ENIGMA Cortical QC 2.0

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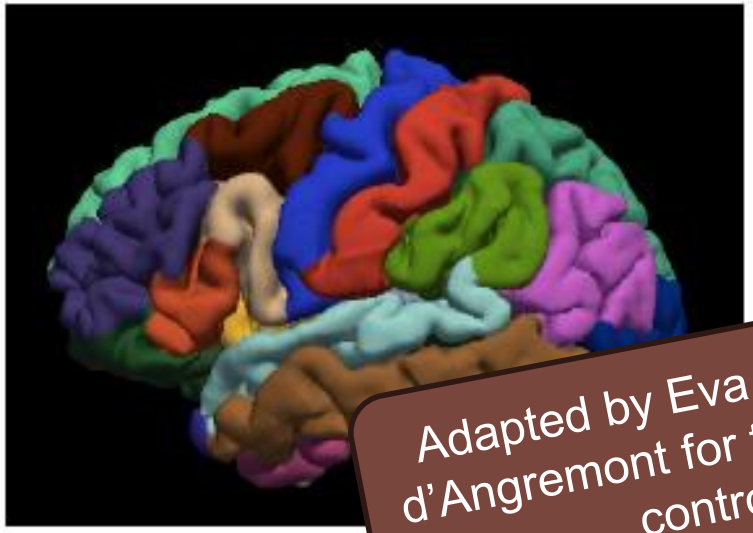


Adapted by Eva van Heese and Emile d'Angremont for the ENIGMA-PD quality control (July 2025)

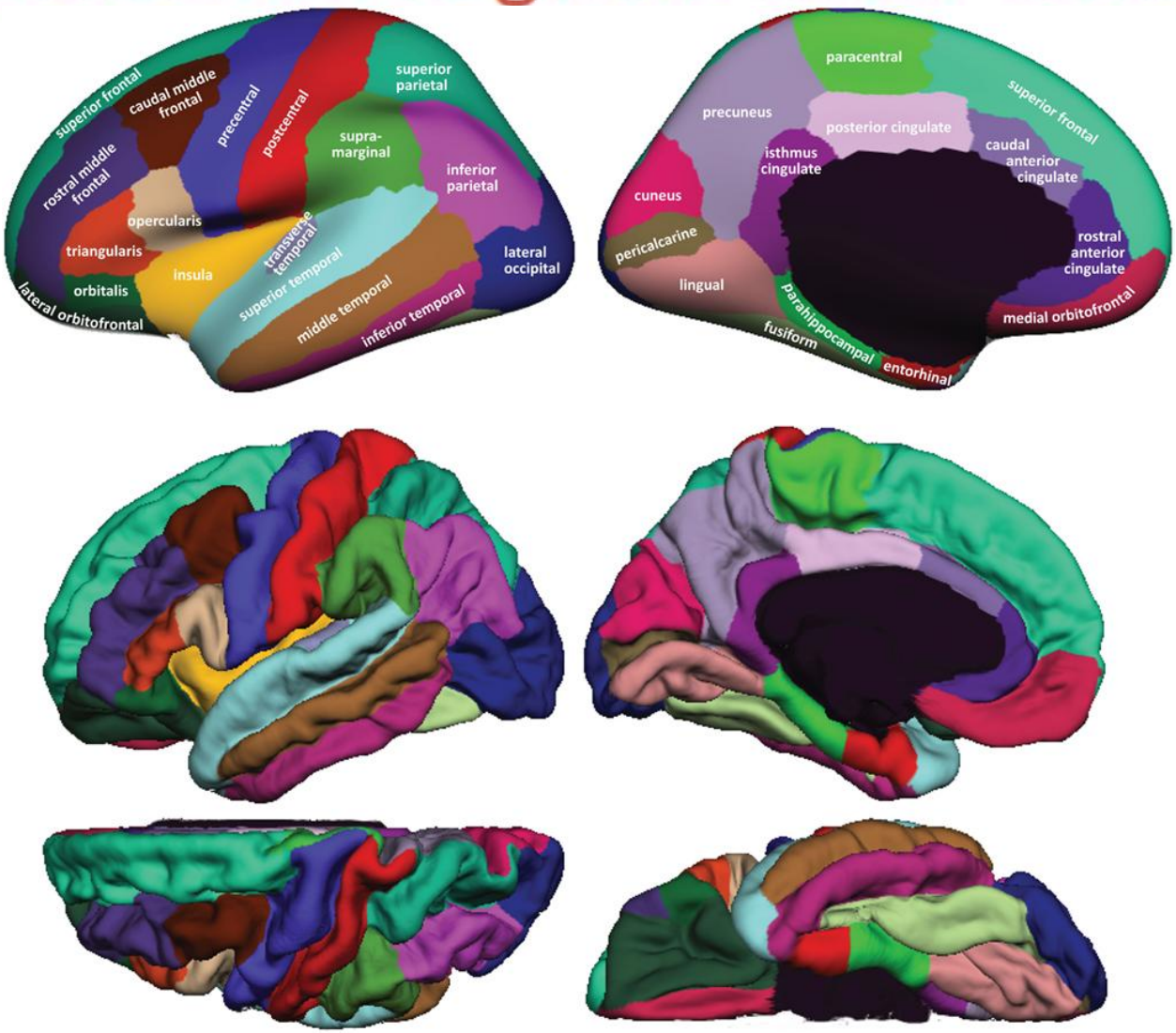
This guide provides:

- Introduction to ENIGMA visual cortical QC
- Introduction to ENIGMA_Cortical_QC_Template.xlsx (standardizes qc records across sites)
- Common QC issues including examples of pass/fail
- Additional issues for optional QC

FreeSurfer Cortical Quality Check

- If you're new to the cortical QC, we highly recommend spending some time viewing some subjects using the fsqc html file to get familiarized with the FreeSurfer output (see next slide for directions).
- Use the ENIGMA **Internal QC** method for checking cortical segmentation quality which is good for spotting under/ overestimations.
- Use the ENIGMA **External QC** for checking cortical labels, anatomical boundaries, and confirming errors spotted on internal QC.
- Make sure to QC all subjects, ~~not just those flagged in the outlier log file.~~
- Use the ENIGMA_Cortical_QC_Template.xlsx to record your QC ratings.

Freesurfer regions color-coded



Desikan-Killiany Atlas

https://surfer.nmr.mgh.harvard.edu/fswiki/CorticalParcellation

Use the "ENIGMA_Cortical_QC_Template.xlsx" to record your QC

Download the template here: http://enigma.ini.usc.edu/protocols/imaging-protocols/

Regions color-coded based on FS labels

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Subject	Internal_QC	External_QC	QC_code	Notes_Questions	temporalpole	frontalpole	bankssts	superiortemp	middletempo	precentral	postcentral	supramargina	superiorparie	precuneus	cuneus	pericalcarine	lingual
2	subj_1	pass	moderate	central;superparietal								L	L	R	R	R		
3	subj_2	fail	fail	pathology	lesion RH	R/L	R/L	R/L	R/L	R/L	R/L	R/L	R/L	R/L	R/L	R/L	R/L	R/L
4	subj_3	pass	pass	paracingulate														
5	subj_4	pass	moderate	meninges	motion artifact						R/L	R	R					
6	subj_5	moderate	moderate	poles;pericalcarine		R											R	R
7	subj_6	moderate	moderate	poles;meninges		R/L						L						
8	subj_7	moderate	moderate	meninges;bankssts;central				R	R			L	L					
9	subj_8	pass	pass	ERC/parahippo														
10	subj_9	pass	moderate	bankssts				L	L	L								
11	subj_10	moderate	pass	poles			L											

First Tab: QC

Subject: Subject ID's

Internal/External_QC Columns:

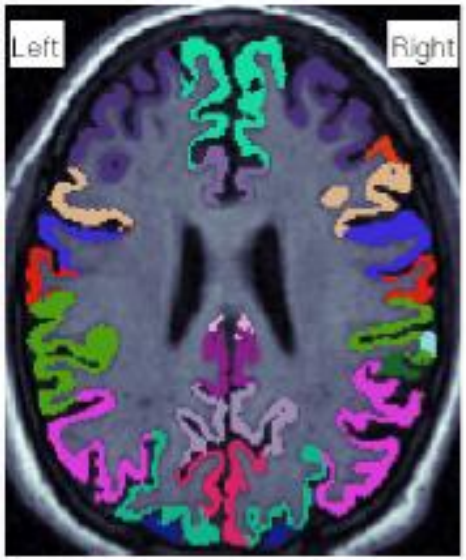
- Pass – no issues with internal/external QC
- ~~Moderate – fail particular regions (indicate R, right; L, left; or both R/L)~~
- Fail – severe pathology, image artifacts, registration problems causing severe mislabeling (list R/L for all regions)

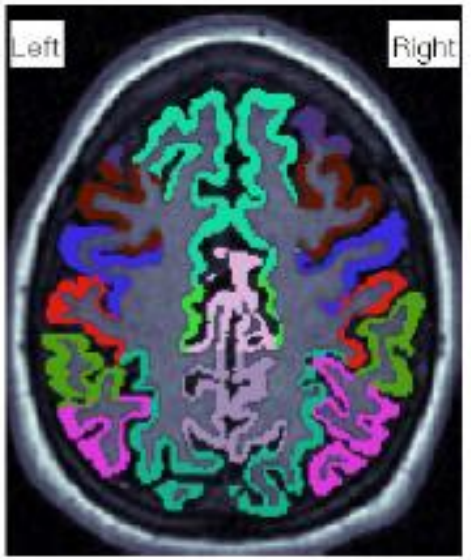
Second Tab: QC_Code Key

- Provided codes for the "QC_Code" column on first tab to keep track of errors
- Examples of these common errors are provided in this guide

Good examples

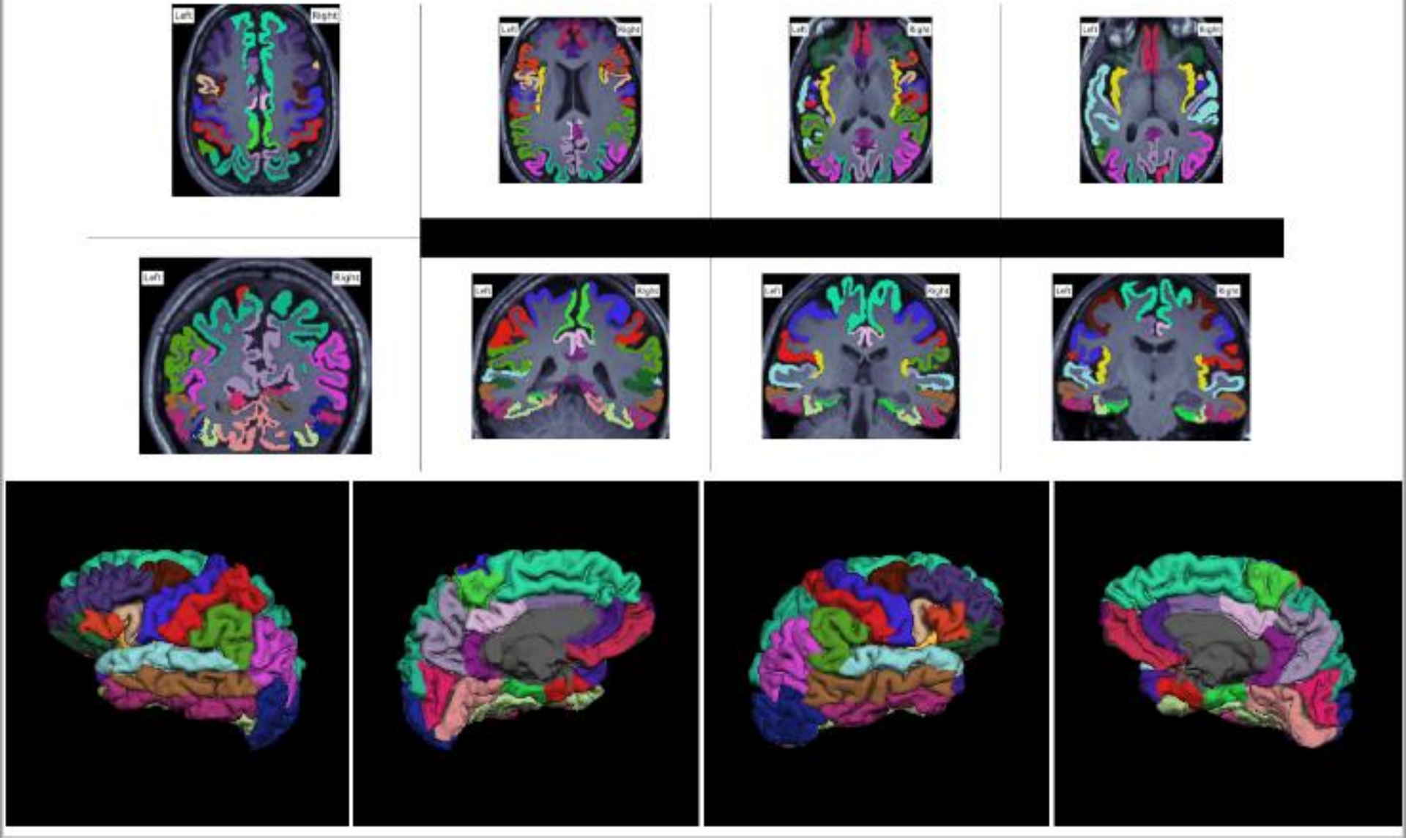
Labels generally correspond to known anatomical boundaries



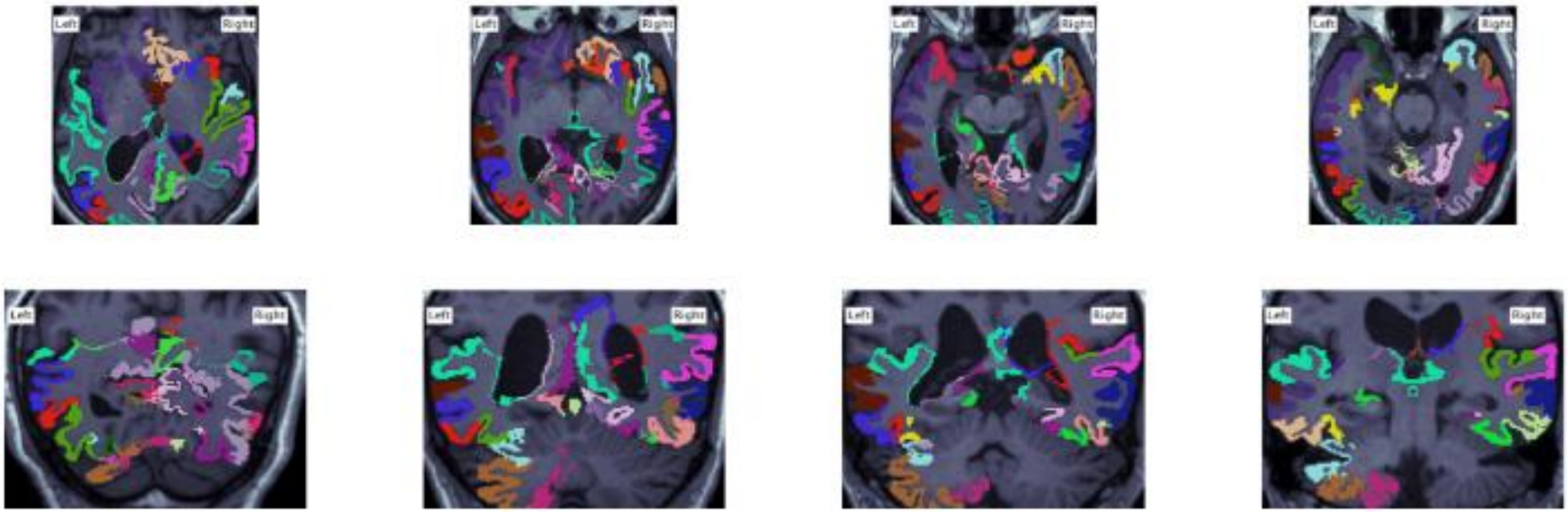


Grey matter properly segmented (no under/overestimations)

More good examples

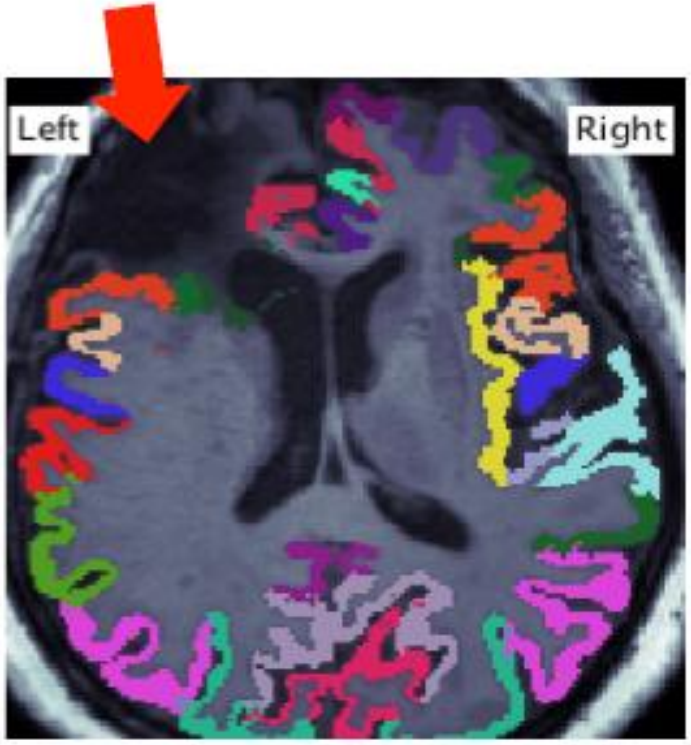


Internal QC Fail



Fail entire subject: cerebellum misclassified and other severe global underestimations

Internal QC Fail

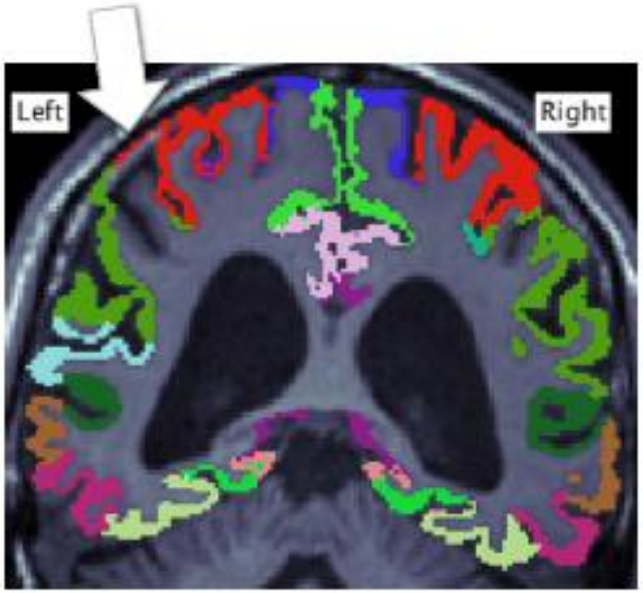


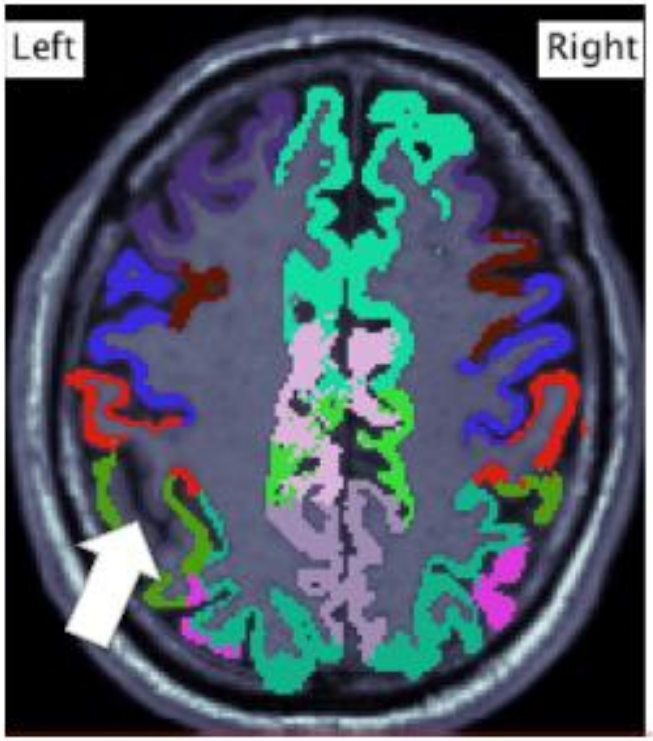
Complete fail (pathology)

Complete fail
(motion causing failed segmentation)

Internal QC: Moderate

marked as *pass*!

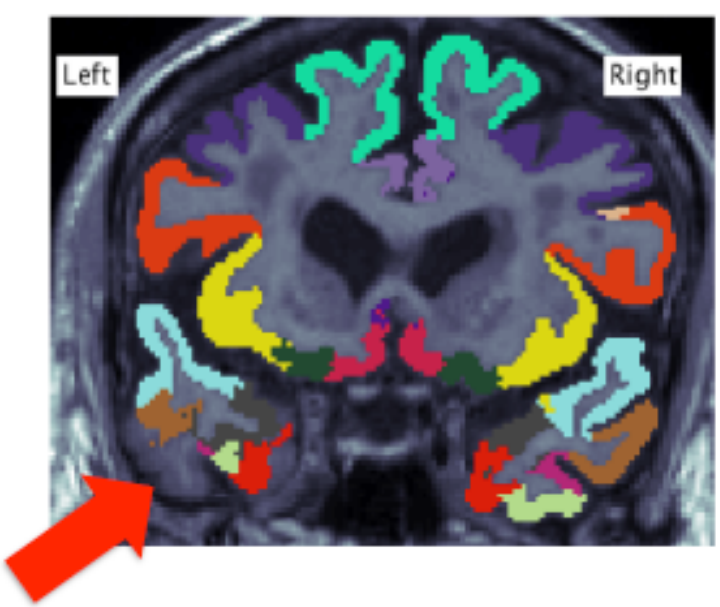


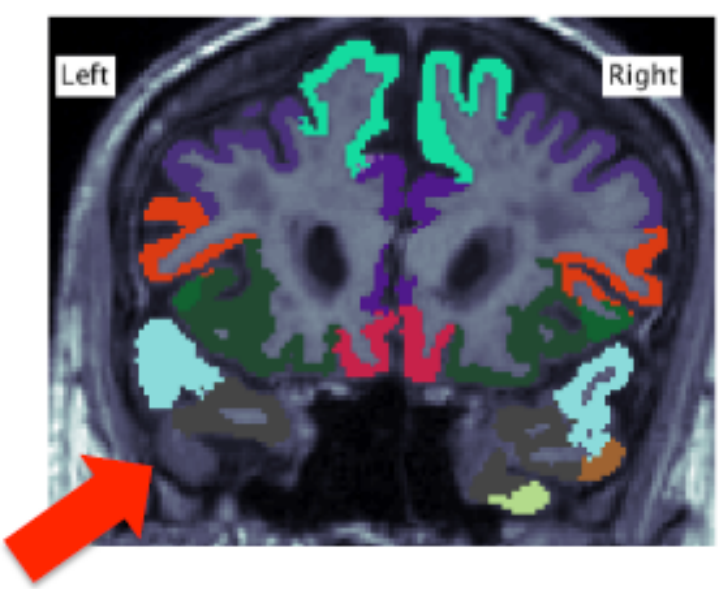


- Certain regions are under/overestimated but rest of segmentation looks good.
- Can use External QC to confirm affected regions (examples to follow).
- List regions misclassified in QC spreadsheet (L, R, or R/L) so they can be withheld from analysis.

Internal QC: Moderate Temporal Pole Underestimation

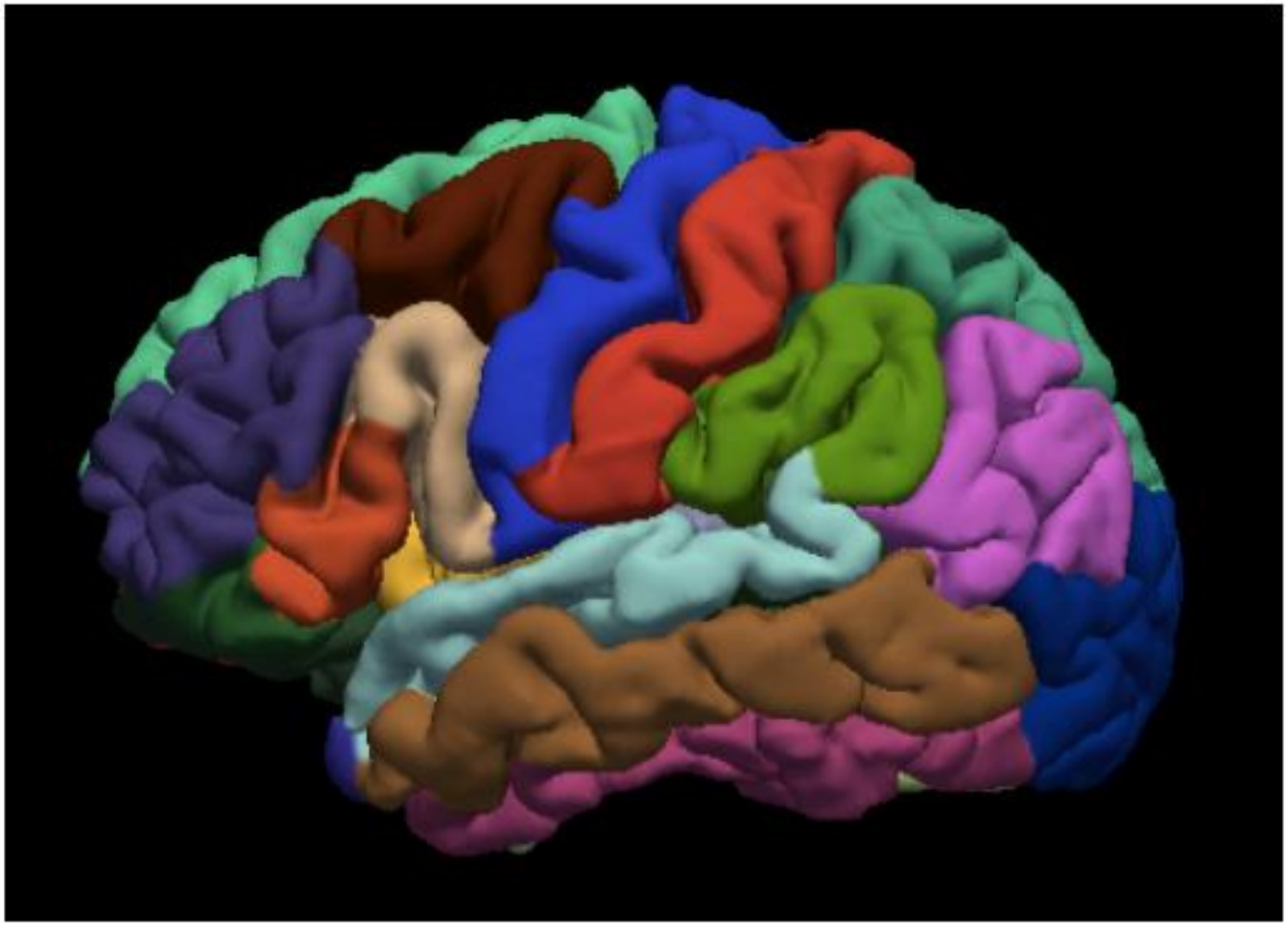
marked as *pass*!





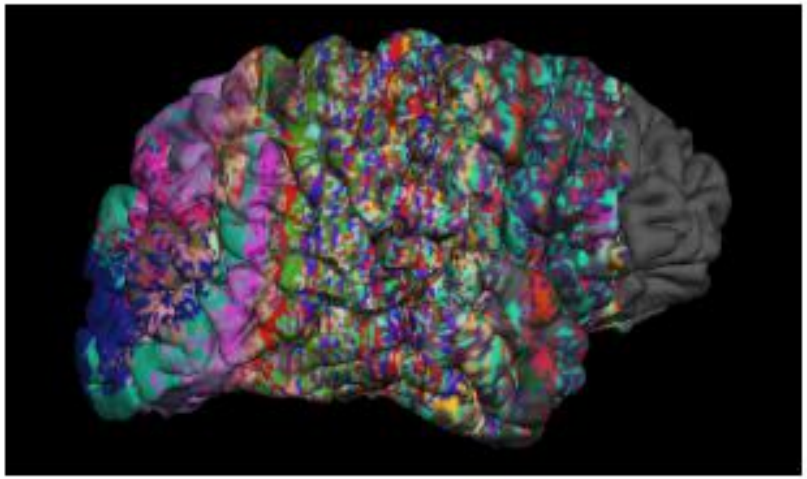
- FreeSurfer sometimes (<10% cases) underestimates the anterior temporal and frontal poles.
- List underestimated regions in QC spreadsheet (L, R, or R/L) so they can be withheld from analysis.

External QC

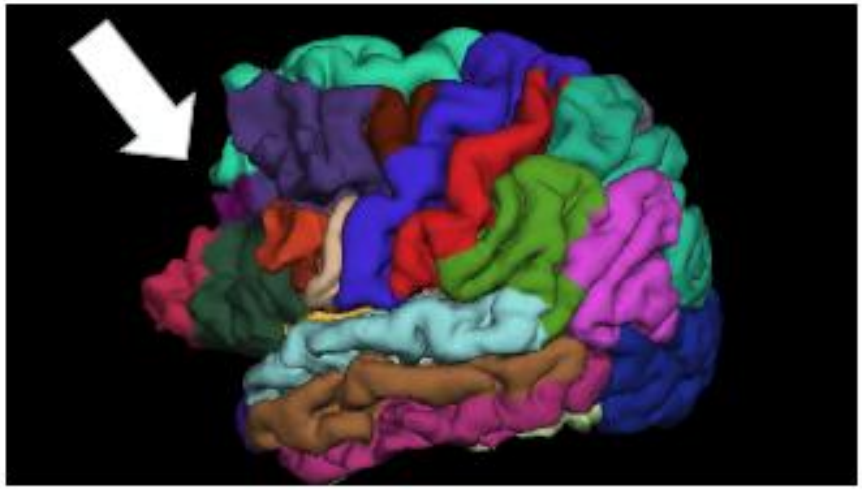


Ideal external segmentation
(generally correspond to known anatomical boundaries)

External QC: Fail



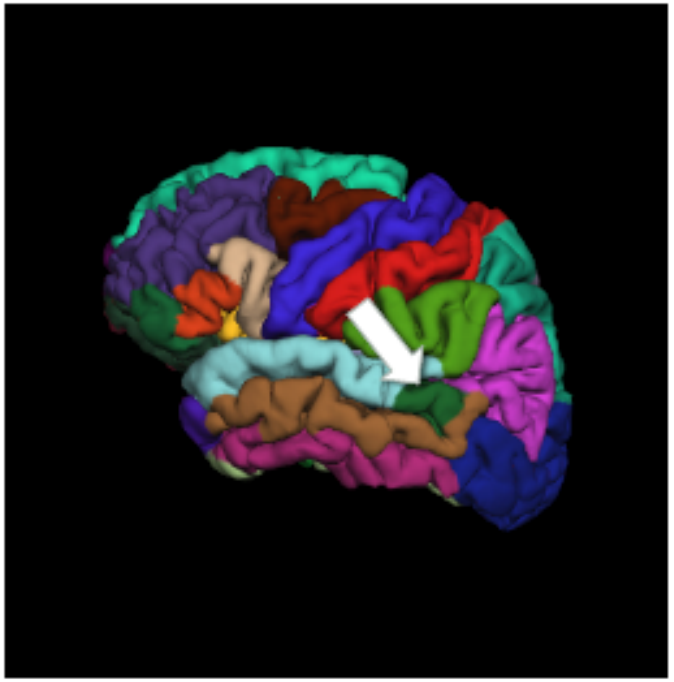
FAIL (Processing Error)



Fail (pathology)

marked as *pass*!

Moderate: Banks of superior temporal sulcus overestimation



In about 20-30% of subjects, the BanksSTS appears on gyral surface.

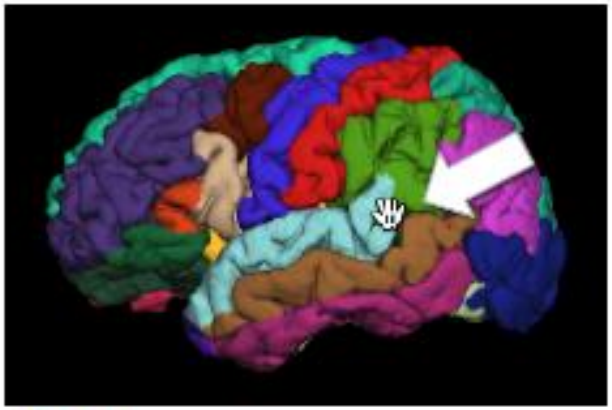
In some cases (≈15%) the size of the mislabeled BanksSTS may influence the surrounding ROIs (e.g. superior temporal/ middle temporal gyri).

BanksSTS QC Steps:

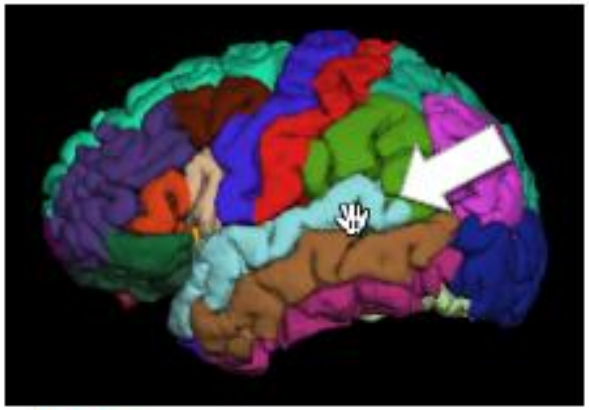
1. Load index.html into browser.
2. Press: " Command and + " which zooms in once – match the size of your QC images to the size of image above (**Tip: view the PDF version of the guide at 100% and your QC images should be about the same size as the brain above**)
3. IF the mislabeled BanksSTS is larger than hand/cursor, THEN

fail the BanksSTS + surrounding affected regions (e.g. superior temporal gyrus and/or middle frontal gyrus – see examples on next slides.)

OK examples (do not fail BanksSTS)

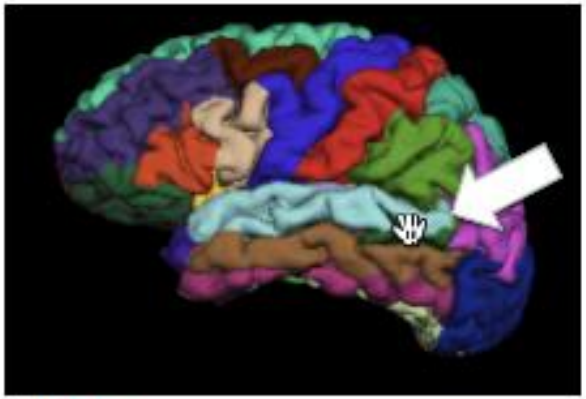


Pass



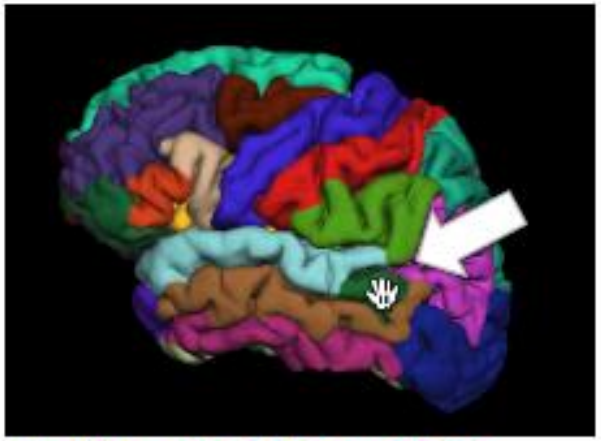
Pass

Pass

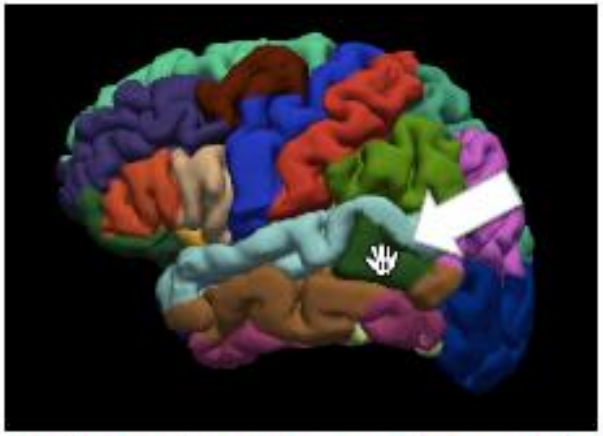


Pass

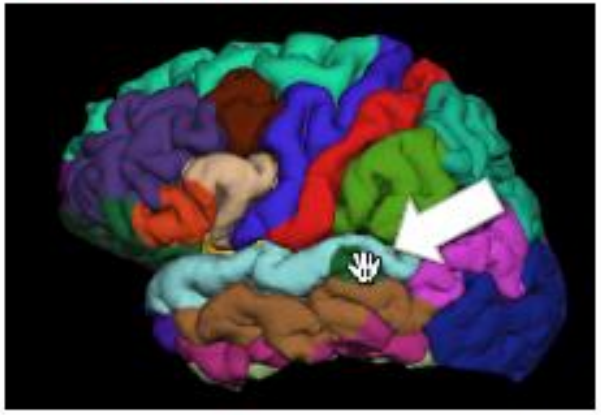
Bad examples BanksSTS (List affected regions in QC sheet)



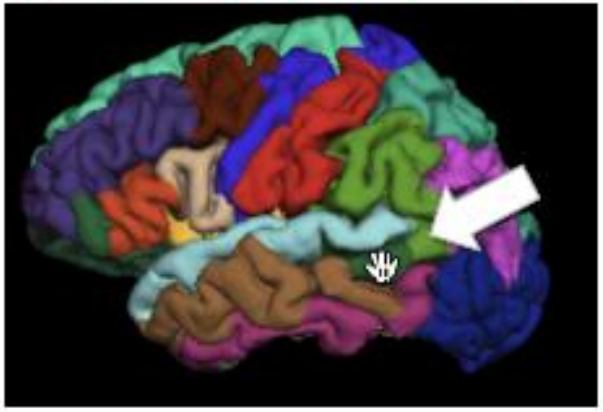
Fail BanksSTS + STG



Fail BanksSTS + STG + MTG



Fail BanksSTS + STG + MTG

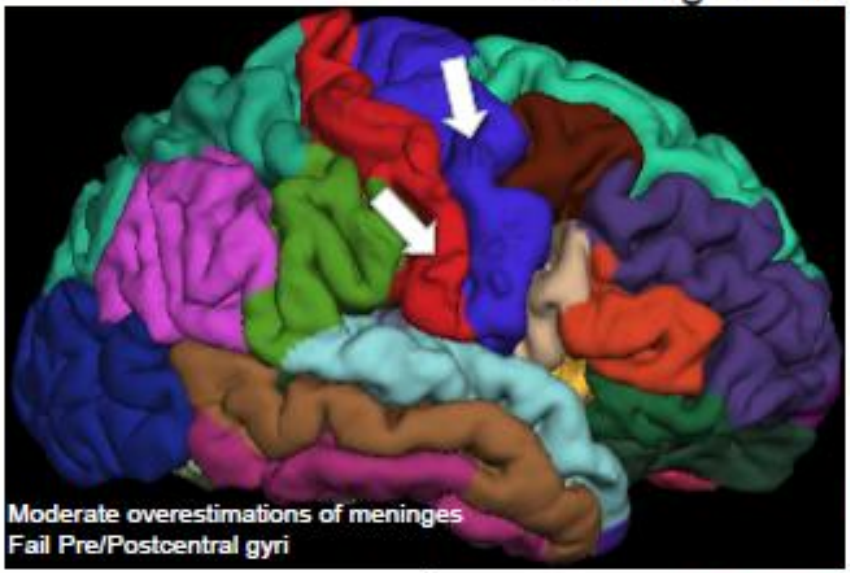


Fail BanksSTS + MTG

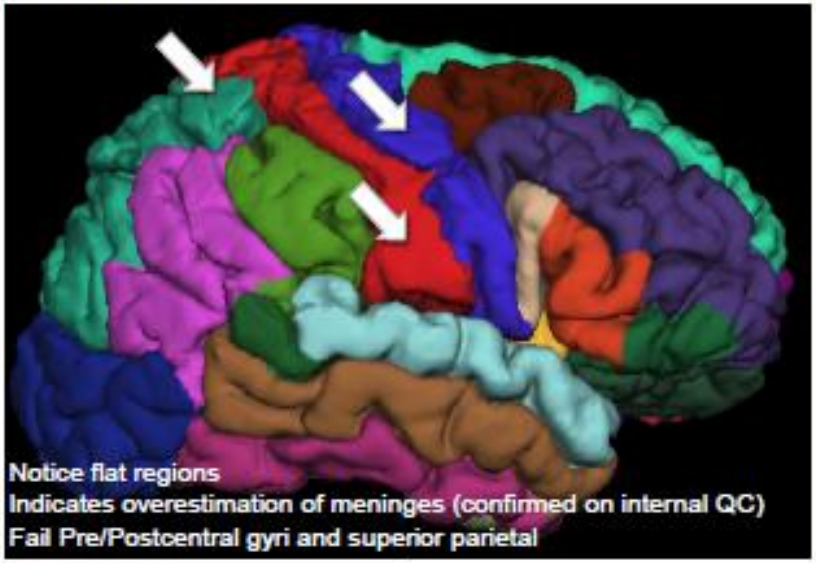
STG: superior temporal gyrus; MTG: middle temporal gyrus

Pre/Postcentral Gyrus Issues (<15% cases)

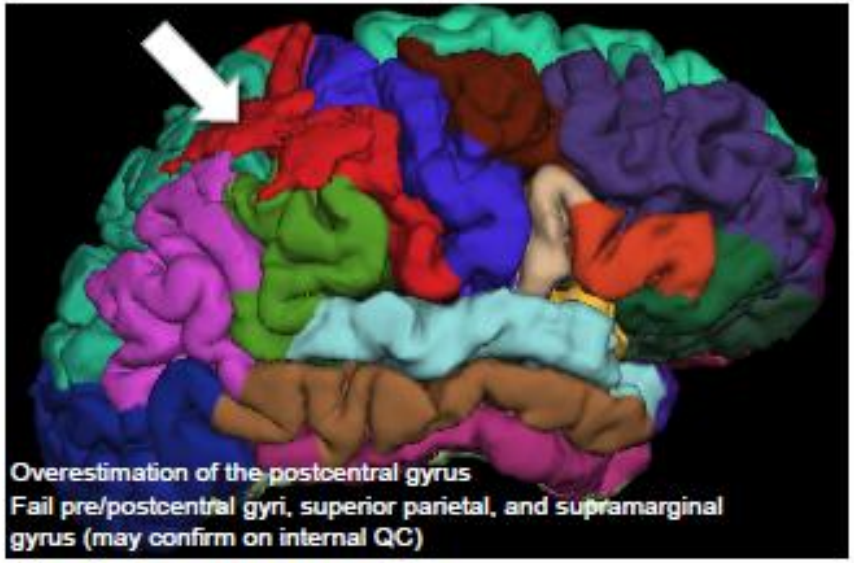
Meninges overestimations



Moderate overestimations of meninges
Fail Pre/Postcentral gyri



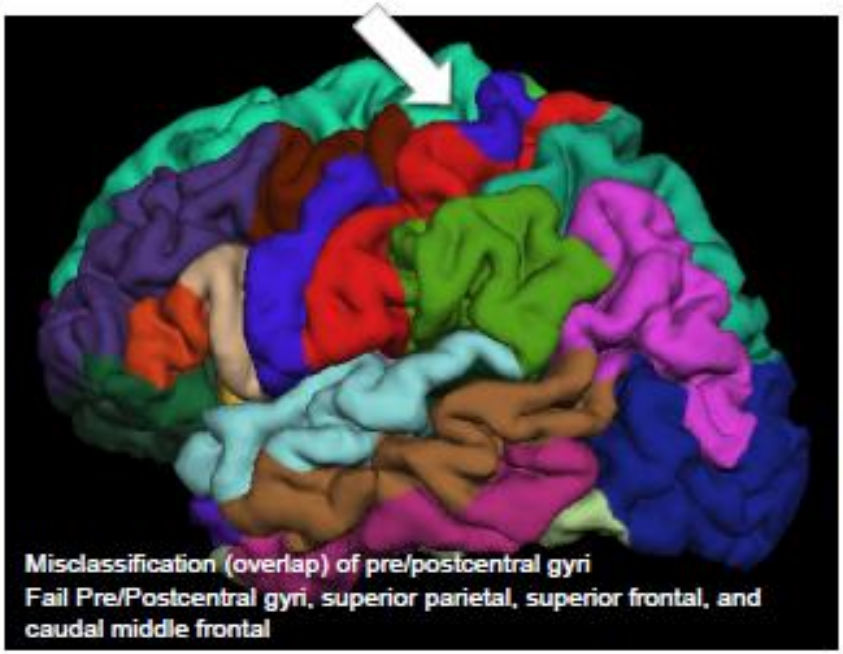
Notice flat regions
Indicates overestimation of meninges (confirmed on internal QC)
Fail Pre/Postcentral gyri and superior parietal



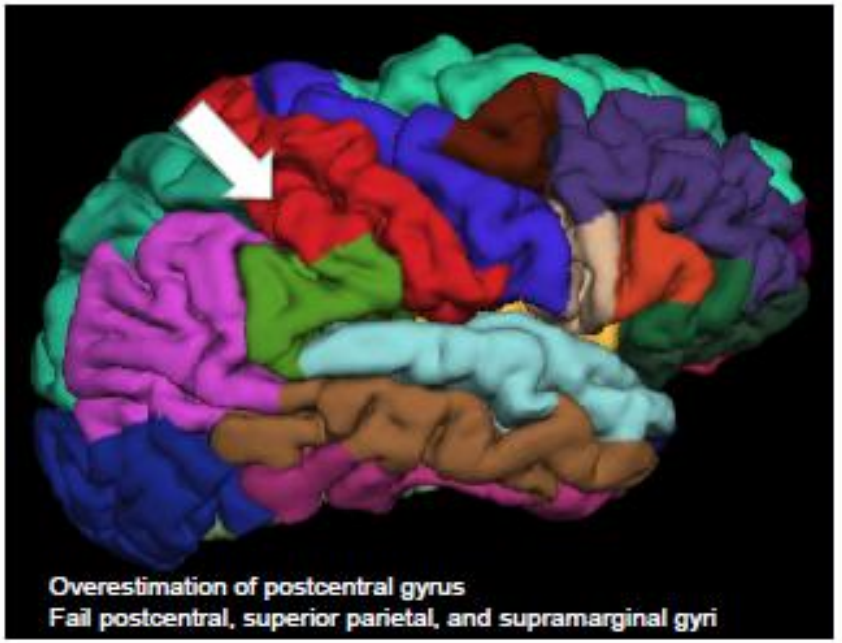
Overestimation of the postcentral gyrus
Fail pre/postcentral gyri, superior parietal, and supramarginal gyrus (may confirm on internal QC)

Pre/Postcentral Gyrus Issues (<15% cases)

Misclassifications



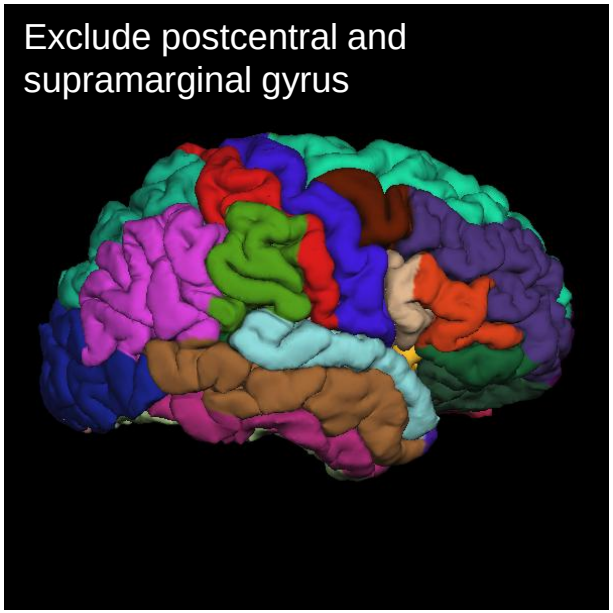
Misclassification (overlap) of pre/postcentral gyri
Fail Pre/Postcentral gyri, superior parietal, superior frontal, and caudal middle frontal

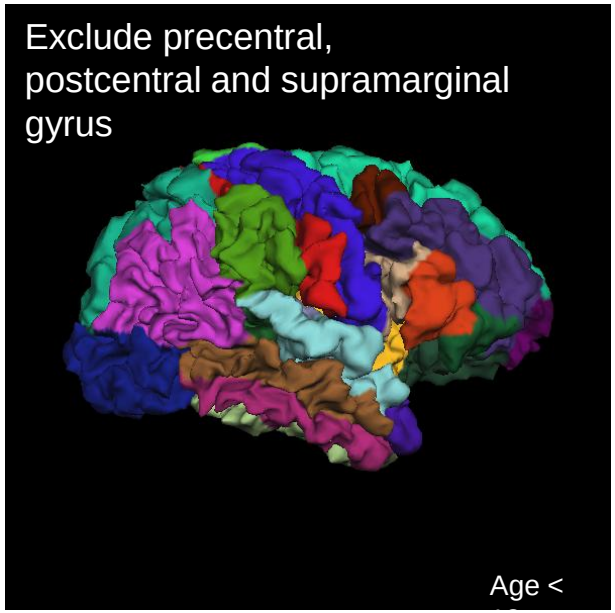


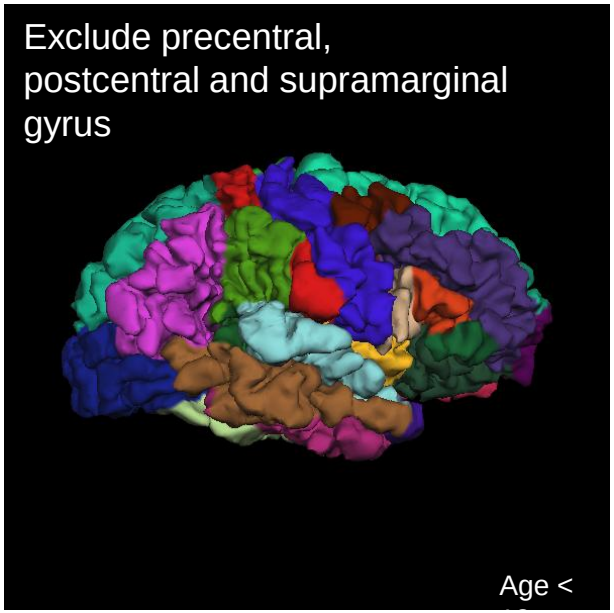
Overestimation of postcentral gyrus
Fail postcentral, superior parietal, and supramarginal gyri

Bad examples

Precentral (blue), postcentral (red) and supramarginal gyrus (green)

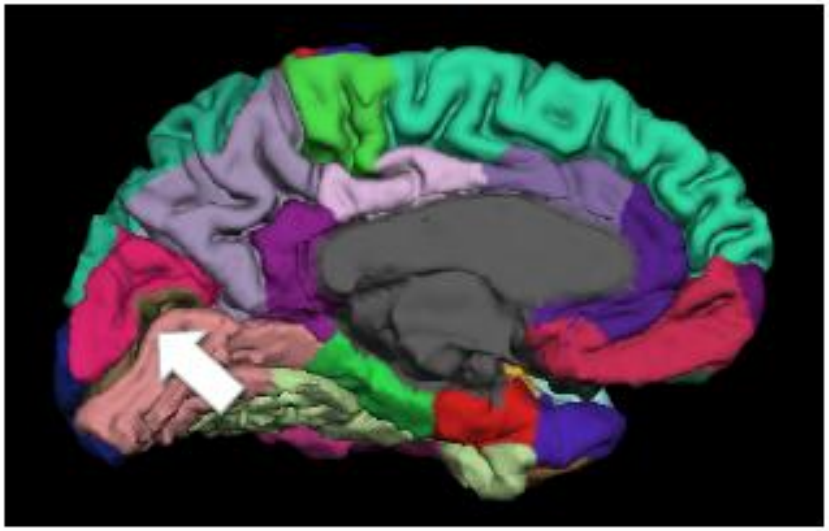






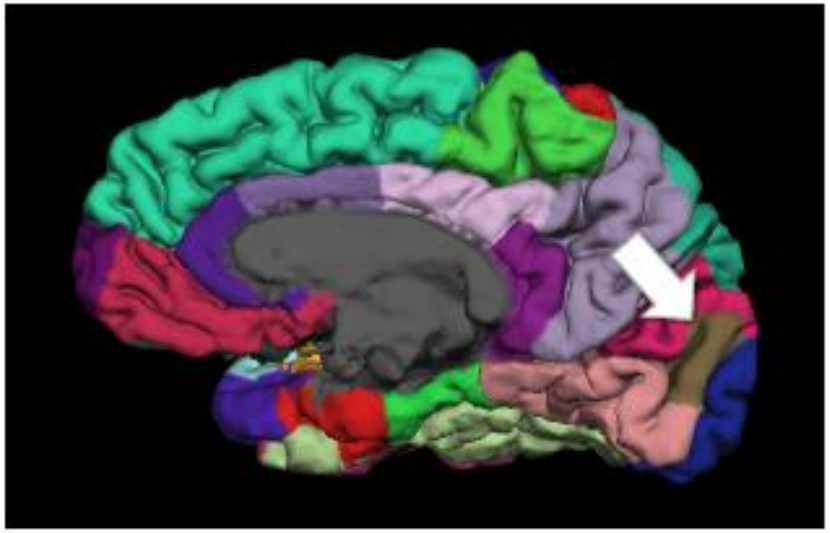
Pericalcarine Overestimations (<5% cases)

GOOD



- Segmentation confined to calcarine sulcus

BAD



- Segmentation overestimates pericalcarine region
- Note failed regions (above: pericalcarine, lingual, and cuneus regions)

The next slides offer additional, optional examples to help you get more familiar with specific regions.

Additional Issues

Ready to test your quality control eye? Skip to the quiz at slide 33!

The following includes regions that have been noted as possibly problematic but to a lesser extent than the previous examples.

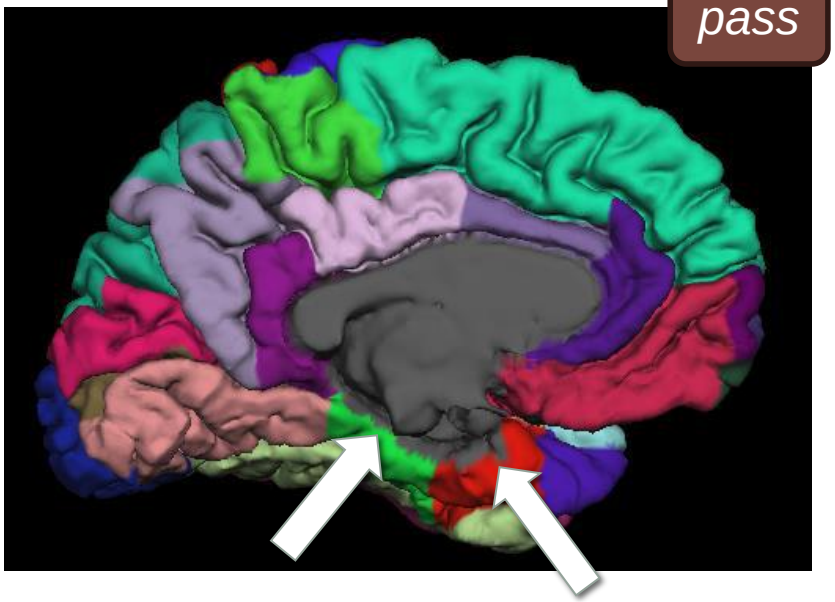
Choosing to record instances of the following issues may make it easier to perform follow-up analyses.

You don’t have to record these issues for ENIGMA-PD

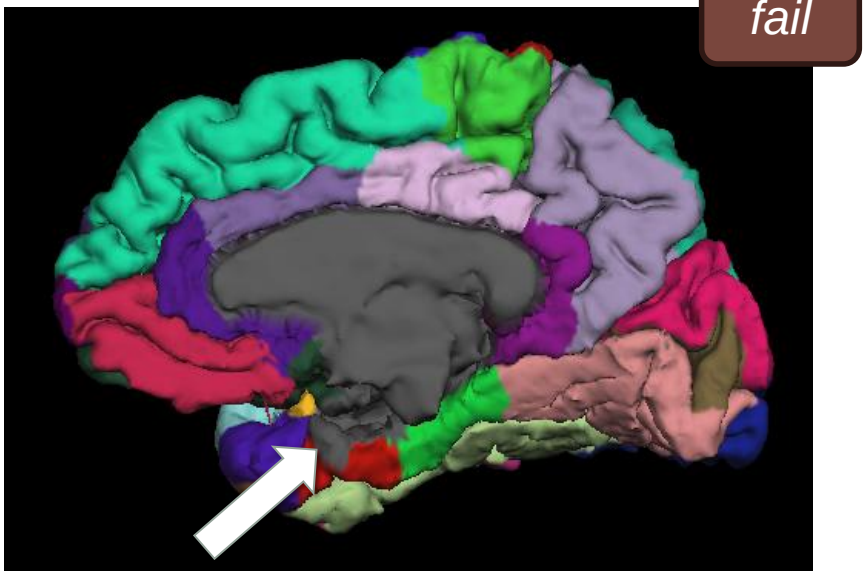
Uncertain; delineation ventricles vs parahippocampal (light green) and entorhinal cortex (red)

Questionable examples:

A



B



Part of the grey matter of the gyri seem not to be allocated to PHG or ERC (but probably to ventricles instead)

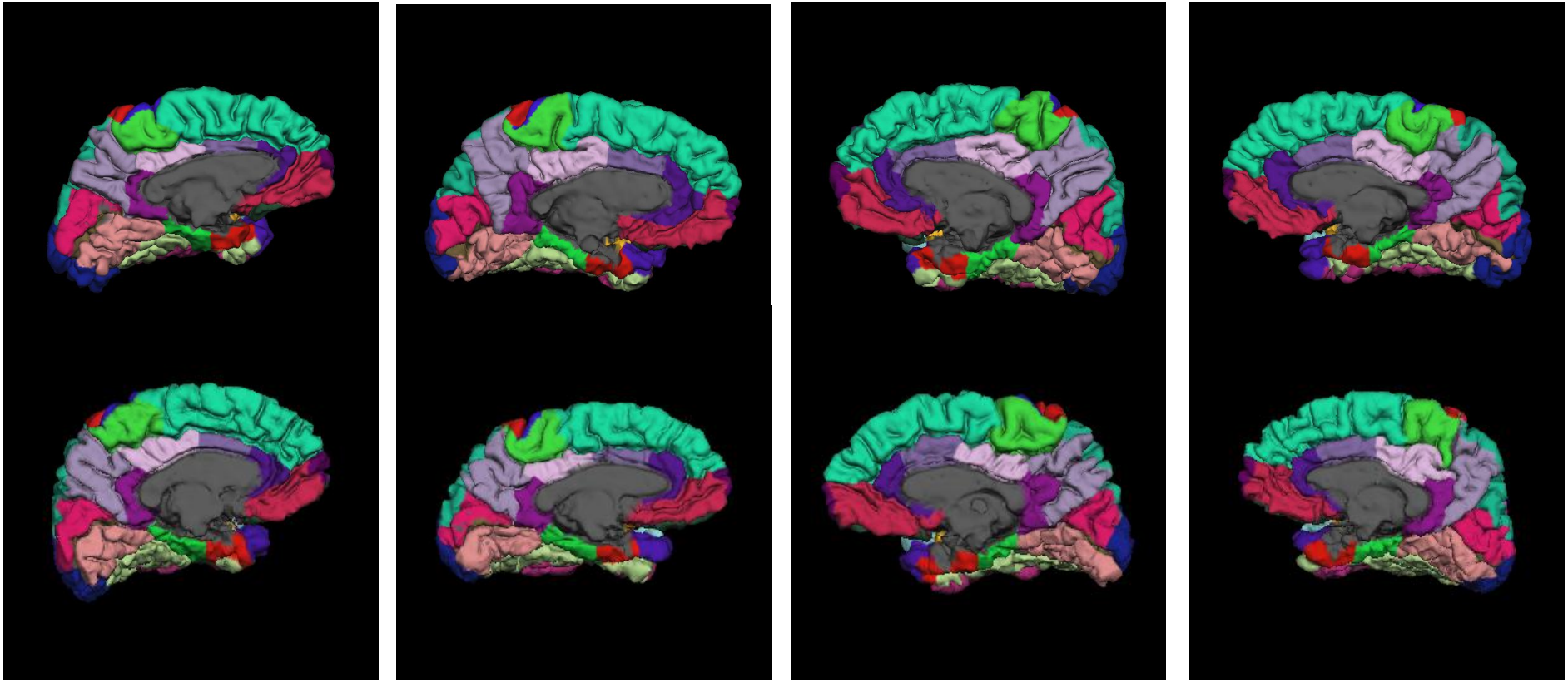
However, example A detected in ~70-80% of cases (?), so only exclude when a large part of the gyrus is clearly missing (entorhinal cortex in example B)

Other issues; Entorhinal cortex

- In a large percentage of subjects this region is only partially correctly labeled
- Therefore, we decided to be less stringent with regard to the segmentation of the entorhinal cortex
- We excluded the entorhinal cortex only if more than 50% of the region was poorly segmented (examples on next slides)
  - **So only exclude when a LARGE part of the gyrus is clearly missing**
- Importantly, possible findings in the entorhinal cortex will be interpreted with caution

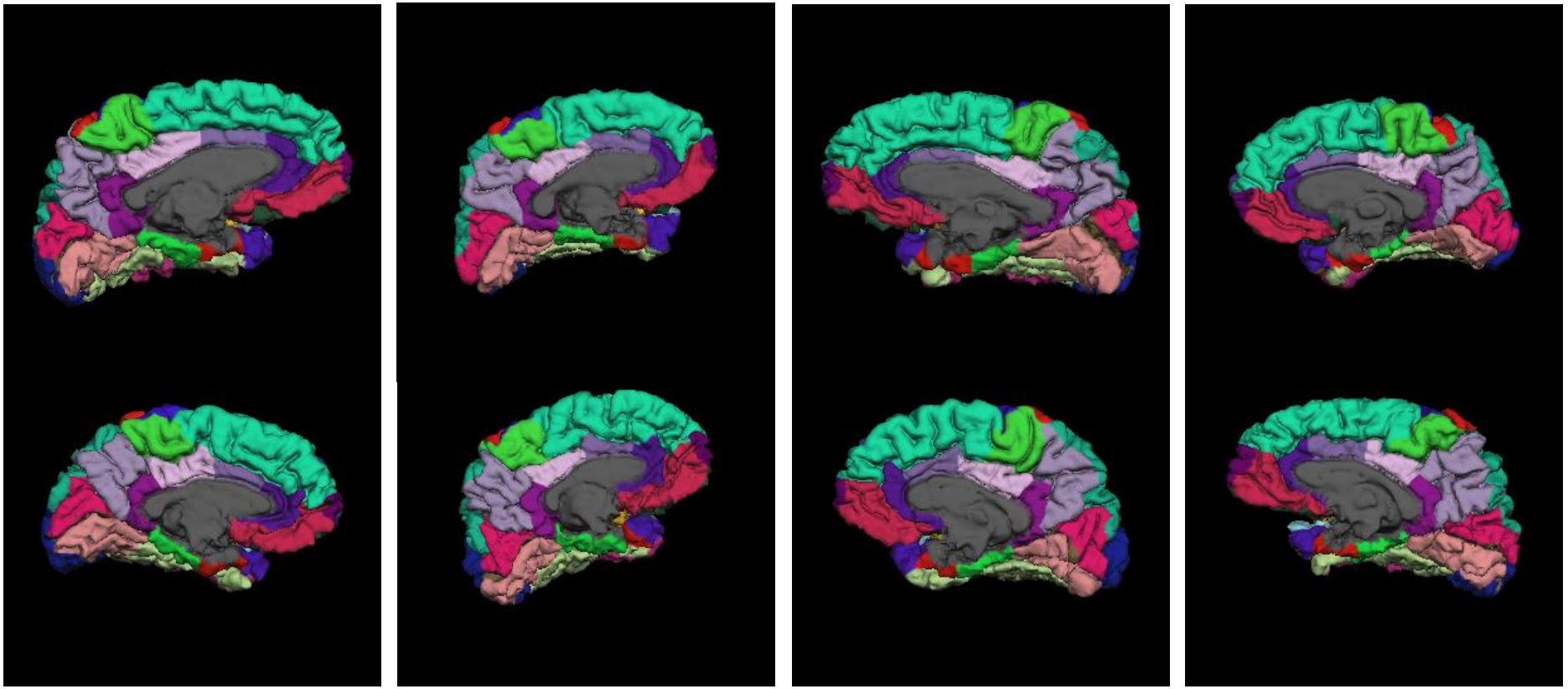
Ok examples:

Entorhinal cortex (red)

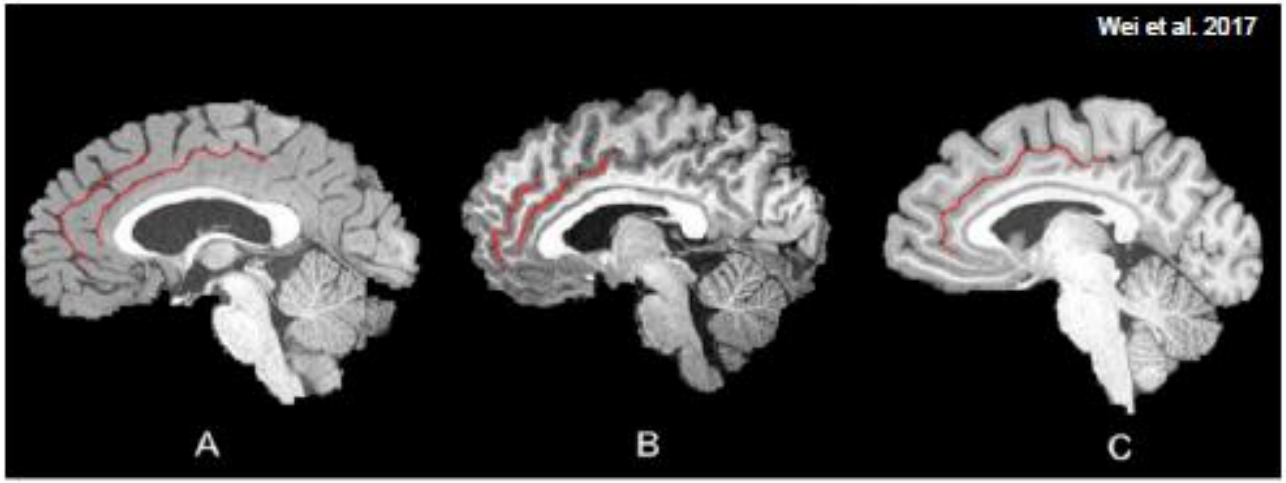


Bad examples:

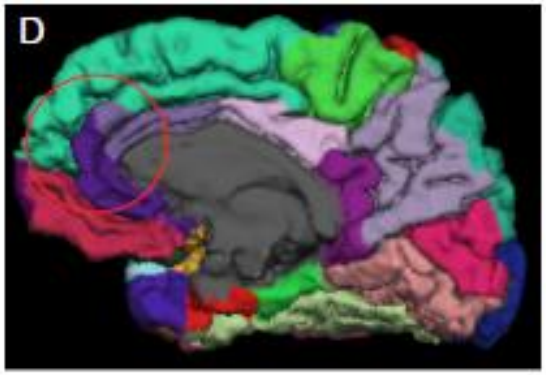
Entorhinal cortex (red)

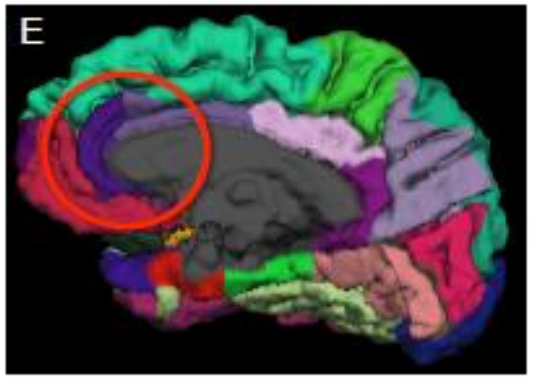


Other issues: cingulate cortex



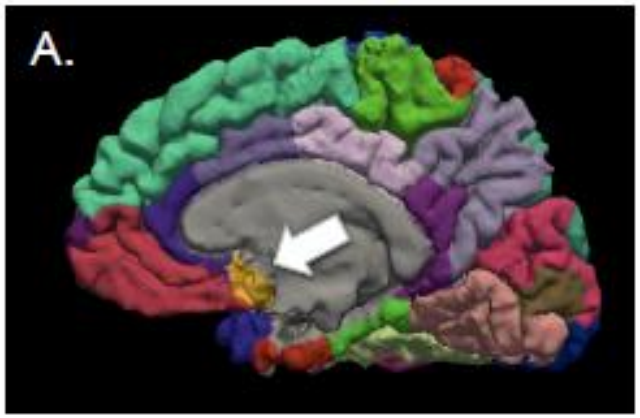
- A paracingulate sulcus (PCS) is present in 30–60% of cases and is more frequently found in the left hemisphere (A and B). This can cause segmentation problems in the cingulate and surrounding regions.

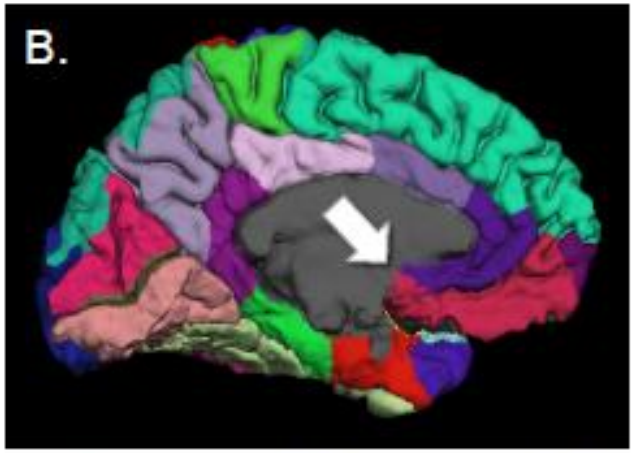


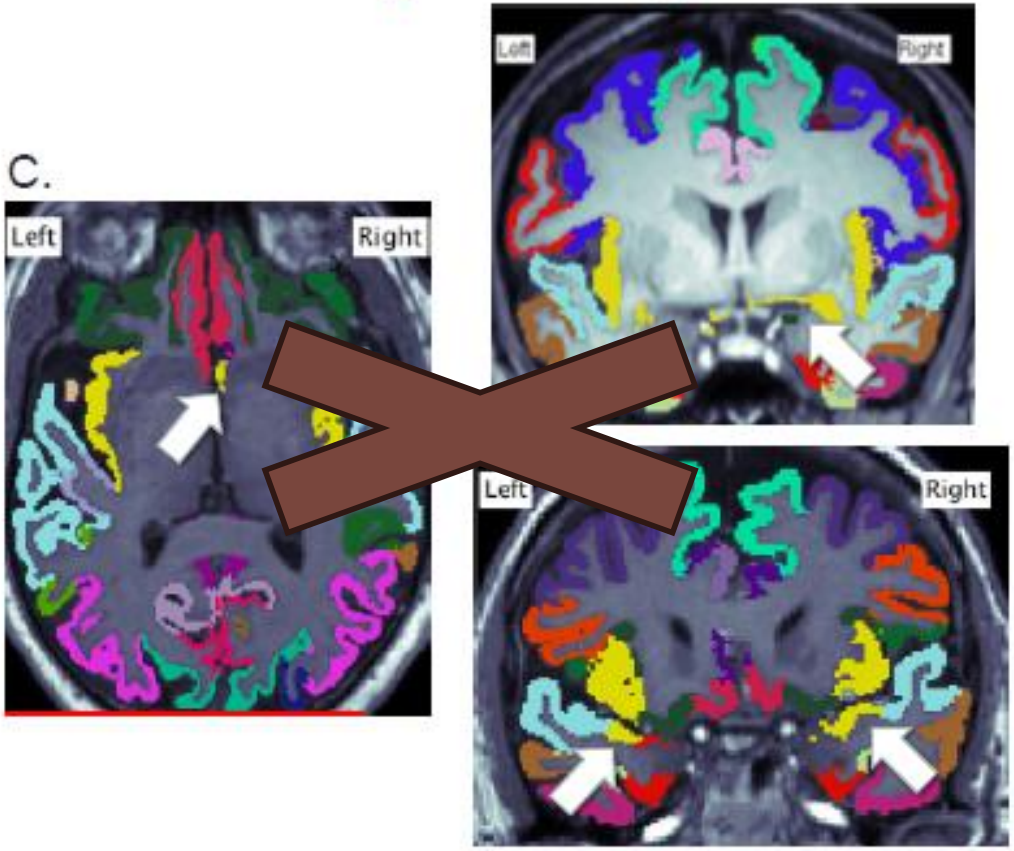


- In subjects with prominent paracingulate sulcus (example D, E), portions of the cingulate may be underestimated while superior frontal regions may be overestimated.
- **We tend to be less stringent with the QC in this region because of the variability of the anatomy/segmentation. Findings in this region should be interpreted with caution and it may be useful to track this issue for follow-up analysis.**

Other issues: Insula (yellow)



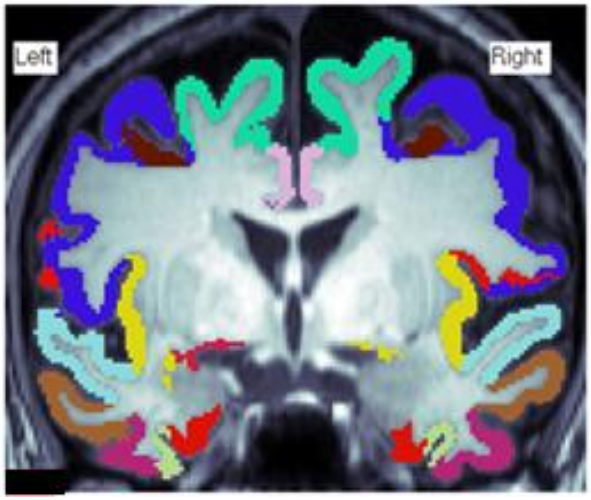




- This Freesurfer atlas does not include a subgenual ACC region and sometimes assigns this to the insula (yellow) or medial OFC (red/pink) instead – Example A. Example B is probably more anatomically correct, but judging the accuracy of the insula or medial OFC boundaries becomes difficult.
- Example C shows other somewhat common issues regarding Insula overestimation into the temporal lobes and midline.
- **We tend to be less stringent with the QC of the insula because of the variability of the anatomy/ segmentation and the difficulty with establishing consistent pass/fail criteria. However, it may be useful for some groups to note how often you observe these issues for follow-up analysis.**

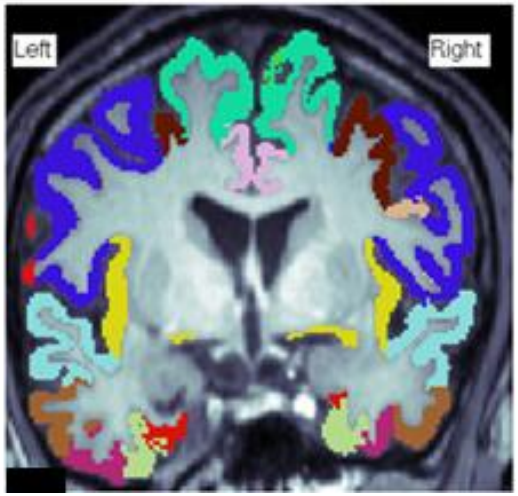
Other issues; Insular cortex

- In some samples structures are incorrectly labeled as insular cortex (yellow)



Exclude left and right

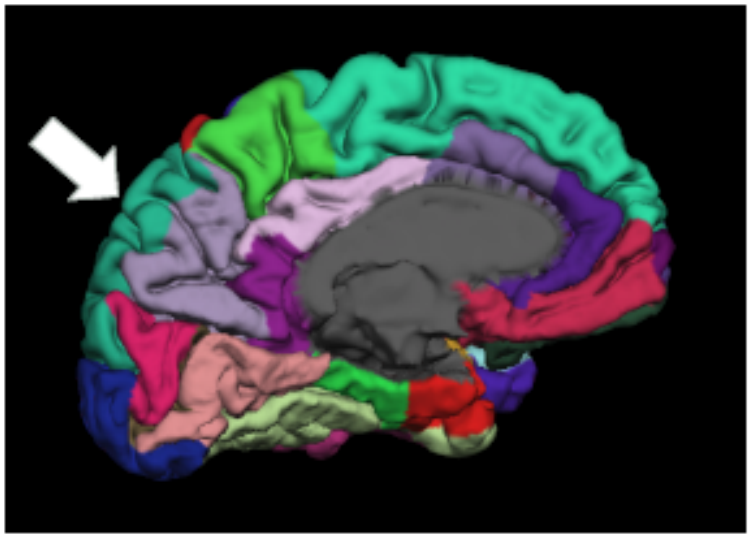
Exclude left and right



Exclude only right

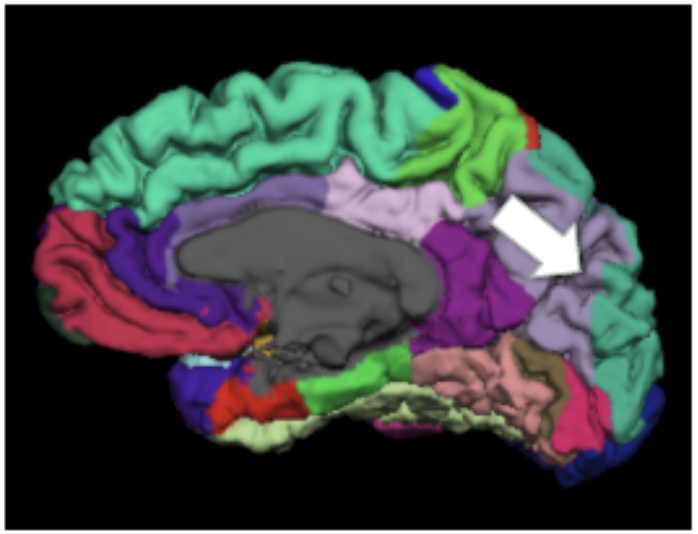
Other issues: Superior Parietal Overestimation

Normal



- Segmentation obeys known anatomical boundaries and does not overestimate superior parietal region

Overestimation



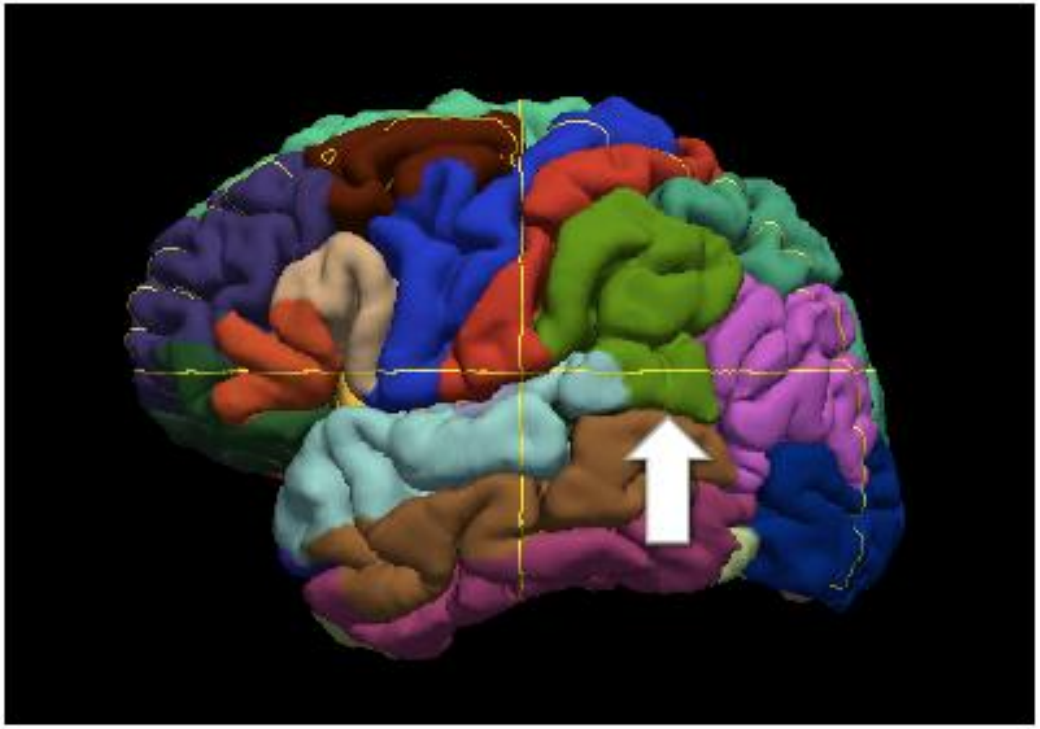
- Segmentation overestimates superior parietal region and impacts precuneus/cuneus regions

Other issues: middle/inferior temporal gyrus

- When the middle temporal gyrus looks as if it covers the inferior temporal gyrus, this is usually due to the rotation angle of the brain and is probably Okie Dokie (Pass).

- It is considered normal when the middle and inferior temporal gyri are somewhat overlapping on each other as in the above examples (see examples of non-continuous inferior temporal sulcus).

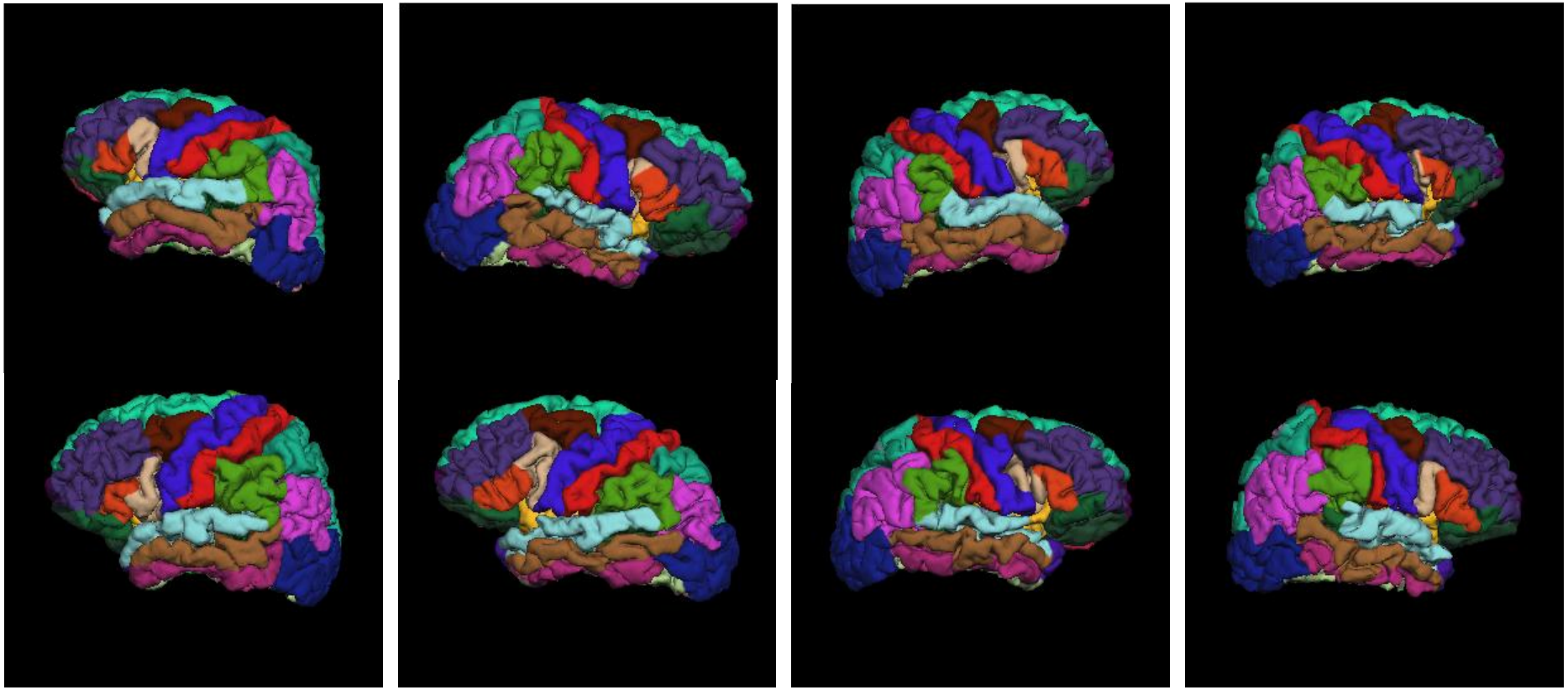
Supramarginal gyrus overestimation: Extends into superior temporal gyrus



- In some cases the supramarginal gyrus (green) may appear to invade adjacent regions (in this example the superior temporal gyrus).
- We tend to be less stringent with the QC in this region because there is quite a bit of anatomical variability and the exact boundaries dividing the supramarginal gyrus from surrounding regions can be difficult to assess.

Ok examples:

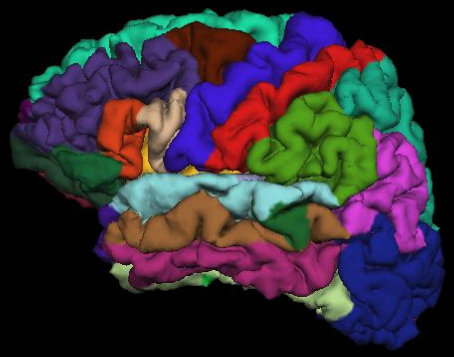
Superior (blue), middle (brown) and inferior (pink) temporal gyrus



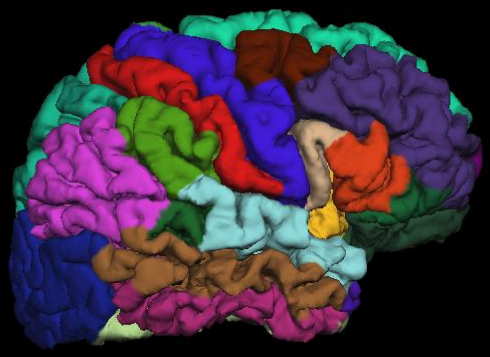
Bad examples:

Superior (blue), middle (brown) and inferior (pink) temporal gyrus

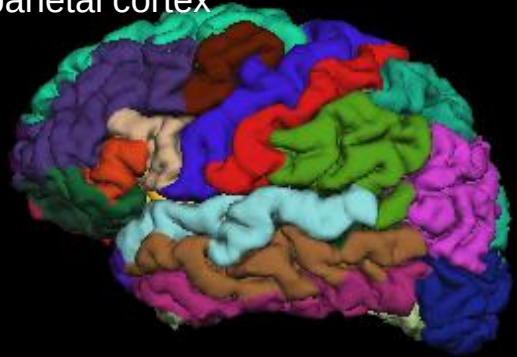
Exclude BSTS and middle temporal cortex



Exclude BSTS, superior temporal and inferior parietal cortex

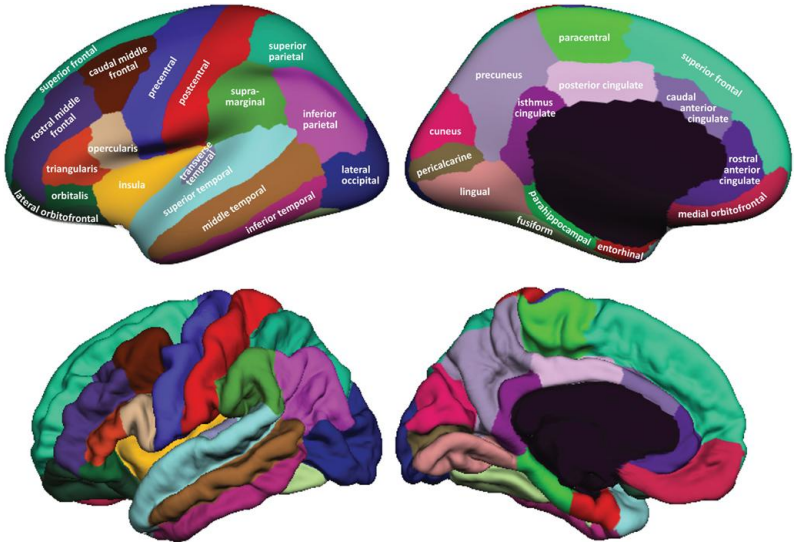


Exclude superior temporal, supramarginal gyrus and inferior parietal cortex



QUIZ TIME

Spot the problem



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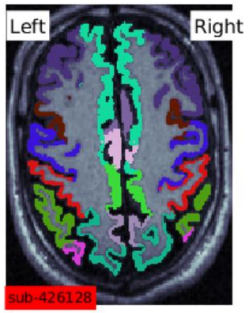
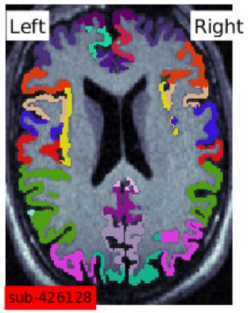
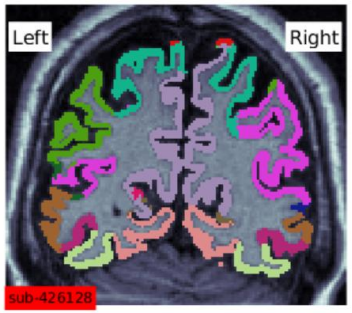
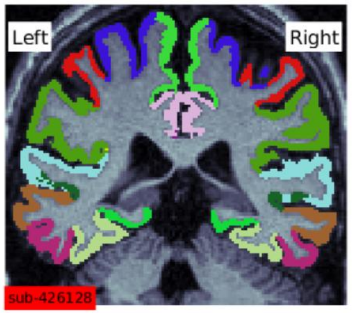
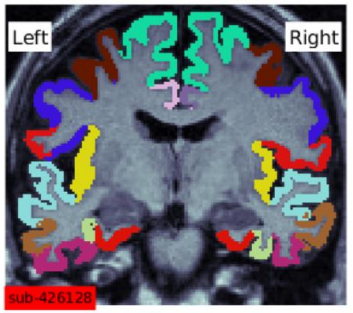
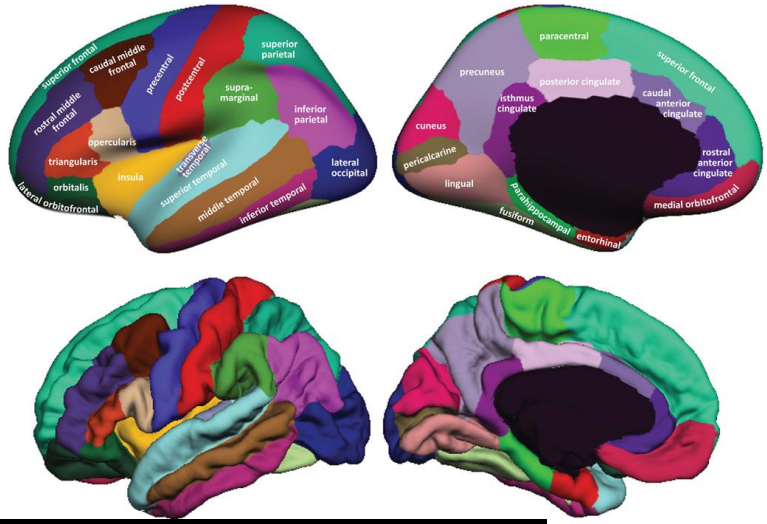
		
		

Spot the problem



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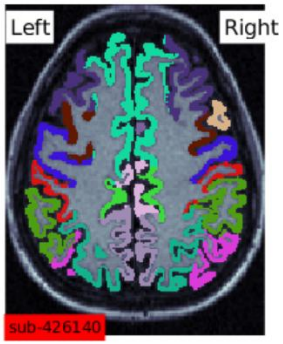
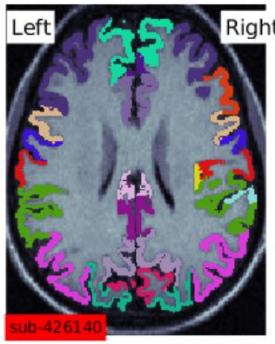
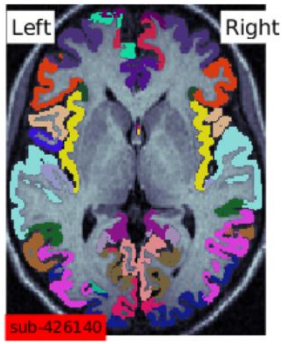
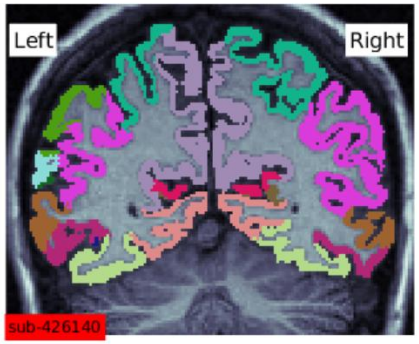
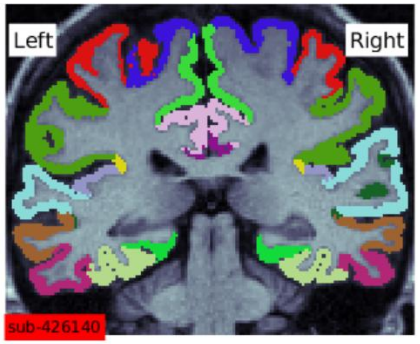
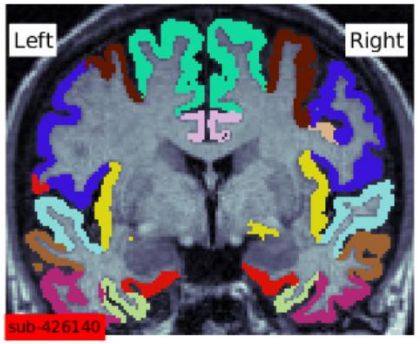
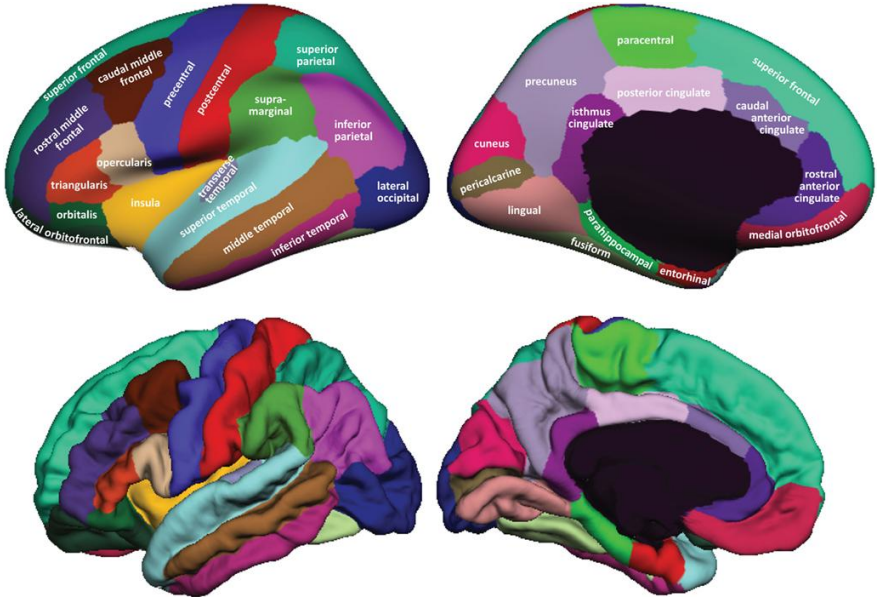
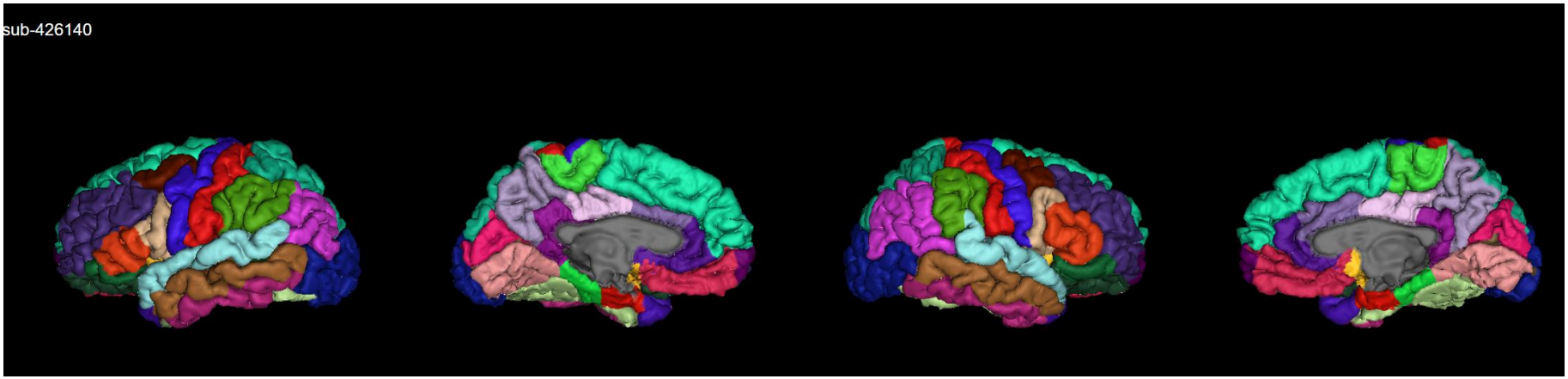
		
		

Spot the problem





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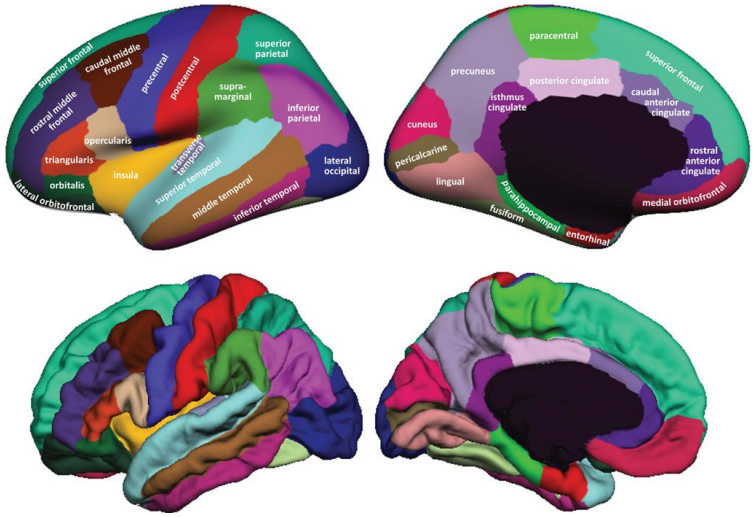

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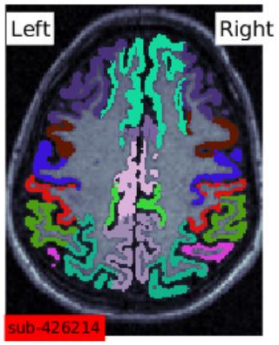
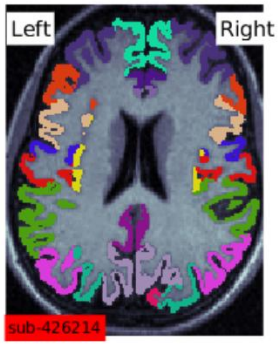
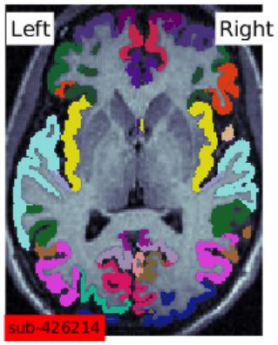
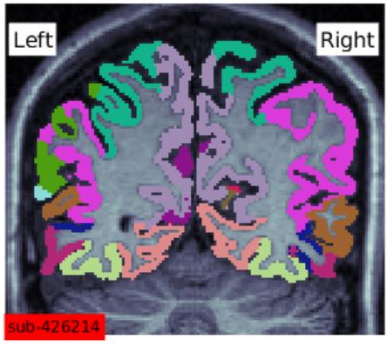
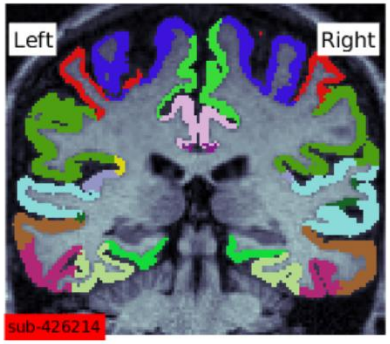
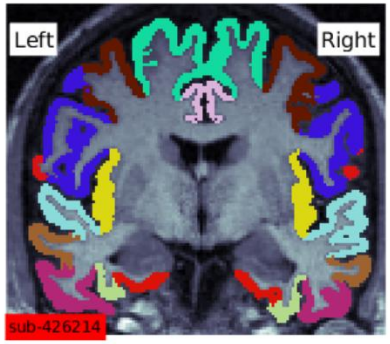
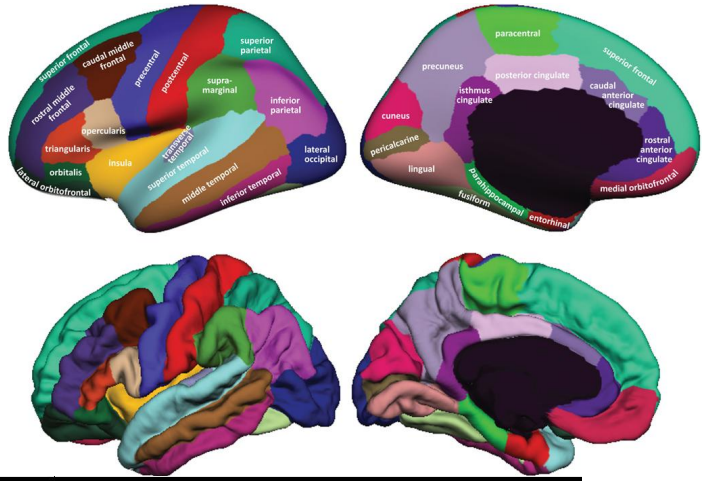
		
		

Spot the problem



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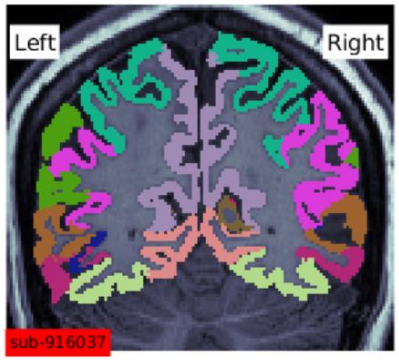
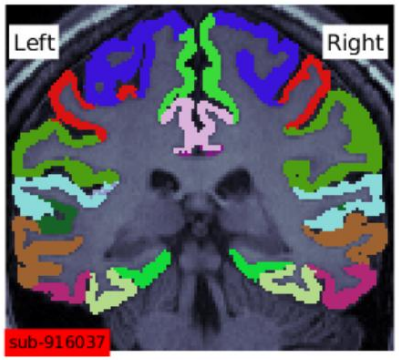
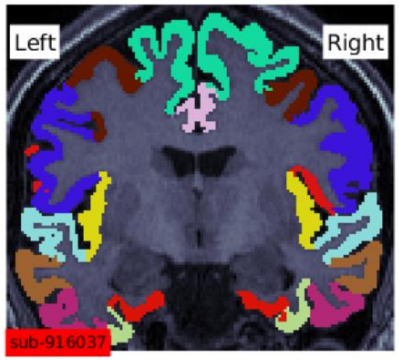
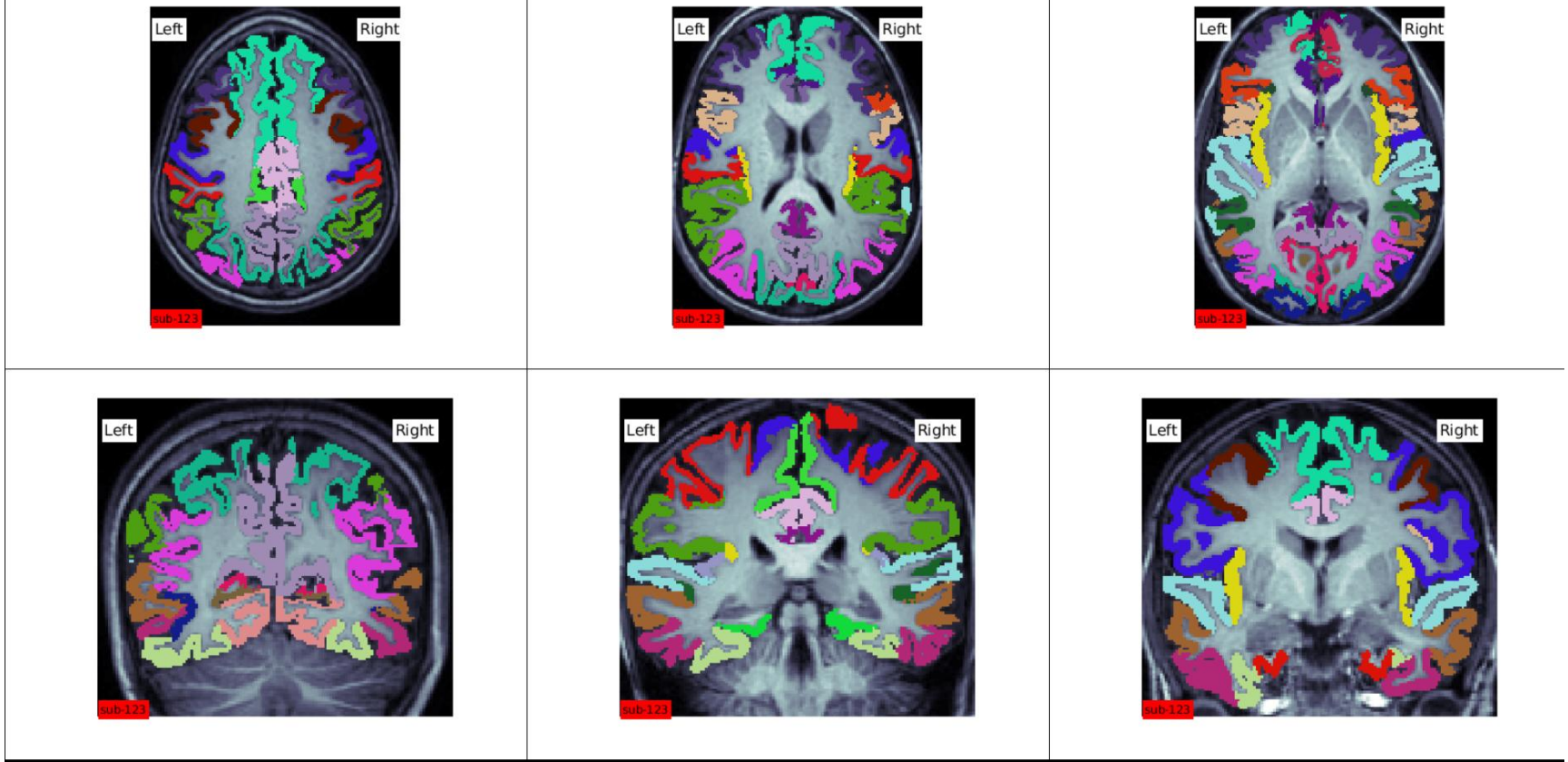
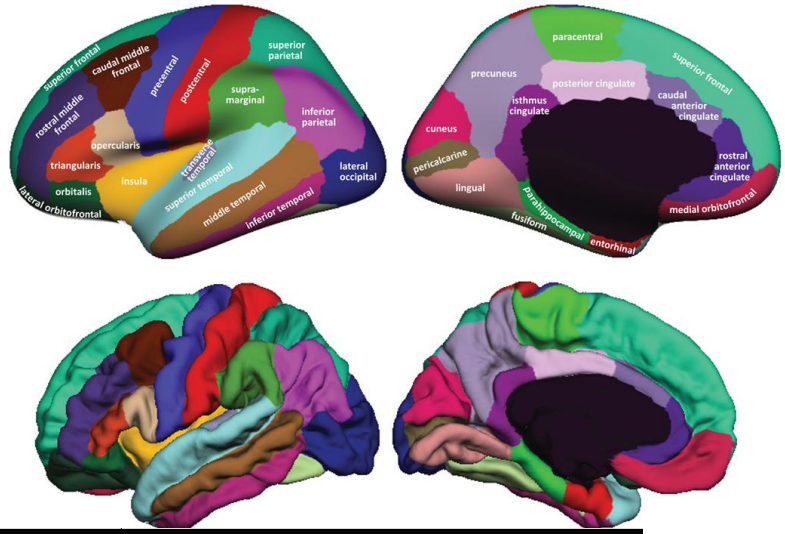
		

Spot the problem

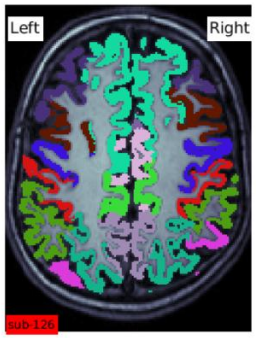
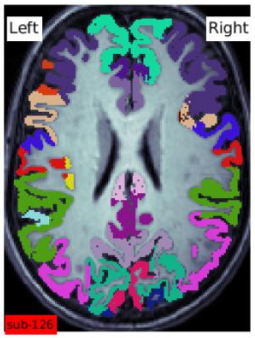
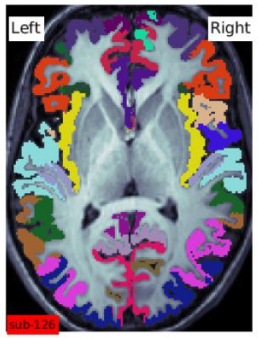
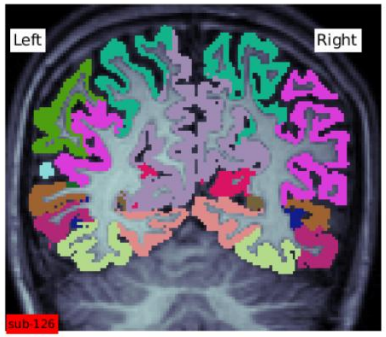
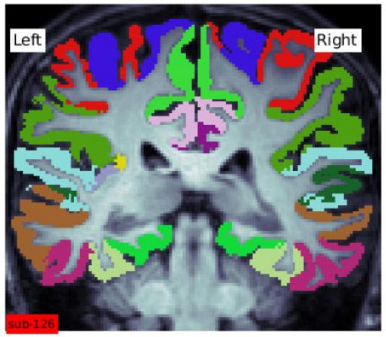
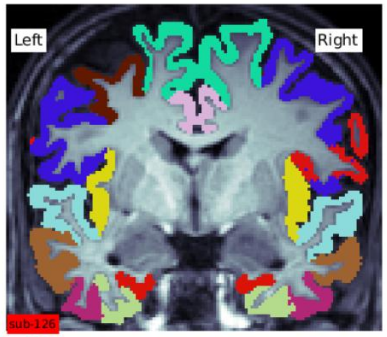
sub-123/



Spot the problem



sub-126/

Spot the problem

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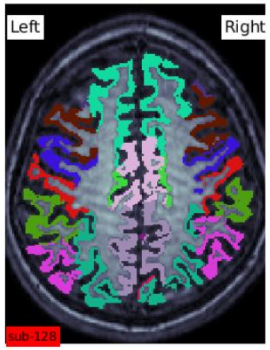
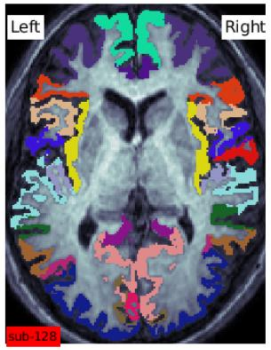
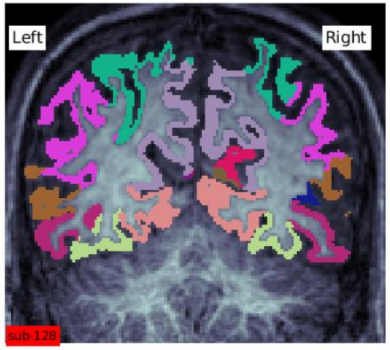
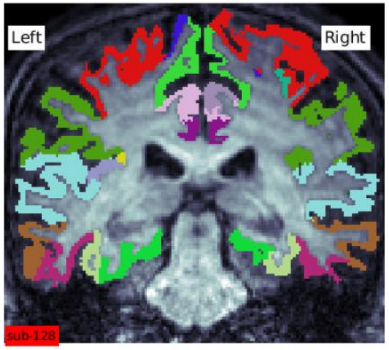
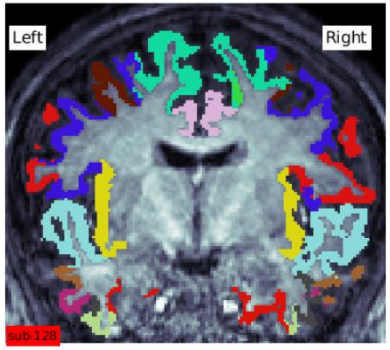
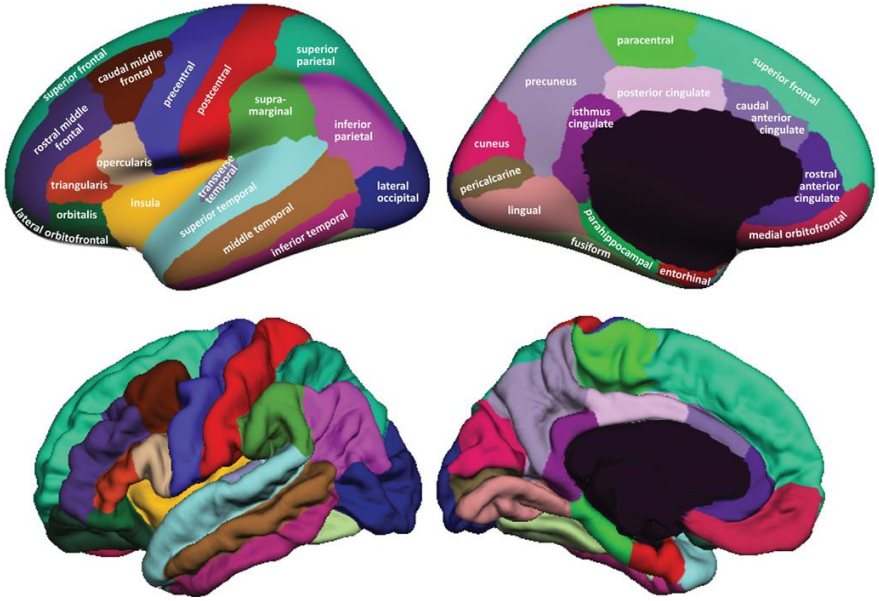
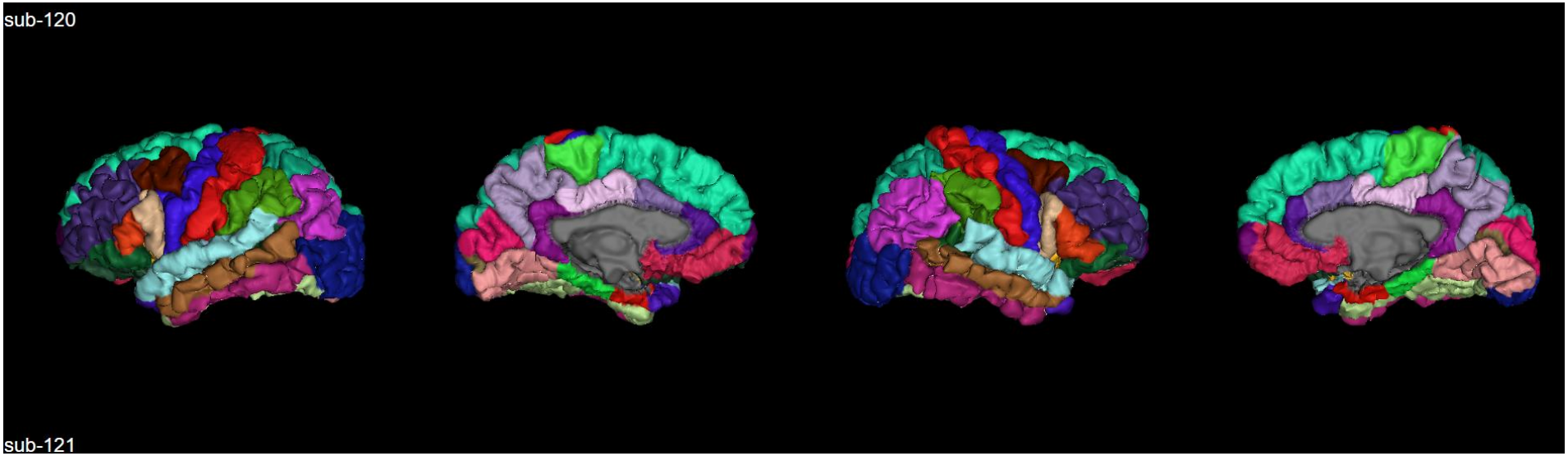
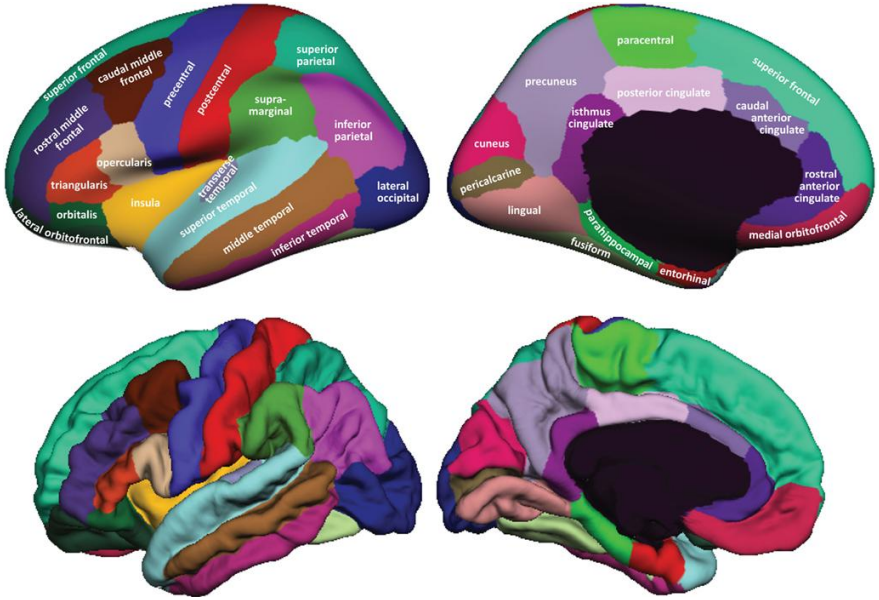
		
		

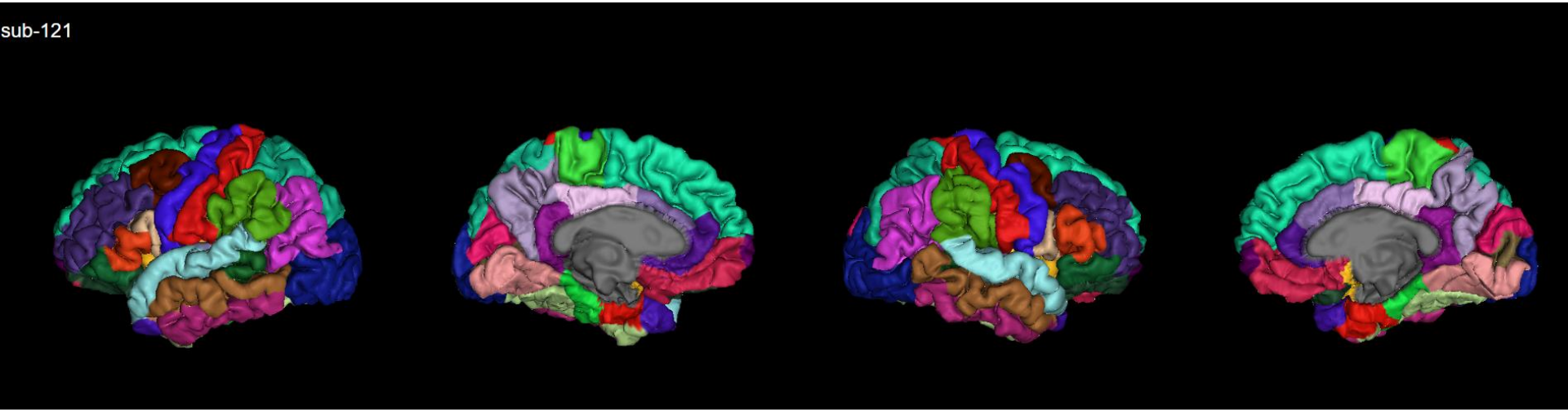
Spot the problem





Spot the problem





Spot the problem

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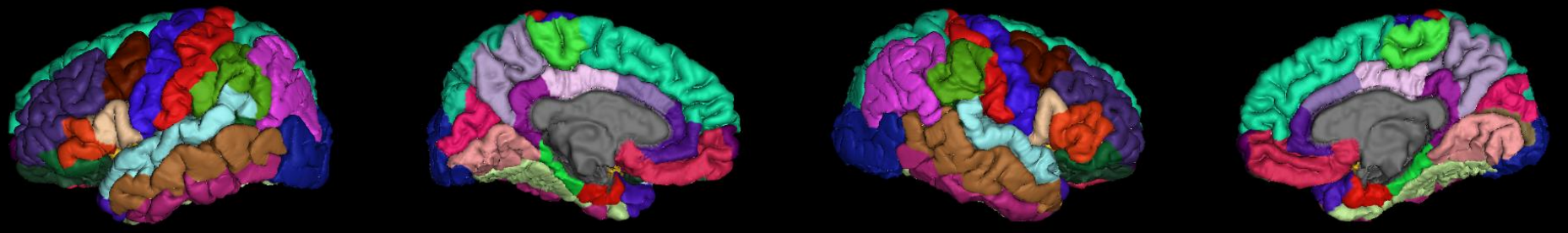

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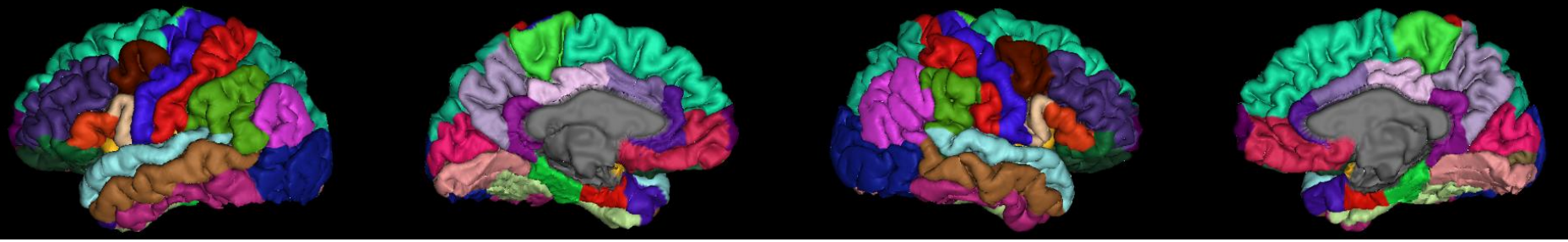
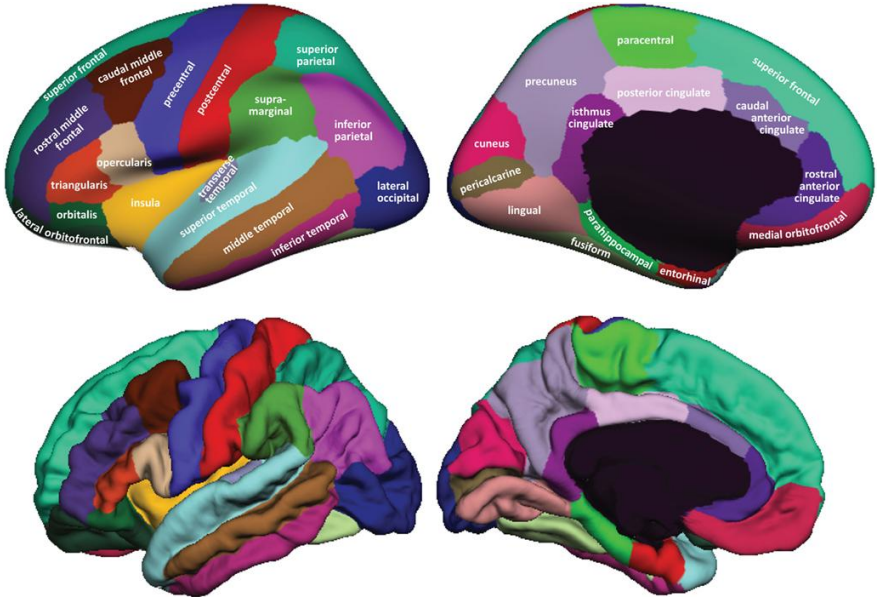
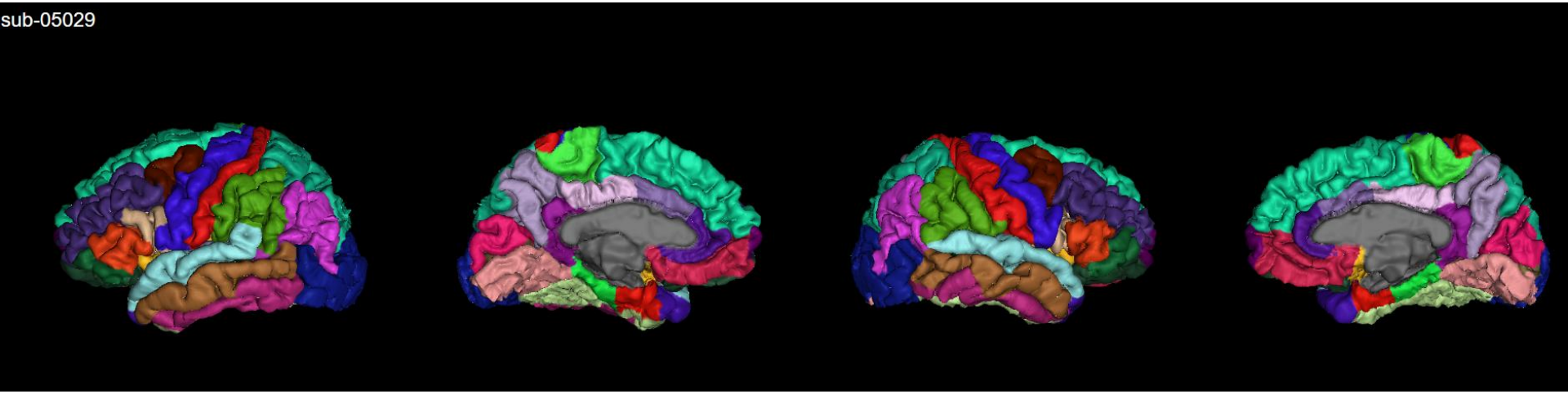
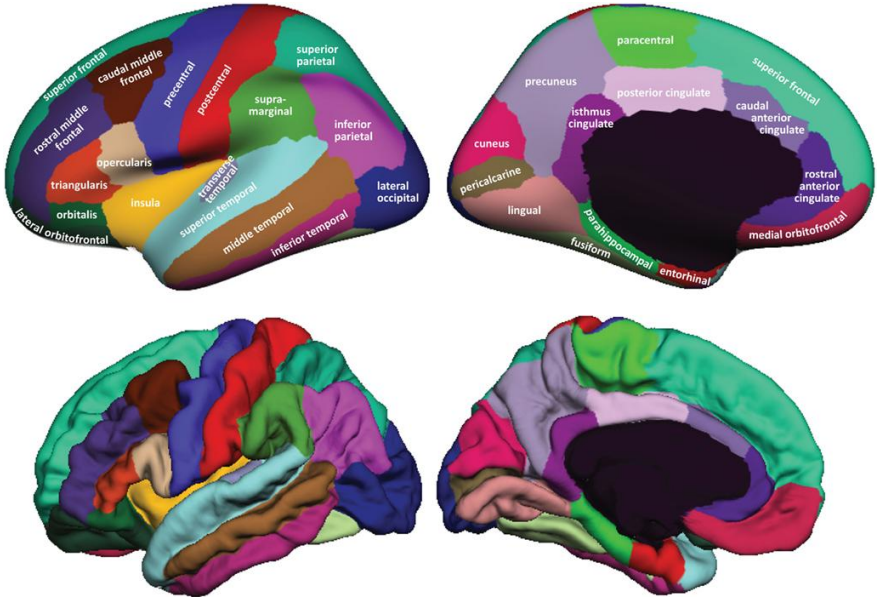


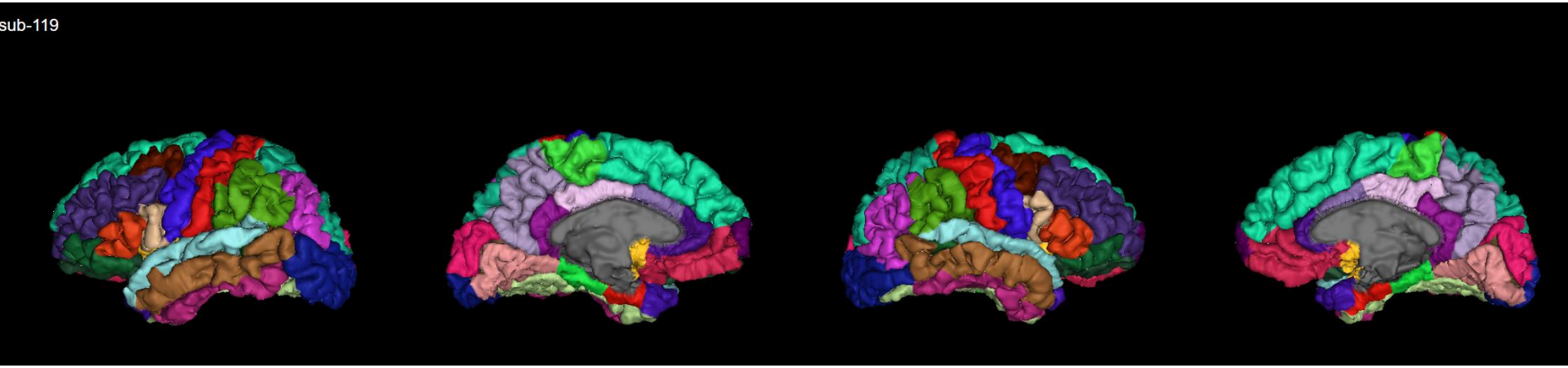
Spot the problem



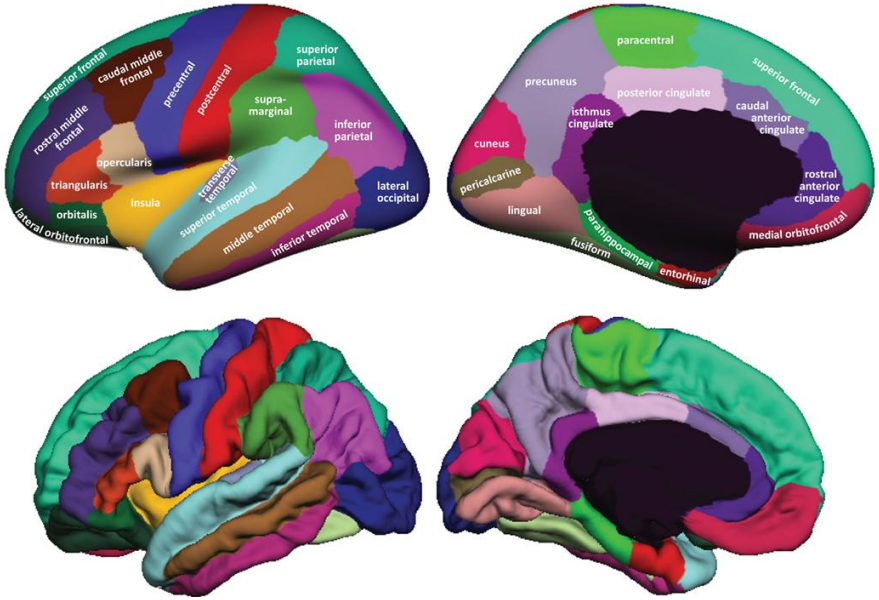


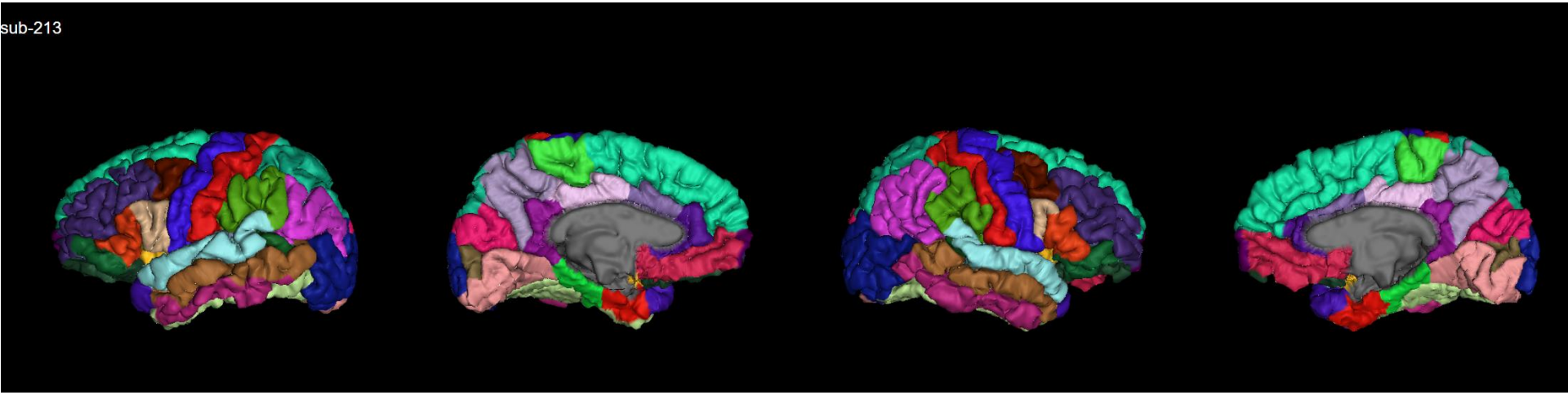
Spot the problem



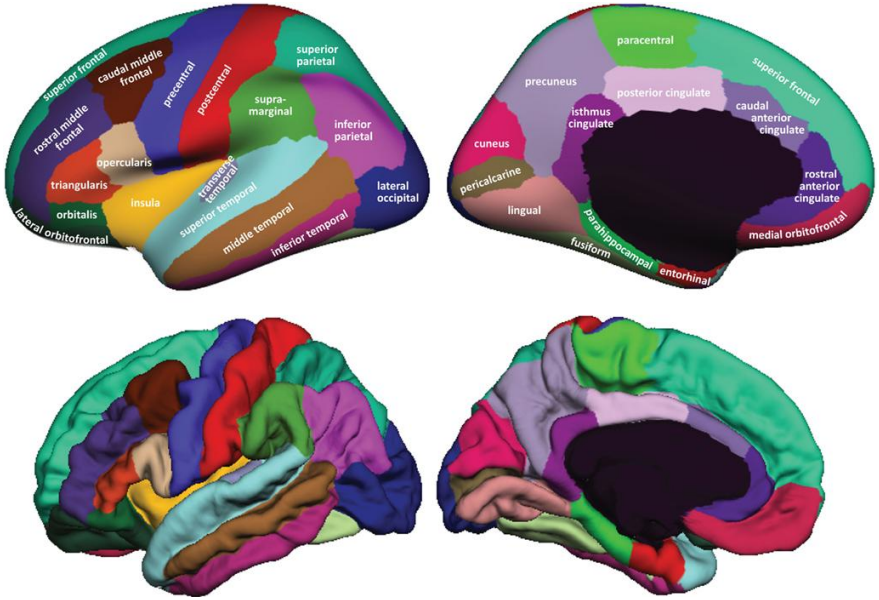


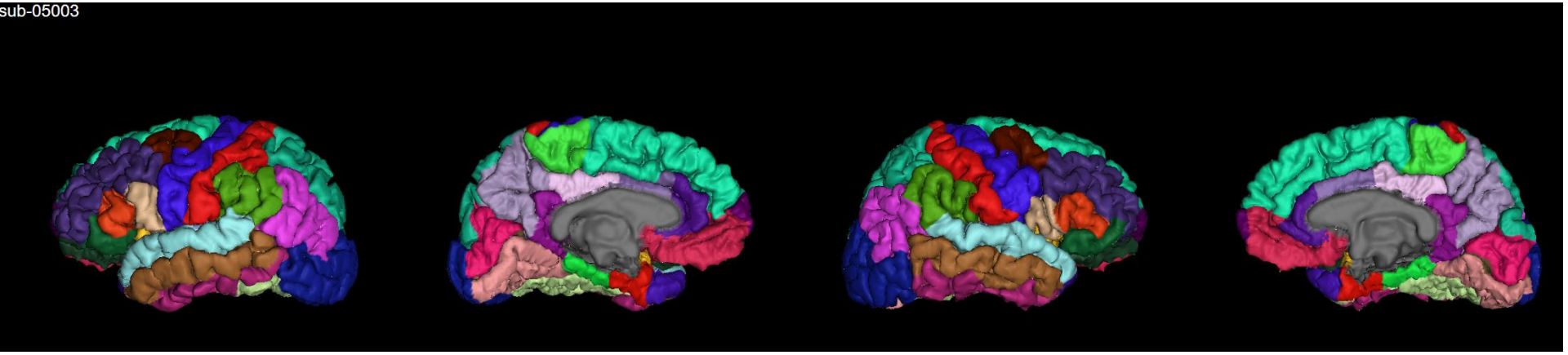
Spot the problem



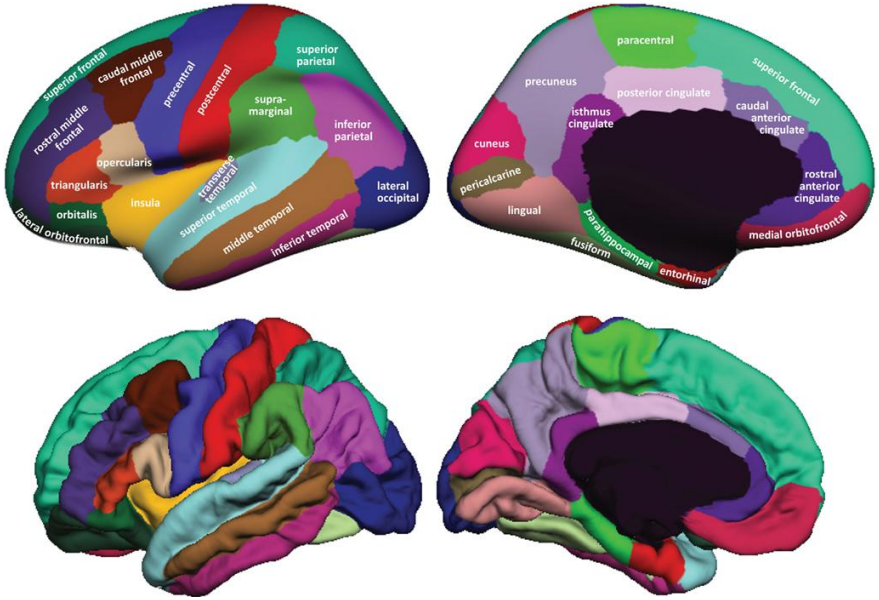


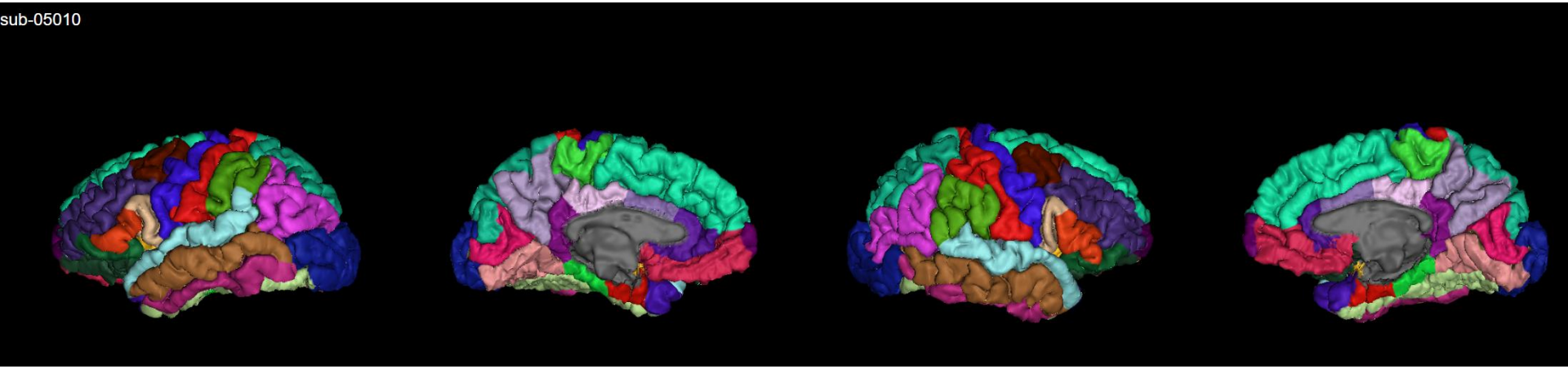
Spot the problem





Spot the problem





GOOD LUCK!