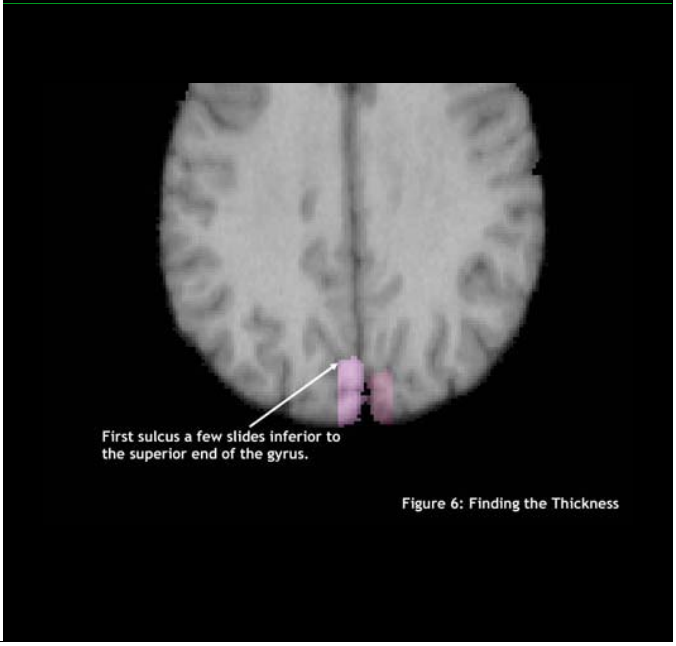


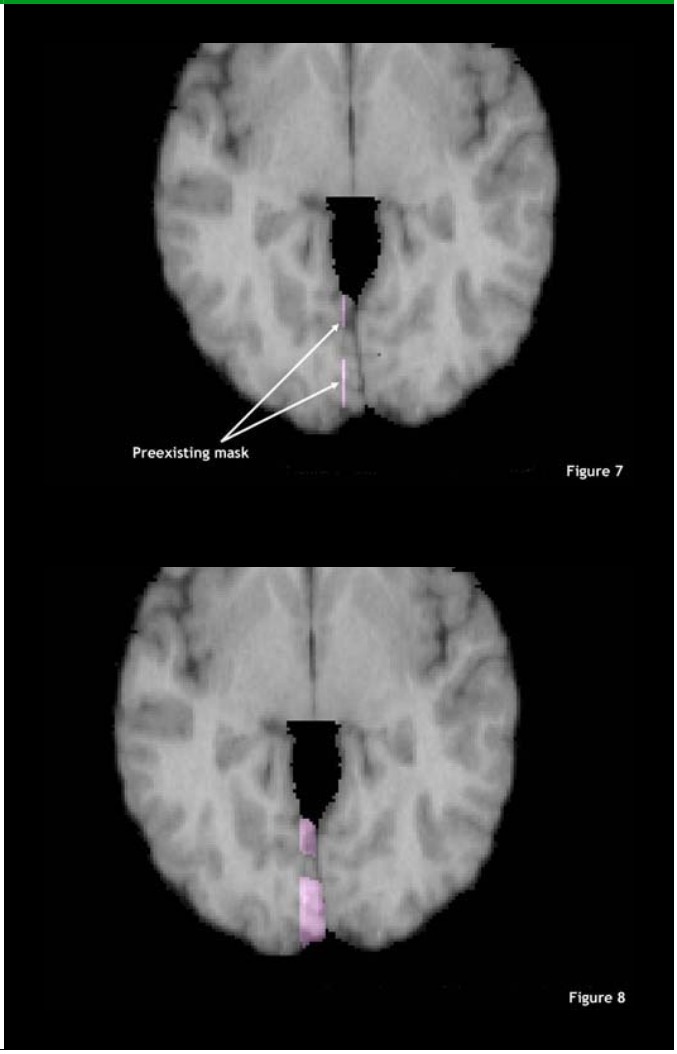
Figure 6: Finding the Thickness

Cuneus

Step 4

At the inferior portion of the cuneus, there may be a few gaps in the preexisting label made by the calcarine sulcus. Follow the preexisting label by splitting the mask into two sections, filling in everything between the label and the interhemispheric fissure. (Fig. 7, Fig. 8)

Figures 7 & 8



Step 5

Once you have labeled all of the cuneus, switch to the sagittal view again and clean up any labels beyond the around the calcarine sulcus and the parieto-occipital fissure.

Fusiform

Step 1

For the fusiform gyrus, it is necessary to have a 3D object model in order to reference its boundaries. The lateral boundary of the fusiform gyrus is the lateral occipito-temporal sulcus which separates the inferior temporal gyrus from the fusiform gyrus. The medial boundary is the collateral sulcus which separates the fusiform from the parahippocampal gyrus (Fig. 1). In the coronal view, the fusiform's anterior boundary is marked by the emergence of the temporal horn, collateral sulcus and amygdala (Fig. 2, Fig. 3).

Figures 1 2 & 3

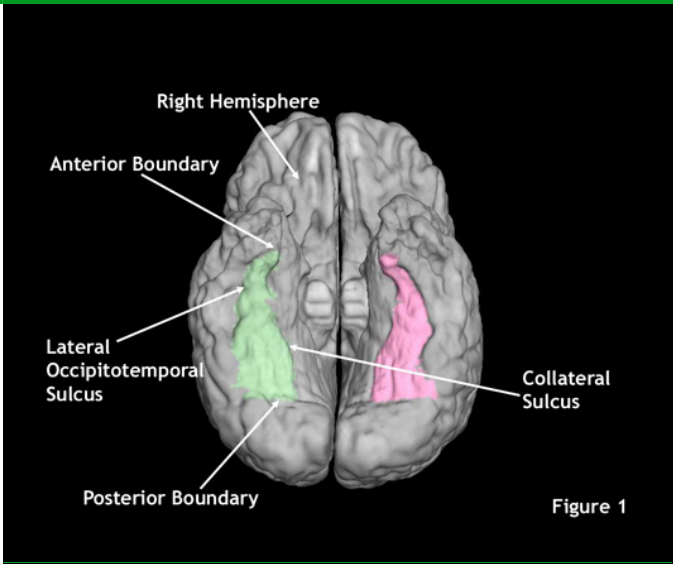


Figure 1

(Before the temporal horn appears)

Figure 2

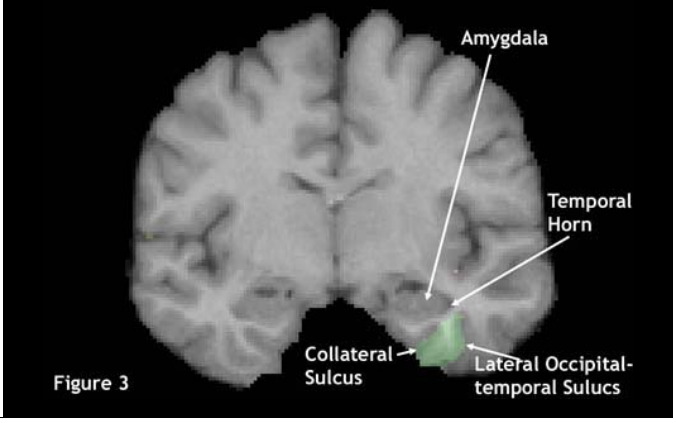
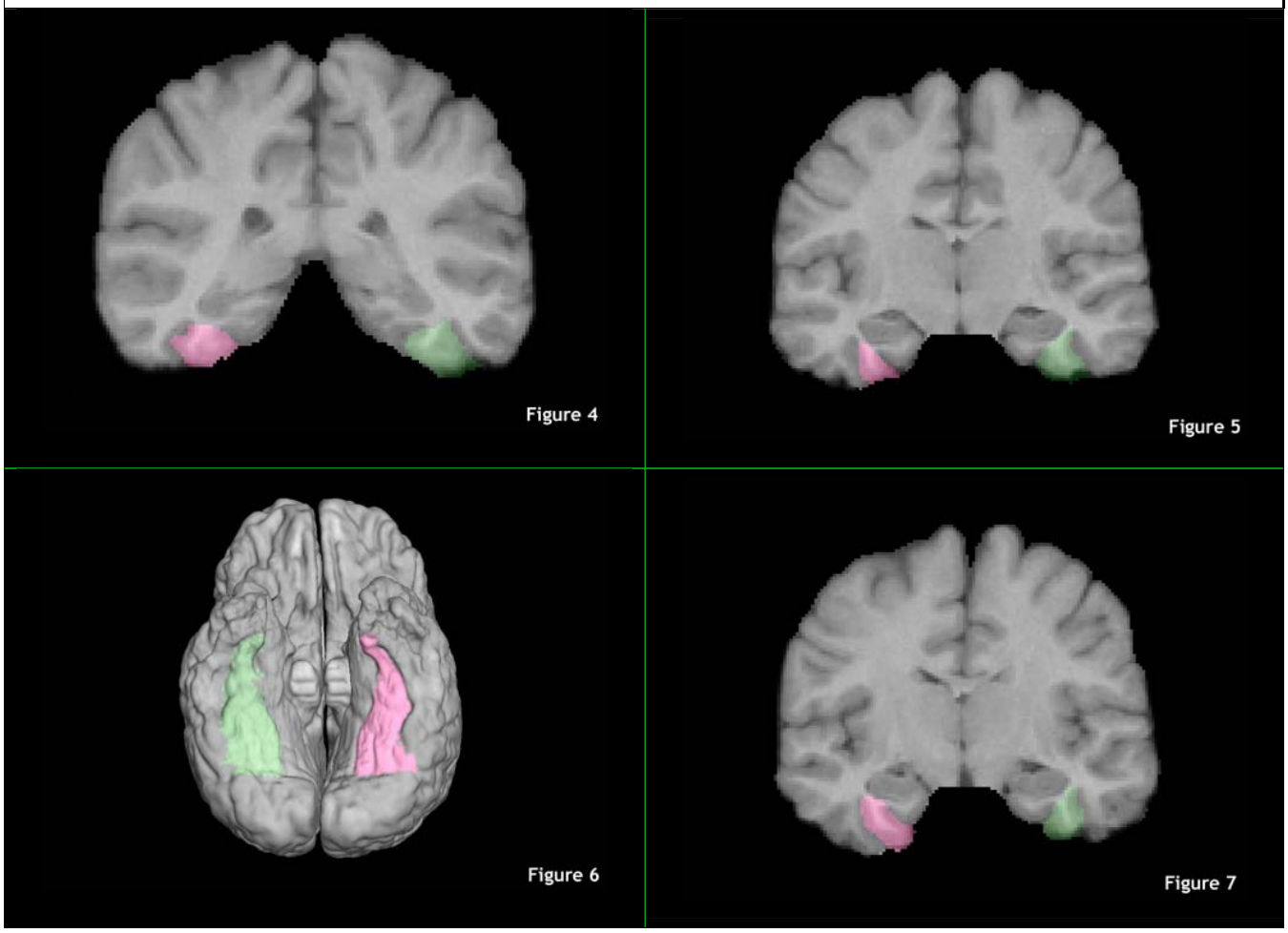


Figure 3

Fusiform

Step 2	Figures 4 5 6 & 7

Masking in the coronal view, trace the lateral occipitotemporal sulcus to its internal end point mask a straight line to the internal end point of the collateral sulcus. Then, trace the collateral sulcus completely and mask the area between the created boundaries. Continue this step until reaching the posterior end of the fusiform. Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, Fig. 10, Fig. 11, Fig. 12, Fig. 13 demonstrate this step moving posteriorly through coronal slices.



Fusiform

Step 2 (continued)

Figures 8 9 10 11 12 & 13

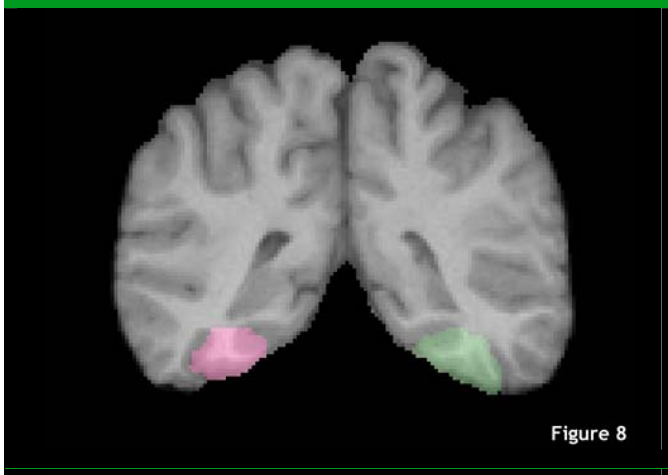


Figure 8

Figure 9

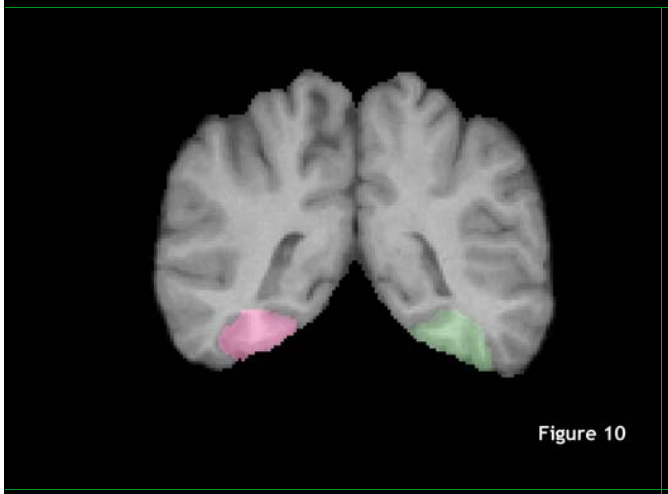


Figure 10

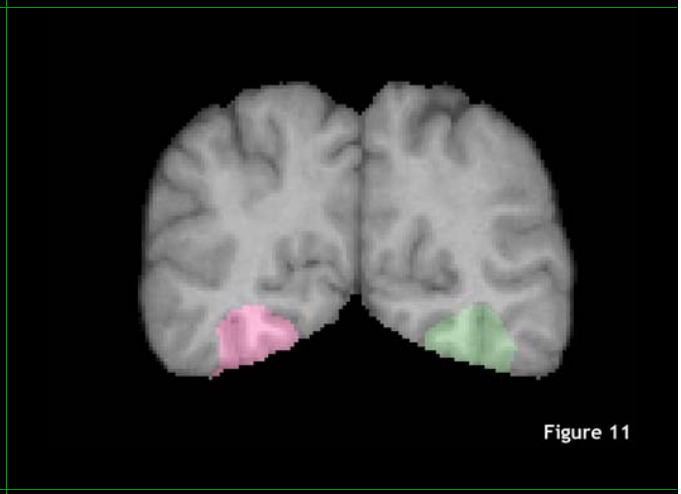


Figure 11

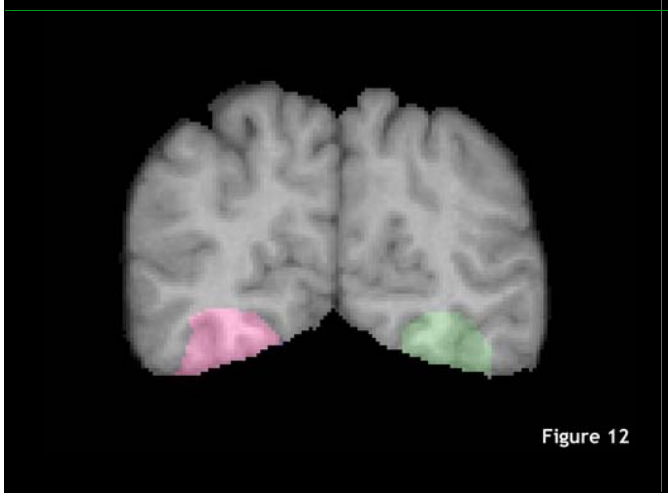


Figure 12

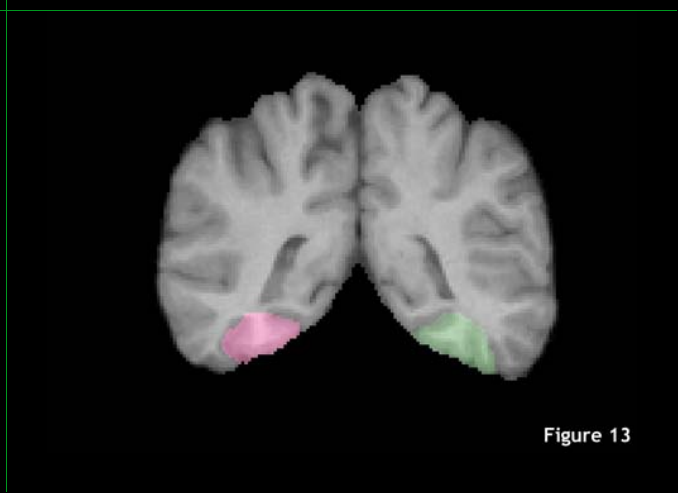


Figure 13

Step 3

Posterior Border Definition - For each hemisphere, go to the most medial slice in the sagittal view where the parietal-occipital sulcus is clearly visible (clicking on the interhemispheric fissure in the axial plane helps to find the most medial slice). Click on the most anterior point of the parieto-occipital sulcus in the sagittal view and check the corresponding coronal view.

Step 4

The most anterior point of the parietal-occipital sulcus is the point right above the calacrine sulcus. The corresponding slice in the coronal view is the posterior boundary of the fusiform gyrus. (Fig. 14, Fig. 15)

Figures 14 & 15

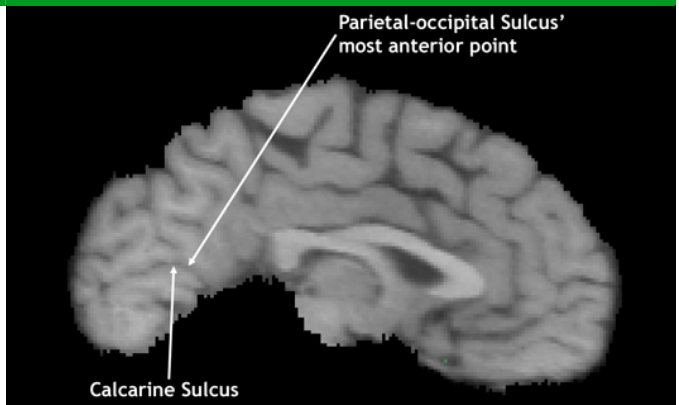


Figure 14

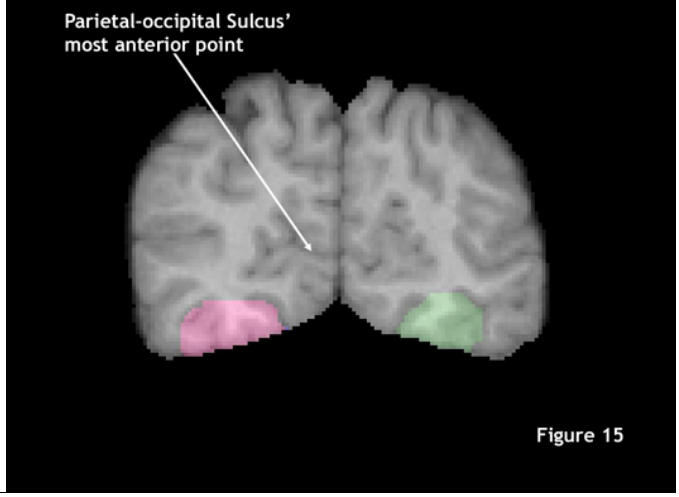


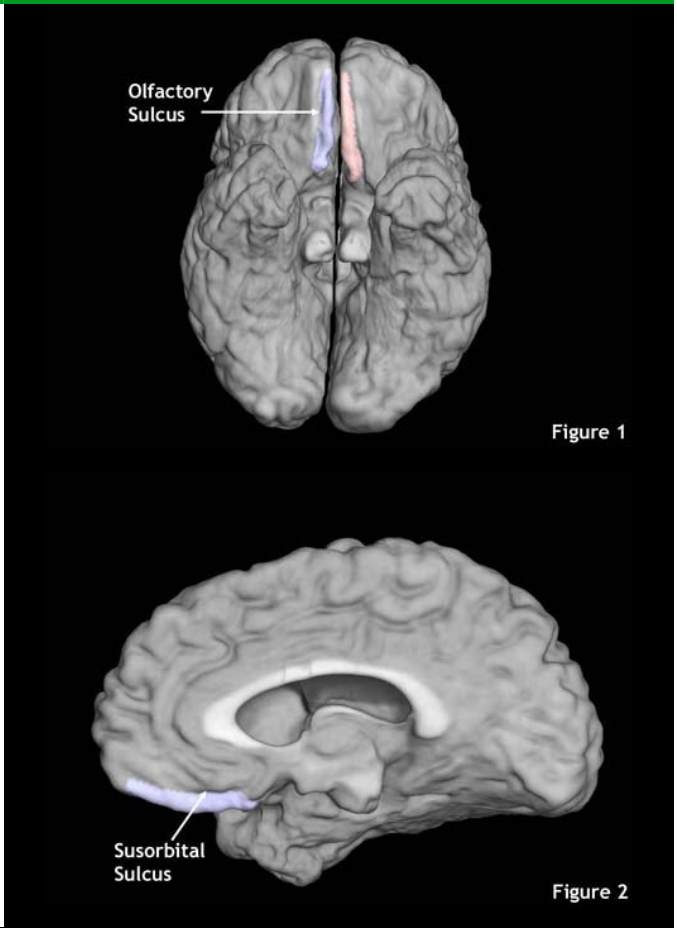
Figure 15

Gyrus Rectus

Step 1

The gyrus rectus is located in the most medial and inferior region of the frontal lobe. Its boundaries are the olfactory sulcus inferiorly and the susorbital sulcus superiorly. (Fig. 1, Fig. 2)

Figures 1 & 2



Gyrus Rectus

Step 2

Figures 3 4 5 & 6

Masking of the gyrusrectus is done in the coronal view. Begin by locating the olfactory sulcus either in the coronal view or on the 3d object. (Fig. 3, Fig. 1) Follow the olfactory sulcus to its most posterior point in the coronal view, and mask from its internal end to the lowest medial sulcus. (Fig. 4) Continue this step until the olfactory sulcus is no longer visible, keeping the height of the gyrus fairly consistent. (Fig. 5, Fig. 6)

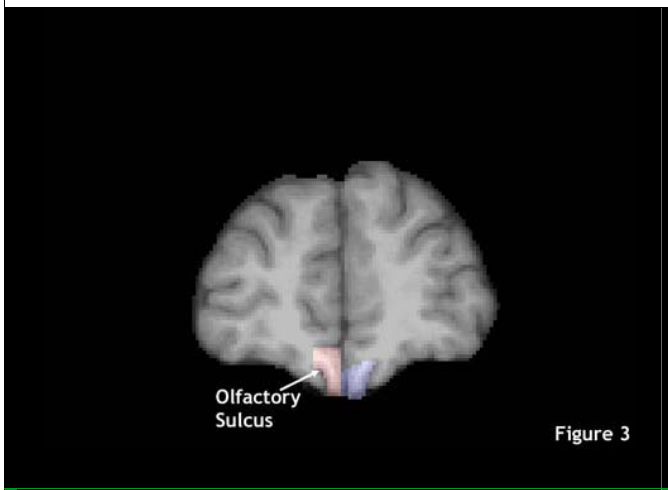


Figure 3

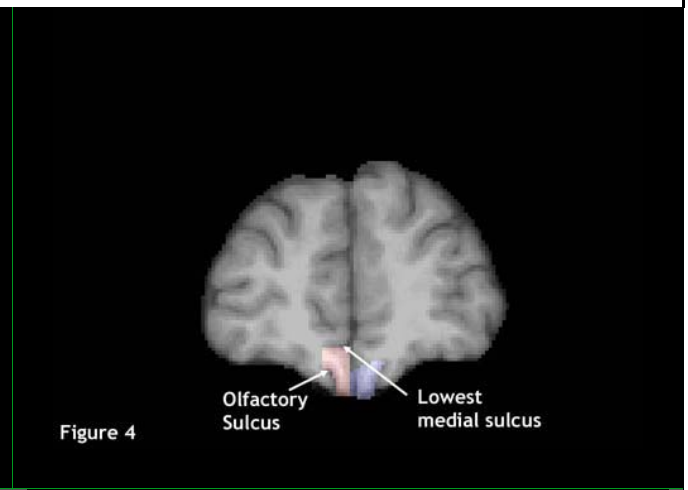


Figure 4

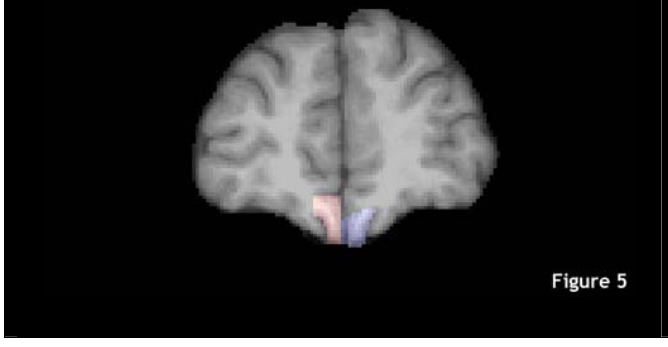


Figure 5

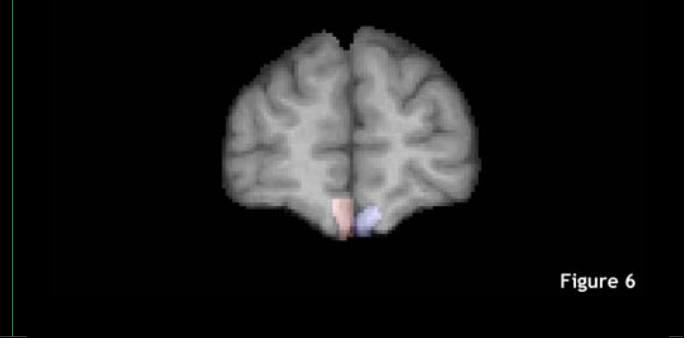


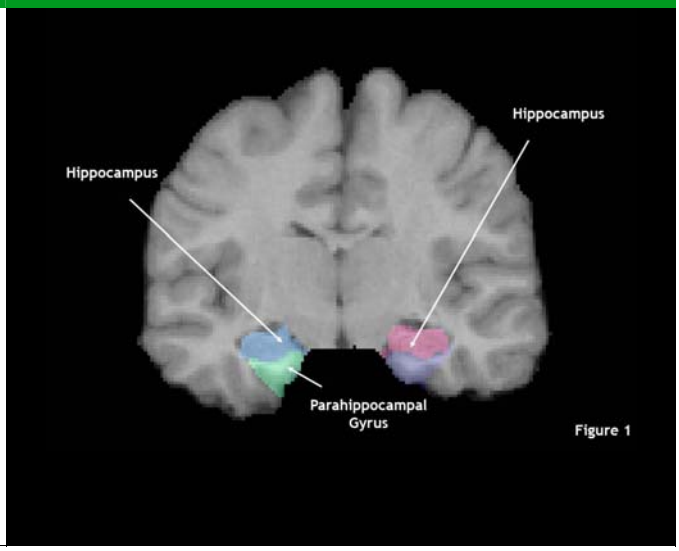
Figure 6

Hippocampus

Step 1

The hippocampus is a gray matter structure in the temporal lobe. It is adjacent to the parahippocampal gyrus. (Fig. 1)

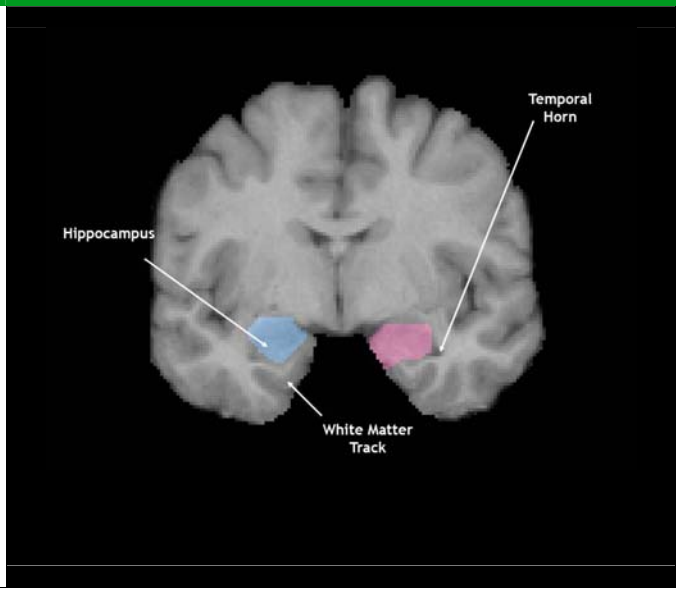
Figure 1



Step 2

Masking of the hippocampus is done in the coronal view. Moving from the anterior end of the brain to the posterior end, begin masking when the temporal horns first appear. Mask all gray matter superior to the white matter track of the parahippocampal gyrus and medial to the temporal horns. This will create a ball like shape. (Fig. 2)

Figure 2

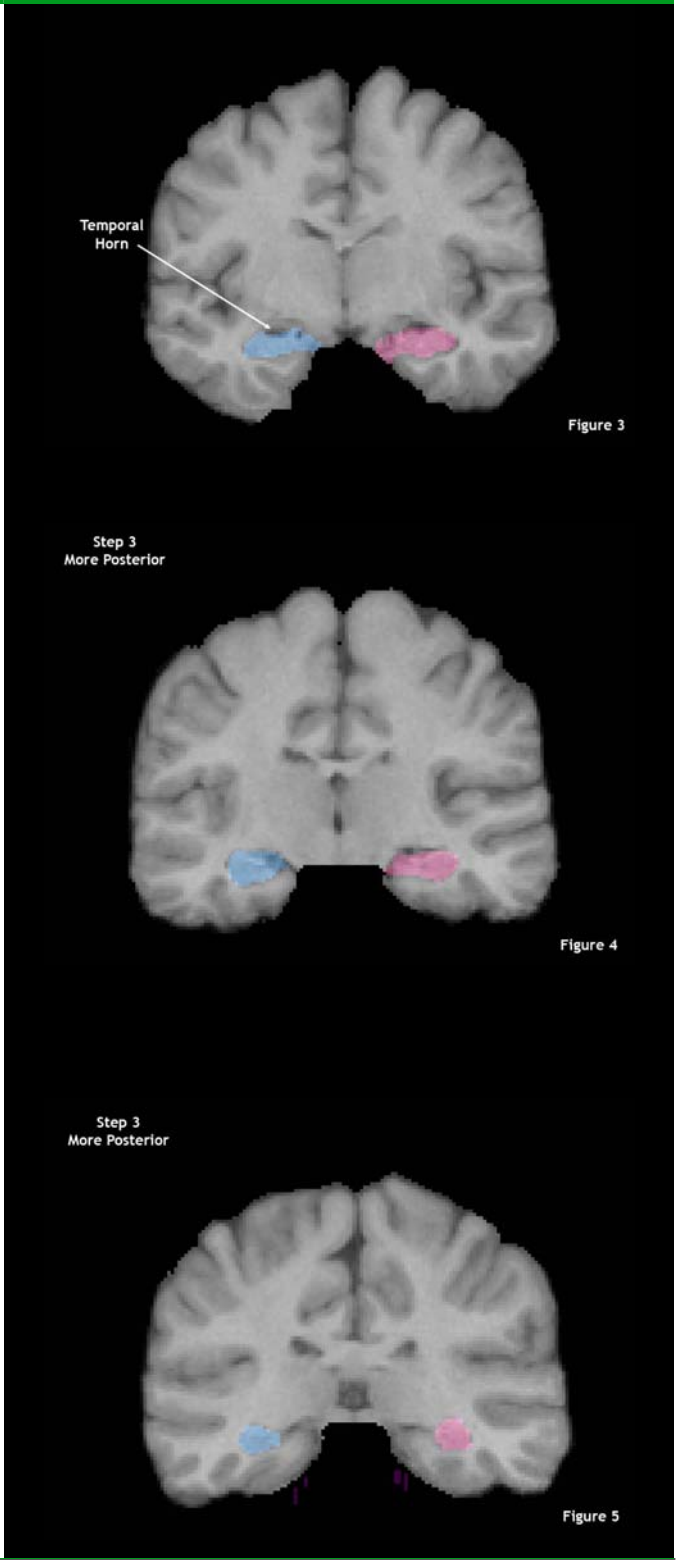


Hippocampus

Step 3

Moving posteriorly, the shape of the hippocampal gyrus will quickly change. The temporal horns will lengthen and the white matter track will become more angled. Continue to follow their shape and color in all gray matter in that area. (Figs. 3, 4, 5)

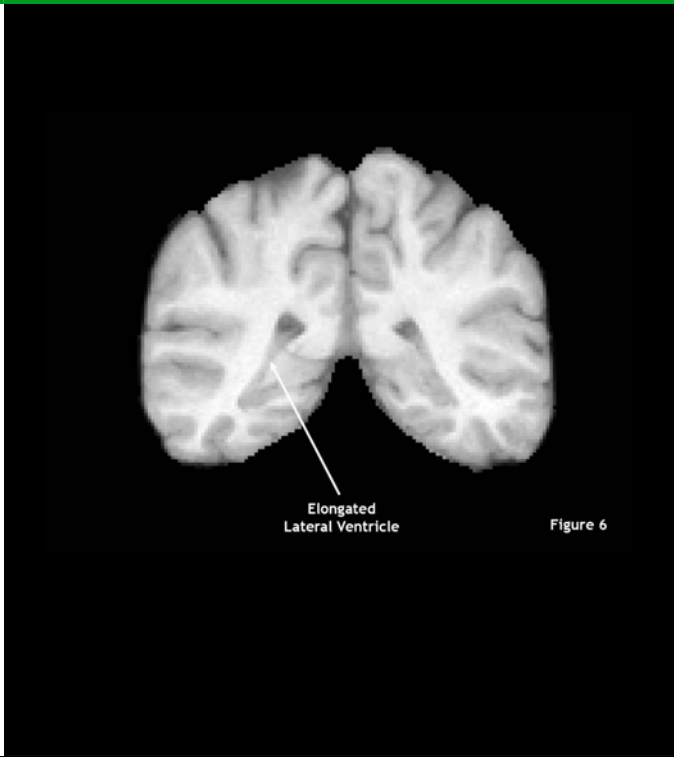
Figures 3 4 & 5



Step 4

Once the lateral ventricles elongate and seem to connect to the gray matter previously masked, end masking.

Figure 6



Inferior Frontal Gyrus

Step 1

The inferior frontal gyrus is bound by the inferior frontal sulcus inferiorly and the precentral sulcus anteriorly. Its inferior lateral boundary is the lateral aspect of the H shaped orbital sulcus. (Fig. 1, Fig. 2)

Figures 1 & 2

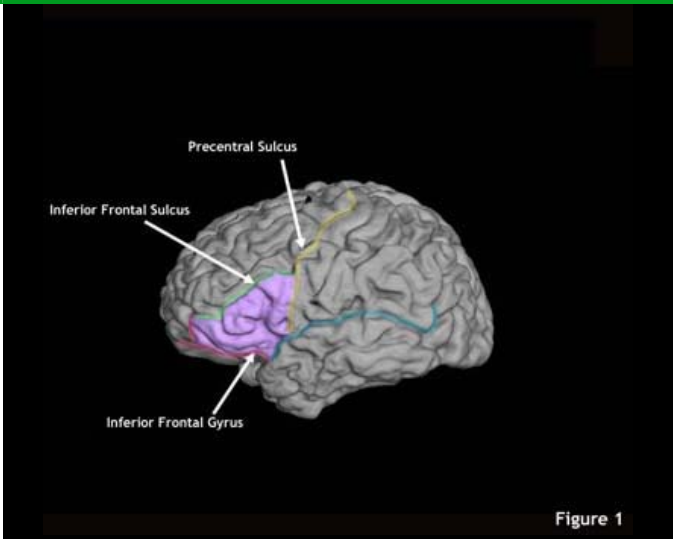


Figure 1

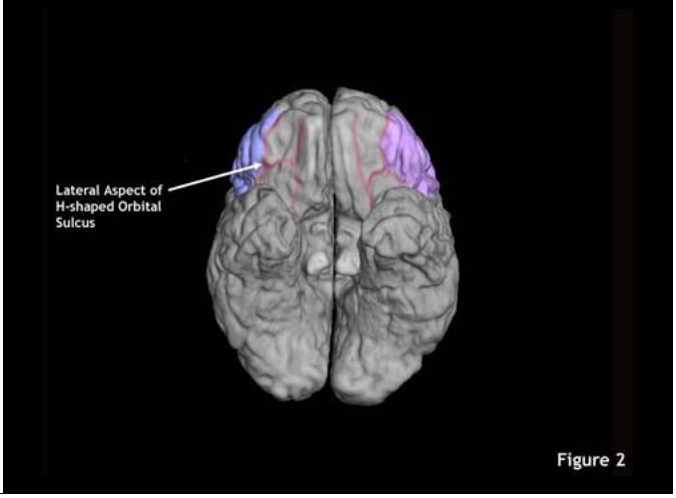


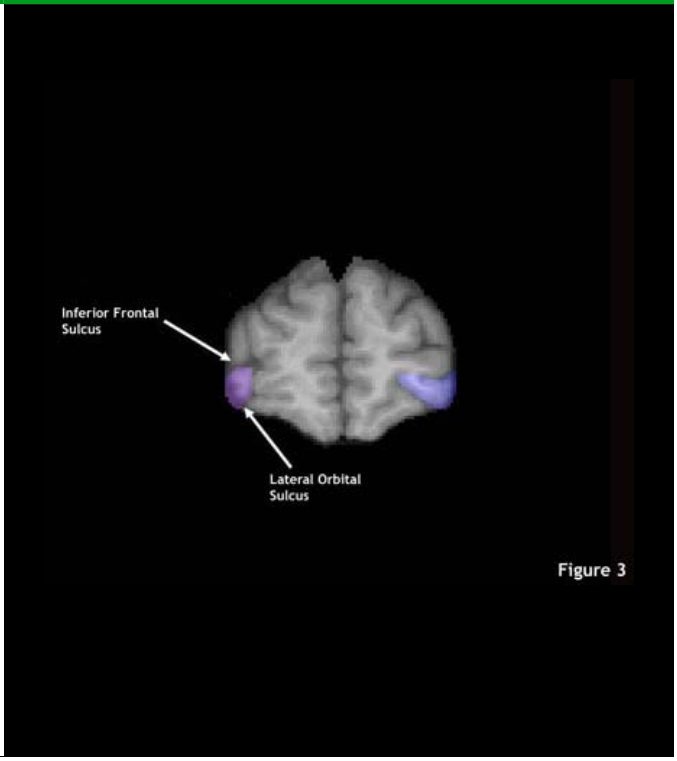
Figure 2

Inferior Frontal Gyrus

Step 2

Masking of the inferior frontal gyrus is done in the coronal view. Begin anteriorly where the lateral orbital sulcus first comes into view. At this point, draw a straight line from the internal end of the lateral orbital sulcus to the internal end of the inferior frontal sulcus. Mask everything within these boundaries. (Fig. 3)

Figure 3

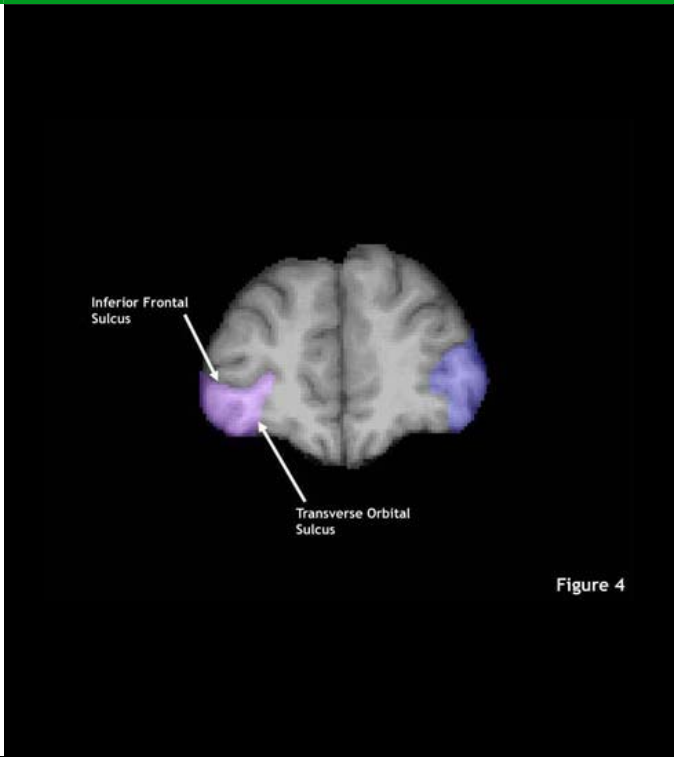


Inferior Frontal Gyrus

Step 3

Moving posteriorly the transverse orbital sulcus will appear soon after step 2. At this point, draw a straight line from the internal end of the transverse orbital sulcus to the internal end of the inferior frontal sulcus. Mask everything within these boundaries. (Fig. 4)

Figure 4

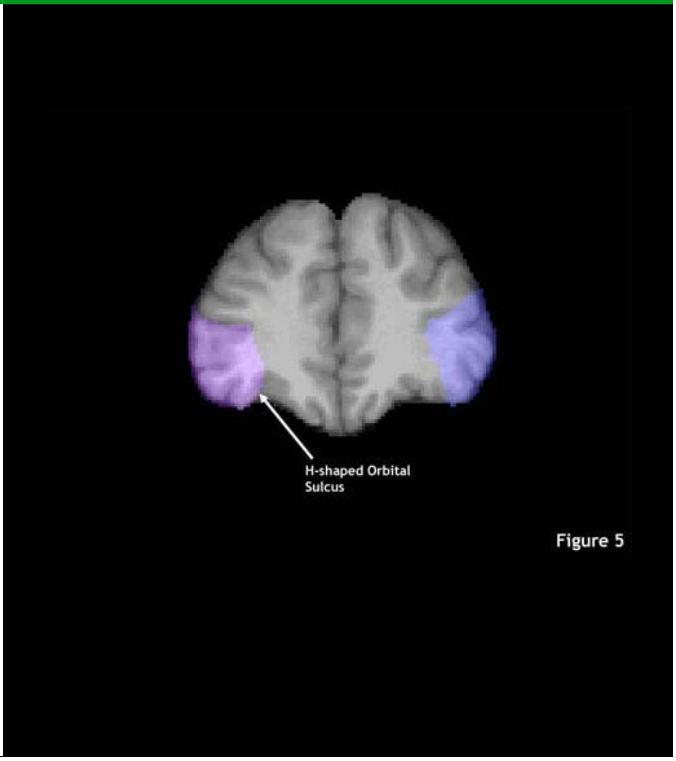


Inferior Frontal Gyrus

Step 4

Moving posteriorly the H-shaped orbital sulcus comes into view. Mask from the lateral segment of the H-shaped orbital sulcus to the inferior frontal sulcus and fill in everything between these two sulci. (Fig. 5)

Figure 5



Inferior Frontal Gyrus

Step 5

Posteriorly, H-shaped orbital sulcus becomes less distinct. At this point, reference the previously masked slice to approximate its location. Draw a straight line between this approximated point and the inferior frontal sulcus. In addition be sure to exclude the temporal pole. Continue this step until the inferior frontal sulcus is no longer visible. (Fig. 6, Fig. 7)

Figures 6 & 7

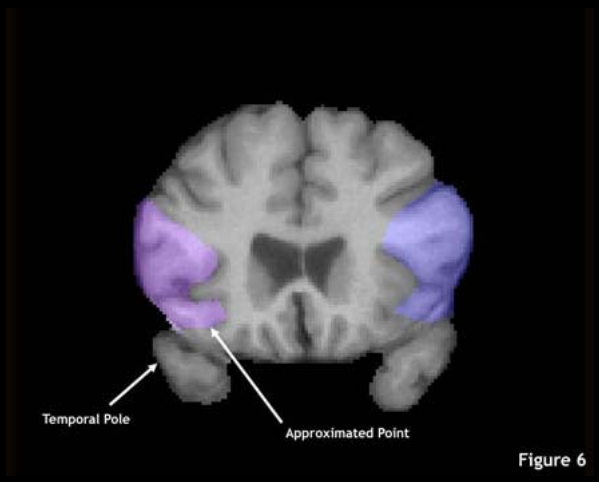


Figure 6

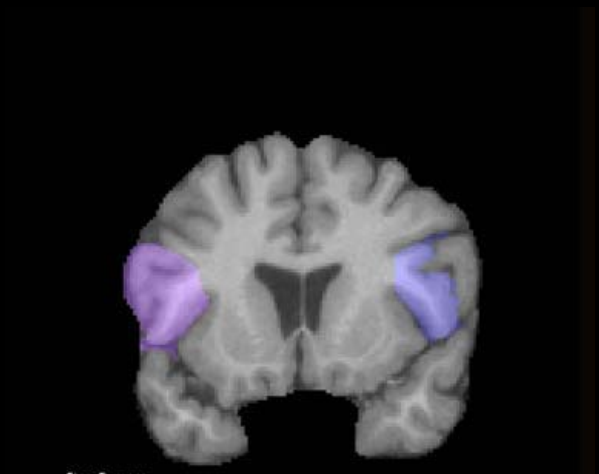


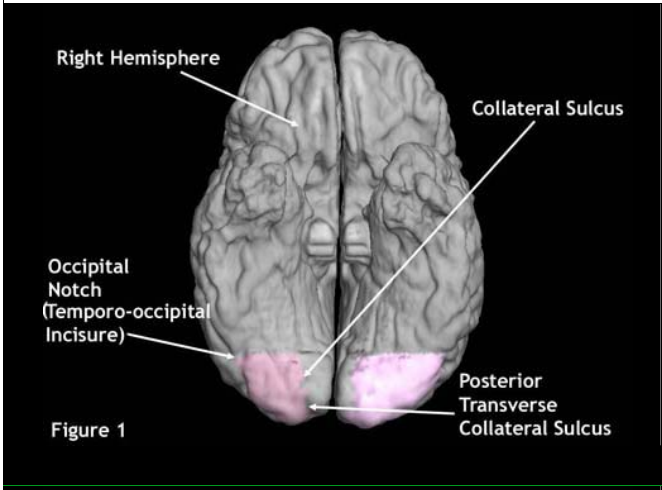
Figure 7

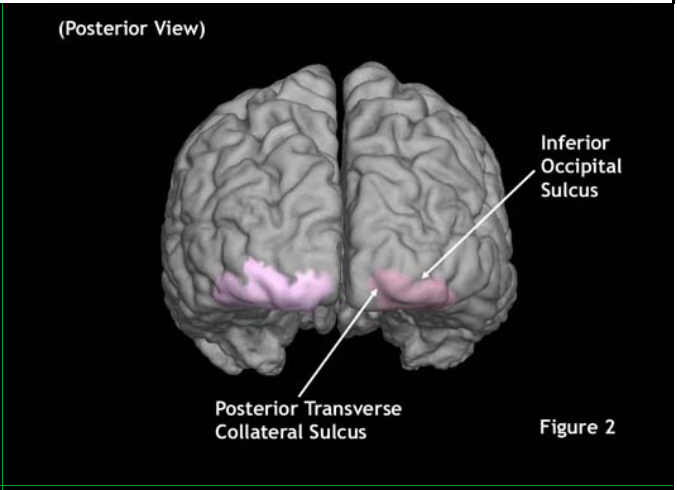
Inferior Occipital Gyrus

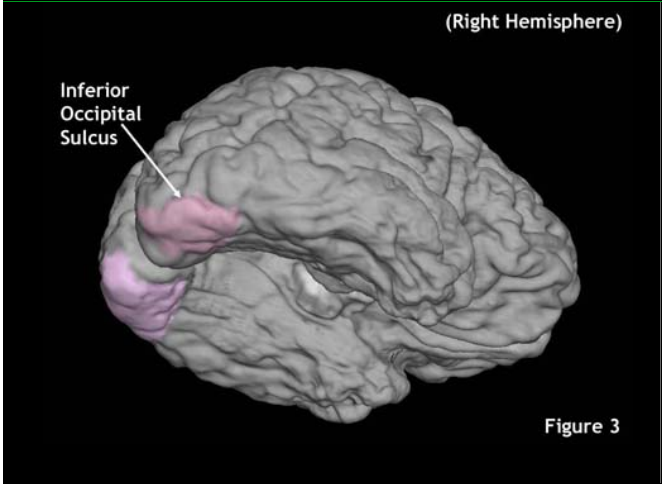
Step 1

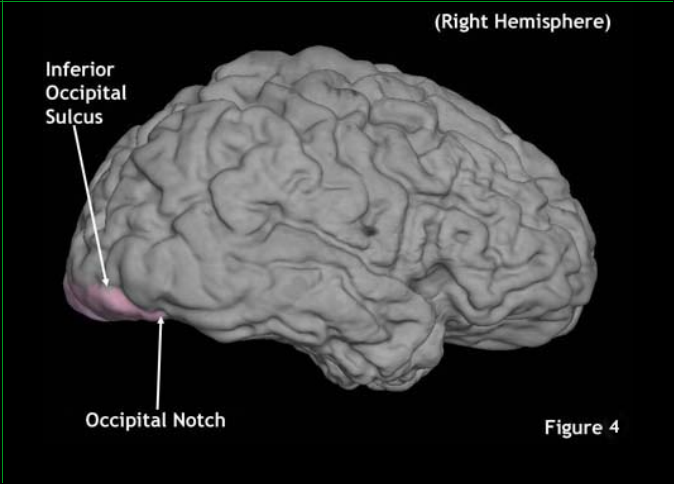
Figures 1 2 3 & 4

The inferior occipital gyrus is bound medially by the collateral sulcus and the posterior transverse collateral sulcus, laterally by the inferior occipital sulcus, and anteriorly by the occipital notch (temporo-occipital notch). A 3D reference model is necessary to delineate the IOG (Fig. 1, Fig. 2, Fig. 3, Fig. 4).







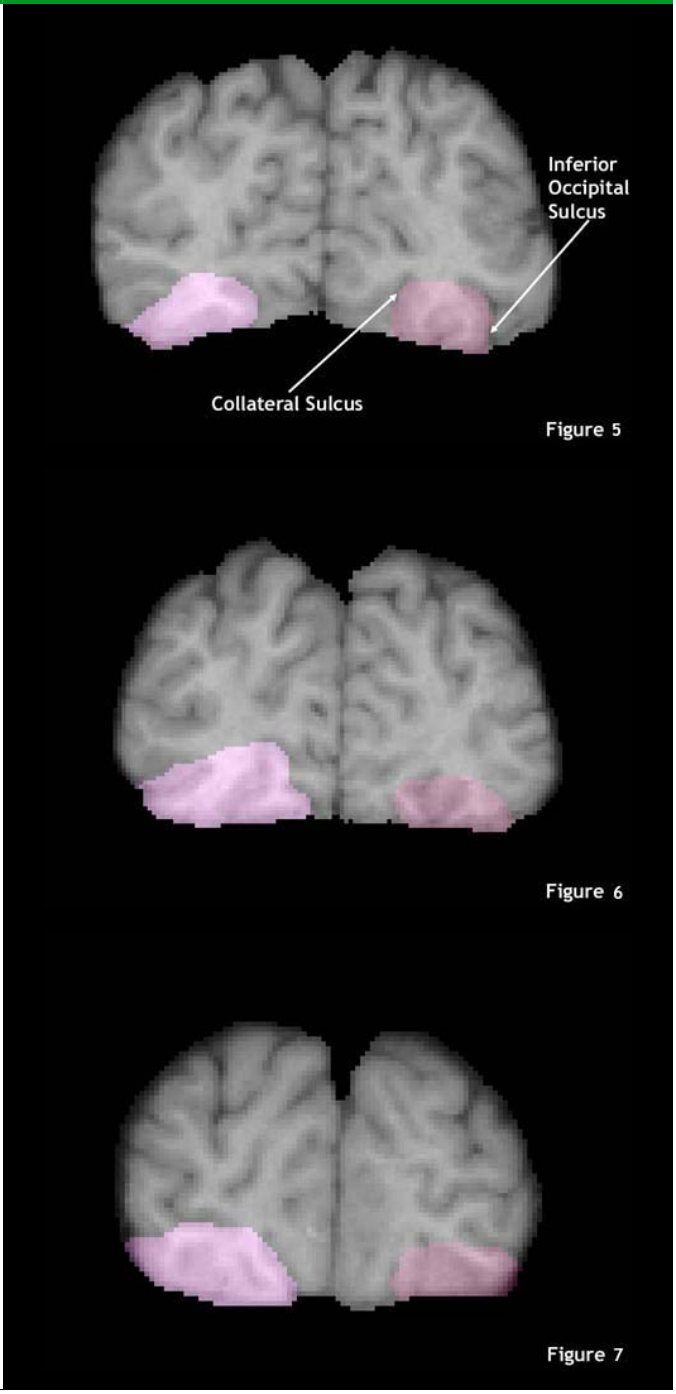


Inferior Occipital Gyrus

Step 2

Mask in the coronal view, starting at a slice that corresponds with the end of the temporo-occipital incisure. This slice can be determined by referencing the 3D model. In the 3D model, click at a point where the temporo-occiptial incisure ends (Fig. 1) and work off of its corresponding coronal slice (Fig. 5). In the coronal view, trace the collateral sulcus it its internal end and cut to the internal end of the inferior occipital sulcus, then completely trace the inferior occipital sulcus. Mask everything within (Fig. 5, Fig. 6, Fig. 7).

Figures 5 6 & 7



Inferior Occipital Gyrus

Step 3

Moving posteriorly, the collateral sulcus becomes the posterior transverse collateral sulcus. When this occurs continue to follow step 2 substituting the posterior transverse collateral sulcus for the collateral sulcus (Fig. 8, Fig. 9). Continue this step until the posterior transverse collateral sulcus is no longer visible.

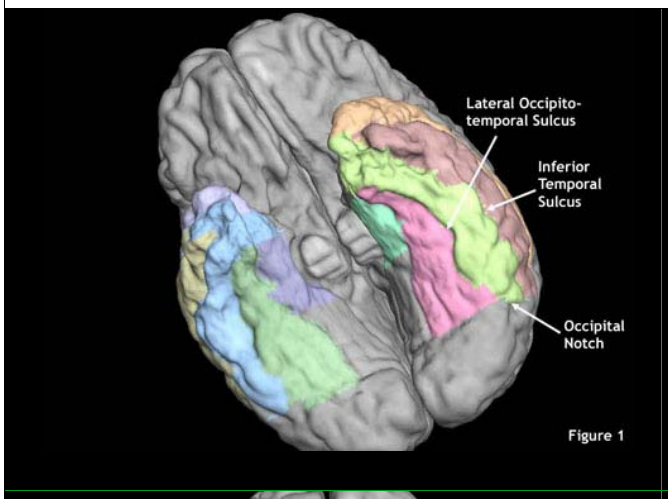
Figures 8 & 9

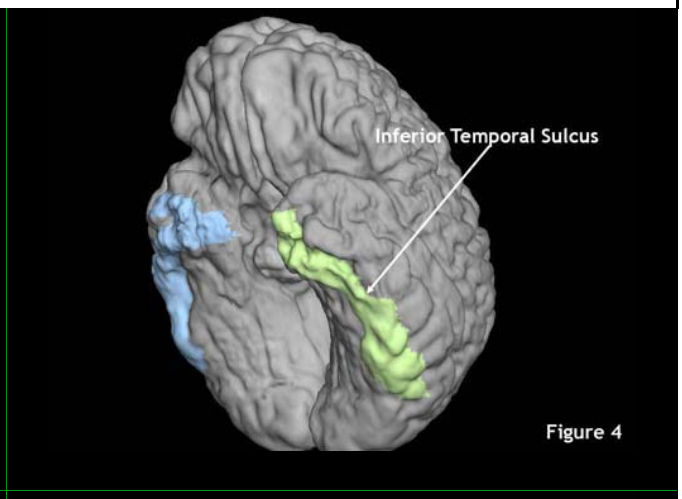
Inferior Temporal Gyrus

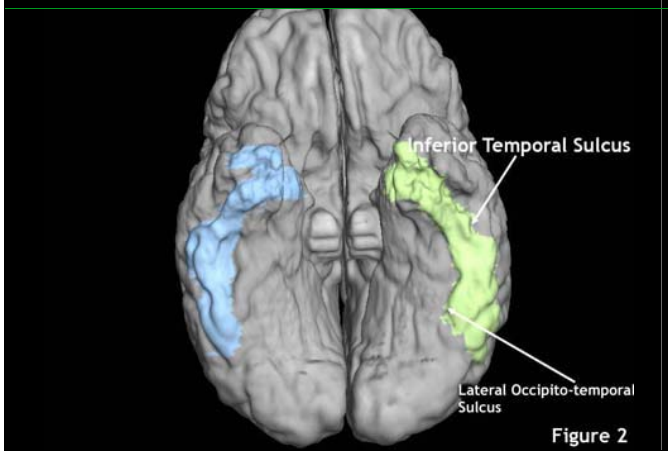
Step 1

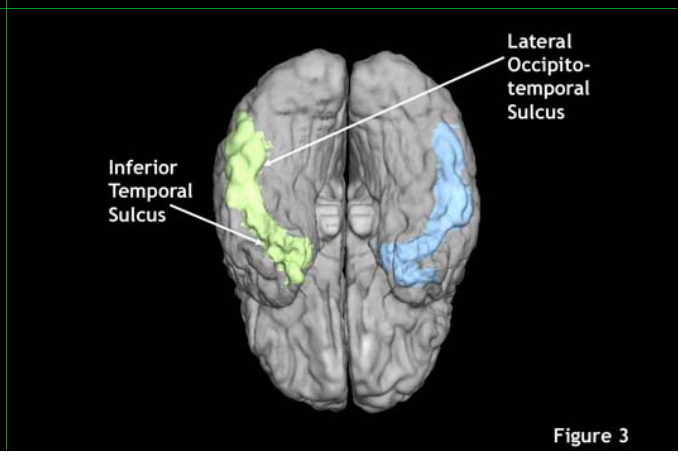
Figures 1 2 3 & 4

The inferior temporal gyrus is parallel to the superior temporal gyrus and the middle temporal gyrus. The superior boundary of the inferior temporal gyrus is inferior temporal sulcus and inferior boundary is the lateral occipito-temporal sulcus. The anterior end is where the lateral occipito-temporal sulcus and the inferior temporal sulcus meet. The posterior end is quite variable but is generally found where the inferior temporal sulcus ends, near the occipital notch. A 3D object is helpful in finding these boundaries. Where the two sulci are unclear make sure that the width of the gyrus is fairly consistent. (Fig. 1, Fig. 2, Fig. 3, Fig. 4)









Inferior Temporal Gyrus

Step 2

Begin masking in the coronal view where the lateral occipito-temporal sulcus and inferior temporal sulci meet. Mask everything between these two boundaries. Continue masking until the inferior temporal sulcus is no longer visible. (Fig. 5, Fig. 6, Fig. 7)

Figures 5 6 & 7

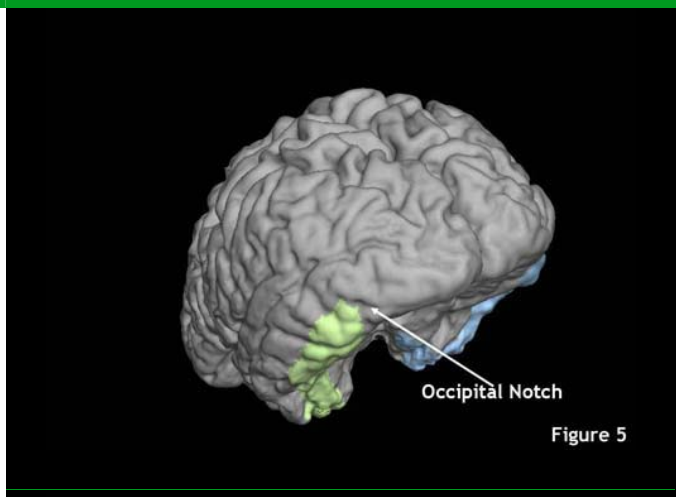


Figure 5

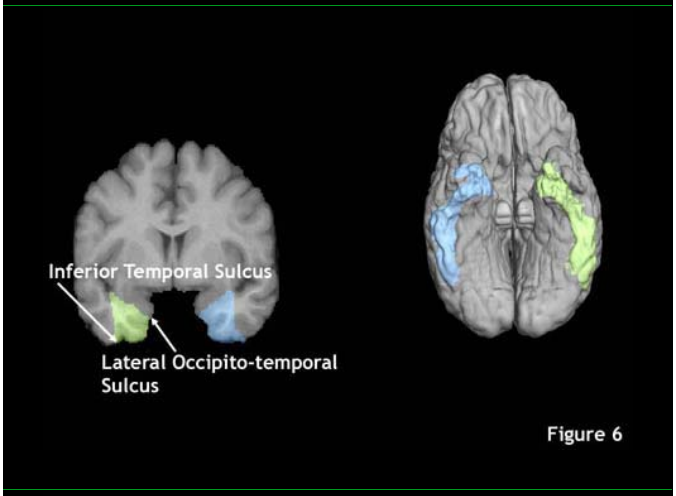


Figure 6

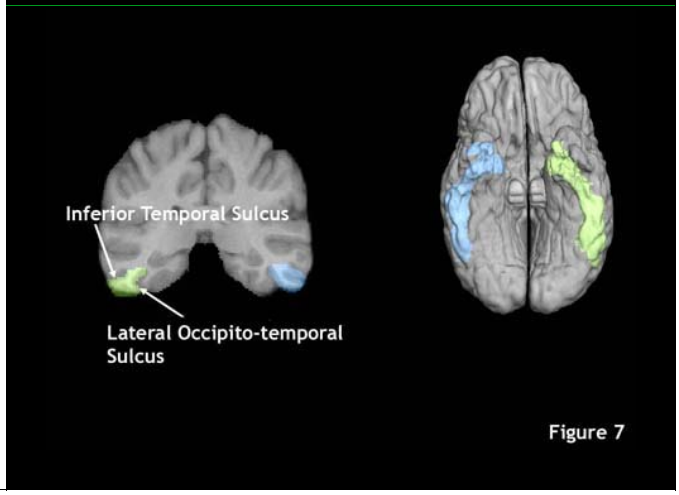


Figure 7

Lateral Orbitofrontal Gyrus

Step 1

This protocol relies on a previously masked inferior frontal gyrus. (See protocol for IFG.) It also assumes that the BrainSuite software is being used.

The lateral orbitofrontal gyrus is at the anterior end of the brain and consists of the inferior aspect of the inferior frontal gyrus (IFG). Its superior boundary is the lateral orbital sulcus and its posterior boundary is where the IFG meets temporal pole. Its medial boundary is the lateral segment of the H-shaped orbital sulcus. Because the lateral orbitofrontal gyrus is the inferior aspect of the IFG, it is useful to first label the inferior frontal gyrus. Masking of the lateral orbitofrontal gyrus is done in the coronal view. (Fig. 1, Fig. 2)

Figures 1 & 2

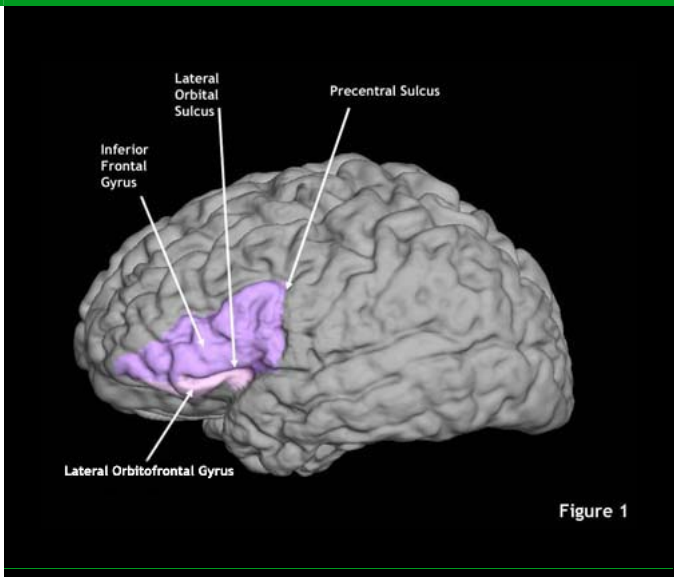


Figure 1

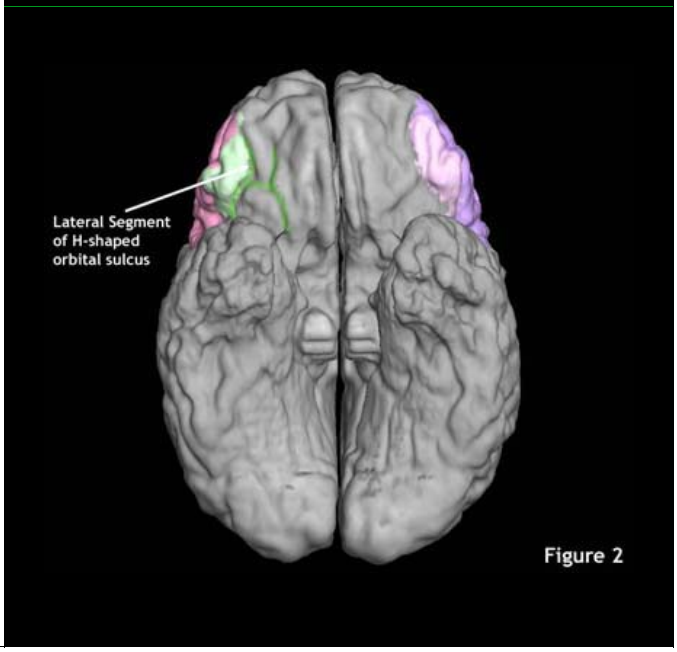


Figure 2

Lateral Orbitofrontal Gyrus

Step 2

First, the superior boundary must be defined. Using a 3D object model, orient the brain so that the anterior pole is lined up in a coronal position. Click on the point where the 3d object peaks upward laterally (Fig. 3). (Looking from the medial end of a hemisphere to the lateral end, the brain will curve up once, then go down again, then curve up again. The second curve upward is where the brain should be clicked). After double clicking on the correct spot, switch to the corresponding slice in the axial view. Fill in the preexisting IFG mask on that slice. (Fig. 3, Fig. 4).

Figures 3 & 4

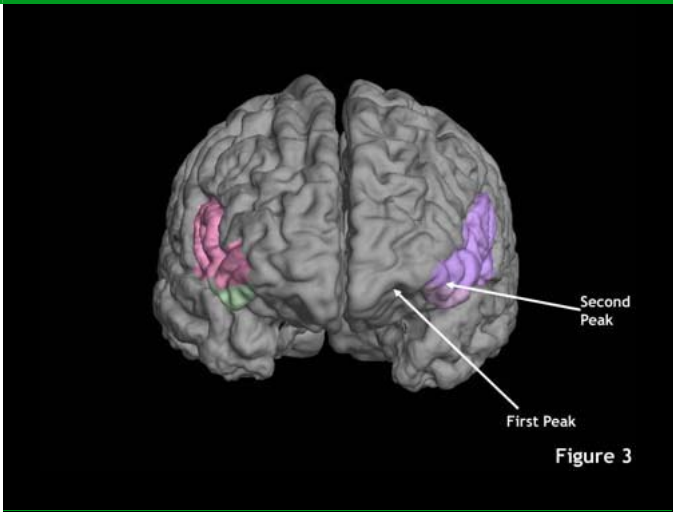


Figure 3

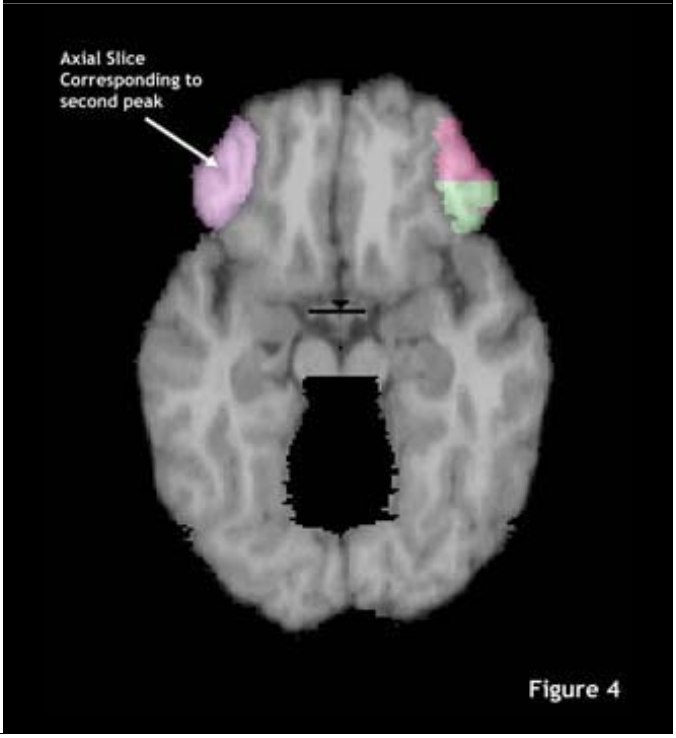


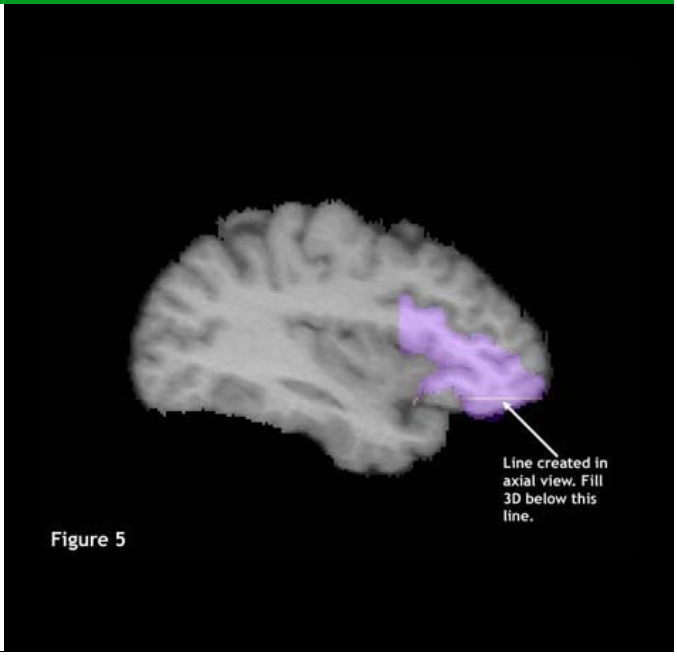
Figure 4

Lateral Orbitofrontal Gyrus

Step 3

After filling the axial view, switch to the corresponding slice in the sagittal view. There should be a horizontal line demarcated from the masking done in the axial view (Fig. 5). Color the area below the line for all sagittal slices. (In BrainSuite click below the line on any slice and fill 3D.) This will set the general boundaries for the structure.

Figure 5



Lateral Orbitofrontal Gyrus

Step 4

Switch to the coronal view and begin at the most anterior slice of the mask created in the previous slices. Moving posteriorly, when the lateral orbital sulcus first comes into view mask it to its internal end. From there mask a straight line out to the boundary of the inferior frontal gyrus (Fig. 6, Fig. 7).

Figures 6 & 7

Figure 6

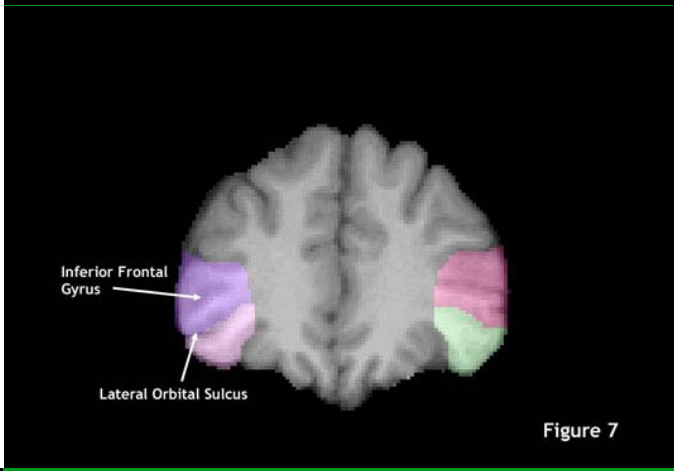


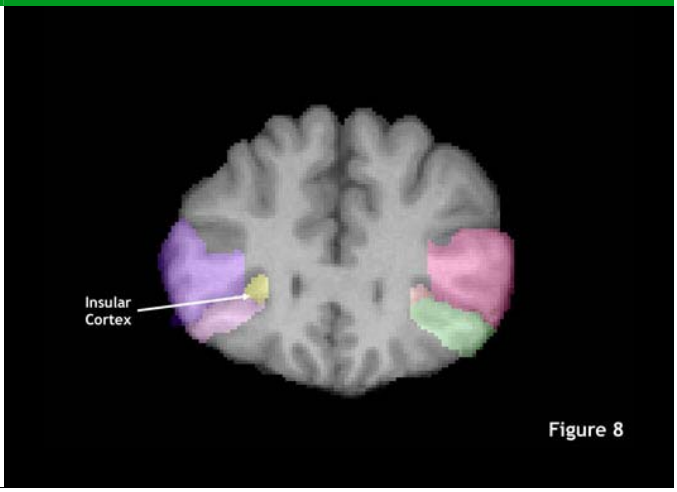
Figure 7

Lateral Orbitofrontal Gyrus

Step 5

Moving posteriorly, the insular cortex will emerge around the slice that the ventricles emerge. At this point, be careful to exclude all insular cortex. (Fig. 8)

Figure 8



Lingual Gyrus

Step 1

The lingual gyrus is located on the inferior aspect of the brain. The anterior boundary of the lingual gyrus is denoted by the posterior endpoint of the corpus callosum; the inferior boundary of the gyrus is the collateral sulcus and the superior boundary is the calcarine fissure. The lingual gyrus ends at the junction of the calcarine fissure and the posterior transverse collateral sulcus at the most posterior point of the brain. (Fig. 1, Fig. 2, Fig. 3)

Figures 1 2 & 3

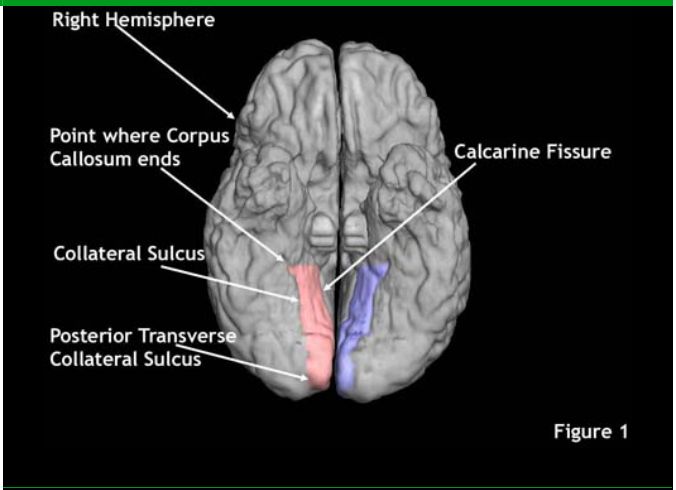


Figure 1

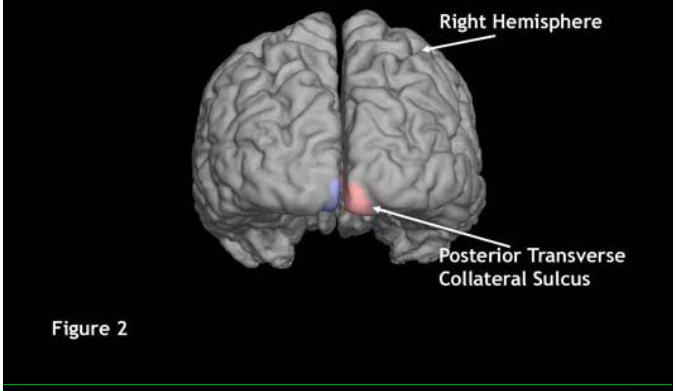


Figure 2

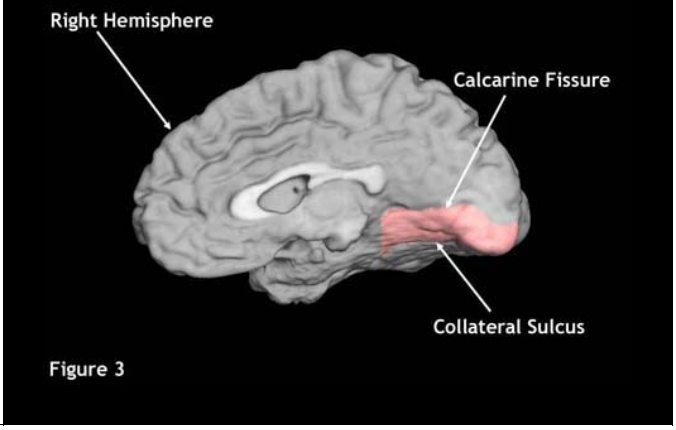


Figure 3

Lingual Gyrus

Step 2

Begin masking the lingual gyrus in the coronal view once the corpus callosum ends (Fig. 4, Fig. 5). Mask the collateral sulcus to its internal end point, then draw a straight line to the internal endpoint of the calcarine fissure. Follow the calcarine fissure to its lateral end, and include all matter within these boundaries.

Figures 4 & 5

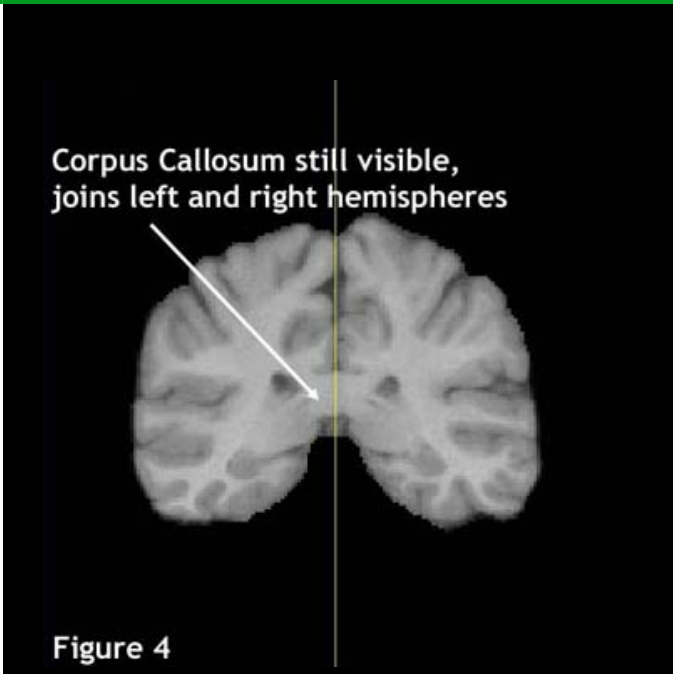


Figure 4

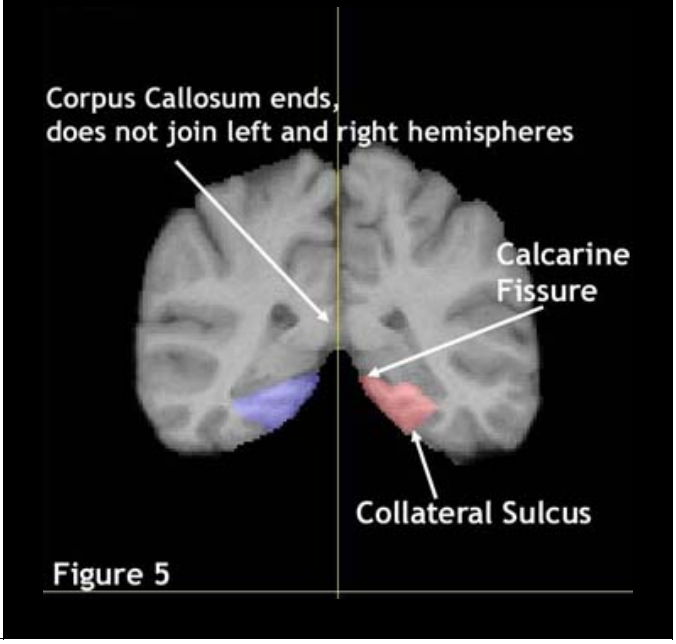


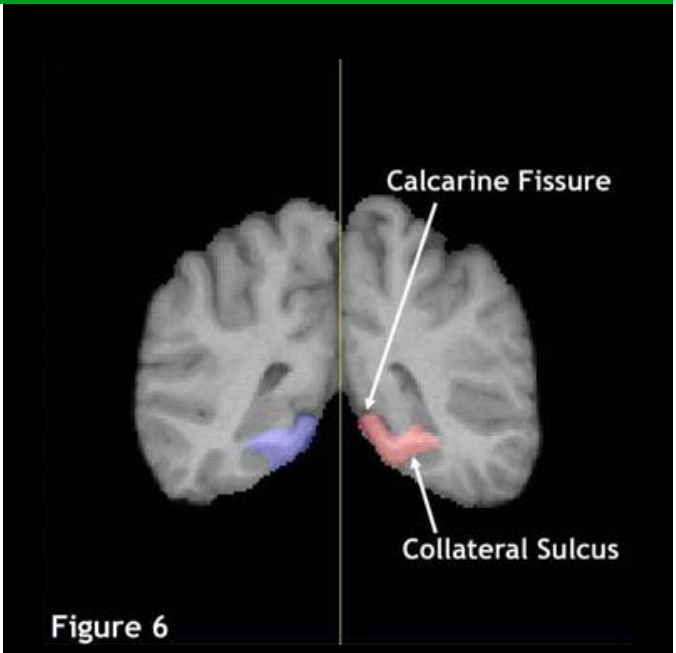
Figure 5

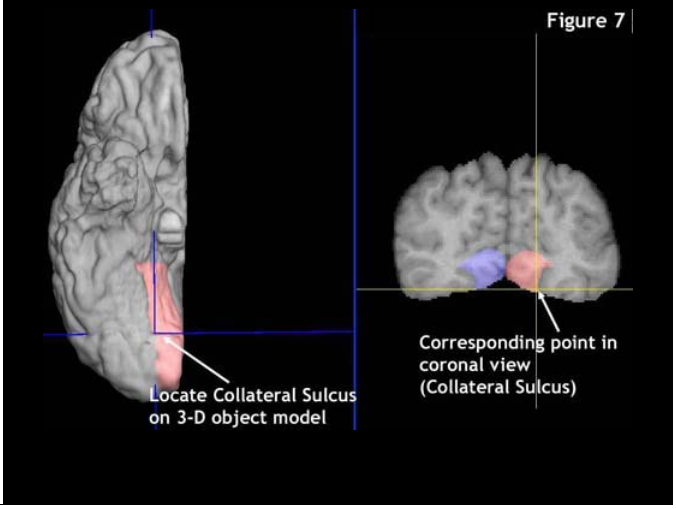
Lingual Gyrus

Step 3

Moving posteriorly, the collateral sulcus becomes difficult to see. At this point, it is useful to reference the 3D object model to find the collateral sulcus. If the collateral sulcus is difficult to differentiate even in the 3D object model, rely on the symmetry of the lingual gyrus in the left and right hemispheres. (Fig. 6, Fig. 7)

Figures 6 & 7





Lingual Gyrus

Step 4

At the posterior end of the brain, the posterior tranverse collateral sulcus becomes visible. At this point mask the posterior transverse collateral sulcus to its internal endpoint and draw a straight line to the internal endpoint of the calcarine fissure. Fill in everything within these boundaries and the interhemispheric fissure. Continue this step until reaching the posterior end of the brain. (Fig. 8, Fig. 9)

Figures 8 & 9

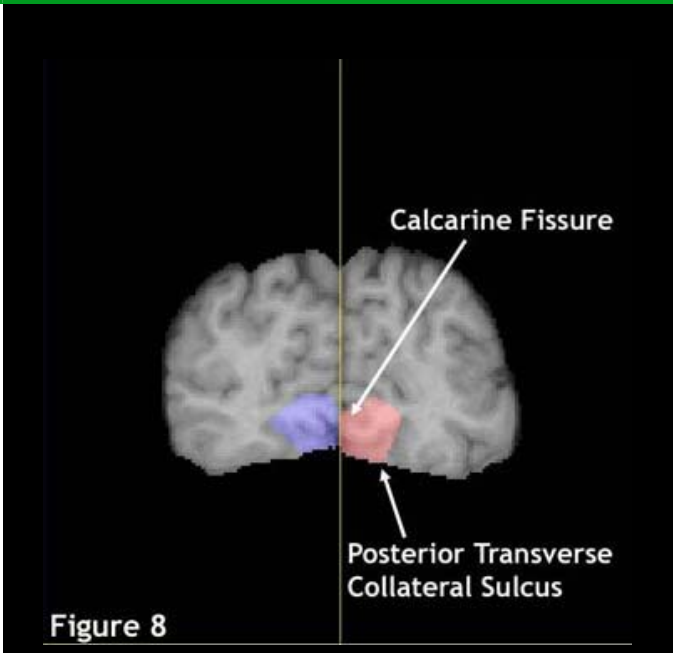


Figure 8

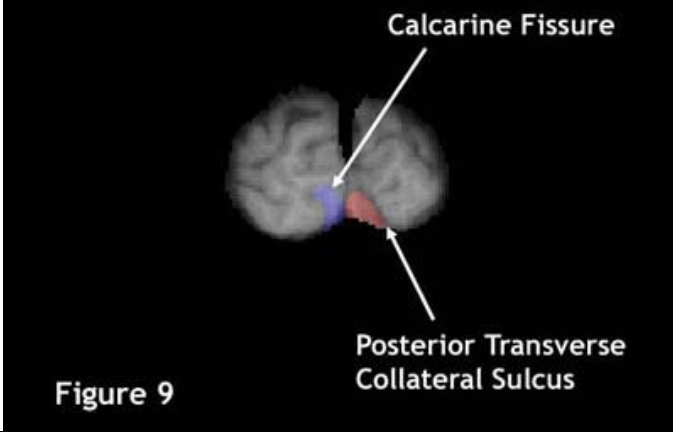


Figure 9

Middle Frontal Gyrus

Step 1

The middle frontal gyrus (MFG) is part of the frontal lobe. The MFG's posterior boundary is the precentral sulcus. The MFG extends anteriorly to the brain's anterior end and curves downward until reaching the temporal lobe. Superiorly, its medial boundary is the superior frontal sulcus, and its lateral boundary is the inferior frontal sulcus. (Fig. 1, Fig. 2, Fig. 4, Fig. 5) Inferiorly, the H-shaped orbital sulcus bounds the MFG both laterally and medially (Fig. 3).

Figures 1 2 & 3

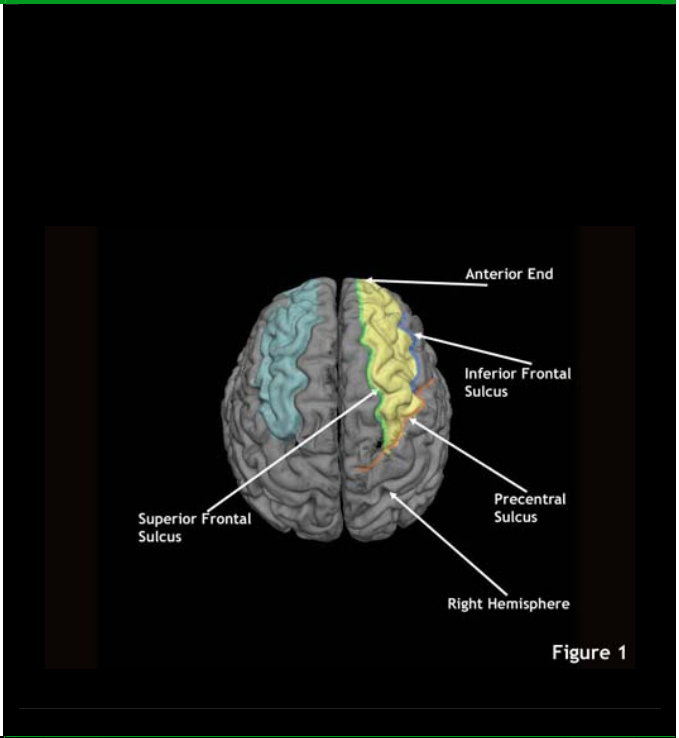


Figure 1

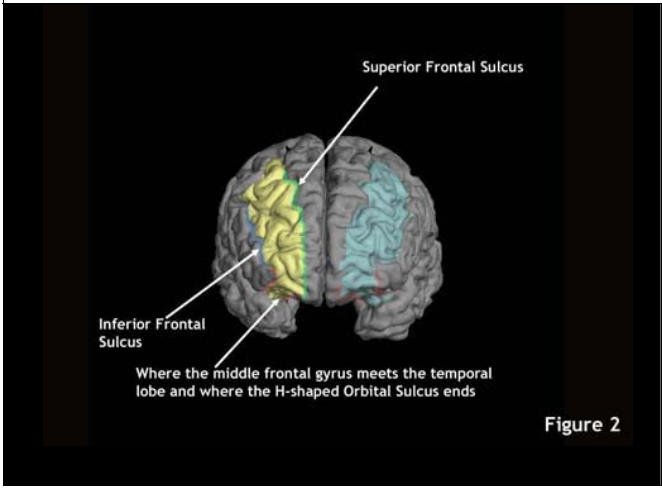


Figure 2

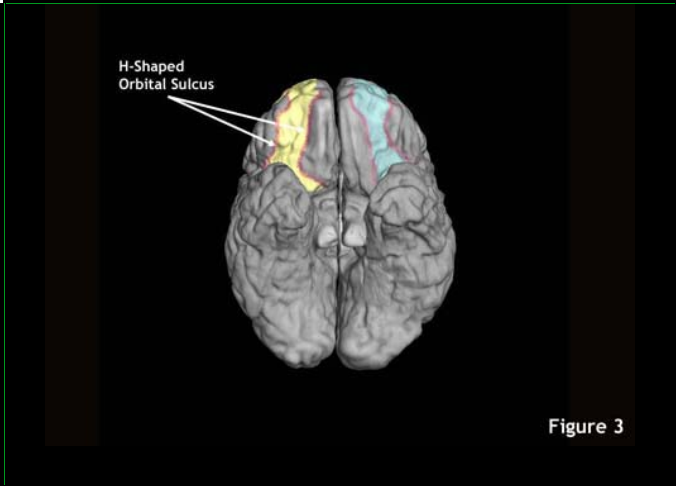


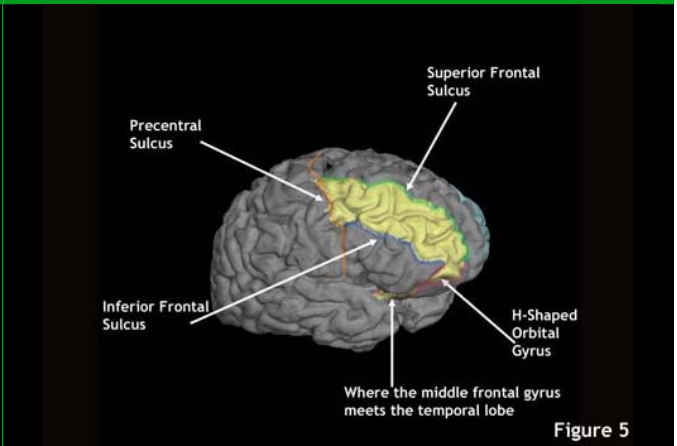
Figure 3

(Protocol refers to images in the right hemisphere)

Middle Frontal Gyrus

Step 1 (continued)

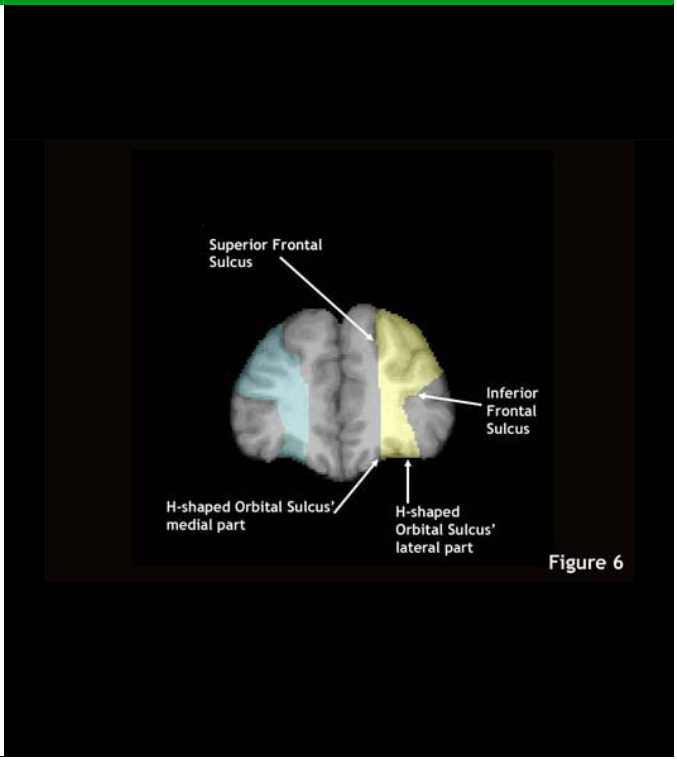
Figures 4 & 5



Step 2

Masking of the MFG is done in the coronal view. Start at an anterior slice where the superior frontal sulcus, the inferior frontal sulcus and the H-shaped orbital sulcus are well defined and when no ventricles are present. To help find this starting slice, reference a 3D object model and locate any of the aforementioned sulci then click on its location on the 3D object to confirm its location on the corresponding coronal slice. (Fig. 6)

Figure 6

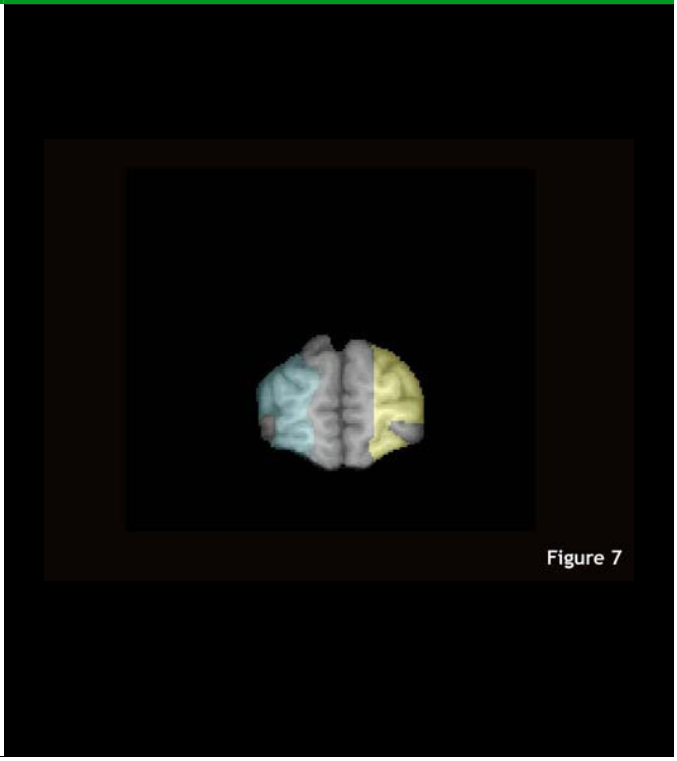


Middle Frontal Gyrus

Step 3

Once a starting slice is determined, trace the superior frontal sulcus to its internal endpoint and cut straight to the internal end of the H-shaped orbital sulcus' medial part. Next trace the inferior frontal sulcus to its internal end and cut to the internal end of the H-shaped orbital sulcus' lateral part. Mask the area between these boundaries. If any boundaries are ambiguous, rely on maintaining a consistent gyrus width. Continue this step moving anteriorly. (Figure 6, 7)

Figure 7



Middle Frontal Gyrus

Step 4

Anteriorly, the MFG's lateral boundaries disappear and the medial boundaries become less distinct. When the superior frontal sulcus and the medial H-shaped orbital boundary are unclear, reference the previously masked slice to approximate their locations. Once locations are approximated, connect the superior and inferior medial boundaries by drawing a straight line between them. Mask everything between the created medial boundary and the lateral end of the brain. Continue still step until reaching the anterior end of the brain. (Fig. 8, Fig. 9)

Figures 8 & 9

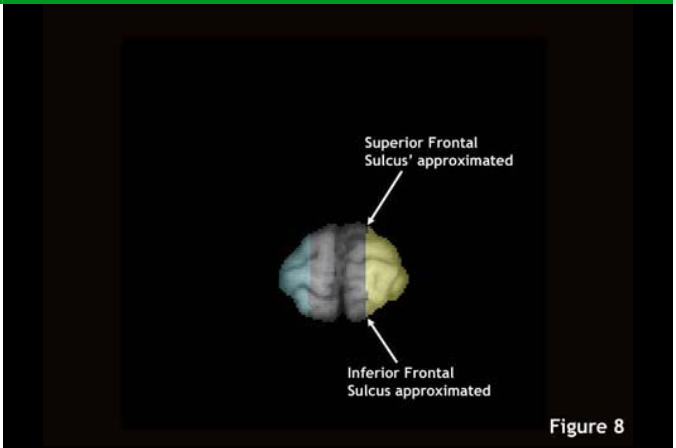


Figure 8

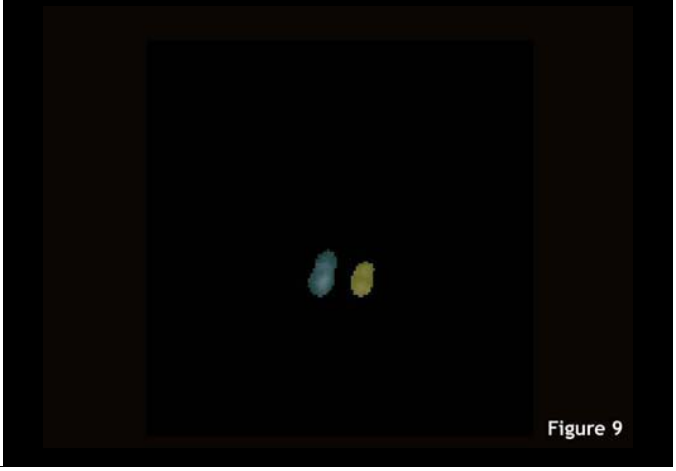


Figure 9

Middle Frontal Gyrus

Step 5

To mask the MFG's posterior portion, return to the first masked slice. Moving posteriorly, continue to follow step 3 until the ventricles start to emerge. At this point the MFG is masked as two regions. Follow the superior frontal sulcus to its internal end and draw a straight line to the internal end of the inferior frontal sulcus. Mask the area within these boundaries. Next, trace the lateral part of the H-shaped orbital sulcus to its internal end and draw a straight line to the internal end of the medial part of the H-shaped orbital sulcus. Mask the area within these boundaries. Continue this step until the H-shaped orbital sulcus no longer exists. (Fig. 6, Fig. 10, Fig. 11)

Figures 10 & 11

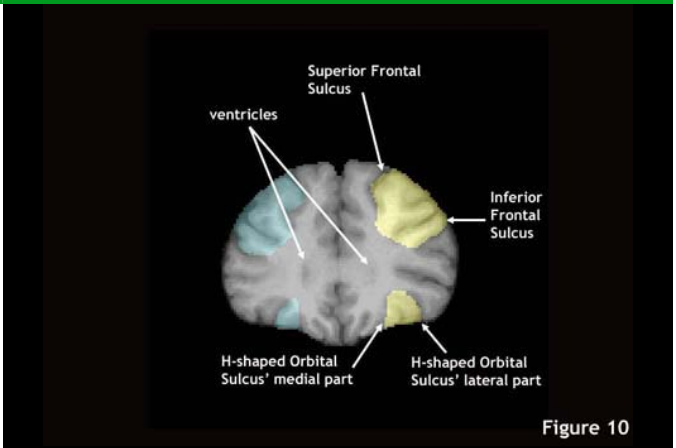


Figure 10

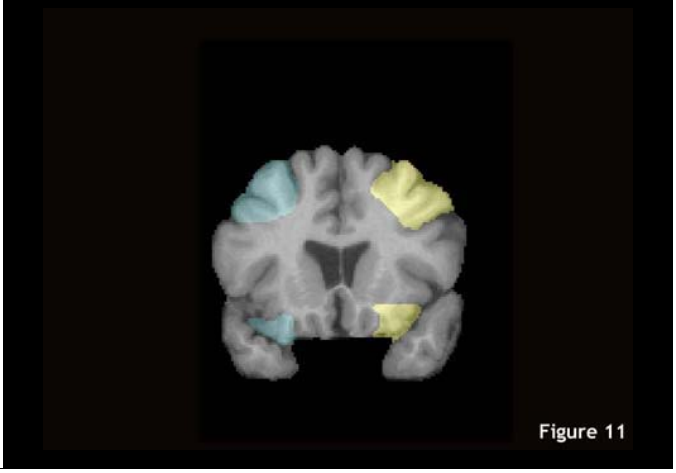


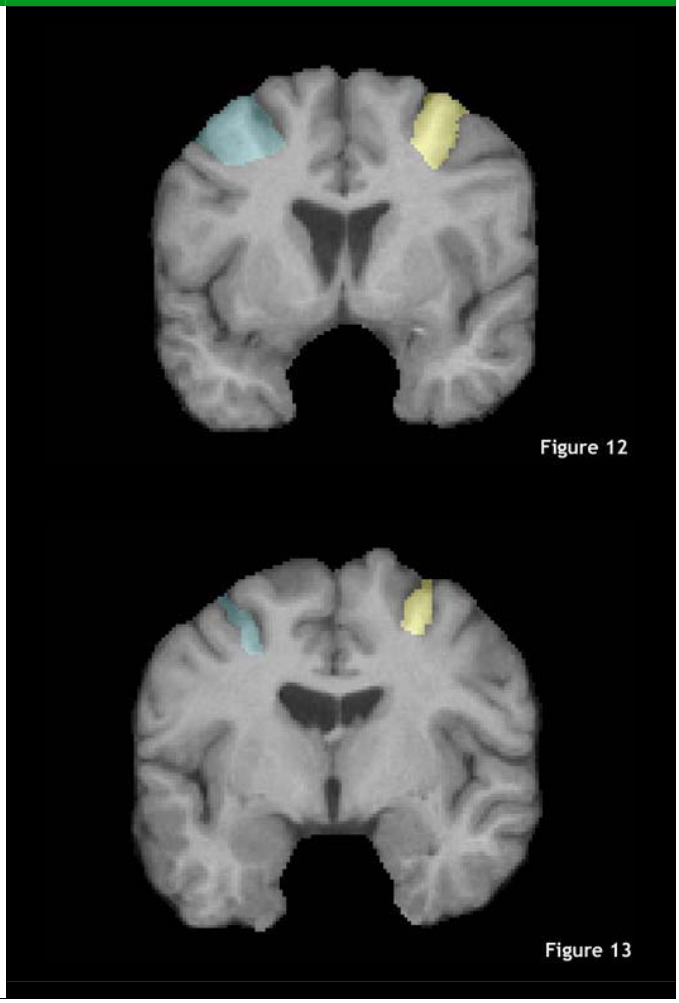
Figure 11

Middle Frontal Gyrus

Step 6

When the MFG meets the temporal lobe, the H-shaped orbital sulcus also ends. This point can be confirmed by clicking on the anterior end of the temporal lobe on the 3D object model and looking at the corresponding coronal slice. When the H-shaped orbital sulcus disappears, the MFG is once again masked as one region. Follow the superior frontal sulcus to its internal end and draw a straight line to the internal end of the inferior frontal sulcus. Mask the area within these boundaries. Continue this step until reaching the precentral sulcus or the precentral gyrus if it has been masked prior to the middle frontal gyrus. (Fig. 12, Fig. 13)

Figures 12 & 13

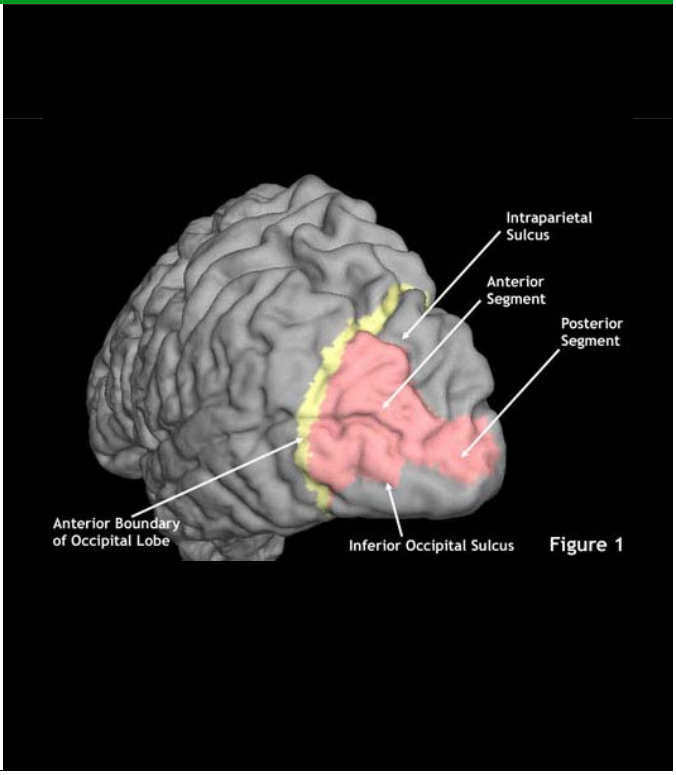


Middle Occipital Gyrus

Step 1

The middle occipital gyrus is the largest gyrus in the occipital lobe whose anterior boundary is the anterior boundary of the occipital lobe. The gyrus can be described as having two segments, an anterior and a posterior segment. The anterior segment is bound by the intraparietal sulcus superiorly and the inferior occipital sulcus inferiorly. The posterior segment's superior boundary is defined by the intra-parietal sulcus, and its inferior boundary is defined by the location of the inferior occipital sulcus as found in the anterior segment of the gyrus. (Fig. 1)

Figure 1

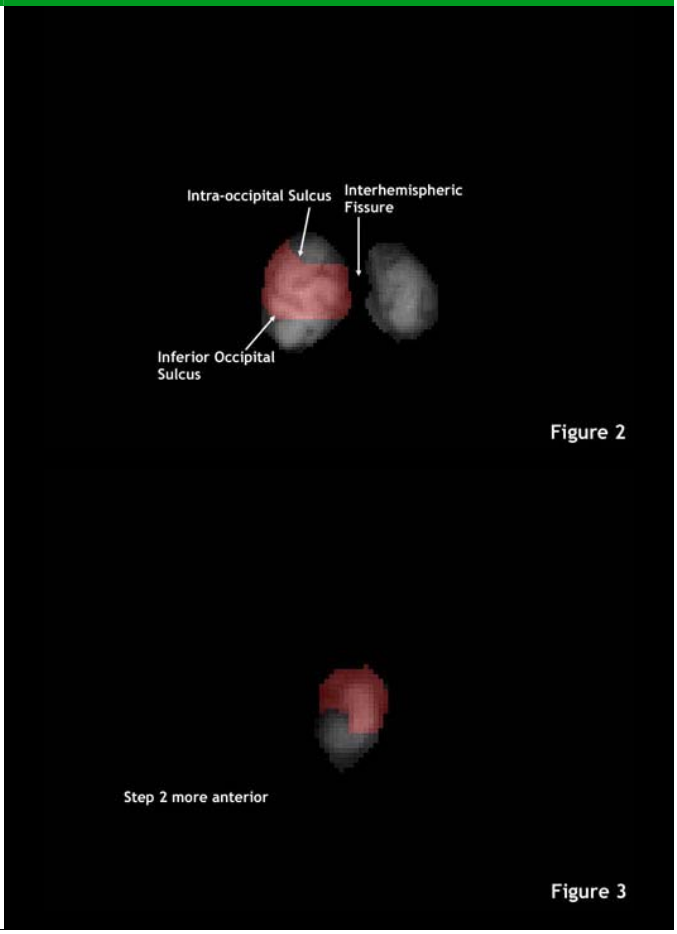


Middle Occipital Gyrus

Step 2

Delineation of the middle occipital gyrus is done in the coronal view. Begin masking posteriorly, where the intra-occipital sulcus and the inferior occipital sulcus first come into view. Follow the intra-occipital sulcus to its internal end and draw a straight line out to the interhemispheric fissure. Secondly, follow the inferior occipital sulcus to its internal end and draw a straight line out to the interhemispheric fissure. Mask everything within these boundaries. Continue this step to the posterior end of the brain. (Fig. 2, Fig. 3)

Figures 2 & 3



Step 3

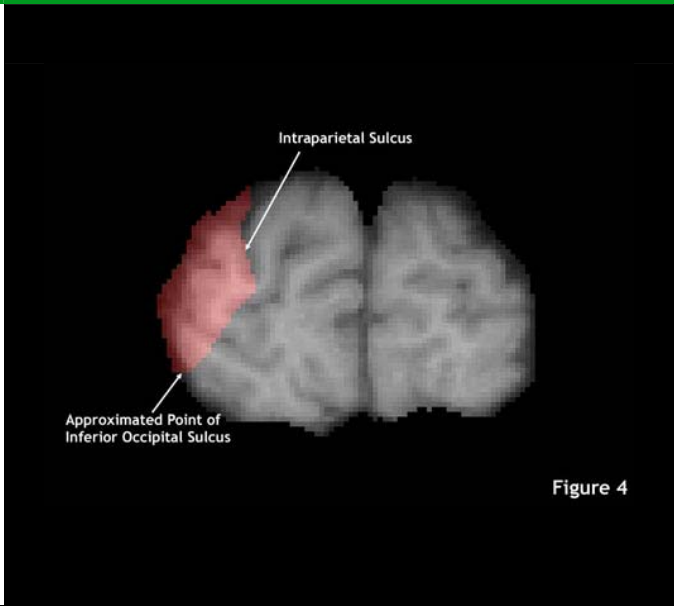
Locate the first slice masked, and continue step 2 moving anteriorly. If the inferior occipital sulcus becomes unclear, reference the last slice where the sulcus was clear and approximate its location on the following slices.

Middle Occipital Gyrus

Step 4

Moving anteriorly, the intra-occipital sulcus becomes the intraparietal sulcus. Mask an angled line from the intraparietal sulcus down to the inferior occipital sulcus, and fill in everything within these boundaries.

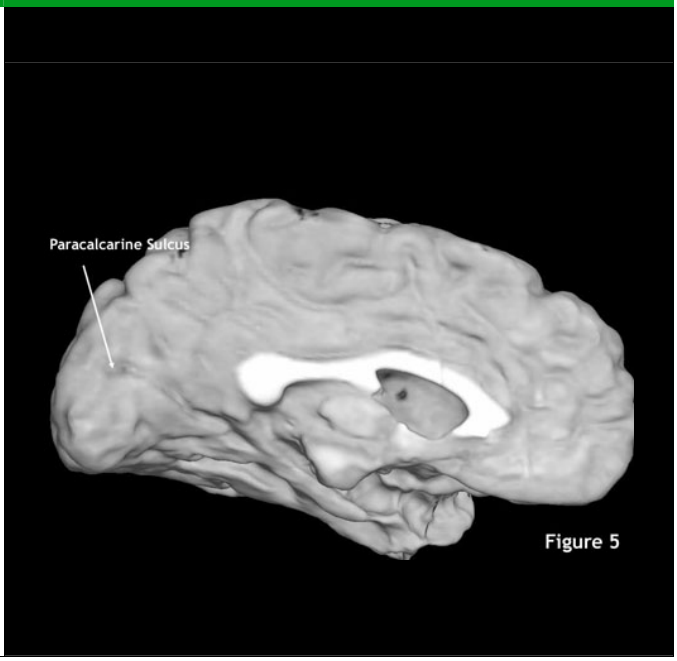
Figure 4



Step 5

Once the paracalcarine sulcus comes into view, mask from the internal endpoint of the intraparietal sulcus to the inferior occipital sulcus (or its approximated point) and fill in everything within these boundaries (Fig. 4). The paracalcarine sulcus can be found best on a medial view of the 3D object, or on a medial sagittal slice, and cuts the occipital lobe in half (Fig. 5).

Figure 5

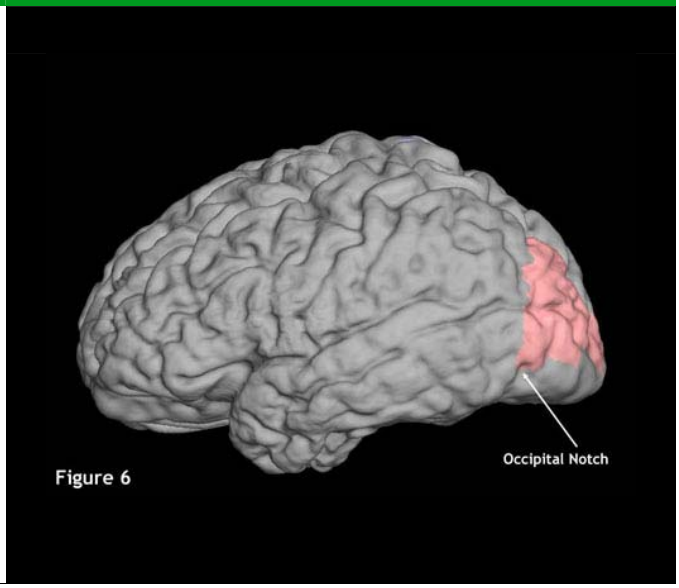


Middle Occipital Gyrus

Step 6

Continue the previous step until the occipital notch appears at the inferior end of the brain. To locate the occipital notch, double click on the notch on the 3D object and locate the corresponding slice in the coronal view. (Fig. 6)

Figure 6



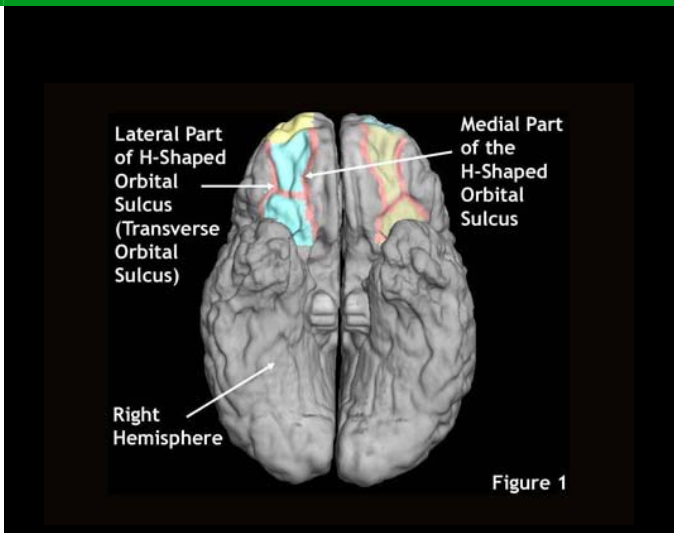
Middle Orbitofrontal Gyrus

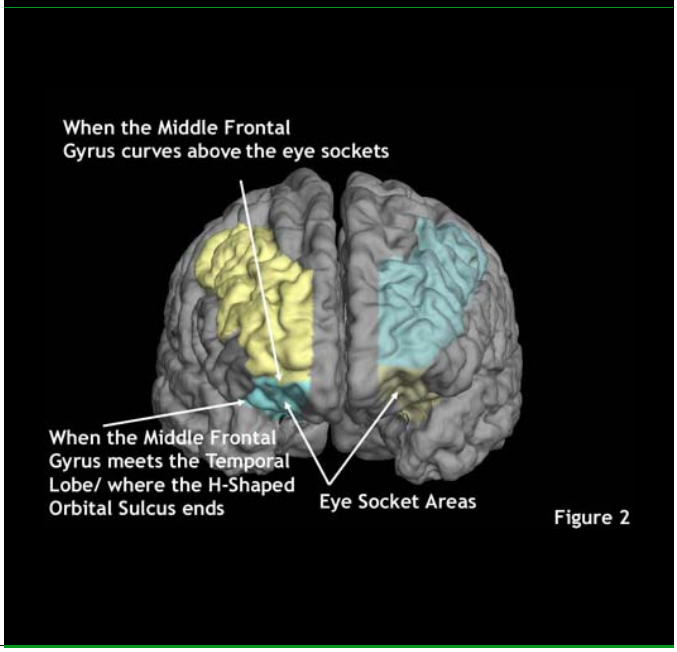
Step 1

The middle orbitofrontal gyrus (MOF) is the inferior aspect of the middle frontal gyrus. Its anterior boundary is approximately where the middle frontal gyrus curves above the eye sockets. Posteriorly, the boundary is where the middle frontal gyrus meets the temporal pole and also where the H-shaped orbital ends. Laterally the MOF is bound by the lateral segment of the H-shaped orbital sulcus (transverse orbital sulcus) and medially by the medial segment of the H-shaped orbital sulcus. It is recommended that the middle frontal gyrus is masked before this structure is. (Fig. 1, Fig. 2)

* This protocol relies on a previously masked middle frontal gyrus. (See protocol for Middle Frontal Gyrus.) It is also recommended that the insular cortex be delineated before starting the MOF (See protocol for Insular Cortex).

Figures 1 & 2





Middle Orbitofrontal Gyrus

Step 2

Using a 3D object model, orient the brain so that the anterior pole is lined up in a coronal position. On the 3D model, approximate where the middle frontal gyrus begins to curve above the eye socket area (Fig. 3). Double click on the approximated area and switch to the corresponding axial slice. In the corresponding axial view, completely fill the middle frontal gyrus on that slice. (Fig. 4)

Figures 3 & 4

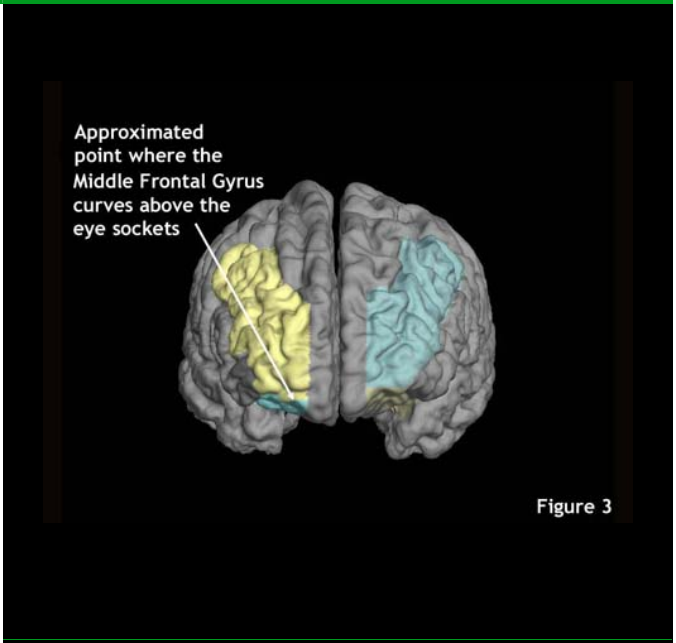


Figure 3

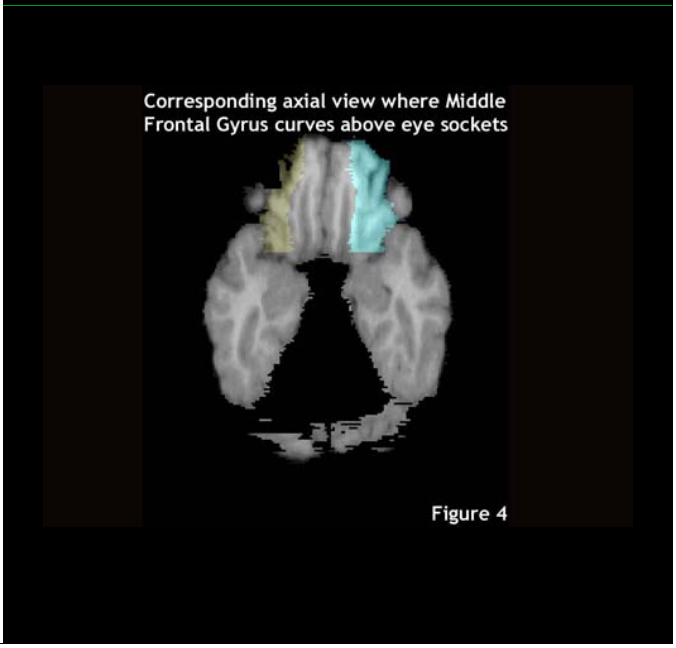


Figure 4

Middle Orbitofrontal Gyrus

Step 3

After filling the axial view, switch to the corresponding slice in the sagittal view. There should be a horizontal line demarcated from the masking done in the previous axial view (Fig. 5). Color the area below the line for all sagittal slices. (In BrainSuite click below the line on any slice and fill 3D.) This will set the general boundaries for the structure. (Fig. 6)

Figures 5 & 6

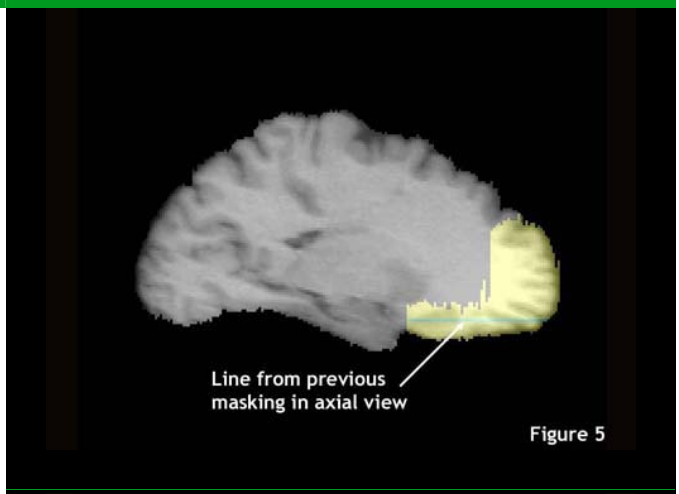


Figure 5

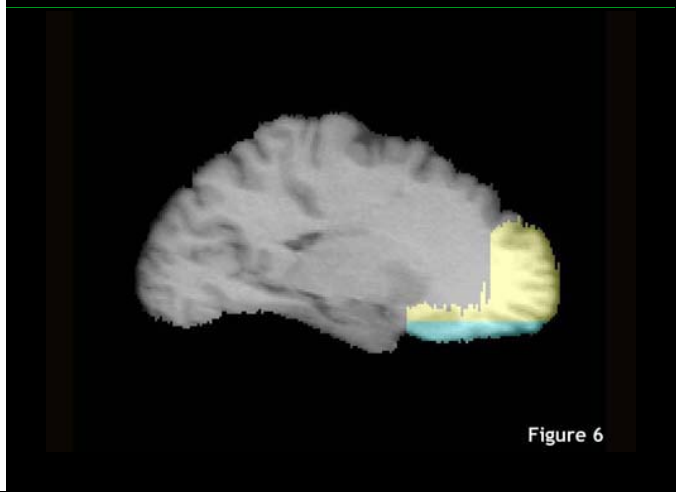
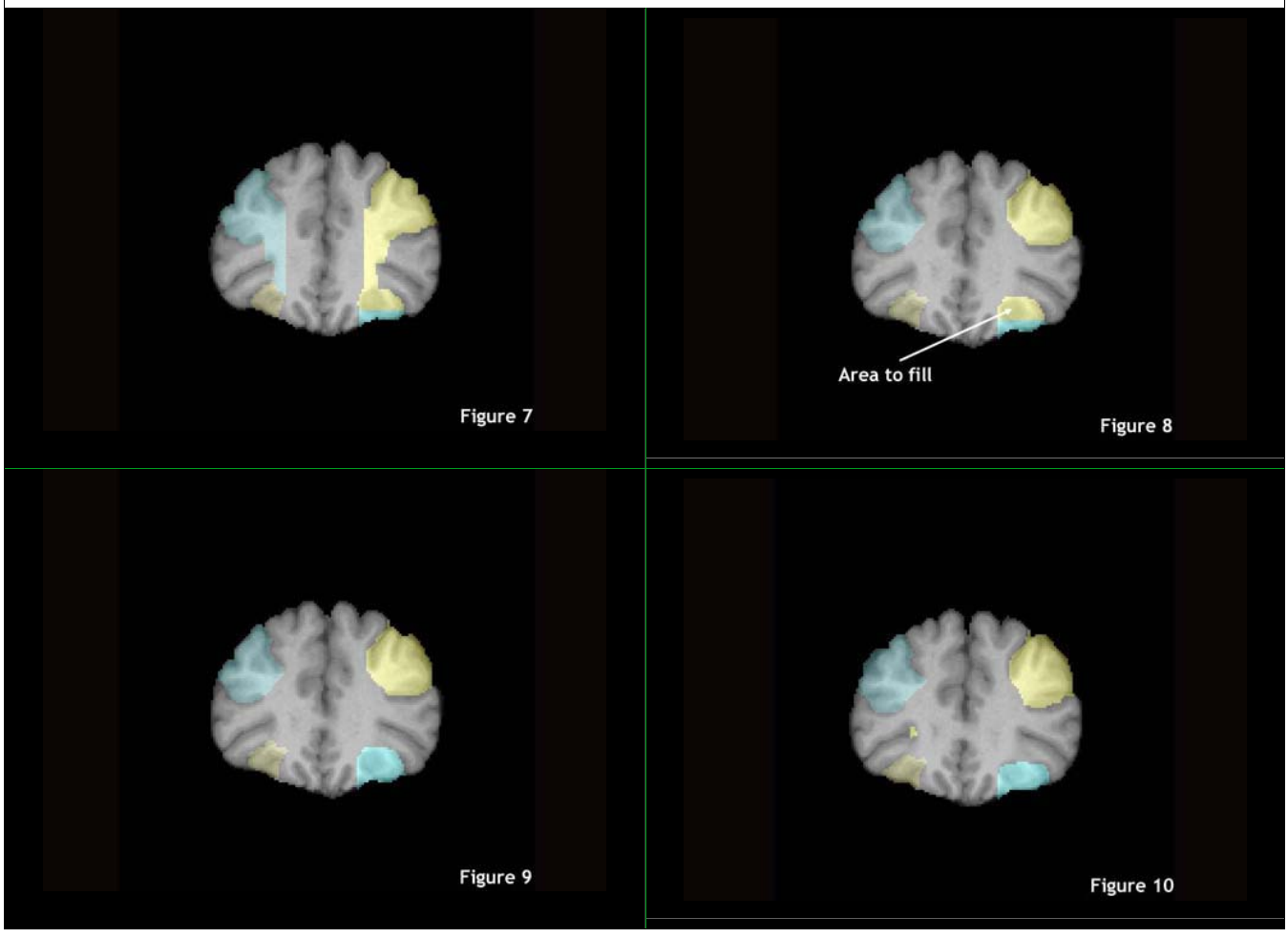


Figure 6

Middle Orbitofrontal Gyrus

Step 4	Figures 7 8 9 & 10

Switch to the coronal view. Starting anteriorly, the middle frontal gyrus is initially seen as one extended region (Fig. 7). Moving posteriorly, the middle frontal gyrus splits into two regions. For the first slice where the middle frontal gyrus splits into two, completely fill in the bottom region (Fig. 8). Move one more slice posterior and completely fill the bottom region again. (Fig. 9, Fig. 10)

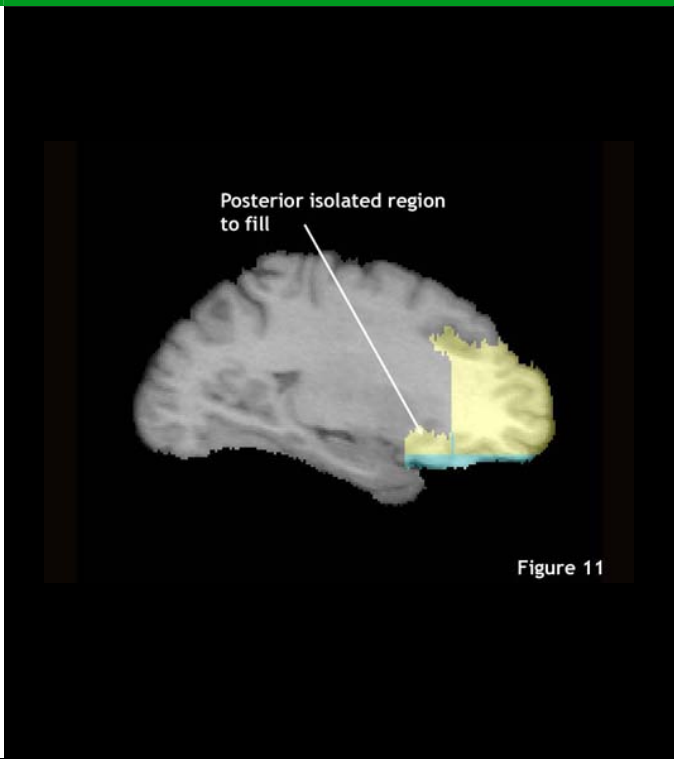


Middle Orbitofrontal Gyrus

Step 5

Switch to the sagittal view. There should be a vertical line demarcated in all sagittal slices from the previous masking in the coronal view. If the line is consistent in all slices, completely color the posterior isolated region in all sagittal slices, or fill 3D in one slice on BrainSuite. (Fig. 11)

Figure 11



Middle Orbitofrontal Gyrus

Step 6

Switch again to the coronal view (Fig. 12). Starting anteriorly and moving posteriorly, the lateral part of the H-shaped orbital sulcus (transverse orbital sulcus) will start to emerge. Once it emerges trace the transverse orbital sulcus to its internal end and draw a straight line to the internal end of the medial part of the H-shaped orbital sulcus (Fig. 13, Fig. 14).

Figures 13 & 14

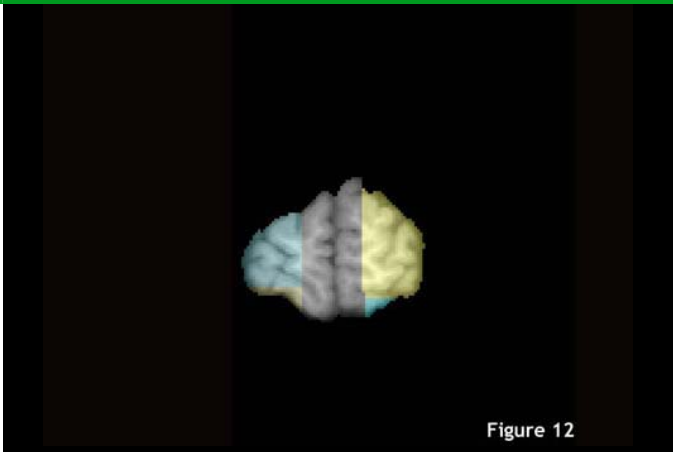


Figure 12

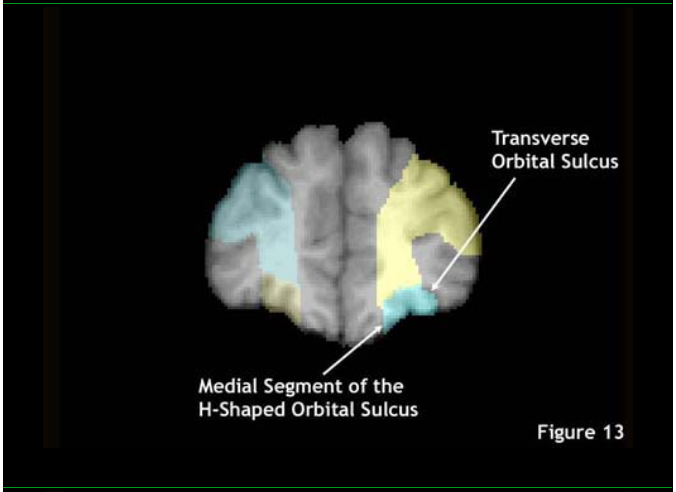


Figure 13

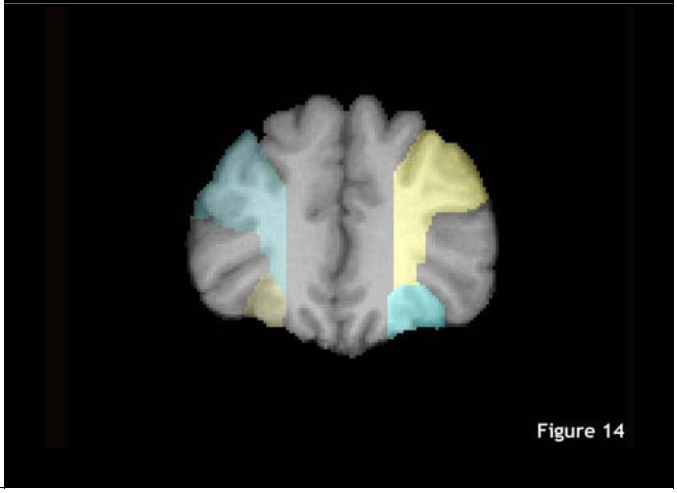


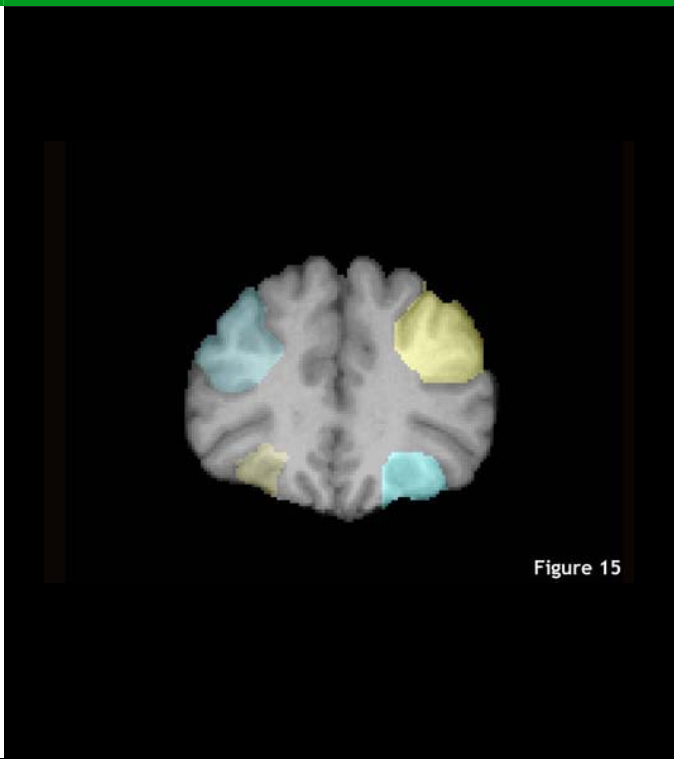
Figure 14

Middle Orbitofrontal Gyrus

Step 7

When the middle frontal gyrus splits into two regions, make sure that the bottom region is completely filled. (Fig. 15)

Figure 15



Middle Orbitofrontal Gyrus

Step 8

When the circular insular sulcus emerges, continue to follow step 6 however be cautious to not include any insular cortex bounded by the circular insular sulcus (Fig. 16, Fig. 17). Continue this step until the middle frontal gyrus meets the temporal pole.

Figures 16 & 17

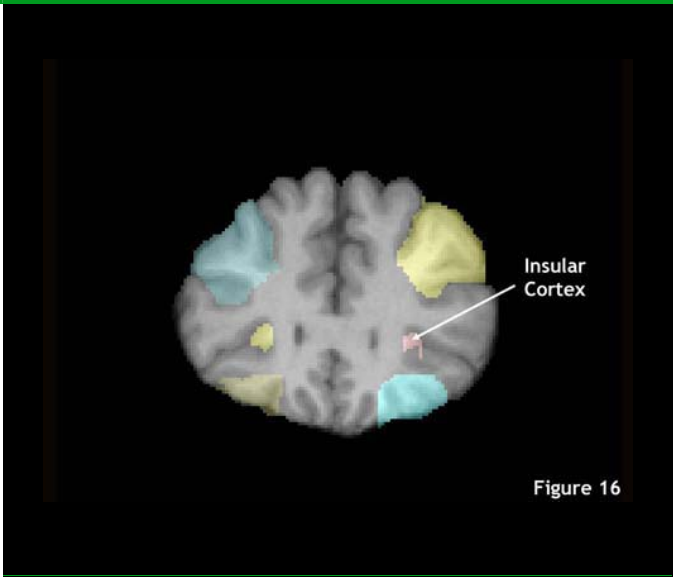


Figure 16

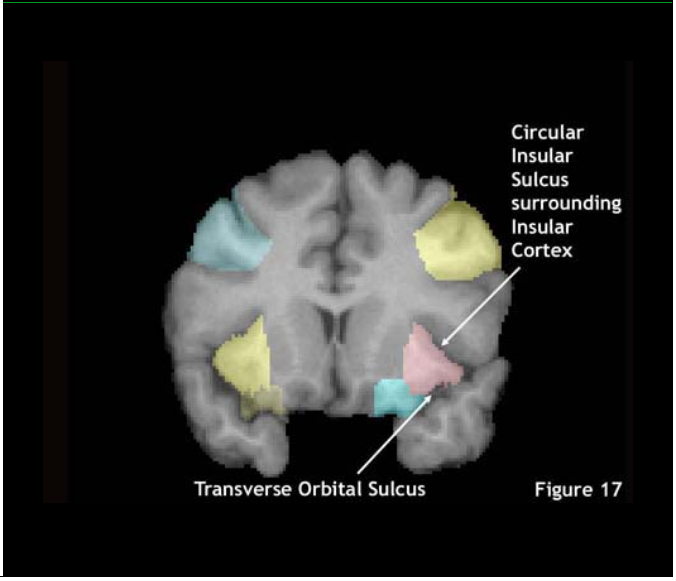


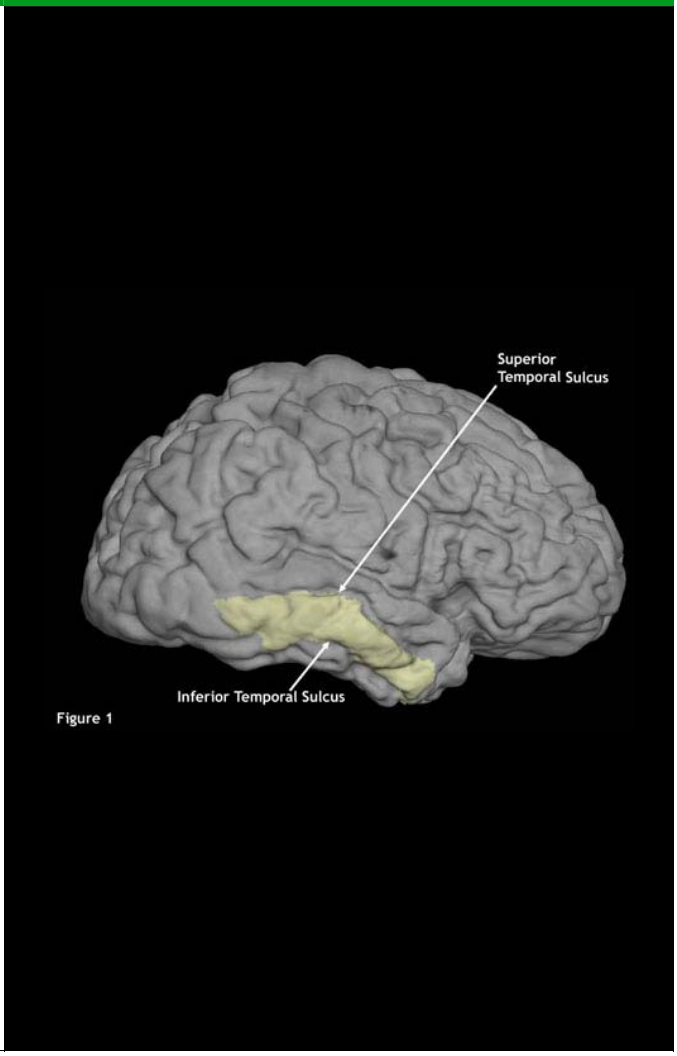
Figure 17

Middle Temporal Gyrus

Step 1

For the MTG, it is necessary to have a 3D object model in order to reference the upper and lower boundaries. The upper boundary of the MTG is the superior temporal sulcus and the lower boundary is the inferior temporal sulcus. In order to easily identify the inferior temporal sulcus, keep in mind that the inferior temporal sulcus is somewhat parallel to the superior temporal sulcus. Sometimes the inferior temporal sulcus is interrupted by gyri, but because the middle temporal gyrus has a consistent width. If this is the case cut across the gyri in order to maintain a consistent width of the MTG. It is also helpful to note that the MTG in the right hemisphere is slightly more at an inclined slope, making the MTG in both hemispheres is slightly asymmetrical. (Fig. 1)

Figure 1

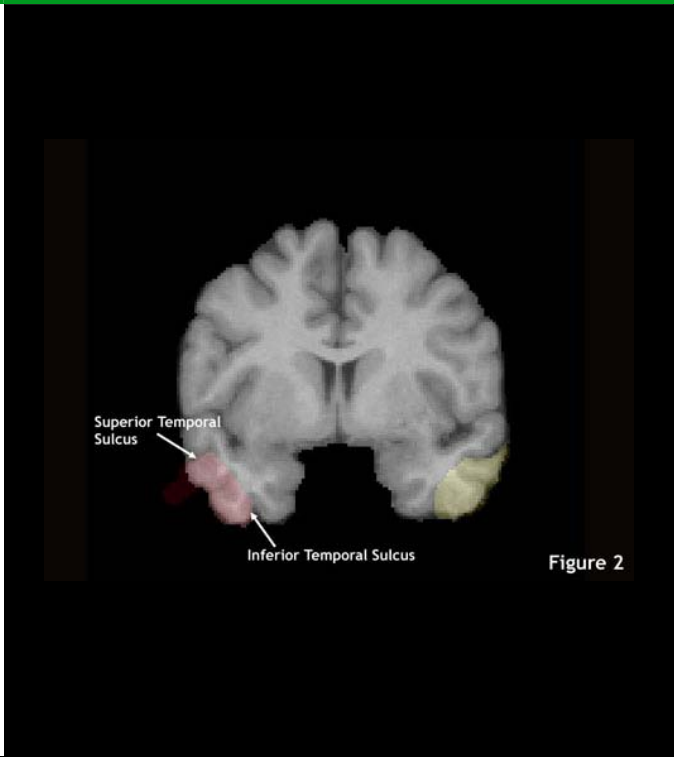


Middle Temporal Gyrus

Step 2

The middle temporal gyrus is masked in the coronal view. Start anteriorly where the superior temporal sulcus and the inferior temporal sulcus are clear. Trace the superior temporal sulcus to its internal endpoint and draw a straight line to the internal endpoint of the inferior temporal sulcus. Fill in everything within these sulci. (Fig. 2)

Figure 2

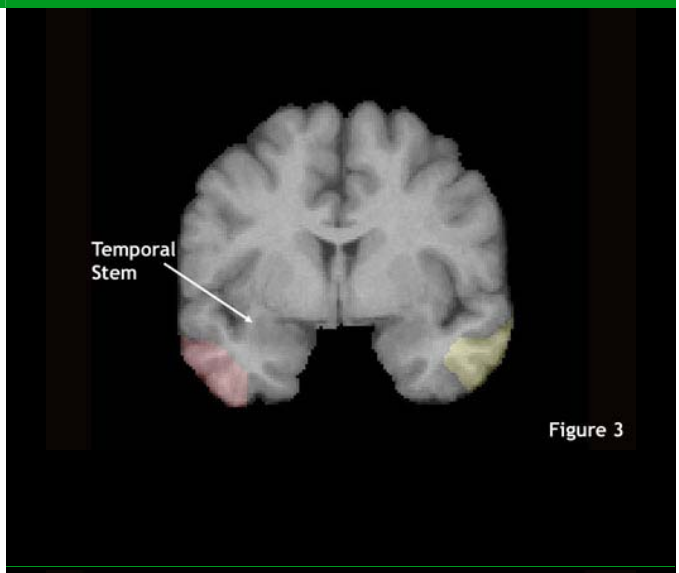


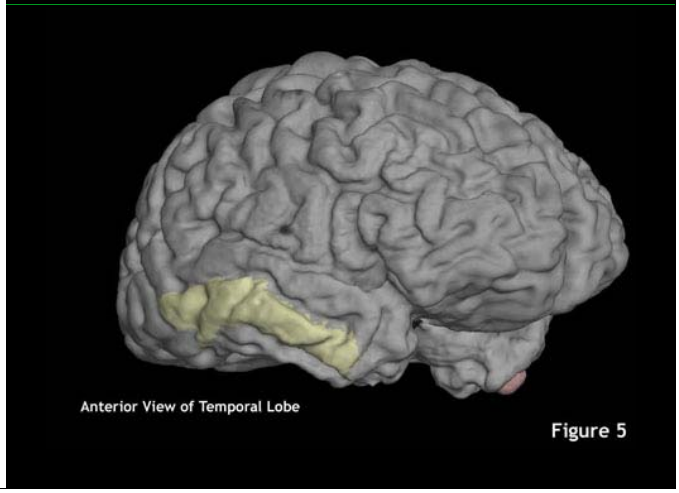
Middle Temporal Gyrus

Step 3

Moving anteriorly the temporal stem disappears. Continue to follow the previous step until then upper and lower boundaries of the MTG are no longer distinguishable, using the 3D object as a reference. Keep in mind that the anterior end of the temporal lobe ends with the superior temporal gyrus, middle temporal gyrus and inferior temporal gyrus merging together. (Fig. 3, Fig. 4, Fig. 5)

Figure 3 4 & 5



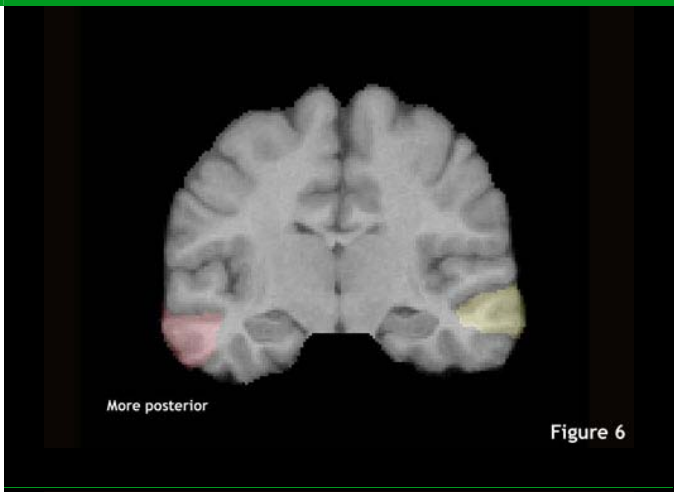


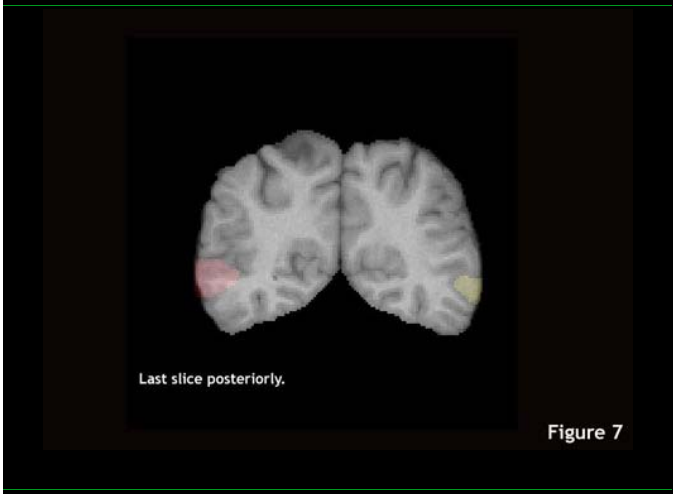
Middle Temporal Gyrus

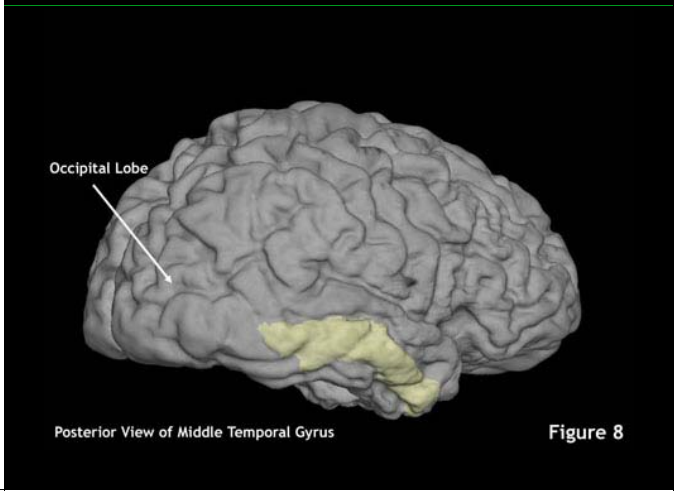
Step 4

To identify the posterior end of the MTG, go to the first slice masked. Continue the previous step until the superior temporal sulcus and the inferior temporal sulcus are no longer distinguishable. The posterior end of the MTG should coincide with the anterior end of the occipital lobe. (Fig. 6, Fig. 7, Fig. 8)

Figure 6 7 & 8







Parahippocampal Gyrus

Step 1

The anterior boundary of the parahippocampal gyrus is the temporal pole. The posterior boundary is where the splenium of the corpus callosum is no longer visible. The inferior boundary is the collateral sulcus and the superior boundary is the hippocampal fissure (choroidal fissure). (Fig. 1, Fig. 2)

Figures 1 & 2

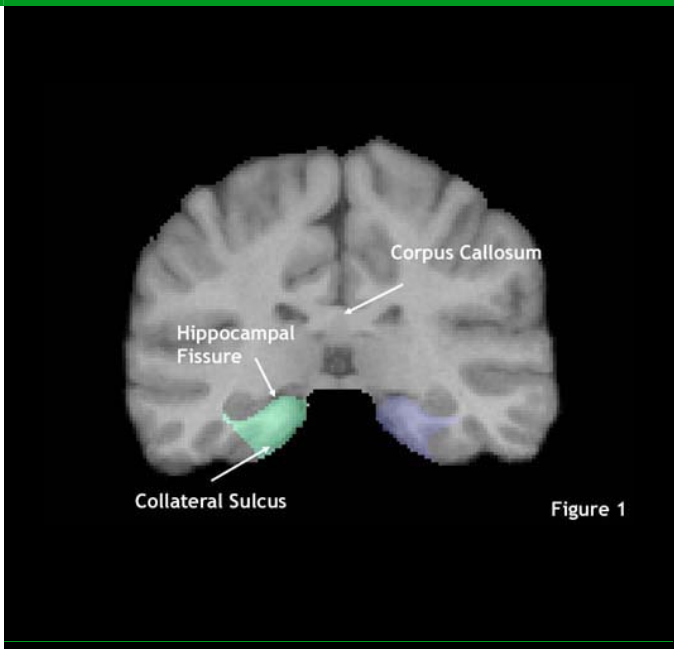


Figure 1

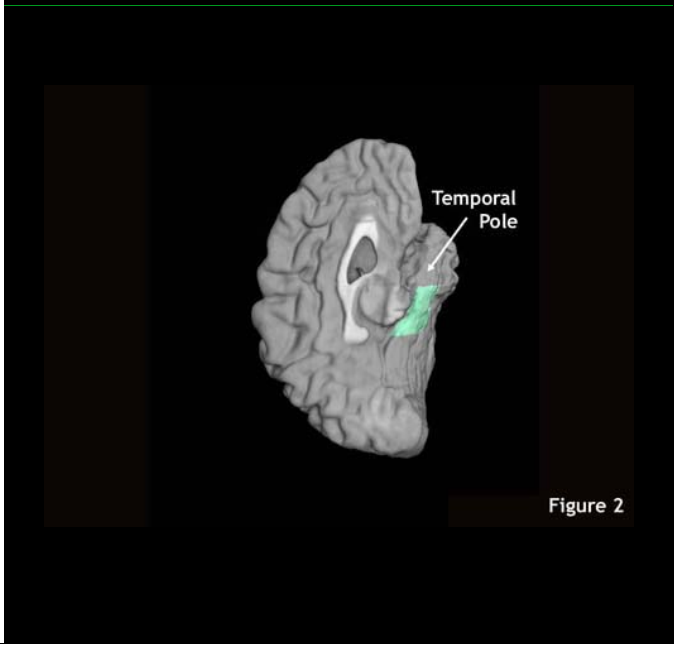


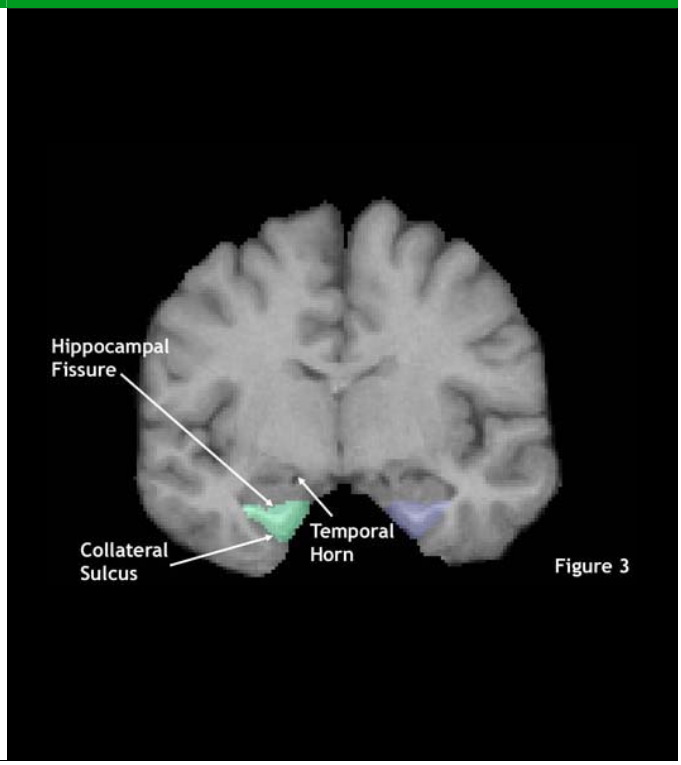
Figure 2

Parahippocampal Gyrus

Step 2

The parahippocampal gyrus is masked in the coronal view. Begin anteriorly where the temporal horns first emerge. Follow the collateral sulcus up to its end point and then connect it to the hippocampal fissure making sure to exclude all hippocampus. Follow the hippocampal fissure up to its medial end point and mask everything in between these two boundaries. (Fig. 3)

Figure 3



Parahippocampal Gyrus

Step 3

Continue the previous step until the end of the splenium of the corpus callosum. This point can be found by finding the most posterior point of the corpus callosum in the 3D object or by doing the same in the most medial slice in the sagittal view. Masking ends at this point. (Fig 4, Fig. 5)

* If the calcarine sulcus appears before the termination of the corpus callosum, follow the collateral sulcus and connect it to the calacarine sulcus. Mask everything in between. (Fig. 6)

Figures 4 & 5

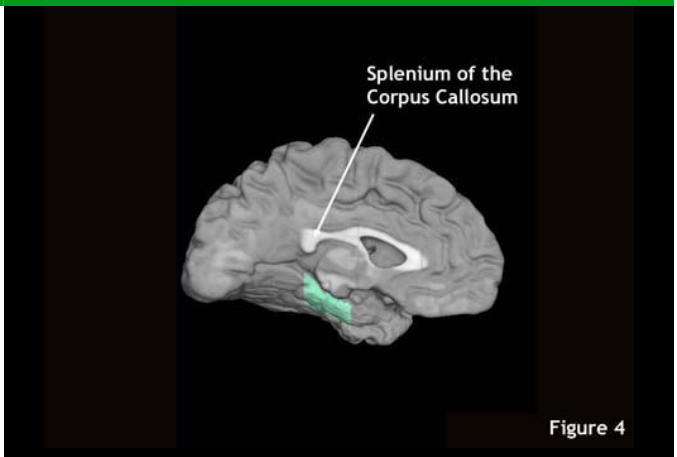


Figure 4

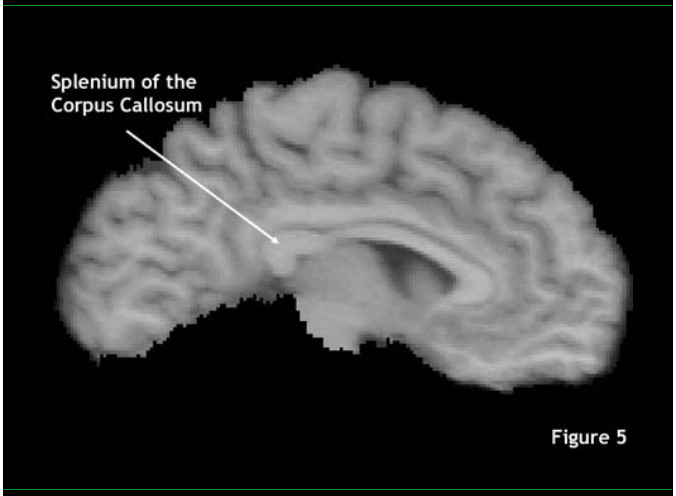


Figure 5

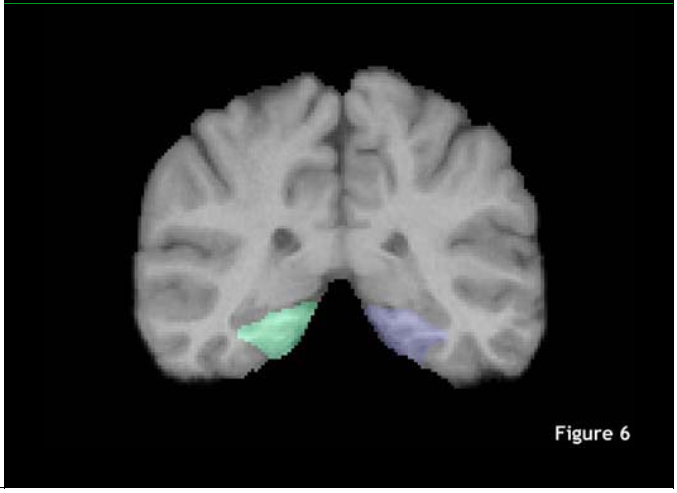


Figure 6

Postcentral Gyrus

Step 1

The postcentral gyrus sets the anterior boundary for the parietal lobe. Its boundaries are the post-central sulcus posteriorly and the central sulcus anteriorly. It spans from the superior boundary of the cortex to the Sylvian fissure inferiorly. Medially, its inferior boundary is the cingulate sulcus. (Fig. 1, Fig. 2, Fig. 3)

Figures 1 2 & 3

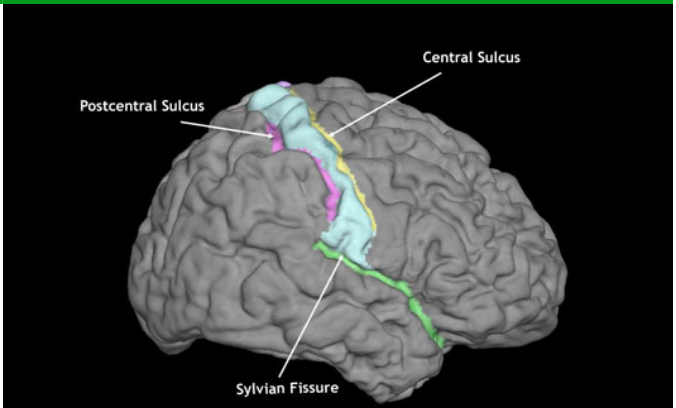


Figure 1

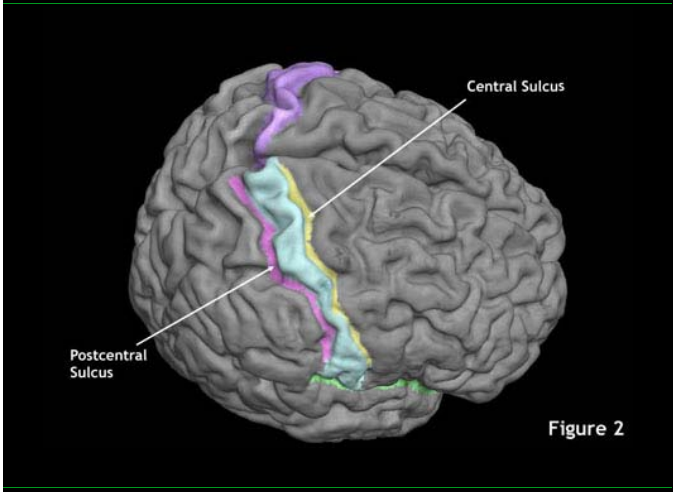


Figure 2

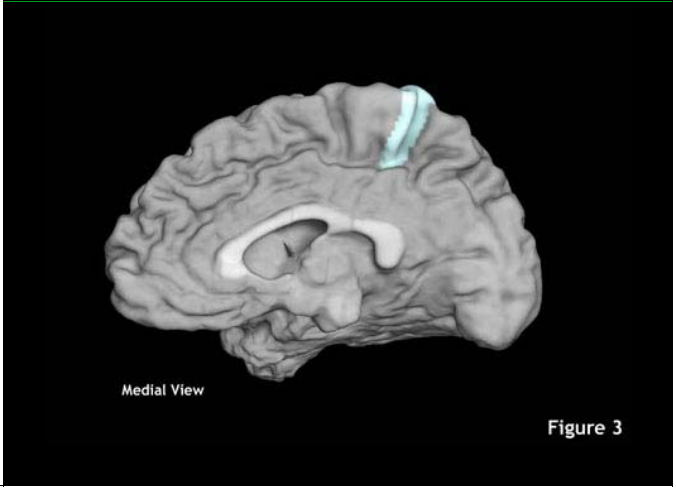


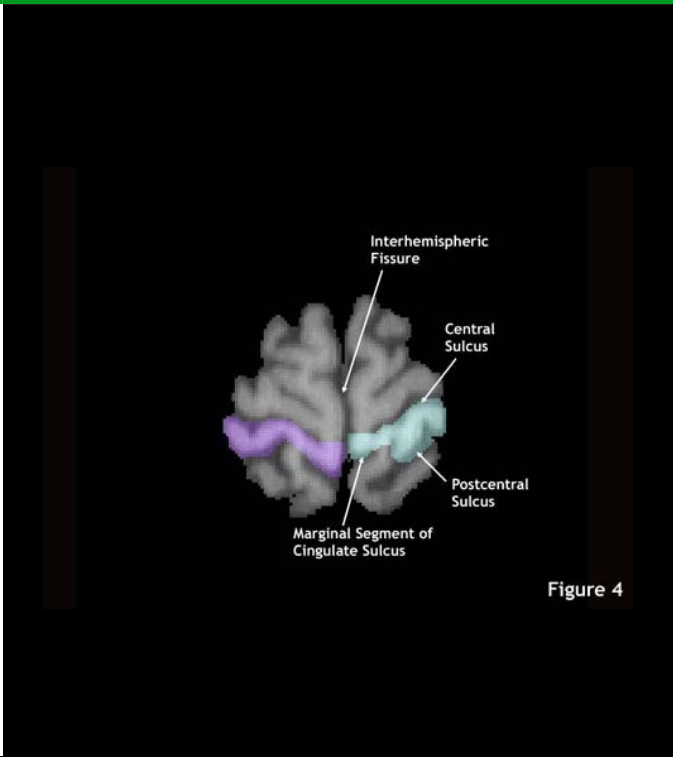
Figure 3

Postcentral Gyrus

Step 2

Mask in the axial view beginning at a slice where the central and postcentral sulci are clear. Follow the central sulcus to its internal end point and draw a straight line out to the interhemispheric fissure. Mask the post central sulcus to its internal endpoint and make a straight line out to the lateral end of the marginal segment of the cingulate sulcus. Mask the marginal segment of the cingulate sulcus to its medial end and draw everything within these two boundaries. (Fig. 4)

Figure 4



Postcentral Gyrus

Step 3

Follow the previous step to the superior end of the brain. If the marginal segment of the cingulate sulcus becomes unclear reference the last slice where the sulcus was clear and approximate its location on the previous slices. In addition, at the superior end of the brain the central sulcus might connect to the interhemispheric fissure. At that point mask the central sulcus to the interhemispheric fissure and the precentral sulcus to the approximated point of the cingulate sulcus. Mask everything between these boundaries. (Fig. 5, Fig. 6)

Figures 5 & 6

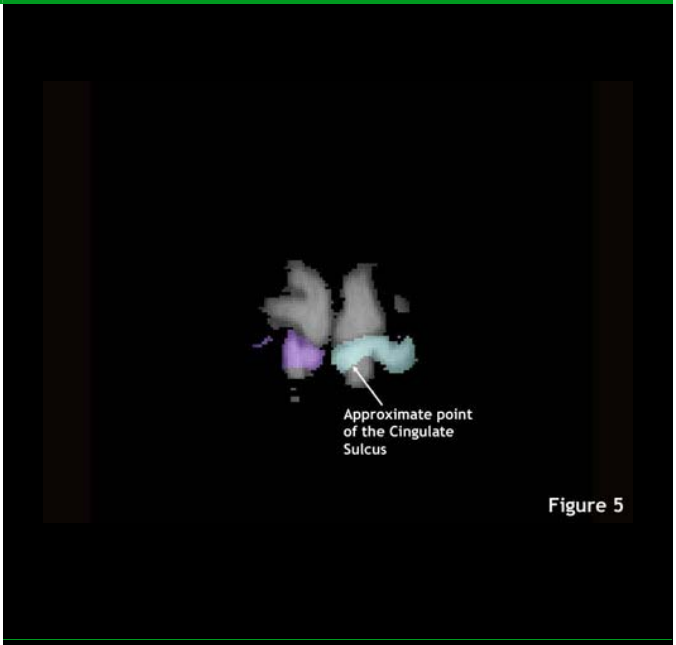


Figure 5

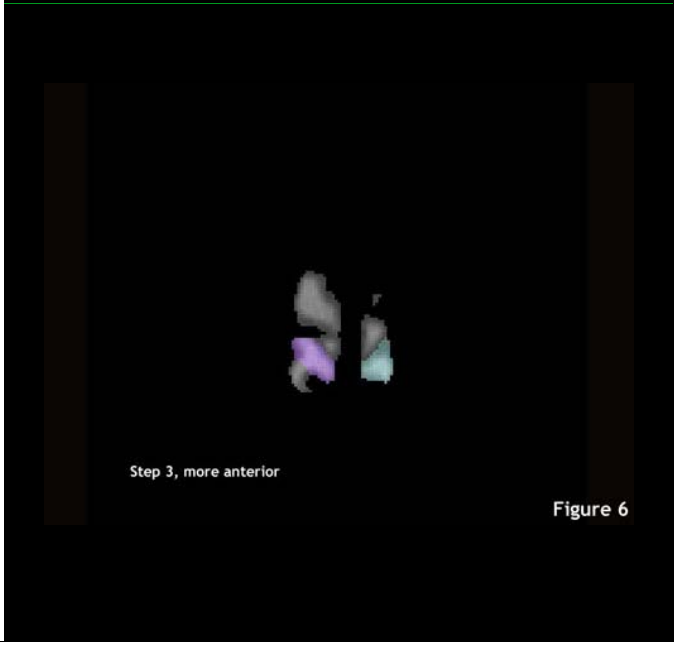


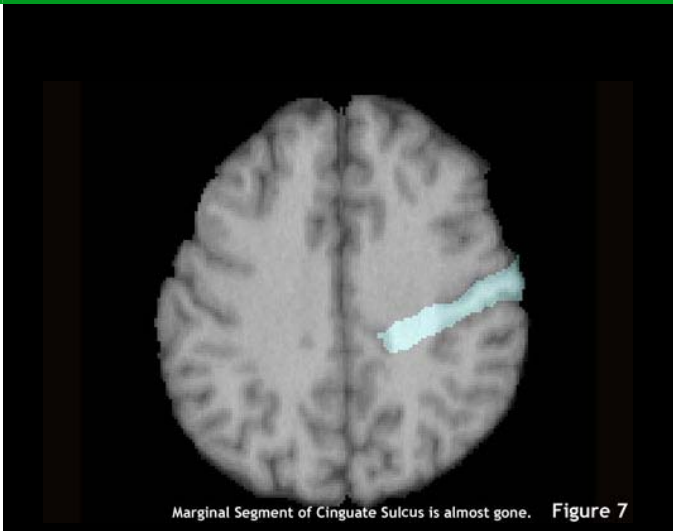
Figure 6

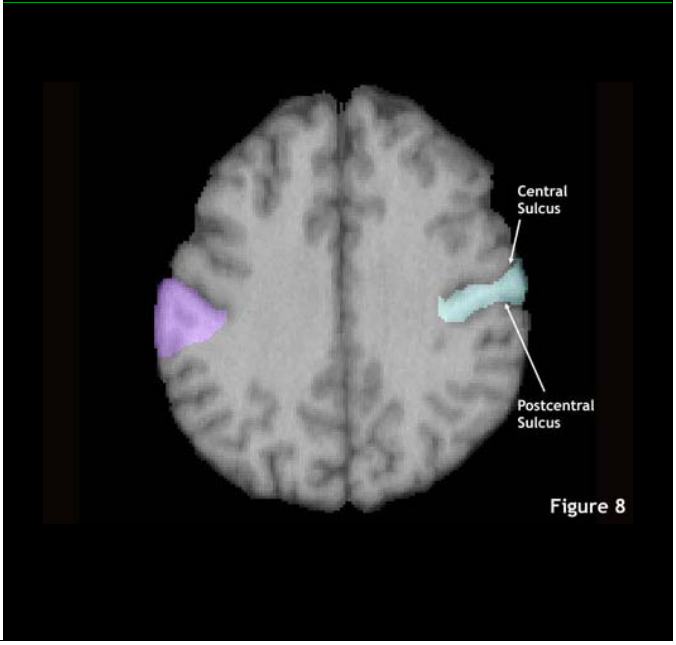
Postcentral Gyrus

Step 4

Once the superior end of the brain is masked, go back to the first slice masked, and moving inferiorly continue step 2. At some point, the cingulate sulcus' marginal segment will become unclear. Mask the central sulcus to its internal endpoint and draw a straight line to the internal endpoint of the postcentral sulcus. Mask everything between these two sulci. (Fig. 7, Fig. 8)

Figures 7 & 8





Postcentral Gyrus

Step 5

Moving inferiorly, the postcentral sulcus may disappear. If this happens, reference the last slice where the sulcus was clear and approximate its location on the following slices. As a reference, the postcentral gyrus tends to get wider inferiorly. (Fig. 9)

Figure 9

Step 6

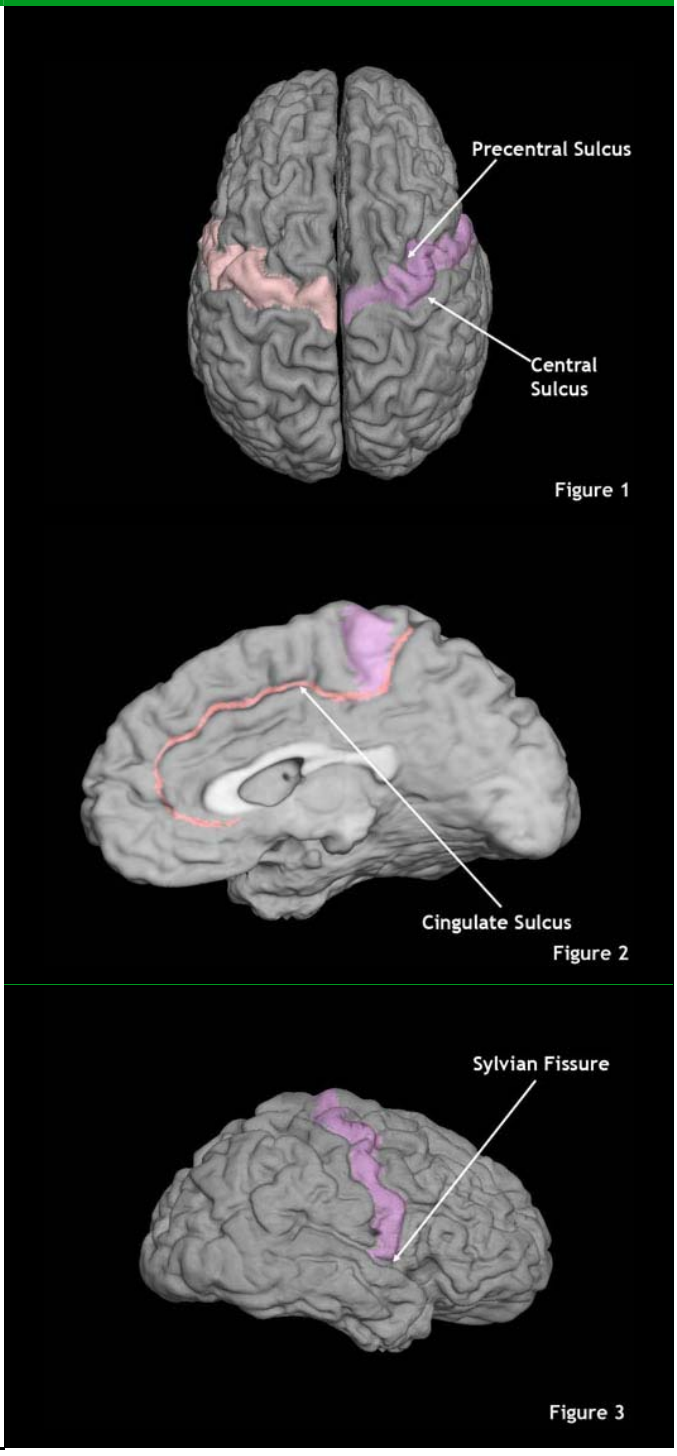
Moving inferiorly, the central sulcus will disappear and in its place the Sylvian fissure appear. End masking at this point.

Precentral Gyrus

Step 1

The precentral gyrus is the most posterior boundary of the frontal lobe. Its anterior boundary is the precentral sulcus and the posterior boundary is the central sulcus. The superior boundary is the superior end of the cortex. The inferior boundary at the medial end is the cingulate sulcus and the inferior boundary at the lateral end is the Sylvian fissure. It is helpful to have a 3D object model to reference the boundaries of the precentral gyrus. (Fig. 1, Fig. 2, Fig. 3)

Figures 1 2 & 3



Precentral Gyrus

Step 2

Mask in the axial view starting superiorly at a slice where the central, precentral, and paracentral sulci are clear. Trace the precentral sulcus to the paracentral sulcus, which is the upper boundary of the paracentral lobule. Trace the central sulcus and angle down to the paracentral lobule's lower boundary. If the lobule's lower boundary is not clear, reference the previous slice to best approximate its location. Including the paracentral lobule, mask everything within these boundaries. Continue this step superiorly. (Fig. 4, Fig. 5)

Figures 4 & 5

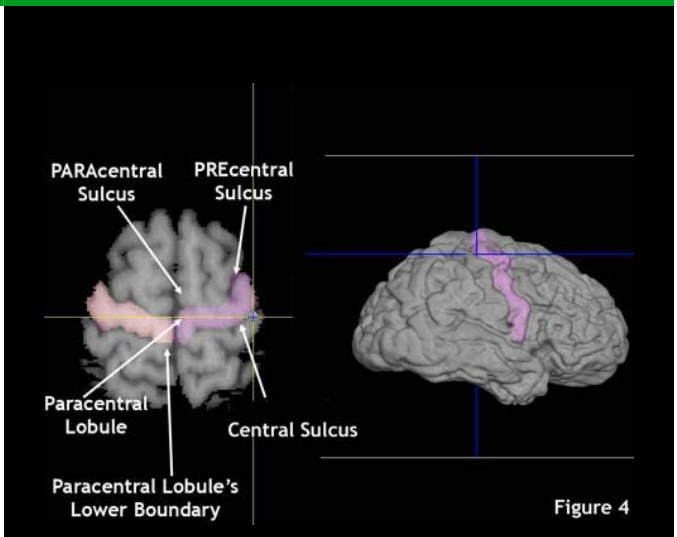


Figure 4

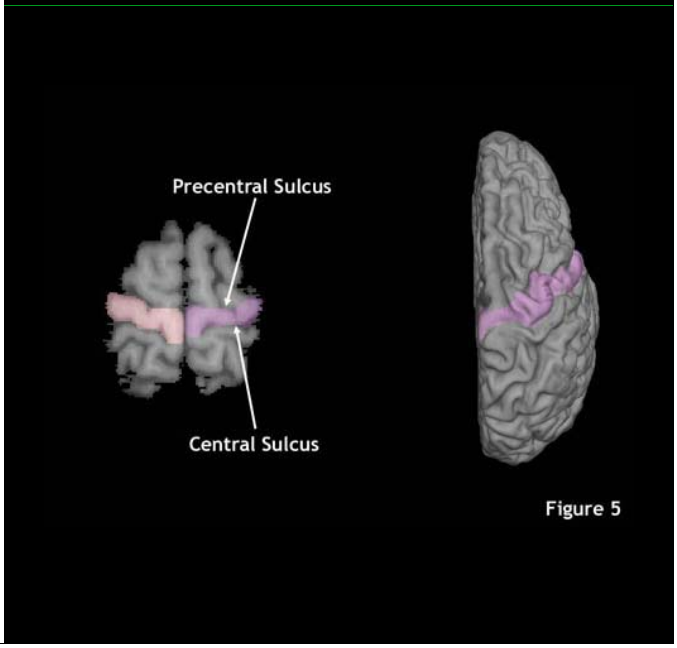


Figure 5

Precentral Gyrus

Step 3

Moving more superiorly, the paracentral sulcus may disappear. When this occurs, refer to the previously masked slice and approximate the anterior end of the precentral gyrus. Continue this step until reaching the brain's most superior point. (Fig. 6, Fig. 7)

Figures 6 & 7

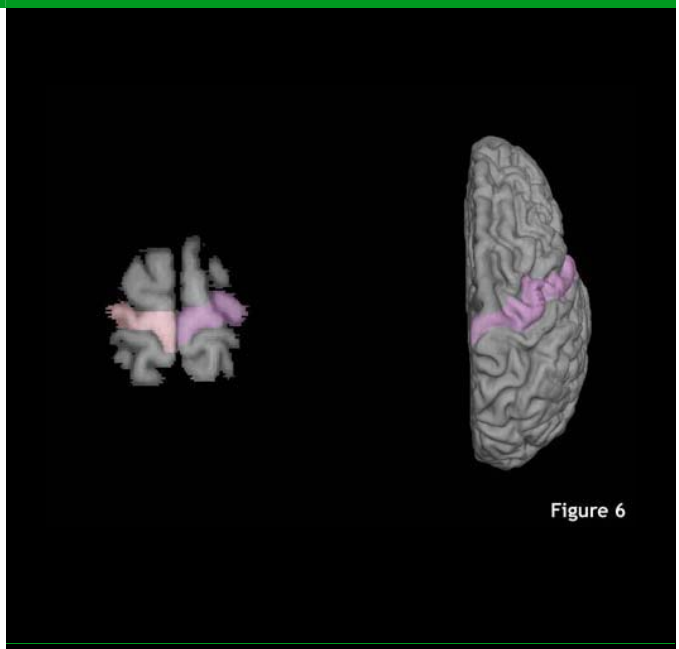


Figure 6

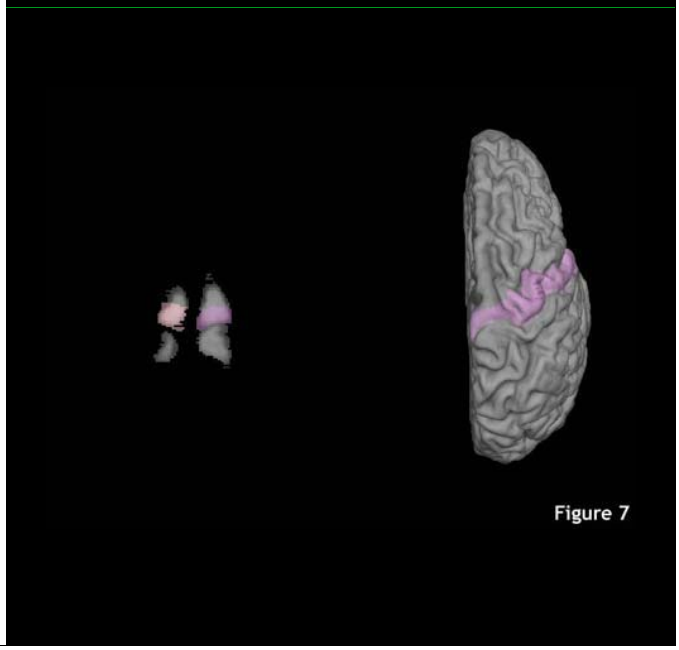


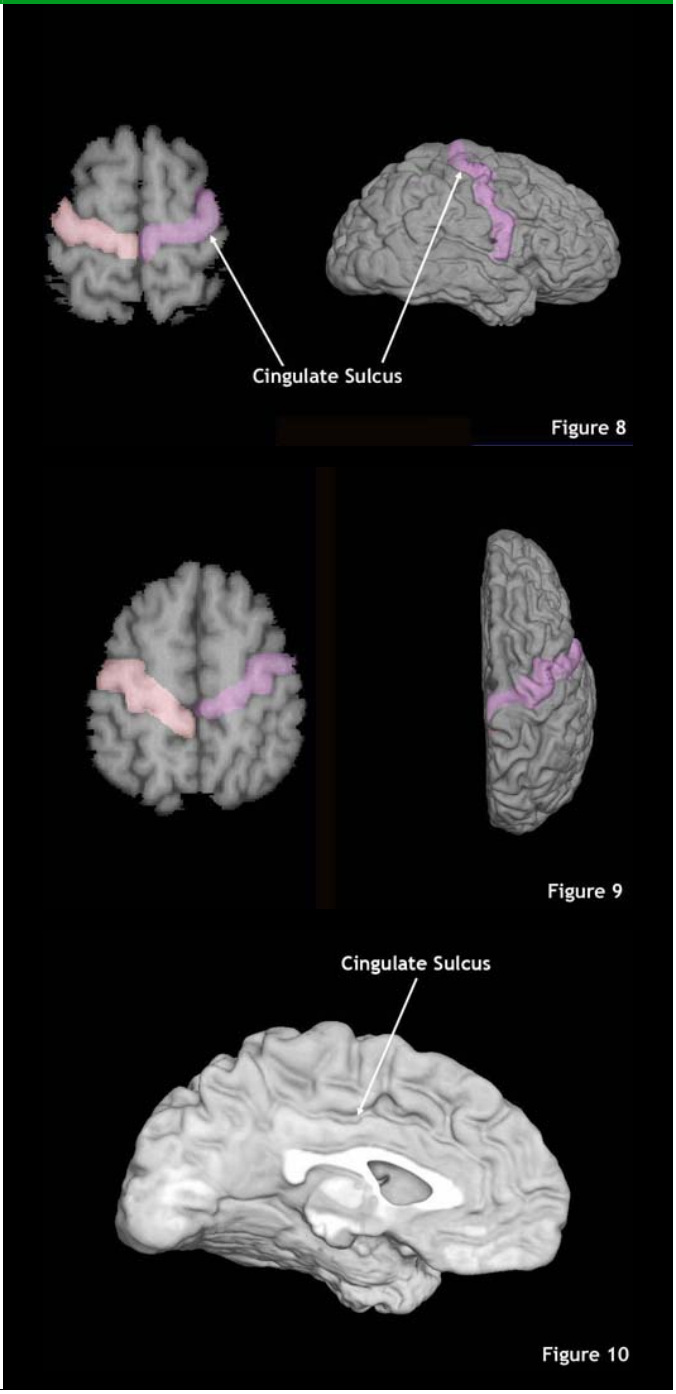
Figure 7

Precentral Gyrus

Step 4

Return to the first slice masked inferiorly. Moving inferiorly, continue Step 2 until reaching the cingulate sulcus. The cingulate sulcus can be found easily on either the 3D object or in the sagittal view. (Fig. 8, Fig. 9, Fig. 10)

Figures 8 9 & 10



Precentral Gyrus

Step 5

Once the cingulate sulcus is reached, the para-central lobule is no longer masked. Trace the precentral sulcus to its interior endpoint, and draw a straight line to the internal end of the central sulcus. Mask everything within these boundaries. If the precentral sulcus disappears, follow the next sulcus above it. Continue this step until reaching the Sylvian fissure. Check the 3D object model to verify the Sylvian fissure's location. (Fig. 11, Fig. 12, Fig. 13, Fig. 14, Fig. 15)

Figures 11 12 & 13

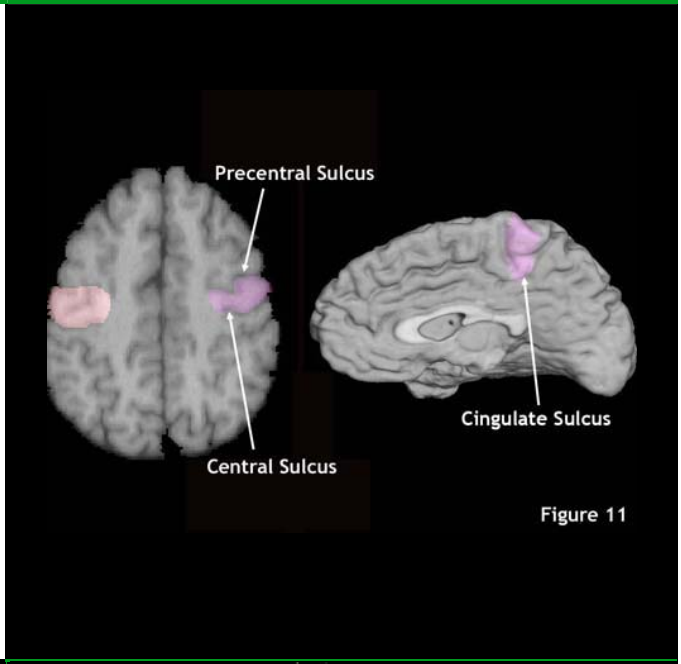


Figure 11

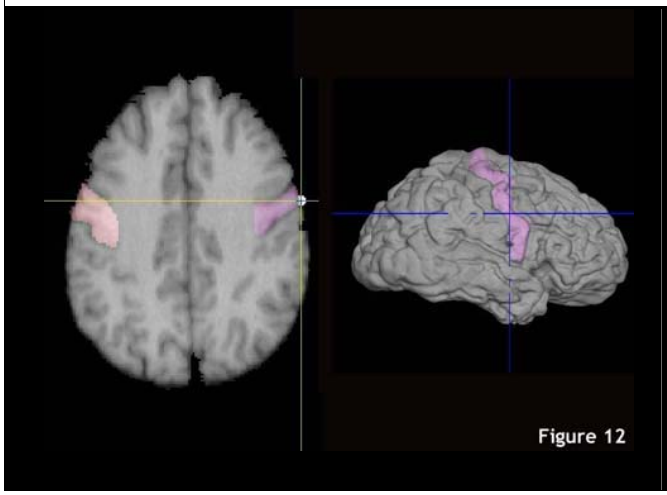


Figure 12

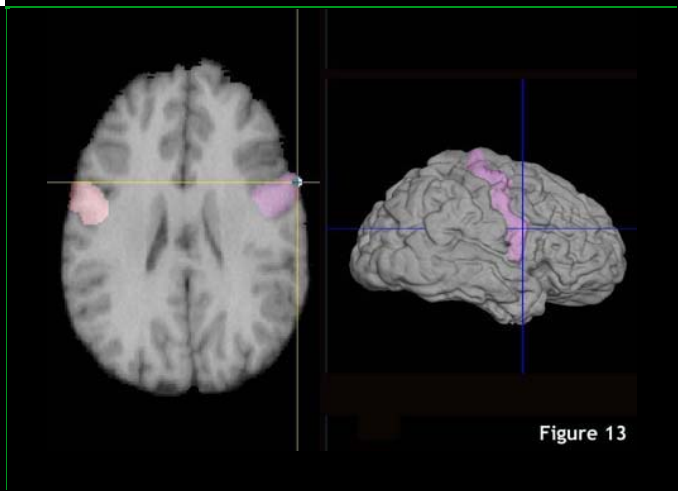
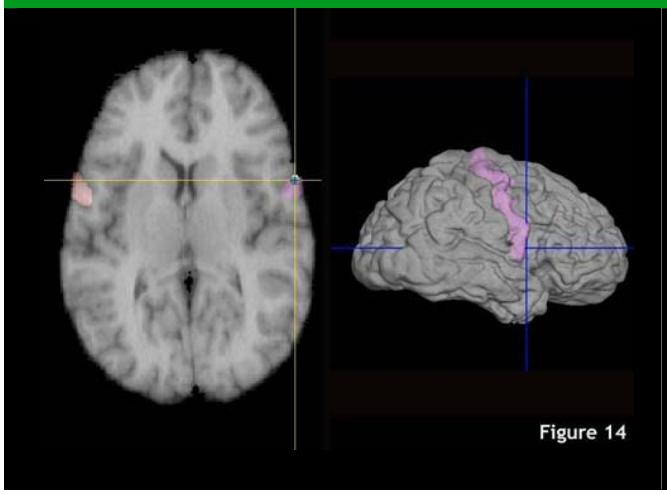


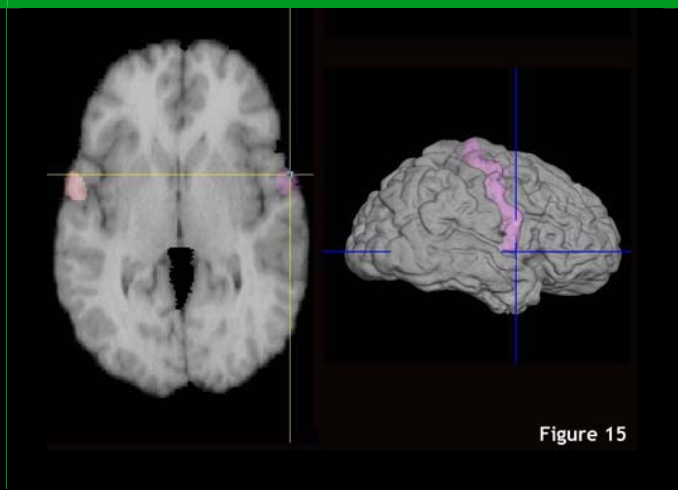
Figure 13

Precentral Gyrus

Step 5 (continued)



Figures 14 & 15



Pre-cuneus

Step 1

The pre-cuneus is the medial cortex of the superior parietal gyrus. Its anterior boundary is the marginal segment of the cingulate sulcus and its posterior boundary is the parieto-occipital fissure. The inferior boundary is the subparietal sulcus. Because the lateral boundary cannot be defined by any clear sulcus, the boundary is defined by the most superior medial sulcus in the coronal view. (Fig. 1, Fig. 2)

Figures 1 & 2

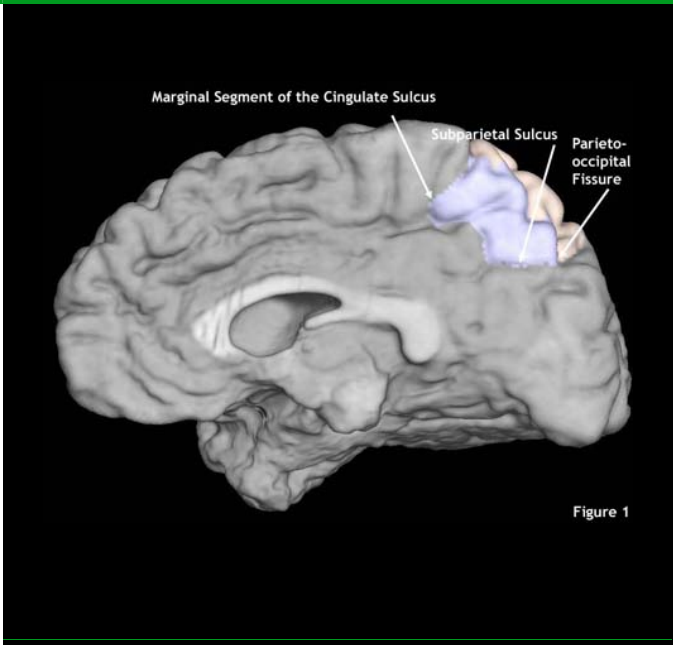


Figure 1

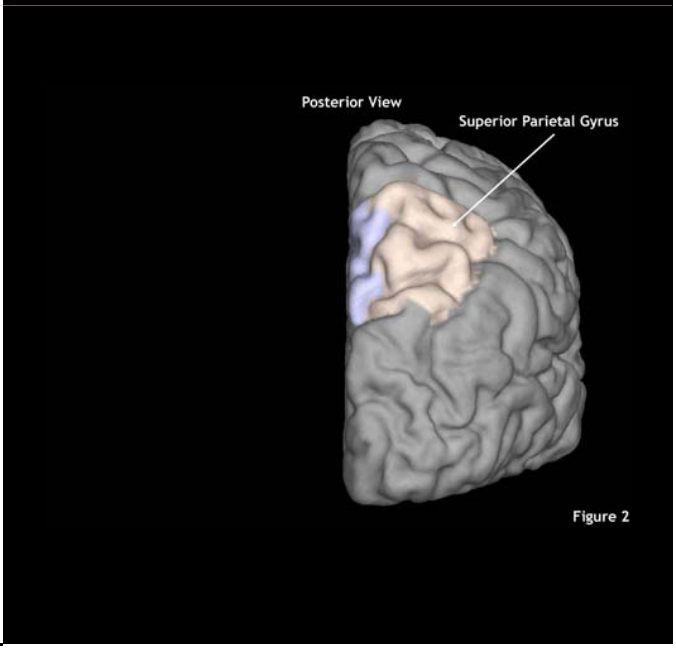


Figure 2

Pre-cuneus

Step 2

Masking of the pre-cuneus is done in the coronal view. Locate the parieto-occipital fissure in the sagittal view, click on its superior end, and switch to the corresponding slice in the coronal view (Fig. 3). At this slice, locate the subparietal sulcus, trace it to its internal endpoint, and draw a straight line up to the internal end of the most superior medial sulcus. Fill in everything within these boundaries. (The most superior medial sulcus may change often between slices.) (Fig. 4)

Figures 3 & 4

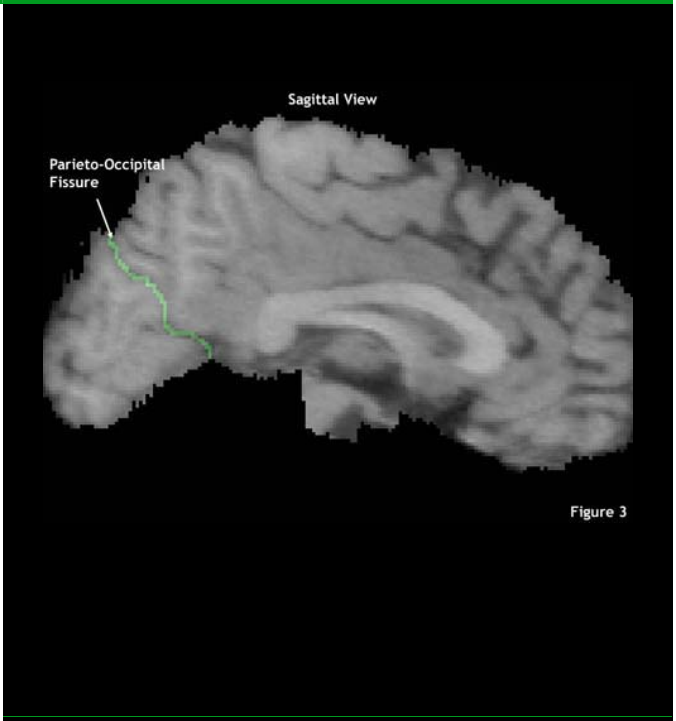


Figure 3

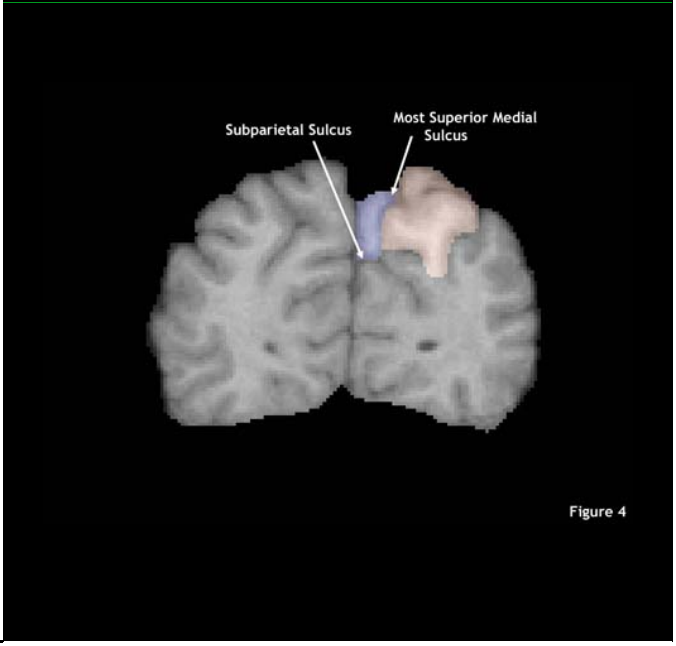


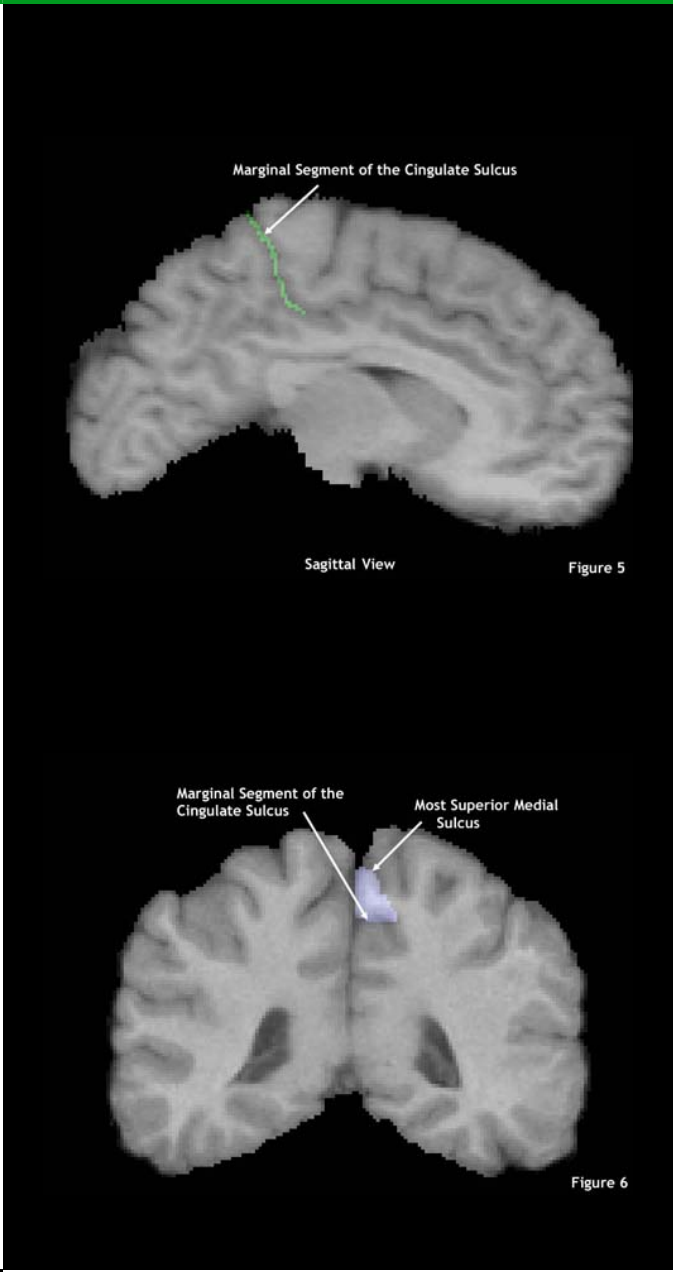
Figure 4

Pre-cuneus

Step 3

Moving posteriorly, the marginal segment of the cingulate sulcus will appear. This sulcus can be found easily in the sagittal view as shown in Figure 5. At this point mask from the marginal segment of the cingulate sulcus to its internal endpoint, and draw a straight line to the internal endpoint of the subparietal sulcus. Mask the subparietal sulcus to its medial end, and fill in everything within these boundaries. Continue this step until the subparietal sulcus in no longer visible. (Fig. 5, Fig. 6)

Figures 5 & 6

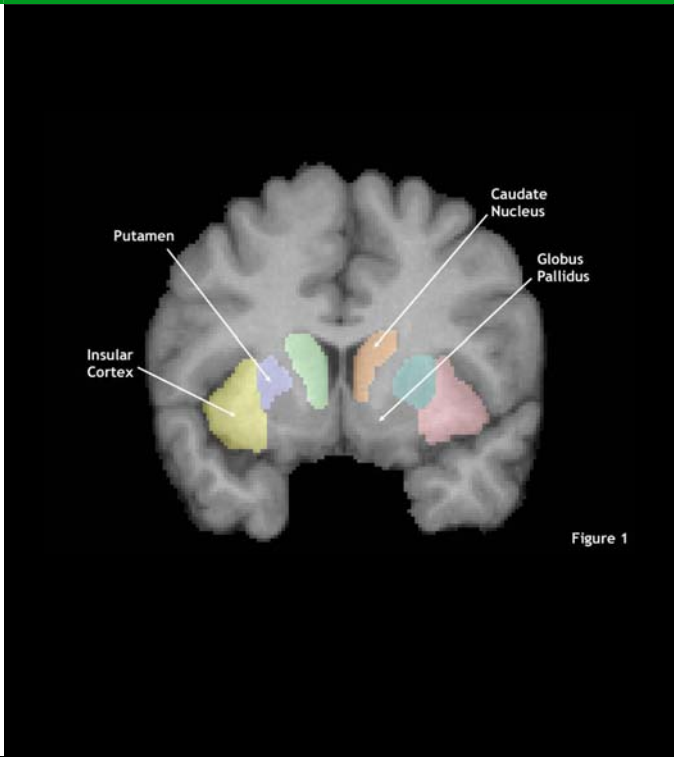


Putamen

Step 1

The putamen is a gray matter structure located inferior to the caudate nucleus. To mask the putamen, it is necessary to work in the coronal view. Since it is a subcortical structure, it is not bound by any sulci. Anteriorly, the putamen is easily identified but moving posteriorly it becomes hard to distinguish the putamen from the globus pallidus and later the insular cortex. (Fig. 1)

Figure 1

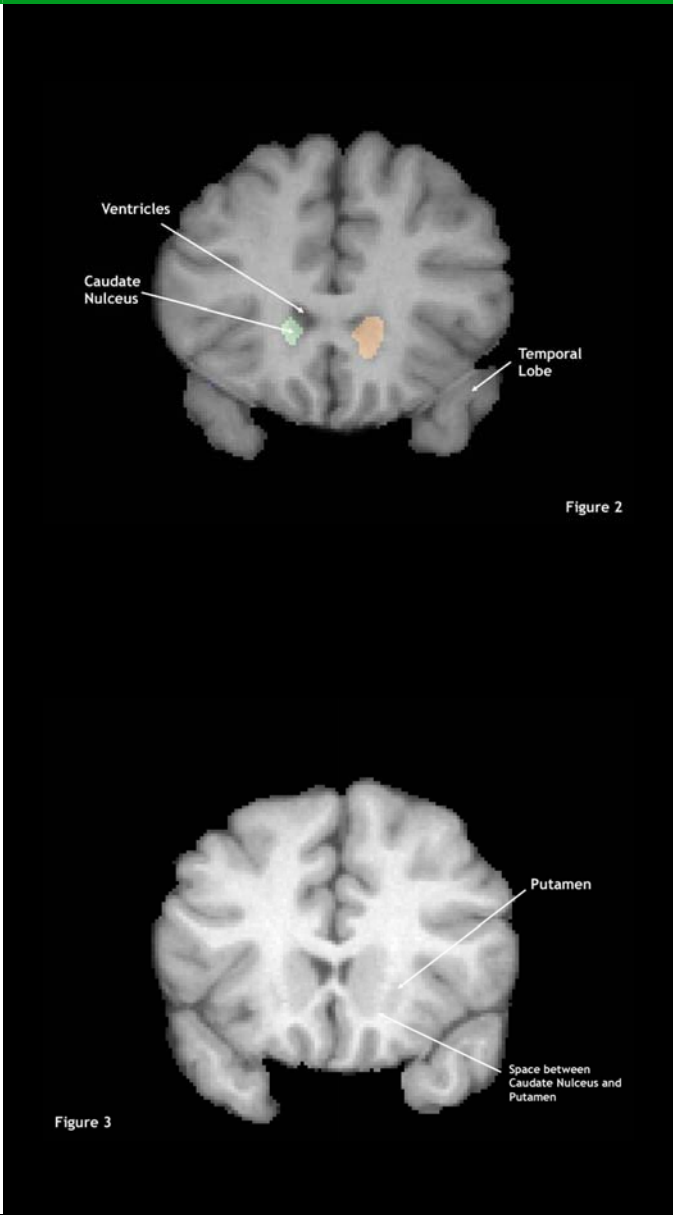


Putamen

Step 2

Masking of the putamen is done in the coronal view. Moving from the anterior end of the brain to the posterior end, the ventricles will appear and then the temporal lobe will appear (Fig. 2). At this point, an area of gray matter will appear directly beneath the ventricles; this is the caudate nucleus. Moving posteriorly, an area of gray matter will appear lateral to the caudate nucleus; this is the putamen. Mask the gray pixels in this area. The space between the putamen and the caudate nucleus should be clear at this point. (Fig. 3)

Figures 2 & 3

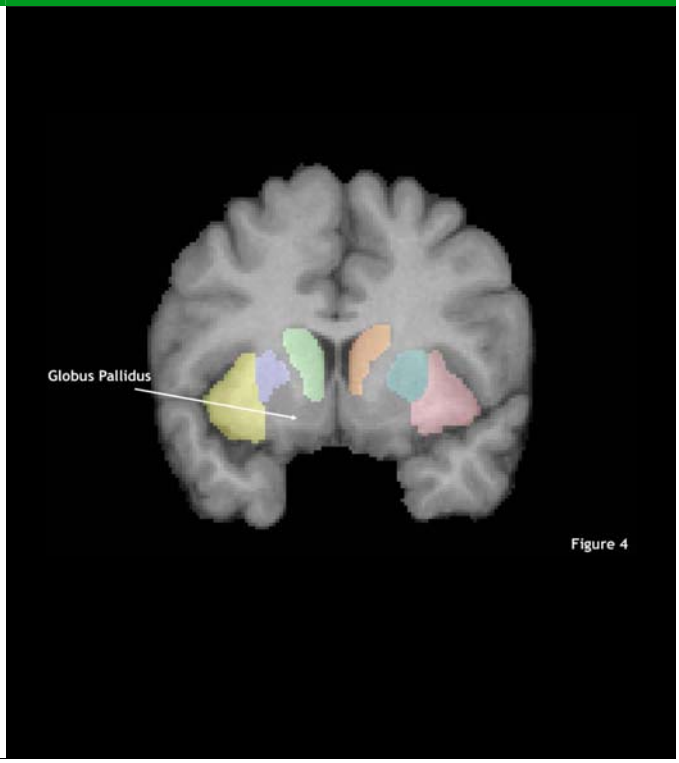


Putamen

Step 3

Moving posteriorly, the globus pallidus will appear, thus a bridge between the putamen and the caudate nucleus is made. At this point, switch up to masking half of the area masked previously for the putamen. This move will insure that the globus pallidus is not masked and that there will be consistency in delineations between brains. (Fig. 4)

Figure 4

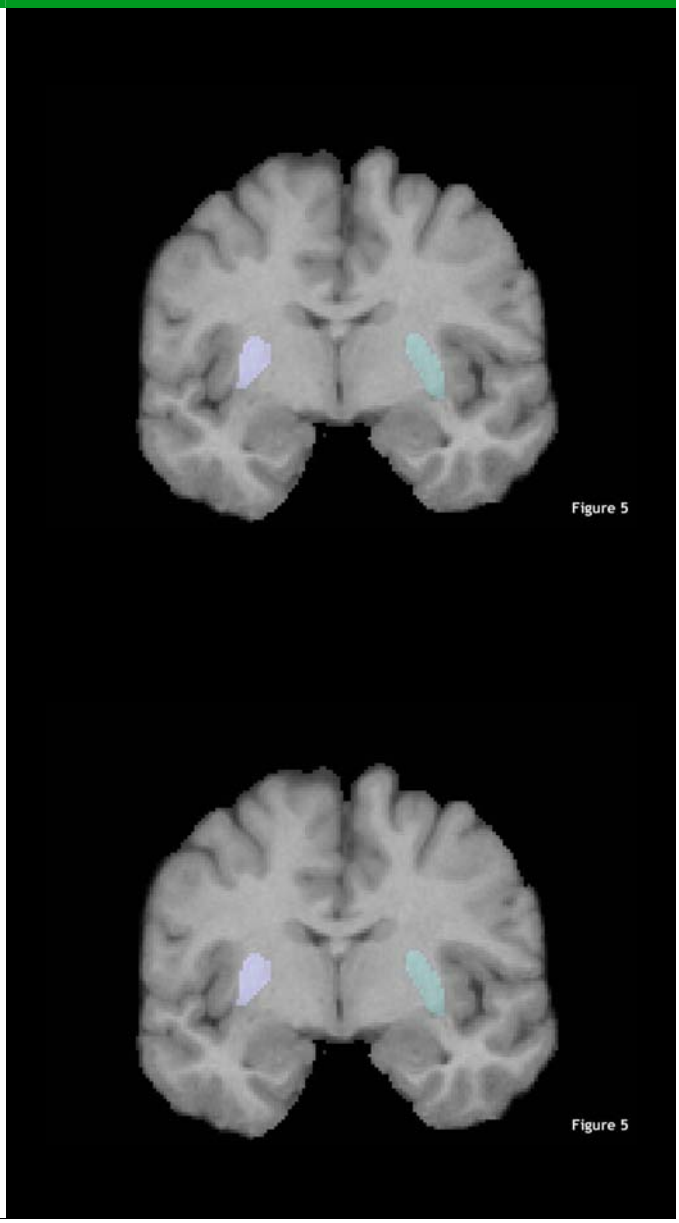


Putamen

Step 4

Moving even further posterior, the globus pallidus will no longer be visible, and the putamen will take on an almond shape. Mask the almond shaped putamen, being careful to exclude all insular cortex (the gray matter surrounding the Sylvian Fissure). The putamen will continue to reduce in size; mask until the putamen is no longer visible. (Figs. 5, 6)

Figures 5 & 6



Superior Frontal Gyrus

Step 1

The superior frontal gyrus consists of all cortex between the cingulate sulcus inferiorly, the superior frontal sulcus superiorly, and the precentral sulcus posteriorly. (Fig. 1, Fig. 2)

Figures 1 & 2

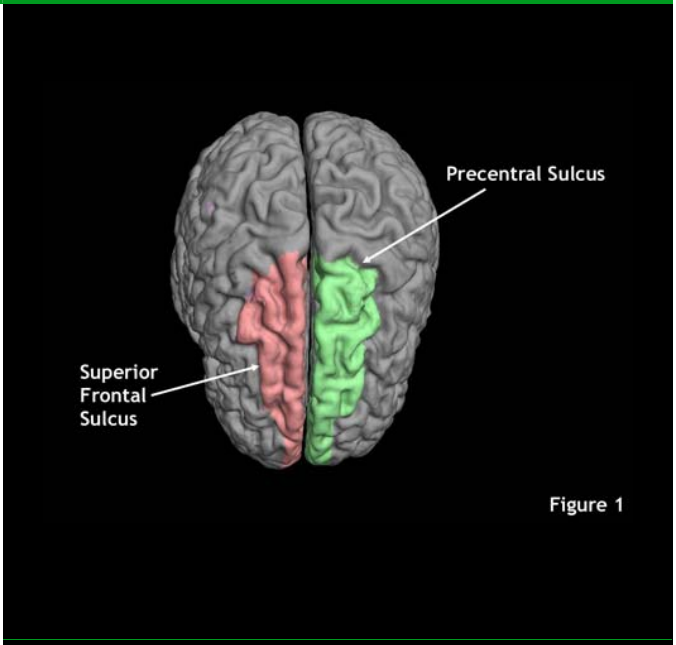


Figure 1

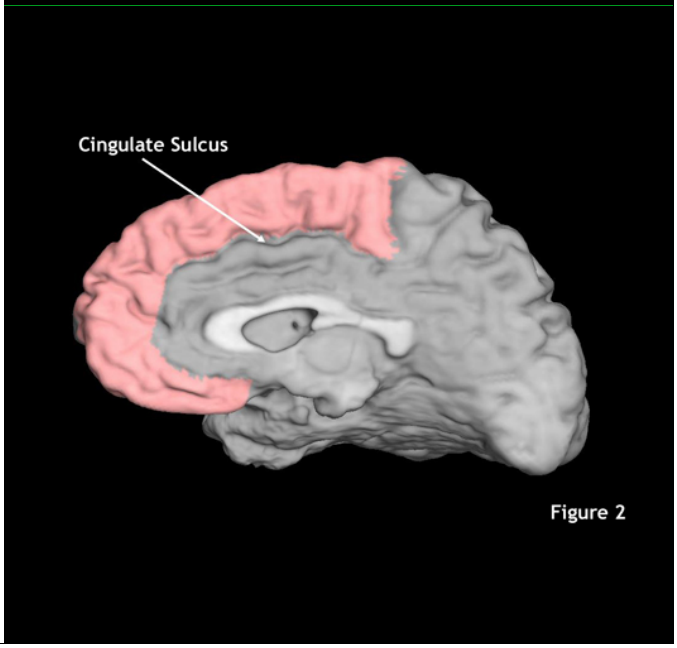


Figure 2

Superior Frontal Gyrus

Step 2

Masking of the superior frontal gyrus is done in the coronal view. Find a slice where the superior frontal sulcus is clearly visible and follow the sulcus to its most anterior slice. Draw a line from the superior frontal sulcus down to the olfactory sulcus and mask everything between this boundary and the interhemispheric fissure. (Fig. 3, Fig. 4)

Figures 3 & 4

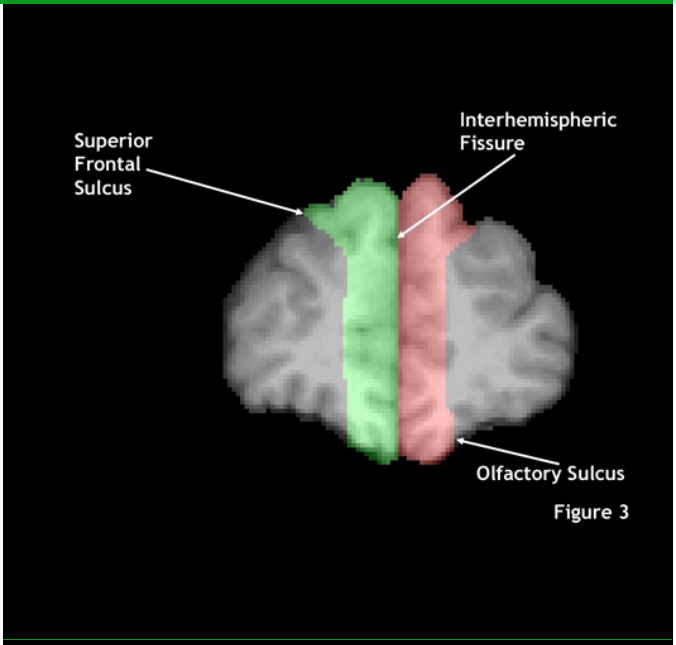


Figure 3

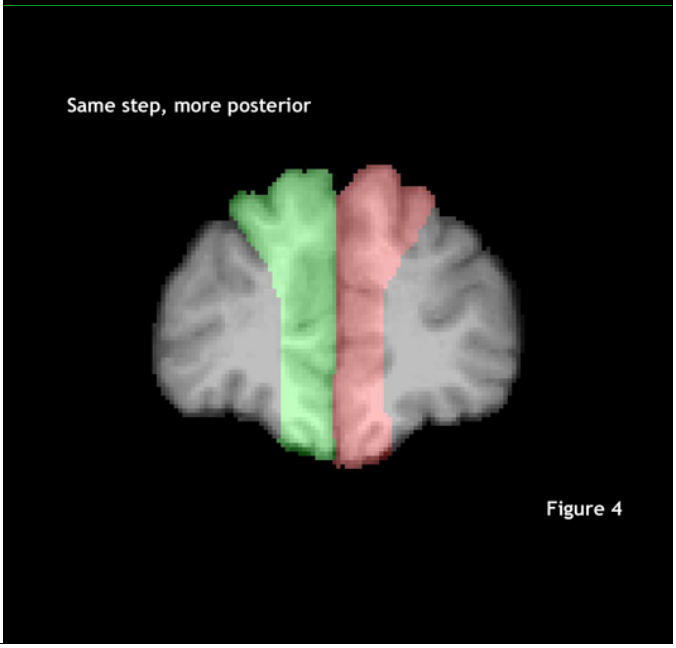


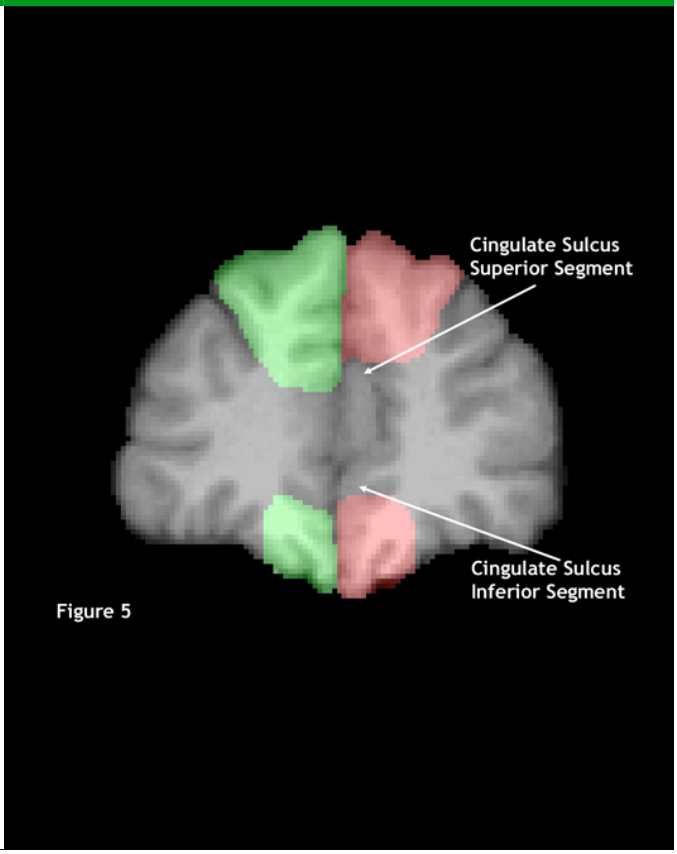
Figure 4

Superior Frontal Gyrus

Step 3

Moving posteriorly, the cingulate sulcus will appear. At this time, the superior frontal gyrus is split into superior and inferior segments. Mask from the superior frontal sulcus to the superior segment of the cingulate sulcus. Follow the cingulate sulcus to the interhemispheric fissure and fill in everything within these boundaries. For the inferior segment, mask from the olfactory sulcus up to the inferior segment of the cingulated sulcus. Follow the cingulated sulcus to the interhemispheric fissure and mask everything within these boundaries. (Fig. 5)

Figure 5



Step 4

Once the olfactory sulcus is no longer visible, only the superior segment of the superior frontal gyrus is masked.

Superior Frontal Gyrus

Step 5

End masking when the precentral sulcus first comes into view. This can be found by finding a slice in the axial view where the precentral sulcus is very clear, click on its most anterior point, then find the corresponding slice in the coronal view. (Fig. 6, Fig. 7)

Figures 6 & 7

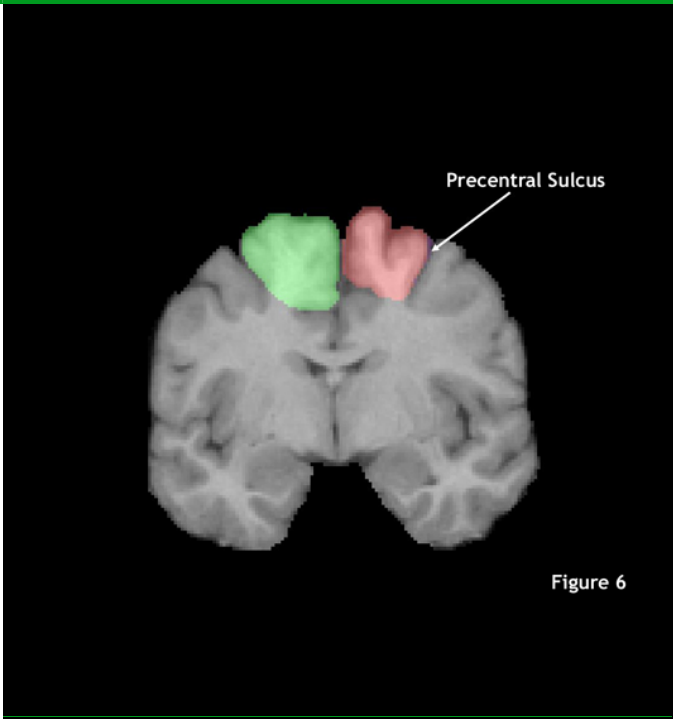


Figure 6

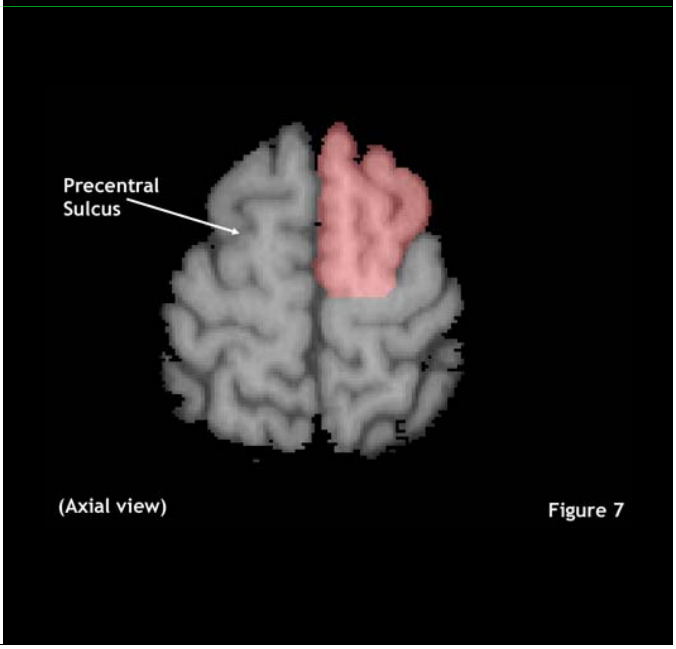


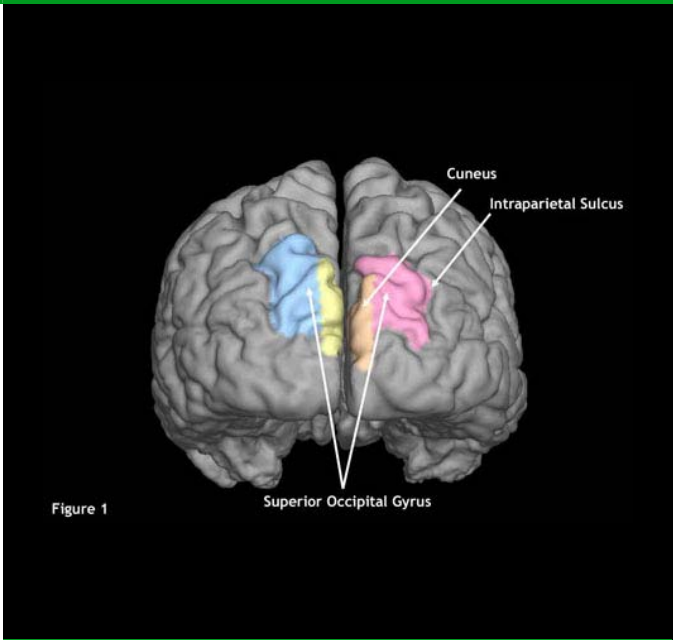
Figure 7

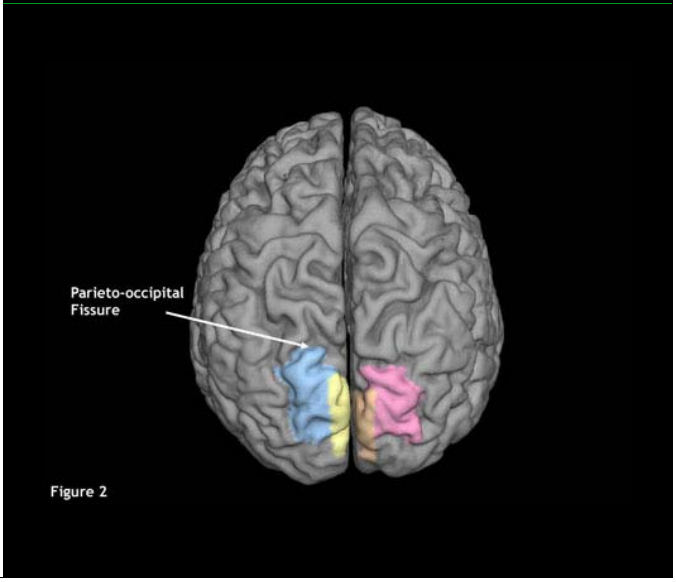
Superior Occipital Gyrus

Step 1

The superior occipital gyrus is the superior part of the occipital lobe. Its anterior boundary is the parieto-occipital fissure. Its lateral boundary is the intraparietal sulcus. Its medial boundary is defined by the lateral boundary of the cuneus. (Fig. 1, Fig. 2)

Figures 1 & 2



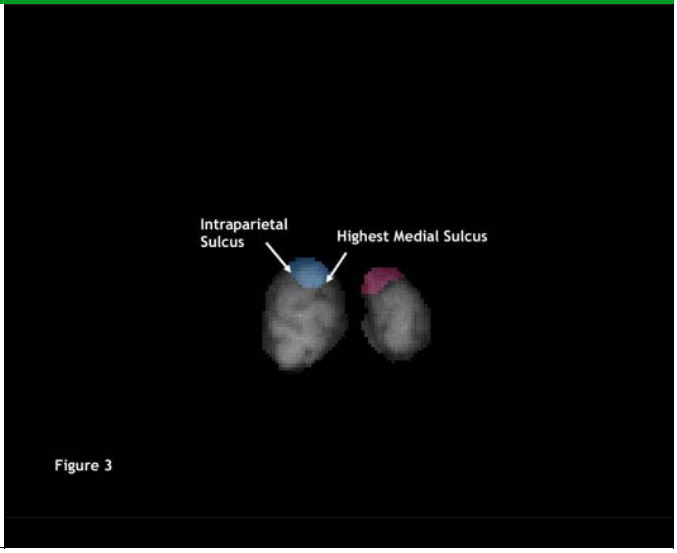


Superior Occipital Gyrus

Step 2

Begin masking in the coronal view where the intraparietal sulcus begins posteriorly. Sometimes this will only be when there is cortex lateral to the intraparietal sulcus, and other times the sulcus will still be clearly defined after this point. Follow the intraparietal sulcus down to its end point and connect it to the highest medial sulcus. (Fig. 3)

Figure 3



Superior Occipital Gyrus

Step 3

Follow step 2 until the parieto-occipital fissure comes into view. This sulcus can be found clearly in the sagittal view. At this point masking of the superior occipital gyrus ends. (Fig. 4, Fig. 5)

Figures 4 & 5

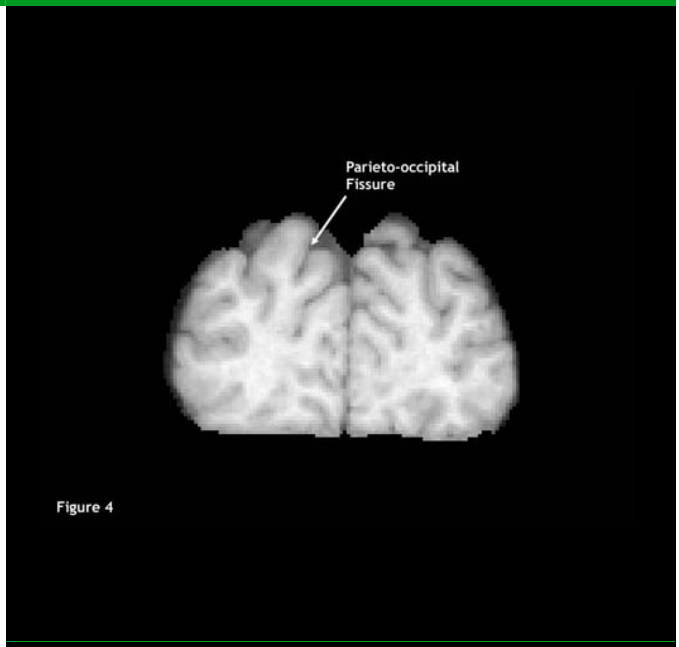


Figure 4

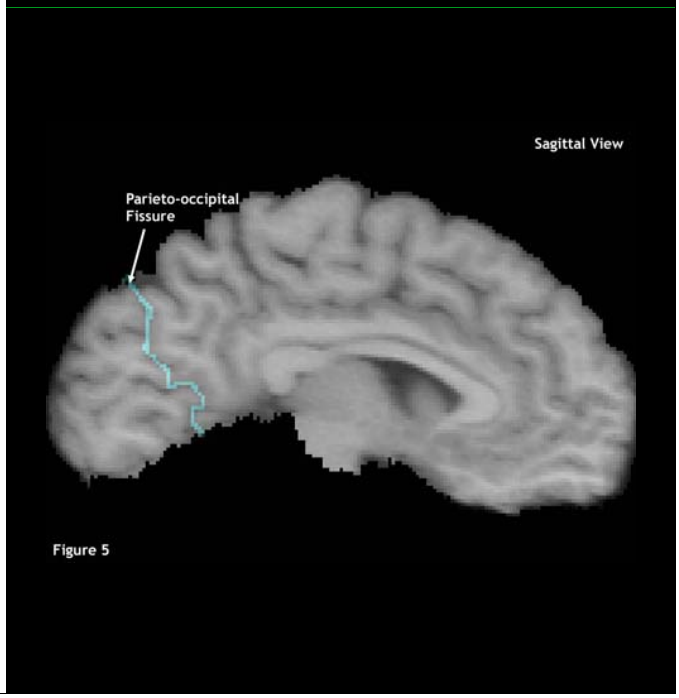


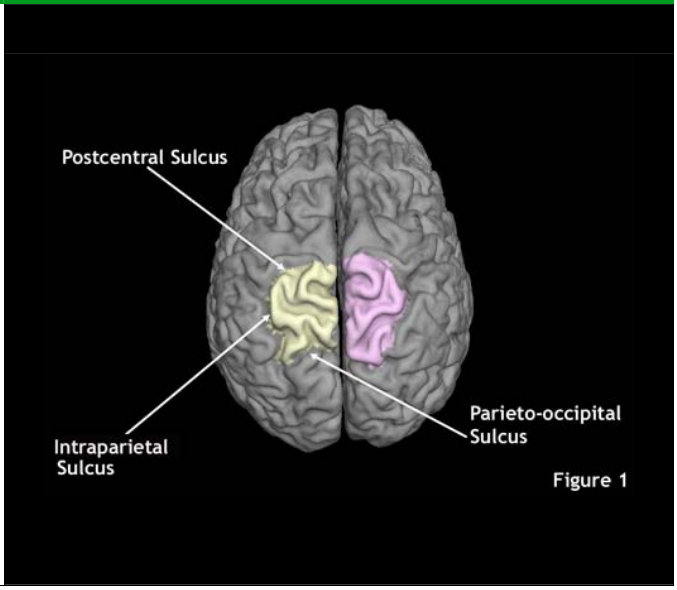
Figure 5

Superior Parietal Gyrus

Step 1

The superior parietal gyrus is the most superior structure of the parietal lobe. The anterior boundary is the postcentral sulcus and the posterior boundary is the parieto-occipital fissure. Laterally, the boundary of the superior parietal gyrus is the intraparietal sulcus. Medially, the inferior boundary is the calcarine sulcus and the cingulate sulcus. (Fig. 1)

Figure 1

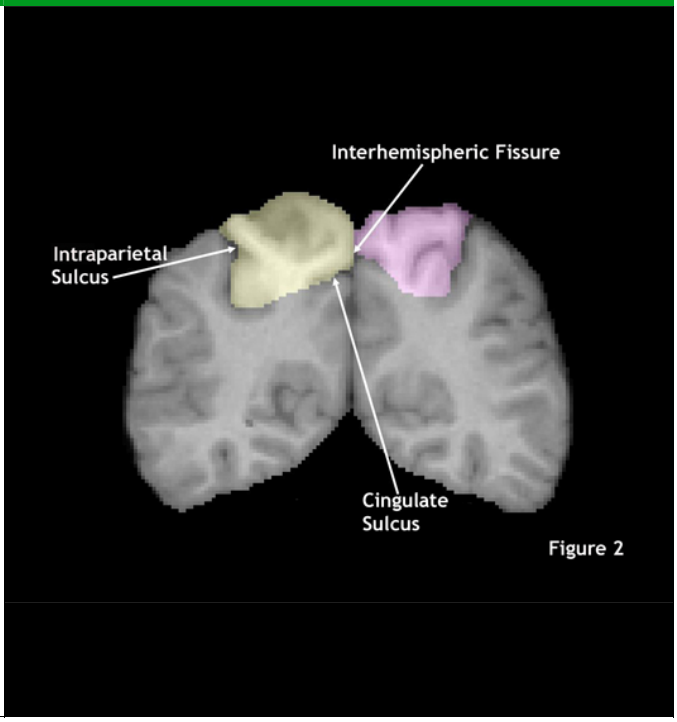


Superior Parietal Gyrus

Step 2

Masking of the superior parietal gyrus is done in the coronal view. Begin masking anteriorly where the intraparietal sulcus first comes into view. Follow the intraparietal sulcus to its inferior end and angle a line to the top of the cingulate sulcus. Follow the cingulate sulcus to its medial endpoint and mask up the interhemispheric fissure, excluding all cortex from the other hemisphere. (The interhemispheric fissure is the division between the left and right hemispheres.) Mask everything within these boundaries. (Fig. 2

Figure 2

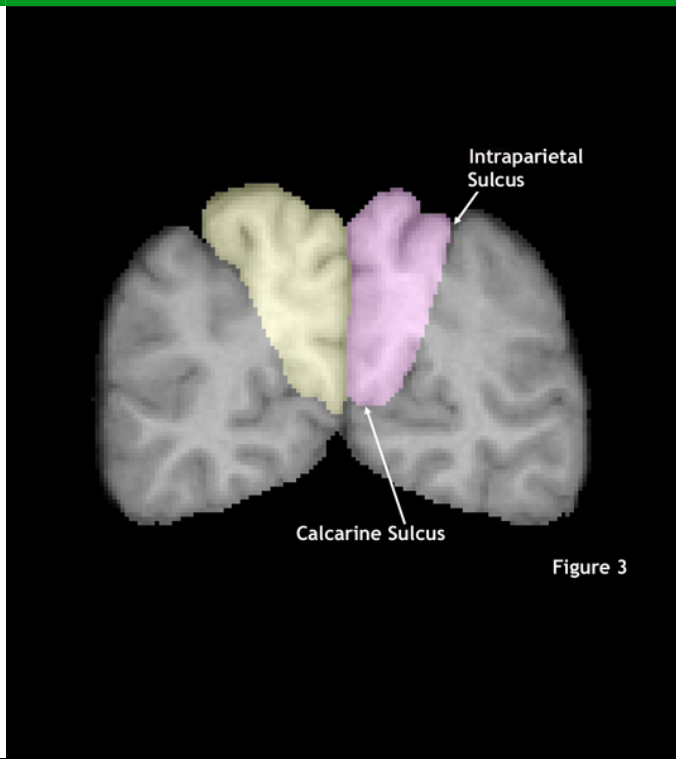


Superior Parietal Gyrus

Step 3

Once the cingulate sulcus is no longer visible, mask from the intraparietal sulcus down to the calcarine sulcus and up the interhemispheric fissure. Mask everything within these boundaries. (Fig. 3)

Figure 3



Superior Parietal Gyrus

Step 4

Moving posteriorly, the parietal occipital fissure will appear. At this point, mask the intraparietal sulcus to its inferior end and draw a straight line to the parieto-occipital fissure. The parieto-occipital fissure can be found easily in the saggital view (Fig. 5). Follow the interhemispheric fissure up to its superior end point and mask everything within these boundaries. End masking when the parieto-occipital fissure is no longer visible. (Fig. 4, Fig. 5, Fig. 6)

Figures 4 5 & 6

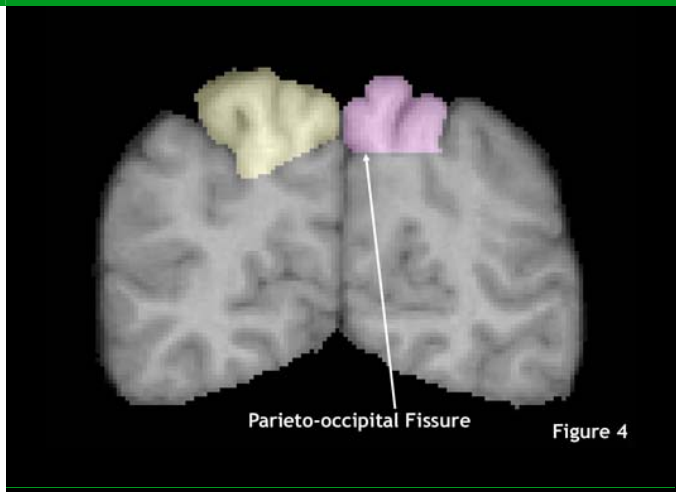


Figure 4

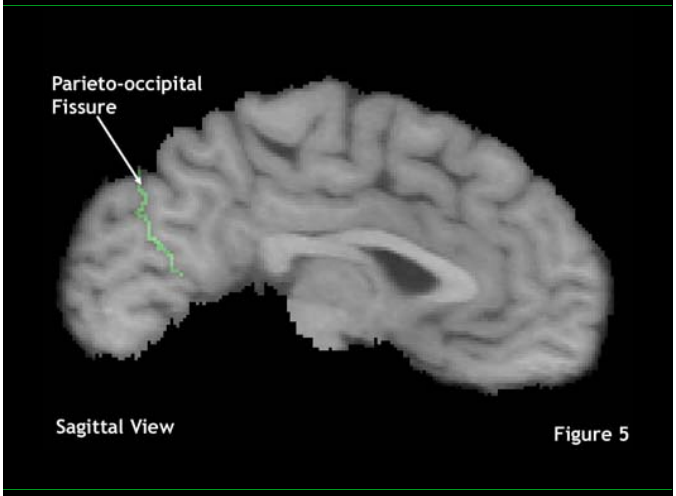


Figure 5

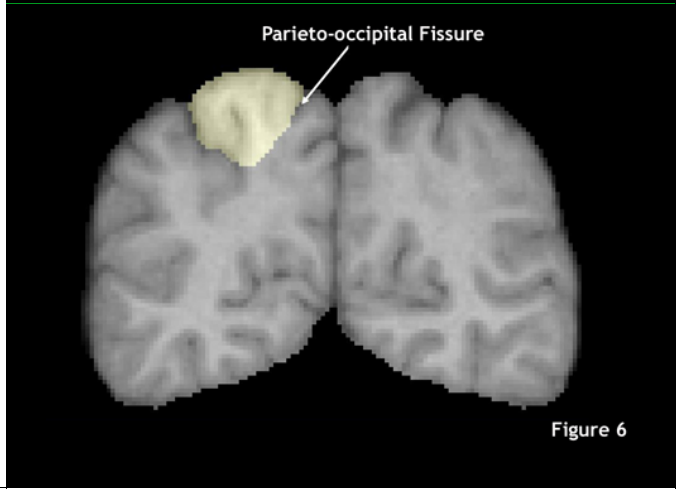


Figure 6

Superior Temporal Gyrus

Step 1

Mask in the coronal view starting when the temporal lobe begins to appear at the anterior end of the brain. The superior boundary of the superior temporal gyrus is the Sylvian fissure and the inferior boundary of the gyrus is the superior temporal sulcus. When the temporal lobe first appears, trace the Sylvian fissure and mask everything inferior to it. An object model is crucial as a reference for the boundaries. (Fig. 1, Fig. 2, Fig. 3)

Figures 1 2 & 3

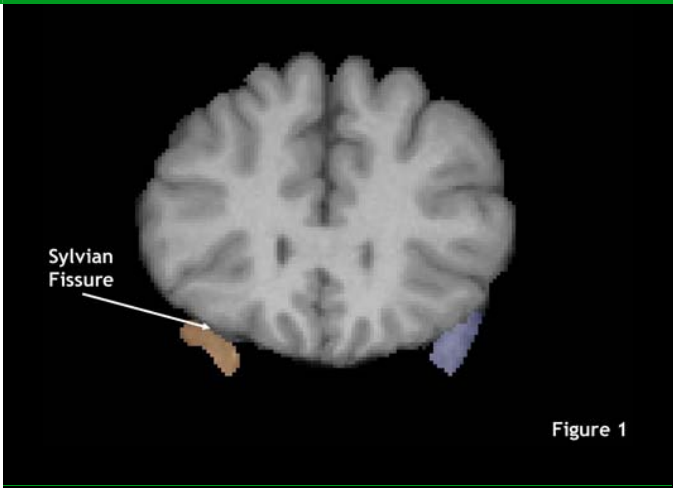


Figure 1

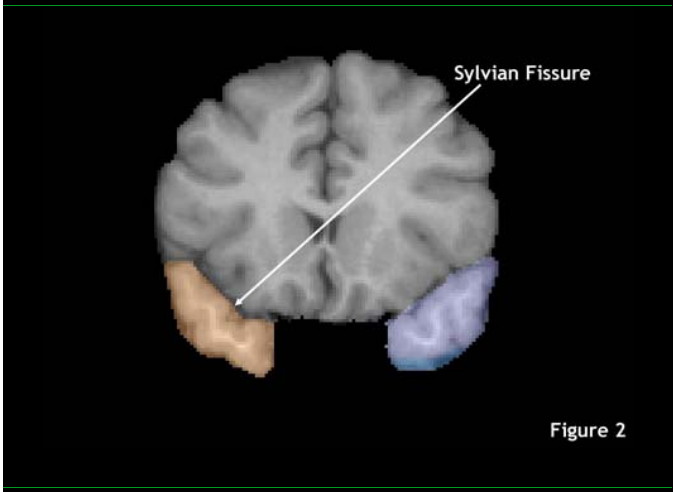


Figure 2

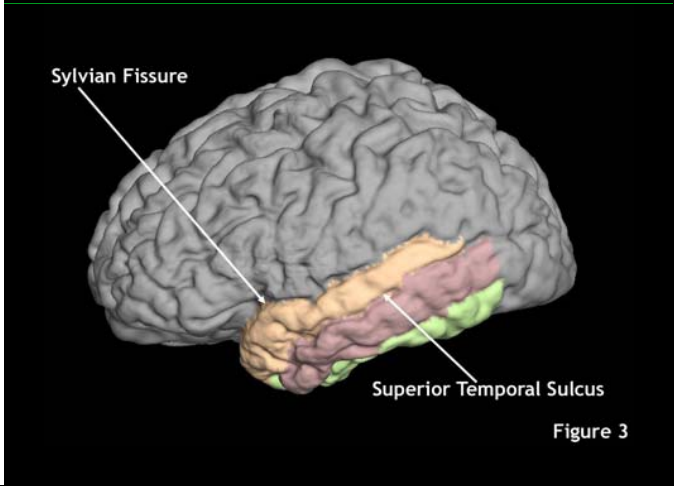


Figure 3

Superior Temporal Gyrus

Step 2

When the superior temporal sulcus starts to appear below the Sylvian fissure, trace the superior temporal sulcus and connect it to the Sylvian fissure tracing the entire gyrus. se the object model as an additional reference to ensure that only the region between the superior temporal sulcus and Sylvian fissure is being masked. At times the superior temporal gyrus appears as a double gyrus. If this occurs, check the object model to reference where the correct boundaries are. (Fig. 4, Fig. 5)

Figures 4 & 5

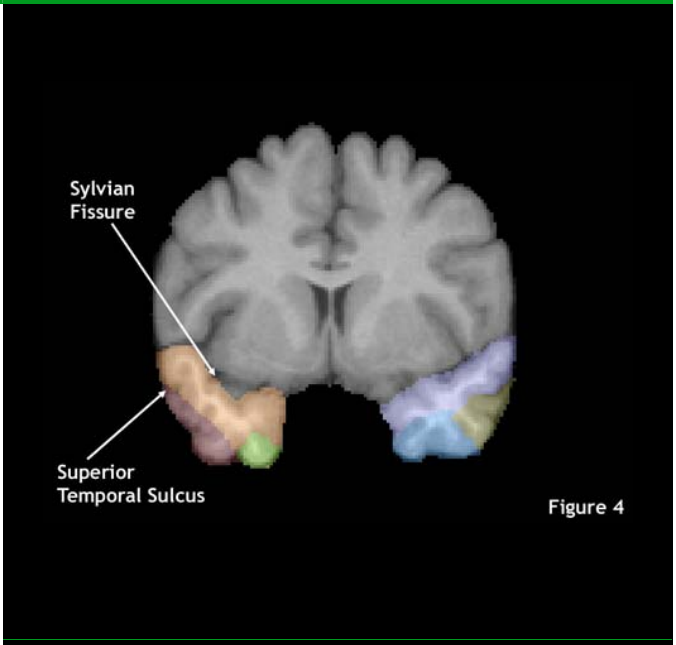


Figure 4

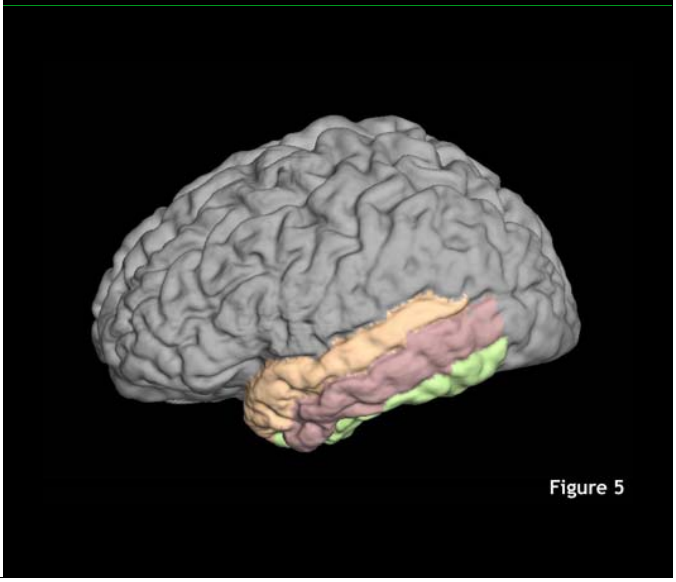


Figure 5

Superior Temporal Gyrus

Step 3

Once the temporal stem appears, trace the Sylvian fissure to the temporal stem then continue to follow the superior temporal sulcus. Because the superior temporal sulcus becomes less clear, reference the object model. Follow this step all the way to the posterior end of the superior temporal gyrus. In some brains, the superior temporal sulcus appears to be a double gyrus. (Fig. 6, Fig. 7)

Figures 6 & 7

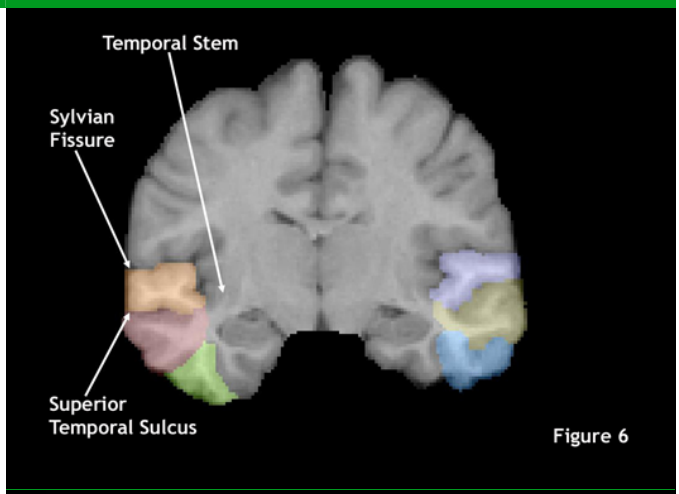


Figure 6

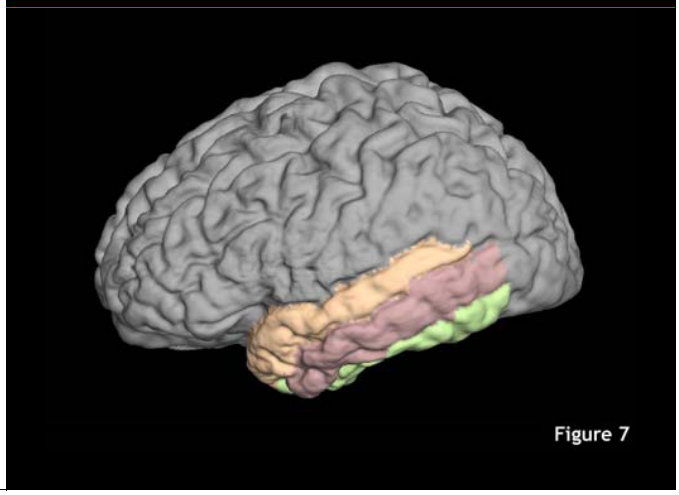


Figure 7

Superior Temporal Gyrus

Step 4

Moving more posterior, the superior temporal gyrus may look like it is merging with the middle temporal gyrus and the supramarginal gyrus. Again, continue to reference the object model to decipher between the superior temporal gyrus and the Sylvian fissure. (Fig. 8, Fig. 9)

Figures 8 & 9

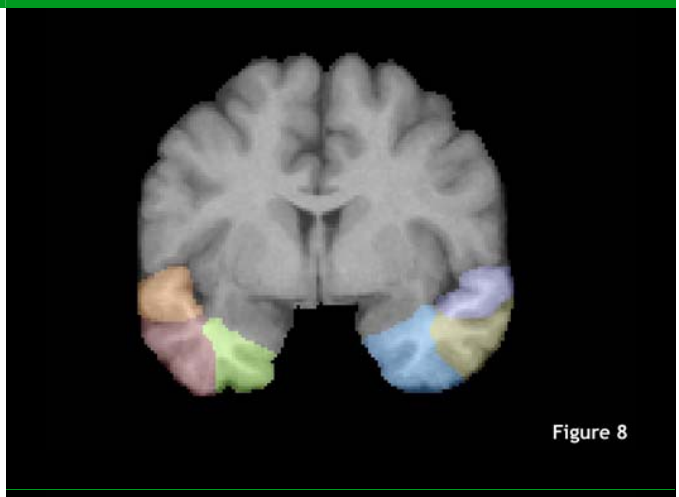


Figure 8

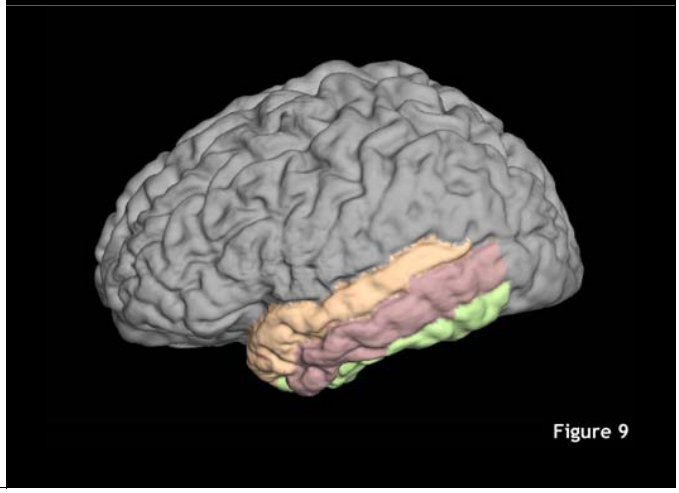


Figure 9

Superior Temporal Gyrus

Step 5

To verify when to stop masking in the coronal view, switch to the sagittal view. The posterior end of the superior temporal gyrus occurs at the junction where the horizontal ramus of the Sylvian fissure and the ascending ramus of the superior temporal sulcus meet. If no ascending ramus of the superior temporal sulcus is seen, a straight line is drawn from the endpoint of the horizontal ramus of the Sylvian fissure down to the superior temporal sulcus. (Fig. 10, Fig. 11, Fig. 12)

Figures 10 11 & 12

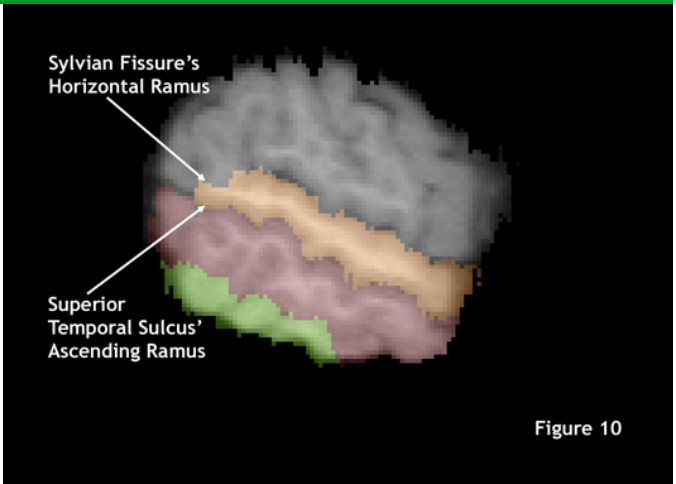


Figure 10

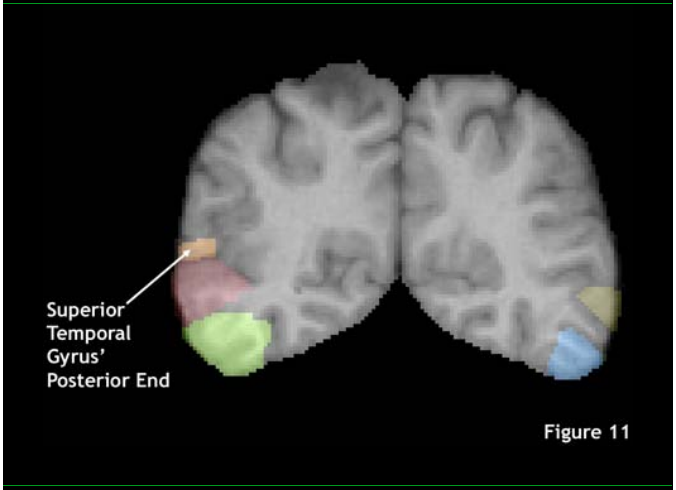


Figure 11

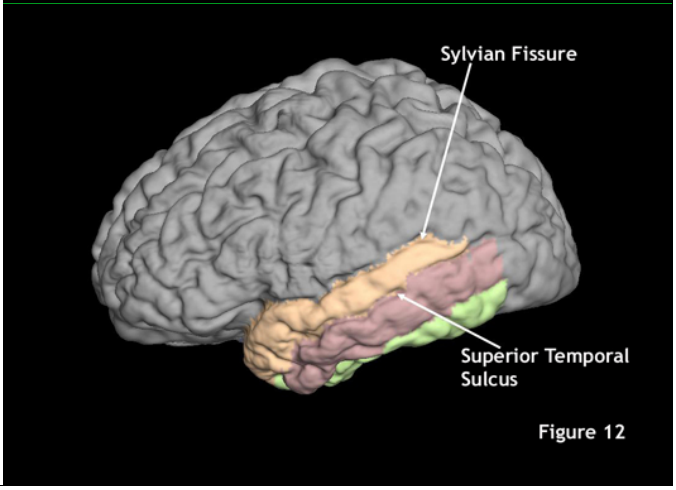


Figure 12

Supramarginal Gyrus

Step 1

The supramarginal gyrus (SM) is part of the parietal lobe. Its superior boundary is the intraparietal sulcus and its inferior boundary is the Sylvian fissure. The anterior boundary is the postcentral sulcus and the posterior boundary is the Jensen sulcus. The Jensen sulcus is located in between the superior end of the Sylvian fissure and the superior temporal sulcus' ascending branch. Although the Jensen sulcus does not always continue all the way to the temporal lobe, mask all the way down to the temporal lobe to complete the posterior boundary of the SM. (Fig. 1, Fig. 2)

Figures 1 & 2

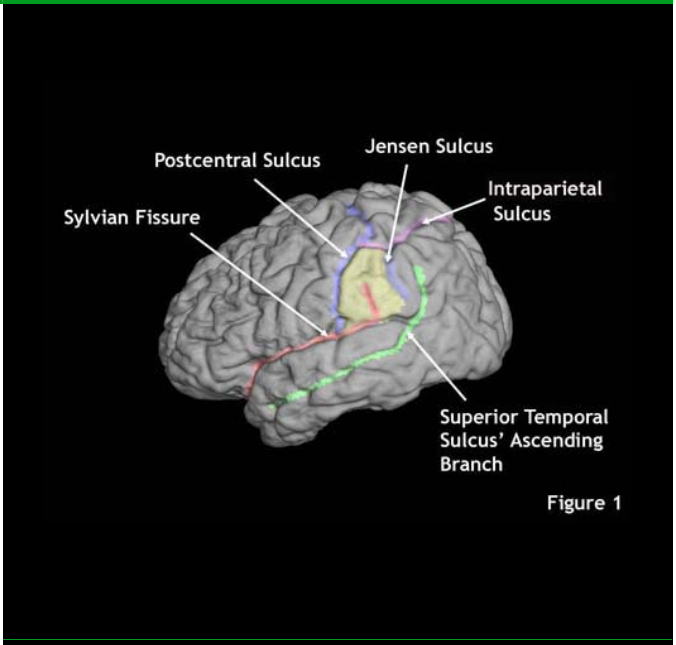


Figure 1

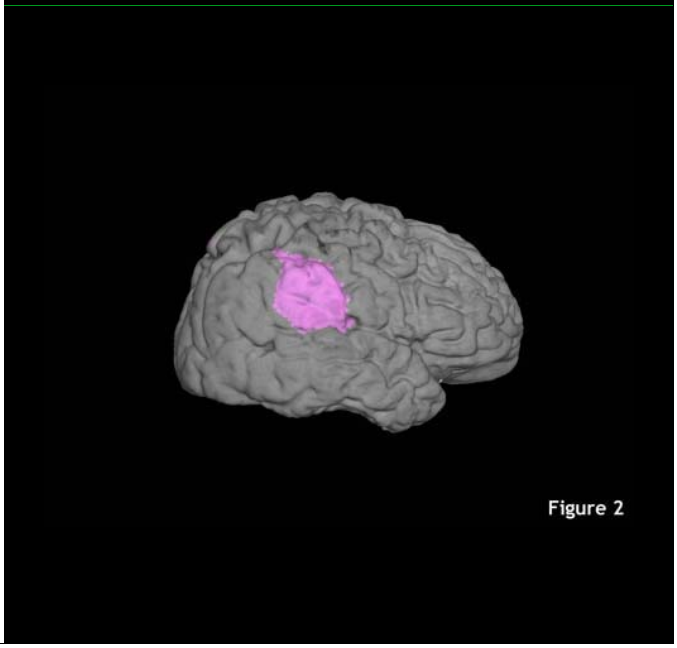


Figure 2

Supramarginal Gyrus

Step 2

Mask in the axial view staring superiorly. Once the postcentral and Jensen sulci emerge adjacent to the intraparietal sulcus, mask the area within all three boundaries. Refer to a 3D object model to locate the SM's boundaries and click on the boundary to see where the sulcus is located on the corresponding axial view. (Fig. 3, Fig. 4)

Figures 3 & 4

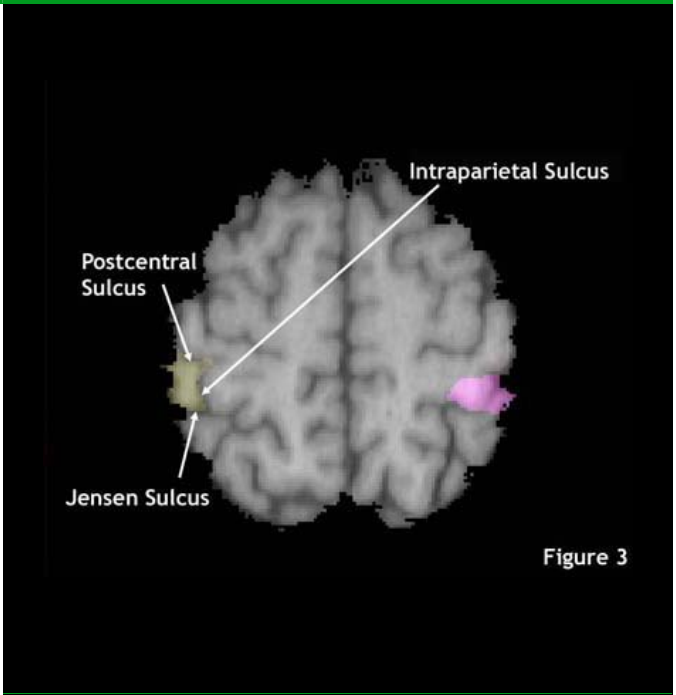


Figure 3

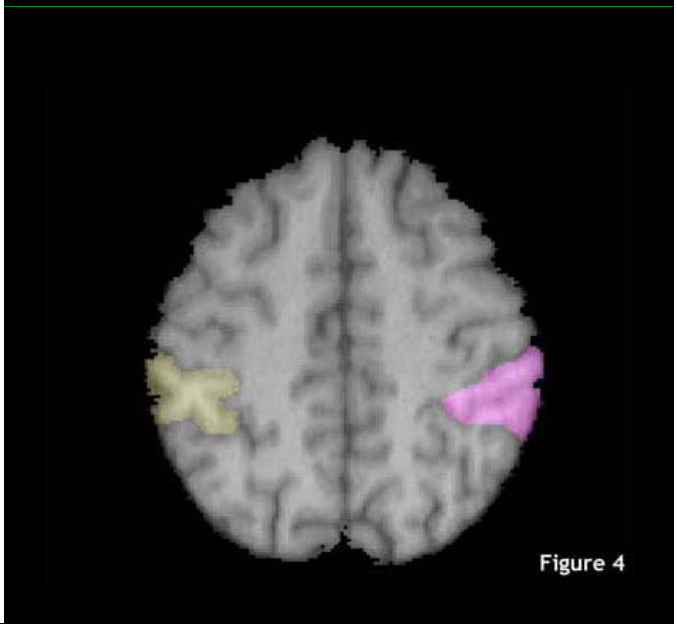


Figure 4

Supramarginal Gyrus

Step 3

When the intraparietal sulcus is no longer visible trace the Jensen sulcus to its interior end and draw an angled line to the interior end of the postcentral sulcus. Continue this step inferiorly until reaching the temporal lobe. (Fig. 5, Fig. 6, Fig. 7)

Figures 5 6 & 7

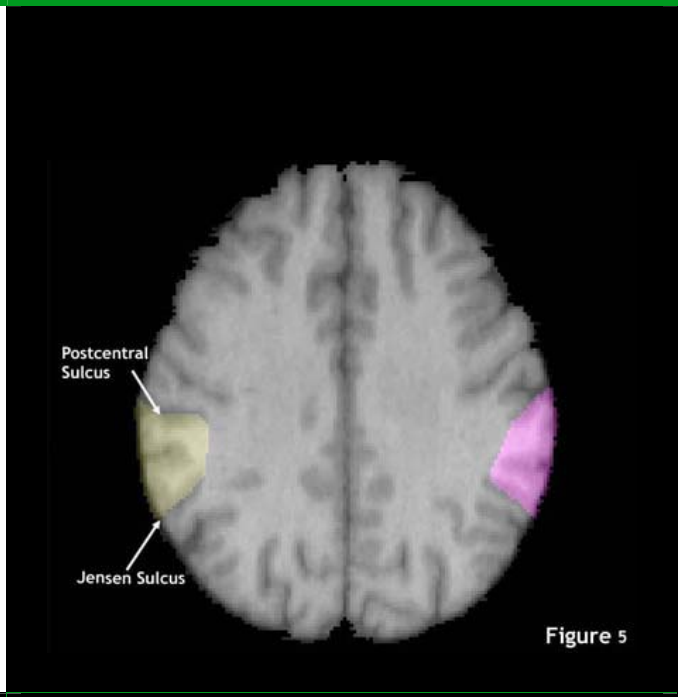


Figure 5

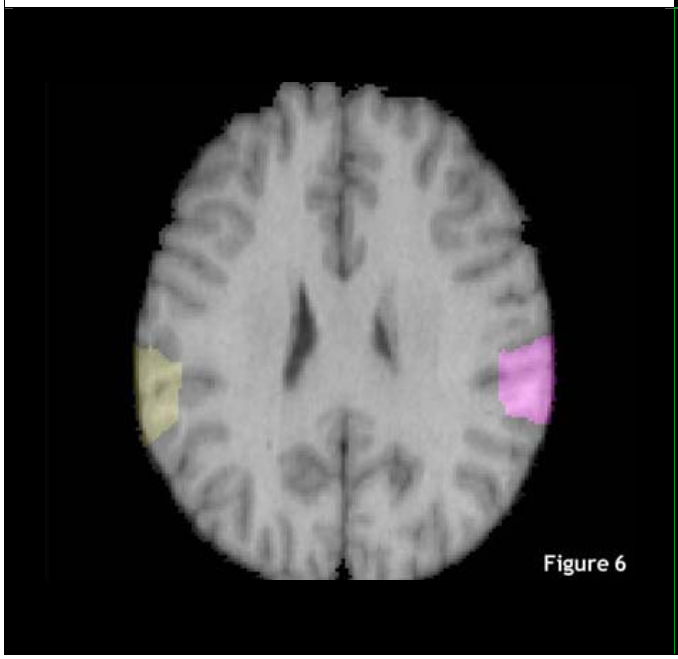


Figure 6

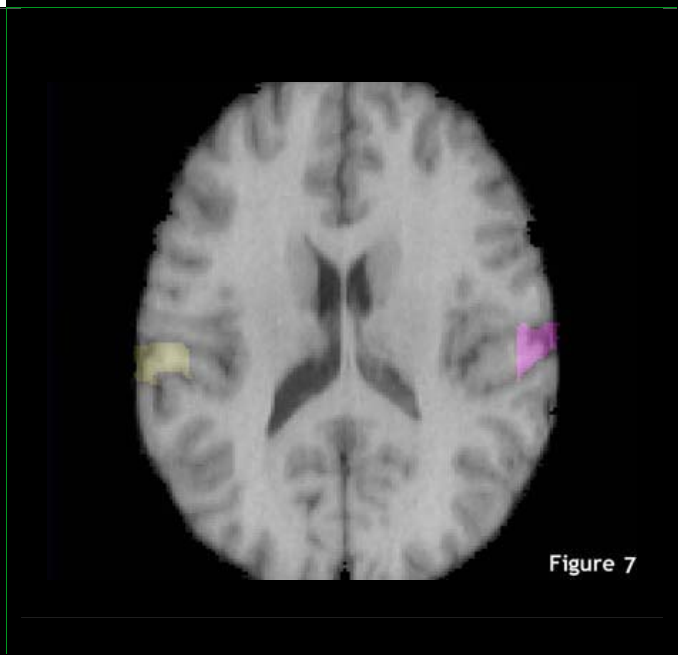


Figure 7

Step 4

Moving posteriorly, the Jensen sulcus will become unclear. At this point, reference the last slice where the sulcus was clear and approximate its location on the following slices. This will create a straight line down from the end of the Jensen sulcus on the 3D object. End masking when the SM reaches the superior end of the temporal lobe on the 3D object. (Fig. 1)