Pediatric datasets for use with FreeSurfer v5.3

When working with pediatric data, a quick run through of the recon from the anterior to posterior of the brain can be helpful in deciding if the recon requires only small or moderate and major edits. For recons requiring more than minor edits, for example, if part of the temporal pole or the posterior part of the occipital lobe are not being included due to signal drop-off, the subject needs to be run once with control point edits and then again after with white matter edits. We always recommend making a copy of the wm.mgz before any edits are done and using the –cp flag or –wm flag based on the type of edits you are doing. It is advisable to always make control point edits first as they more drastically change the white matter surface. Additionally, the –cp flag causes the recon-all stream to begin earlier in the pipeline and therefore does not take the wm.mgz edits into account or may effectively delete them (in general, this shouldn't happen but it can for very difficult regions). If control points do not fix the recon satisfactorily, white matter edits may be needed to further refine the white surface.

Most cases that require edits can be considered fixed after two instances of edits and re-processing (“reruns”) but if there is a lot of motion, signal dropoff, or a large amount of control points were needed, a third rerun may be necessary.

For cases that require a moderate amount of edits, adding control points may take 45 minutes to 1.5 hours. White matter edits can take slightly longer, 1.5 to 2 hours. After 2 or 3 reruns the majority of cases could be brought up to a “good” or “very good” level. However, sometimes, cases could not be fixed and remained relatively “poor” mostly due to motion artifacts making the surfaces almost impossible to fix. These motion artifacts occur mostly in the superior parietal (Figure 1) and superior frontal lobe regions and cause the surfaces to occasionally, in the worst cases, cling to the motion “rings” rather than the actual gyri (figure 2). Very occasionally, signal drop-off in the occipital lobe was unable to be brightened adequately by control points and the surfaces could not be guided by white matter edits to include the posterior portion of these lobes. In both these types of cases we had to eventually exclude them from the study.

Common problem areas are: the temporal poles, the posterior portions of the occipital lobes, as well as the white matter surrounding the hippocampus and white matter strip lateral to the globus pallidus. White matter edits may also be necessary to fix areas where dura (particularly though the parietal lobes superior to the brain), bone, (particularly the eye sockets), or venous sinuses are being mistakenly included in the white surface. It is often possible that editing the wm.mgz and fixing the white surface will also fix the problem with the pial surface in this area, if there is one making editing the brainmask.mgz not necessary.

The aseg structures that most frequently contained errors and needed to be edited were the hippocampus, amgydala and globus pallidus. For these structures, we generally do not edit the aseg but instead use control points or white matter edits to guide the aseg back into place. For example the putamen segmentation often was overlabeled too far laterally, so control points or white matter voxels added to the thin strip of white matter between putamen and insular gray matter (Note: in order for the control points to affect the aseg, you have to run the flag -canorm-usecps when reprocessing the case). After the rerun the aseg would often be improved. The same approach was used when the hippocampal aseg was inaccurate, usually overlabeled too much inferiorly. Control points or white matter voxels were added within the strip of white matter inferior to the hippocampus, guiding the aseg into its correct position. You should make these types of edits first before adding control points to fix the surfaces.

The aseg should generally only be edited if the cerebellum segmentation leaks into the superior brain gray matter or vice versa. In these cases you can “paint” the aseg the correct aseg value for gray matter.

The most time-consuming and common issue with pediatric data sets occurs in the temporal lobes and is due to signal drop-off in these areas. Often this means the pial and white surfaces drop out a few or many slices too early in the temporal pole. Most commonly this means that there are 4-8 slices in which the temporal lobes, usually the anterior temporal poles, are visible but that the surfaces are not following the tissue boundaries adequately or completely. Equally often the pial surface will be more accurate than the white matter surfaces due to the white matter voxels in the temporal lobes not being a high enough intensity (110). In both types of cases, the most efficient approach is to use control points on every other slice in the white matter as far into the temporal lobe gyrii as the white matter reaches. With the pediatric data sets we found we often had to put control points into very thin strips of unlabeled white matter in order to adequately push the surfaces into an accurate position. With adult data we have generally been more conservative, assuring that no control point was placed on any voxel that wasn’t completely surrounded by white matter. With the pediatric data, this approach did not improve the surfaces enough because the signal drop-off was often very extreme. We almost always had to use more control points closer together than would have been recommended for an adult scan. However, sometimes, putting control points on each slice can negatively affect the surfaces, so as a rule of thumb we always placed them on every other slice. On average, in cases that needed moderate edits, we used 5-15 control points every other slice to bring the voxel intensity value up to 110. Placing several control points orthogonal to each other in an evenly spaced line along the strand of white matter was more effective then clumping them together in one spot. Placing control points on voxels that are already at a value of 110 will be largely ineffective.

After re-running recon all with the –cp flag, smaller white matter edits may be necessary, especially if there are places where the thin strands of white matter in the temporal lobes are still disconnected from each other. Adding voxels to the wm.mgz to connect these strands or islands will be additionally helpful. We found that making these strands or connections thicker than the actual underlying white matter (2/3 voxels wide instead of just 1) in order to reinforce and guide the surfaces was more effective. These type of edits may need to be employed to reinforce the strip of white matter inferior to the hippocampus. The temporal lobes themselves can take an hour each in the worst cases, but often they are the only source of large edits.

Lastly, it may be necessary to check the most posterior few slices of the occipital lobe. Both the pial and white matter surface should be checked for accuracy here. Additionally, the inferior and medial most gyri in the anterior portion of the brain were sometimes excluded, but quick white matter edits to reinforce the strip of white matter or control points were effective.

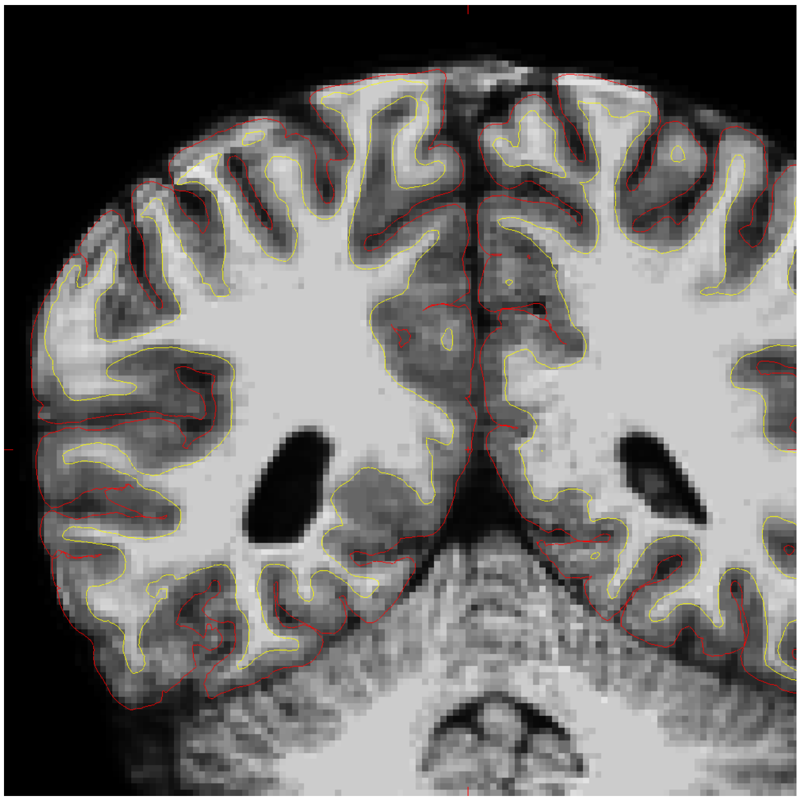

Figure 1: Motion "rings" in superior right hemisphere parietal lobe

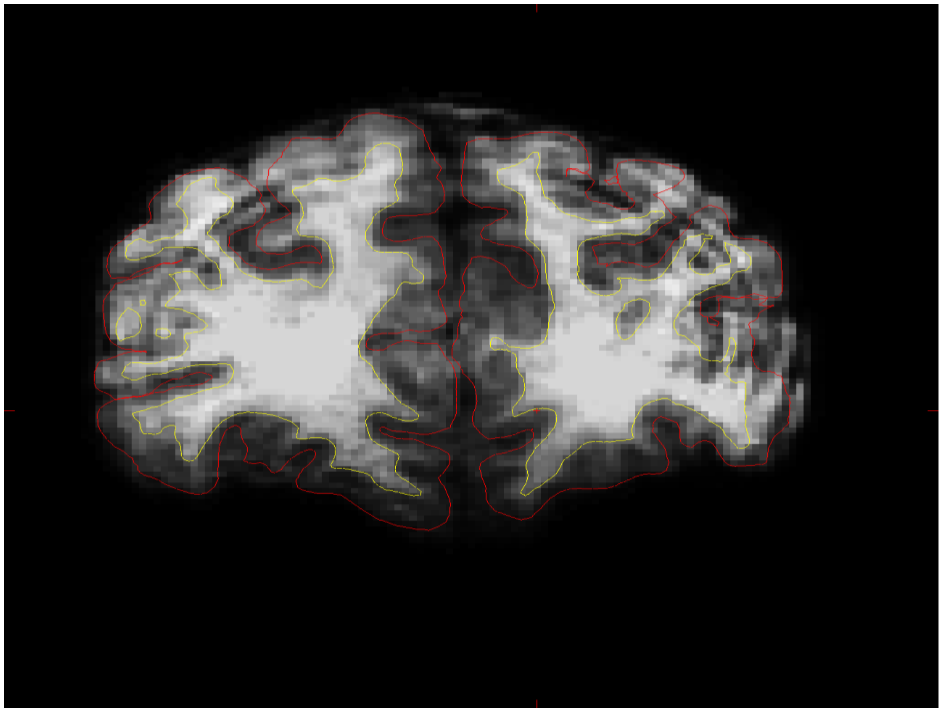

Figure 2: More severe motion ringing throughout the anterior frontal lobe. Notice both the white and pial surface grabbing the motion "ringing" instead of the gyri.