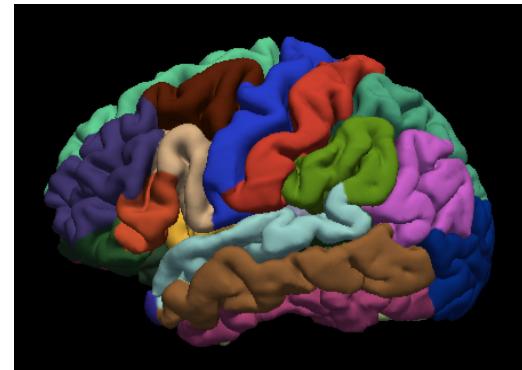


# ENIGMA Cortical QC 2.0; adapted ENIGMA-ANX

*Chris Ching, Faisal Rashid, Sophia Thomopoulos, Lianne Schmaal, Premika*

*Boedhoe, Paul Thompson, and Neda Jahanshad;*

*Adaptations ENIGMA-ANX Janna Marie Bas-Hoogendam, Nynke Groenewold (Dec 2017)*



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

# FreeSurfer Cortical Quality Check

- If you're new to the cortical QC, we highly recommend spending some time viewing some subjects in Freeview 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 Cortical Quality Check

## Steps visual QC

- 1) General
- 2) Internal QC view
- 3) External QC - lateral view
- 4) External QC- mid sagittal vieww

These steps are detailed described in this guide.

# View some subjects in Freeview (optional)

Use the following example commands to view subjects in Freeview, especially if you're new to cortical QC:

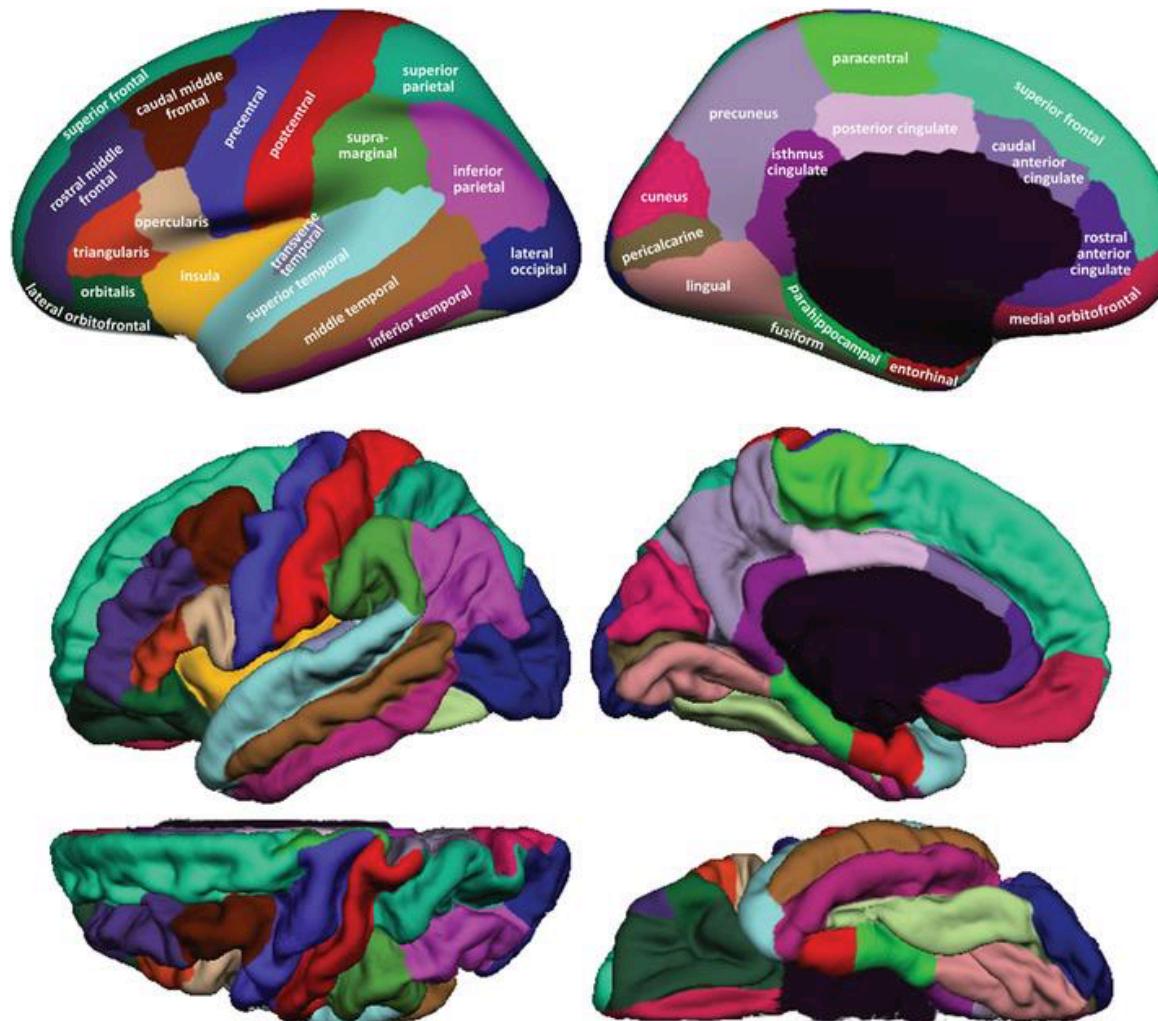
- Replace yellow highlighted portions with your own paths
- Replace \${SUBJECT} with a subject ID from your sample
- Copy and paste into command line to load subject

```
####Configure FreeSurfer#####
export FREESURFER_HOME="/usr/local/freesurfer-5.3.0_64bit"
export LIBGL_ALWAYS_INDIRECT=1
source $FREESURFER_HOME/SetUpFreeSurfer.sh
export SUBJECTS_DIR=/path/to/freesurfer/output
cd ${SUBJECTS_DIR}

####To view internal QC#####
freeview -v ${SUBJECT}/mri/orig.mgz \
${SUBJECT}/mri/aparc+aseg.mgz:colormap=lut:opacity=0.4

####To view external QC#####
freeview -f ${SUBJECT}/surf/lh.pial:annot=aparc.annot:name=pial_aparc:visible=1 \
${SUBJECT}/surf/rh.pial:annot=aparc.annot:name=pial_aparc:visible=1 \
--viewport 3d
```

# Freesurfer regions color-coded



Desikan-Killiany Atlas

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

# Use “Cortical\_QC\_Template\_ENIGMA\_ANX.xls” to record your QC

**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	
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

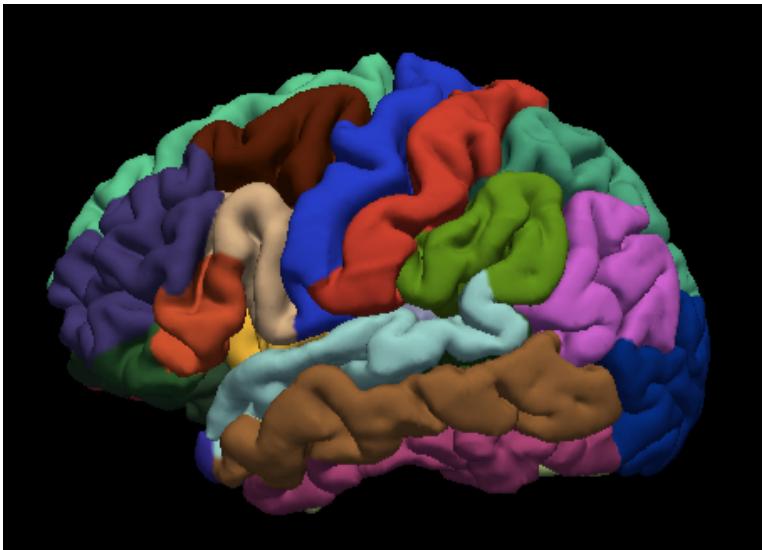
### Internal/External\_QC Columns:

- 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)

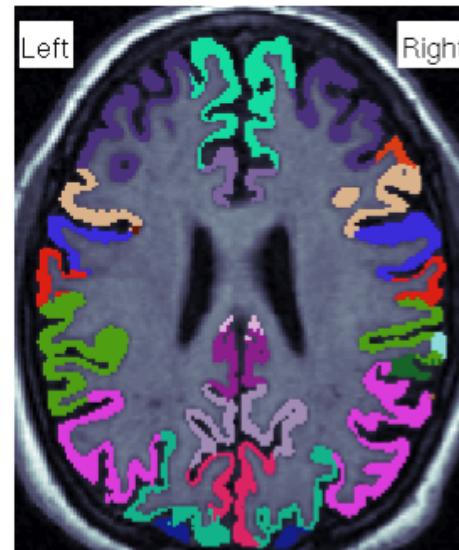
### Second Tab: QC\_Code\_Key

- Provides standardized codes for the “QC\_Code” column on first tab to keep track of common errors
- Examples of these common errors are provided in this guide

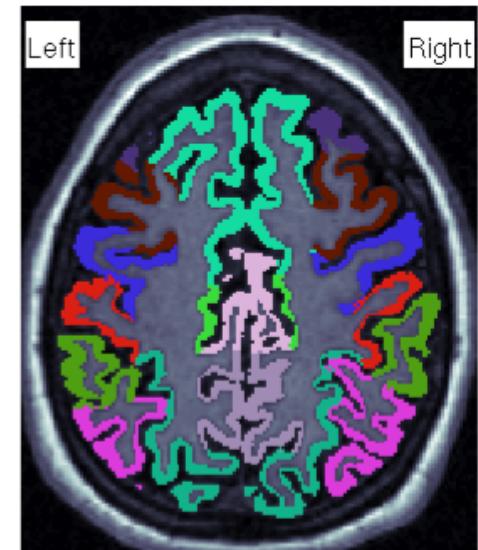
# Good examples



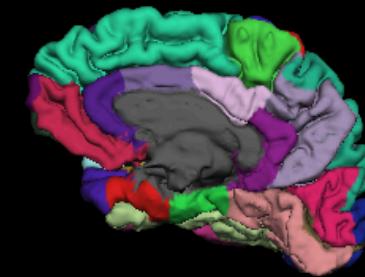
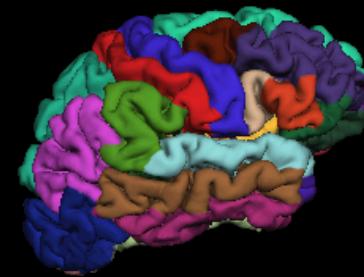
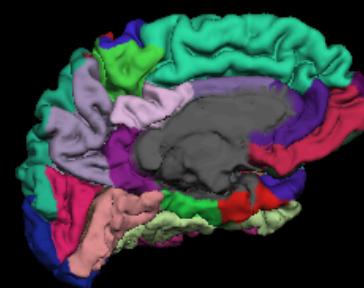
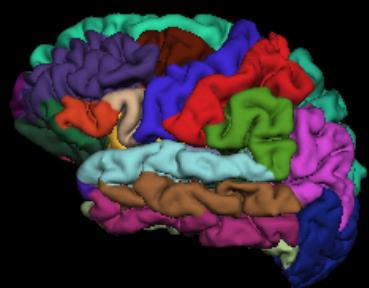
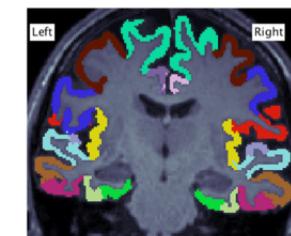
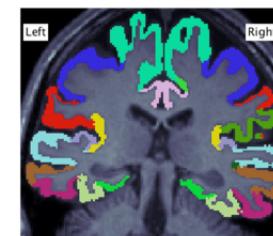
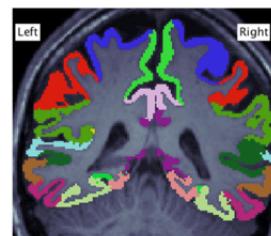
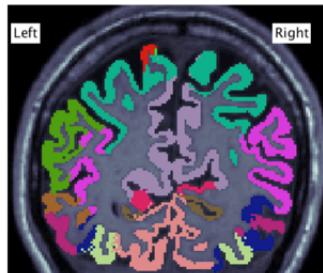
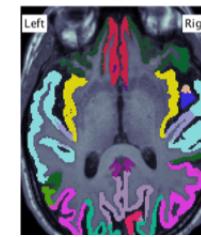
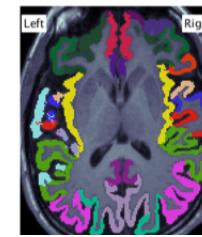
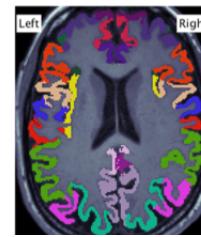
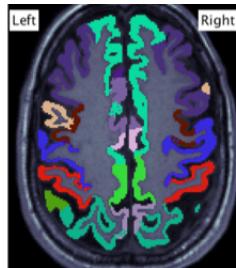
Labels generally correspond to known anatomical boundaries



Grey matter properly segmented  
(no under/overestimations)



# More good examples

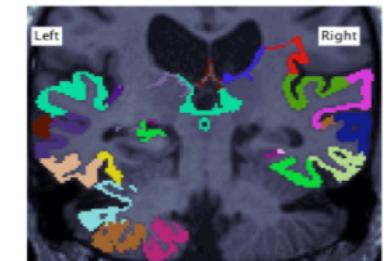
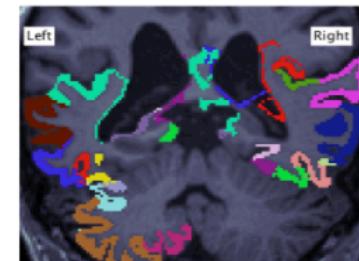
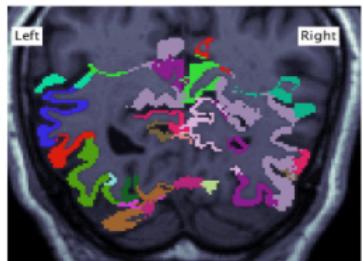
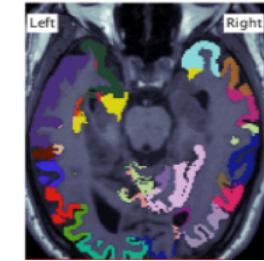
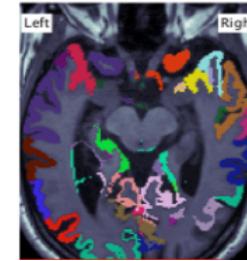
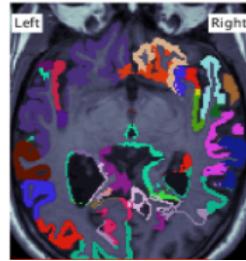
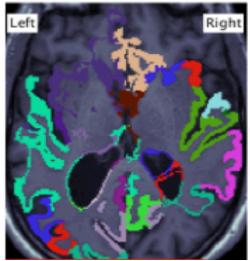


# 1 General QC issues

- **General segmentation failure**
- **Pathology**
- **Imaging artefacts**
- **Meninges overestimations**

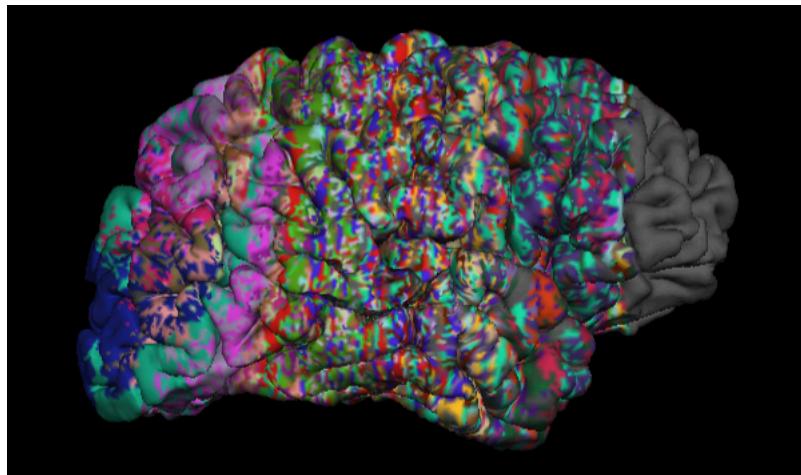
Both internal and external QC images can be used to spot these QC issues.

# General segmentation failure (internal view)

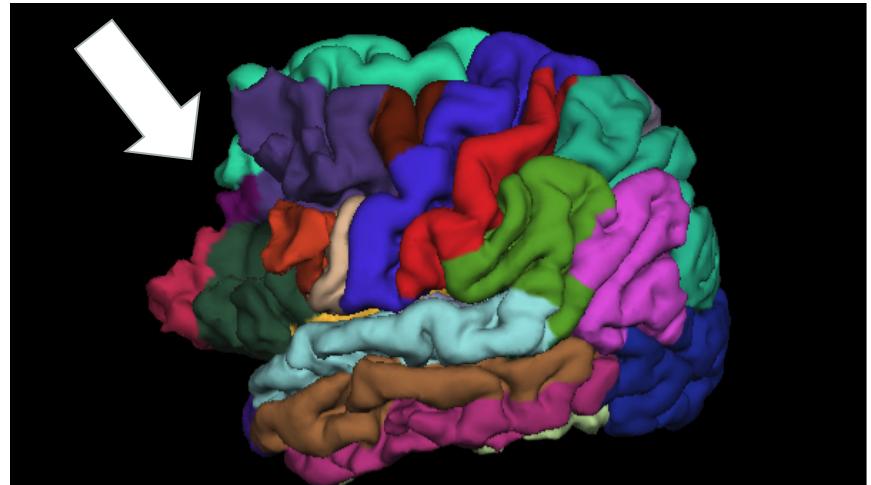


Fail entire subject: cerebellum misclassified and other severe global underestimations

# General segmentation fail (external view)

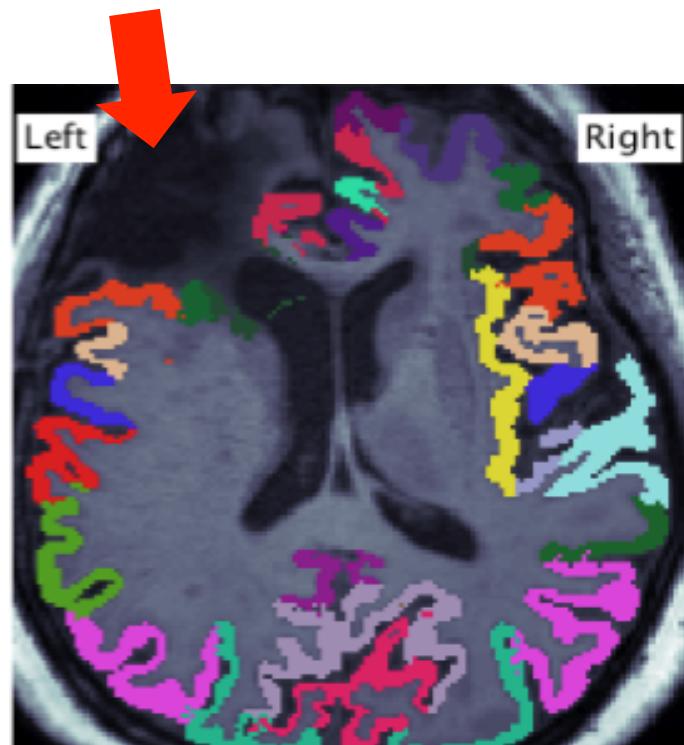


Fail (Processing Error)  
- fail entire subject

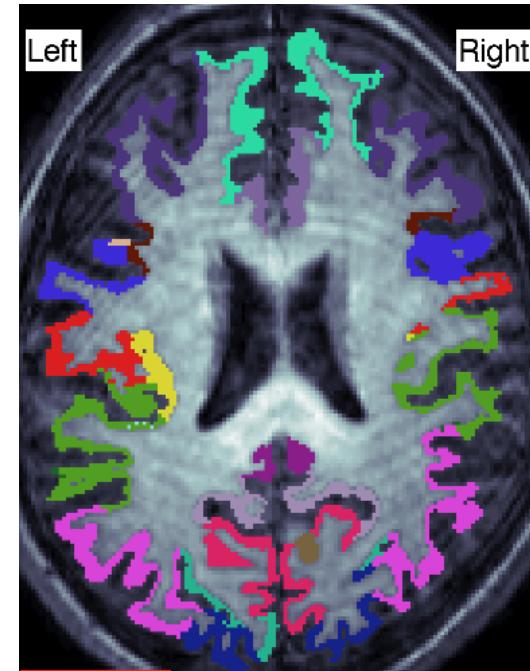


Fail (pathology) -  
fail entire subject

# Fail due to pathology or motion artefacts (internal view)



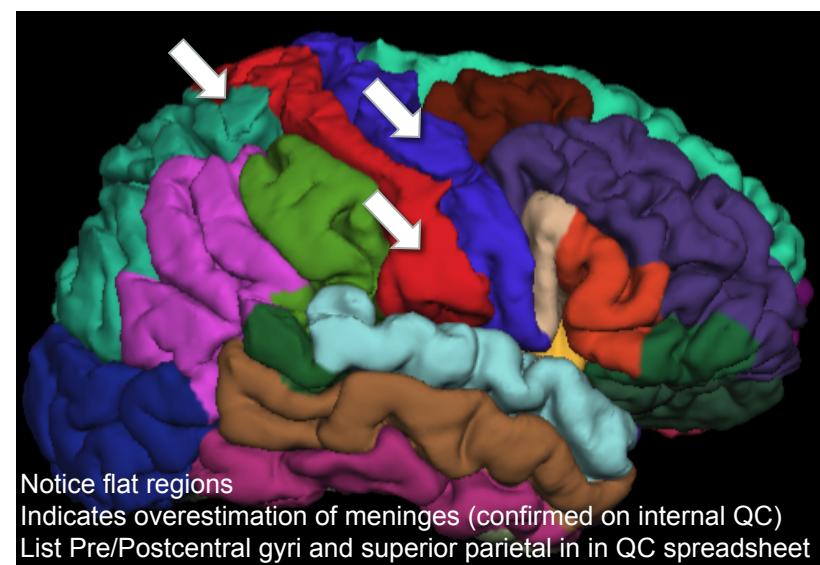
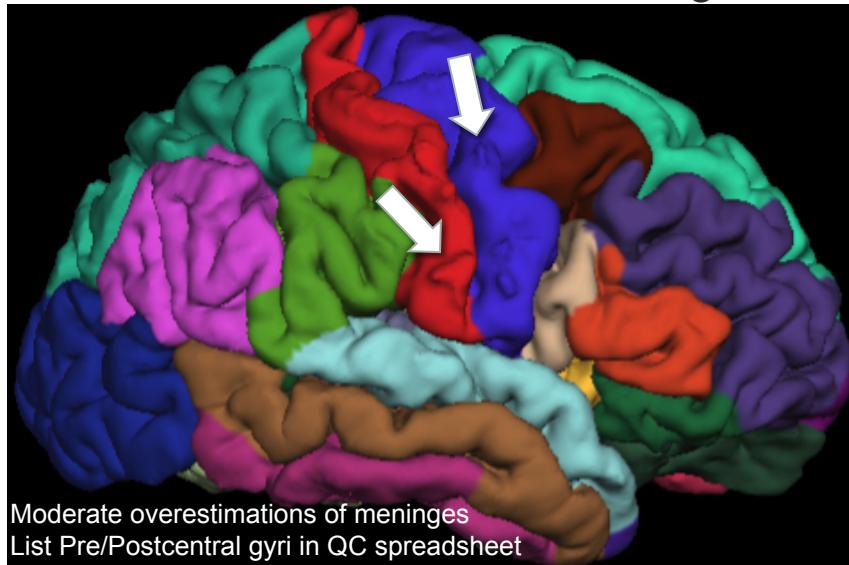
Complete fail (pathology);  
fail entire subject



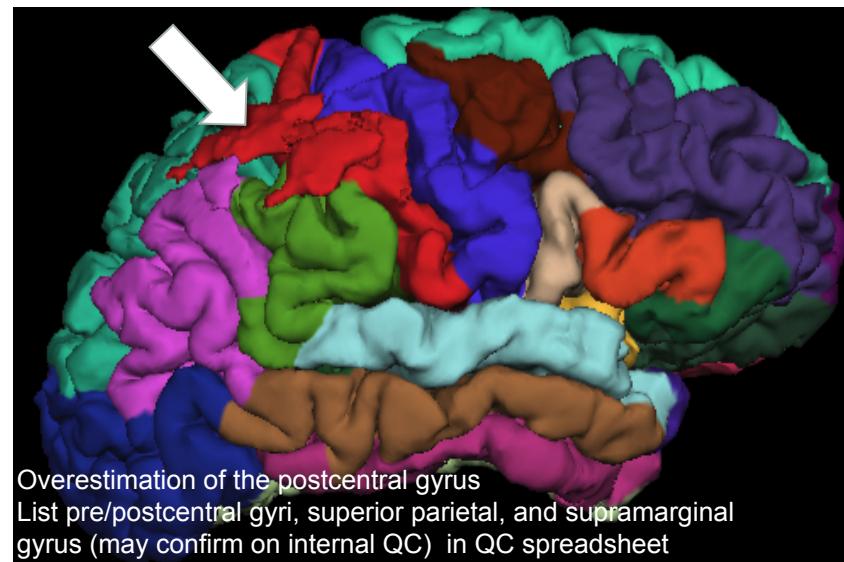
Complete fail (motion causing  
failed segmentation); fail  
entire subject

# Meninges overestimation - moderate fail (external view)

## Meninges overestimations



Please note that meninges overestimation can also be present in other regions (not limited to pre/postcentral)

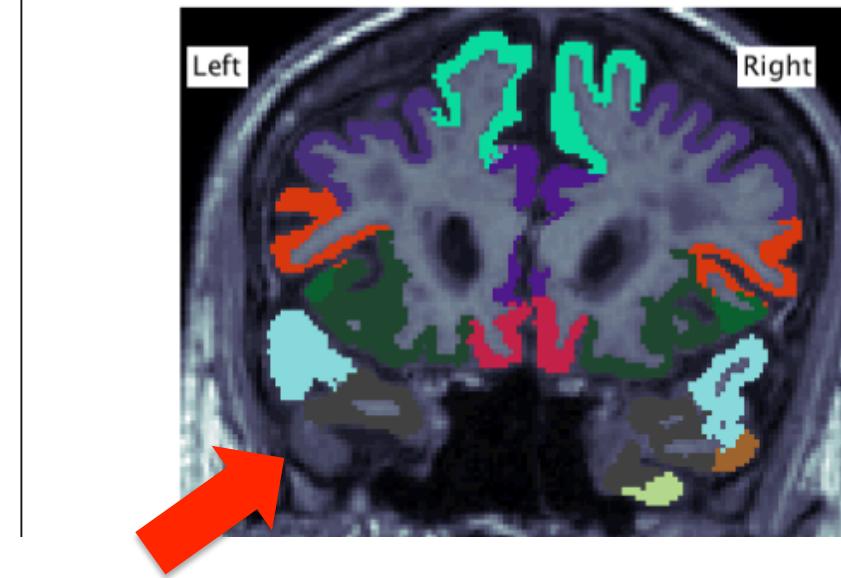
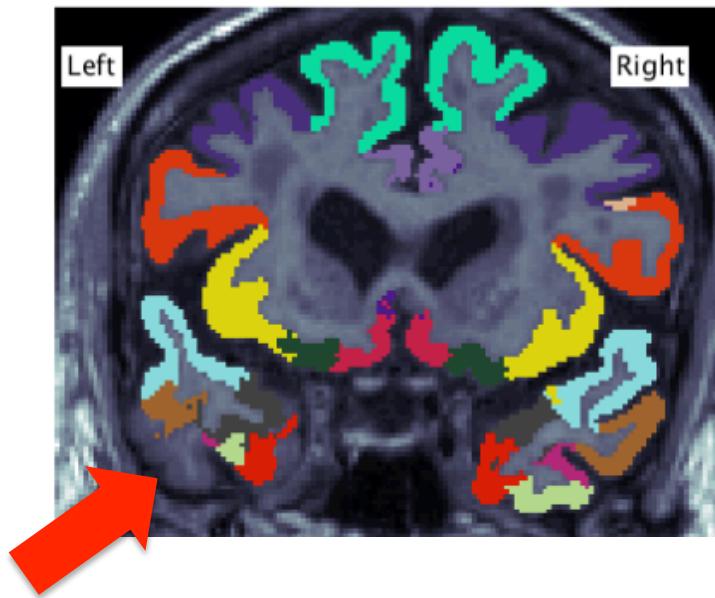


## 2 Internal QC view

- Poles underestimation
- Insula overestimation
- Under/overestimations of the pre/postcentral gyrus regions

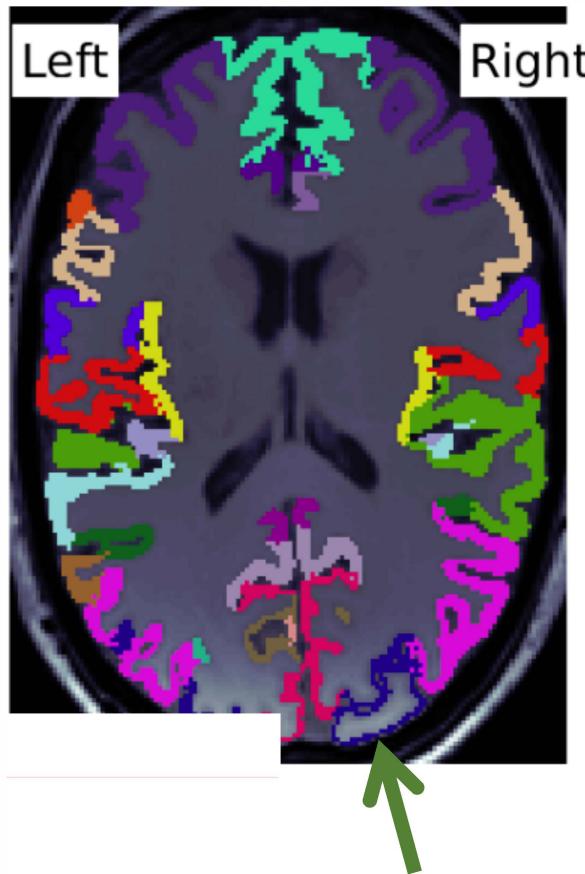
# Temporal Pole Underestimation

- moderate fail

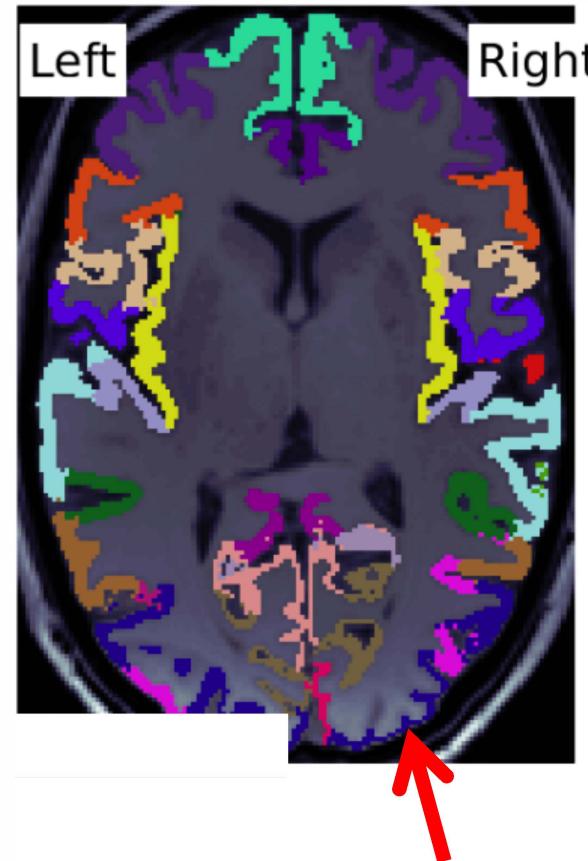


- FreeSurfer sometimes seems to underestimate the anterior temporal and frontal poles. Check using Freeview / FSLview whether a label has been assigned (NB: temporal pole is coloured grey).
- List truly underestimated regions in QC spreadsheet (L, R, or R/L).

# Lateral Occipital Pole Underestimation - moderate fail

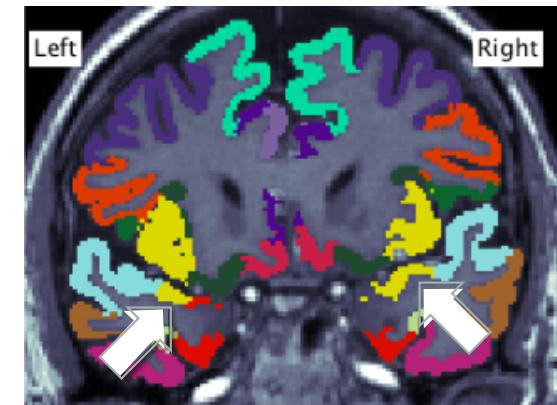
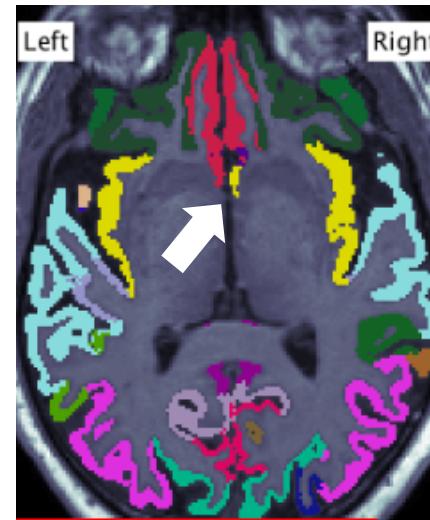
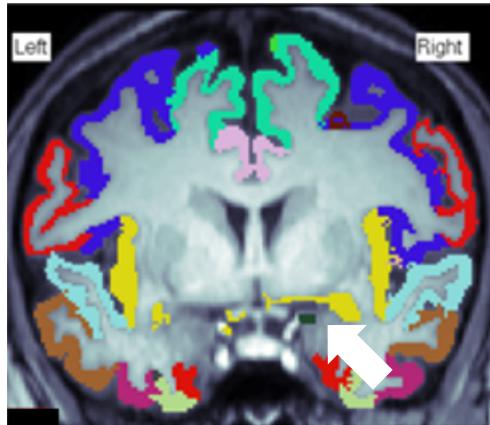


Correct



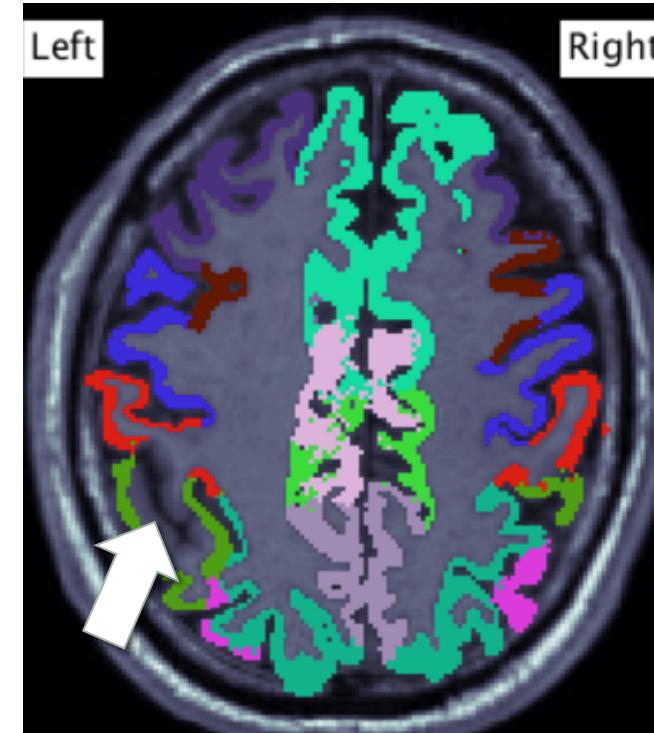
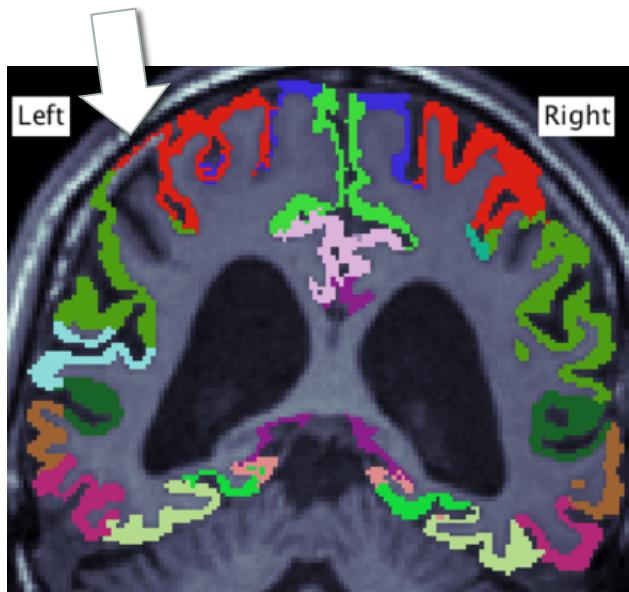
Moderate fail

# Insula (yellow) Overestimation - moderate fail



- This Freesurfer atlas does not include a subgenual ACC region and sometimes assigns this to the insula (yellow) or medial OFC (red/pink) instead. The figures above shows common issues regarding Insula overestimation into the temporal lobes and midline.

# Pre/Postcentral gyrus issues - moderate fail



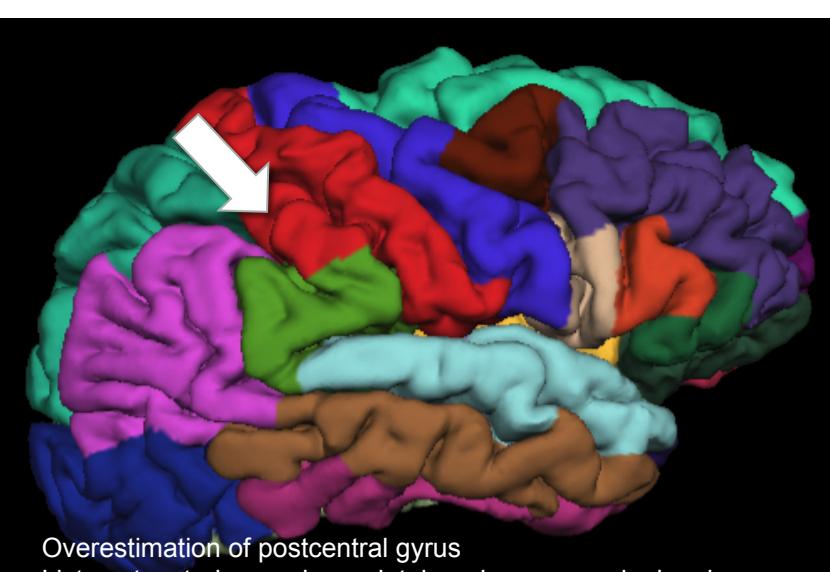
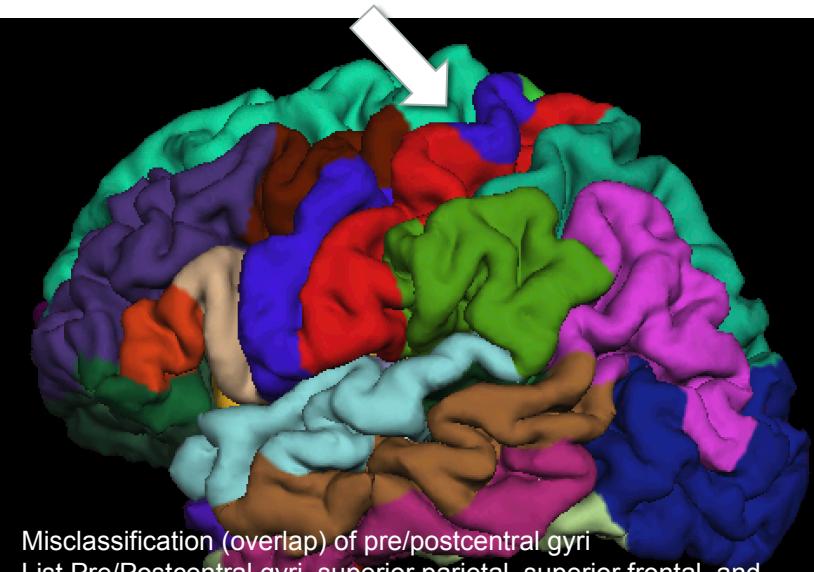
- Certain regions are under/overestimated but rest of segmentation looks good.
- Can use External QC to confirm affected regions (examples to follow).
- List regions misclassified in QC spreadsheet (L, R, or R/L) so they can be withheld from analysis.

## 3 External QC - lateral view

- Central: over/ underestimation pre/postcentral gyrus, or misclassifications
- BanksSTS
- Supramargial

# Pre/Postcentral gyrus issues - moderate fail

Moderate fail

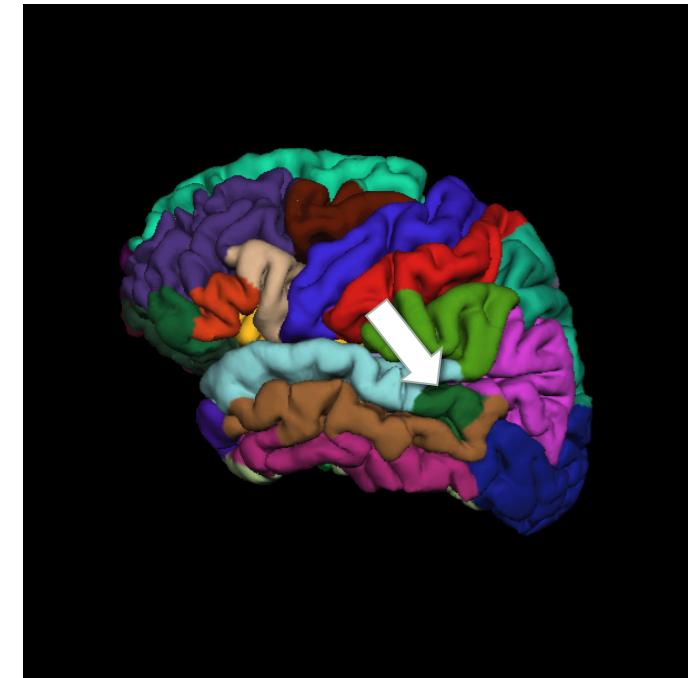


# Banks of superior temporal sulcus overestimation - moderate fail

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

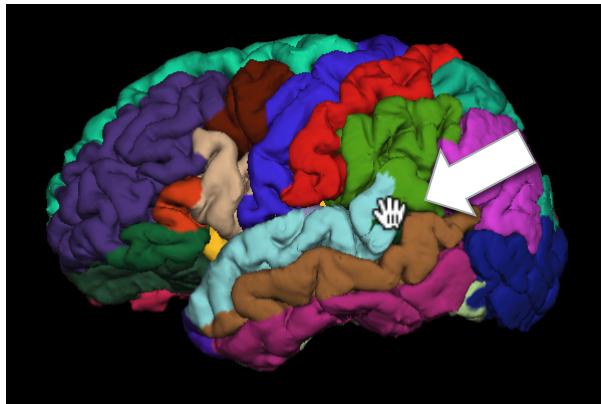
In some cases ( $\approx 15\%$ ) the size of the mislabeled BanksSTS may influence the surrounding ROIs (e.g. superior temporal/middle temporal gyri).

BanksSTS QC Steps:

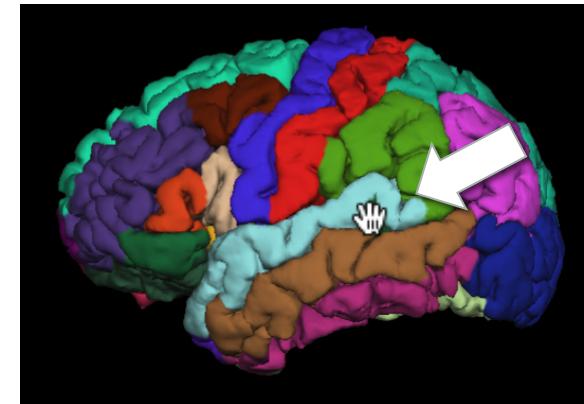


1. Load index.html into browser.
2. Press: “Command and + ” which zooms in once – match the size of your QC images to the size of image above (\*\*Tip: view the PDF version of the guide at 100% and your QC images should be about the same size as the brain above\*\*)
3. IF the mislabeled BanksSTS is larger than hand/cursor, THEN list the BanksSTS and surrounding affected regions (e.g. superior temporal gyrus and/or middle frontal gyrus, see examples on next slides.) in the QC spreadsheet (L, R, or R/L).

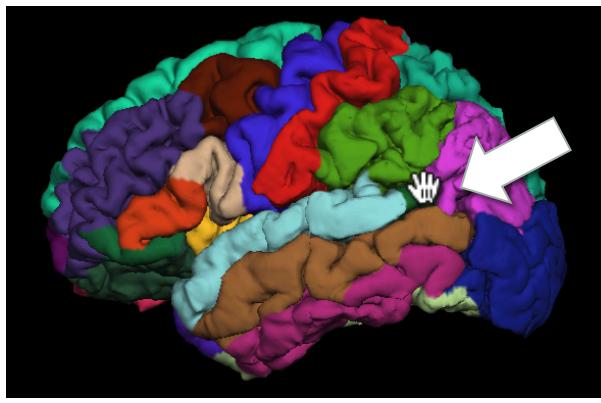
# OK examples (do not fail BanksSTS)



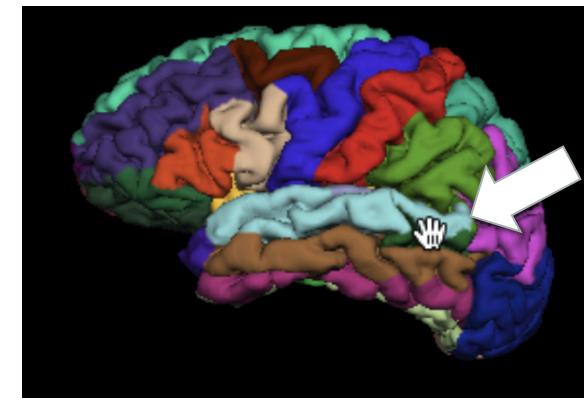
Pass



Pass

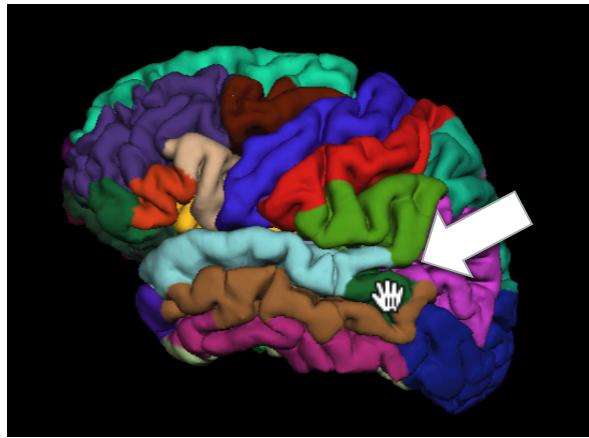


Pass

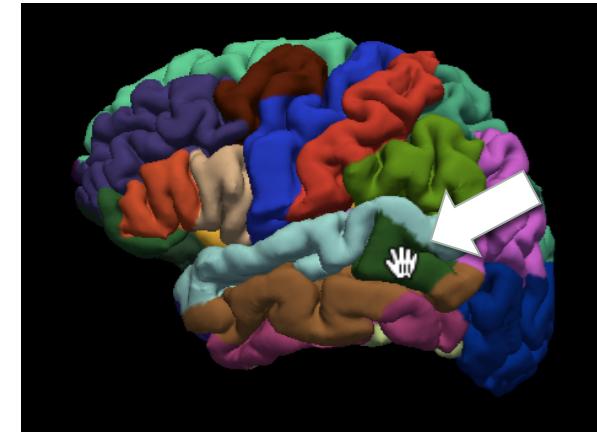


Pass

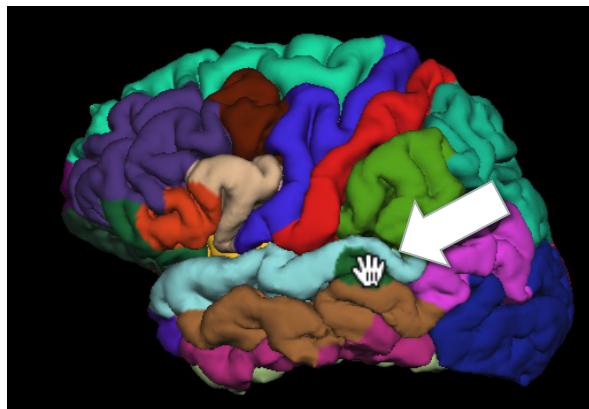
# Bad examples BanksSTS (List affected regions in QC sheet)



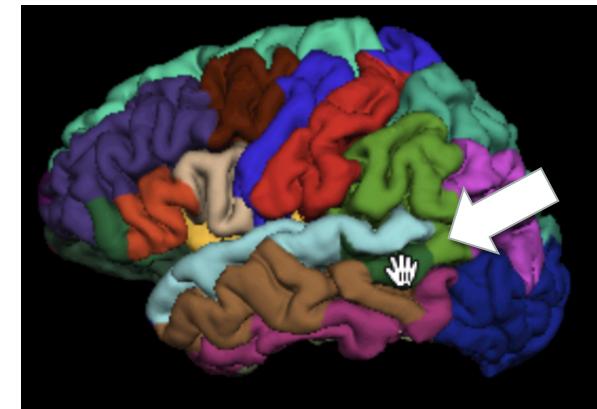
Fail BanksSTS + STG



Fail BanksSTS + STG + MTG



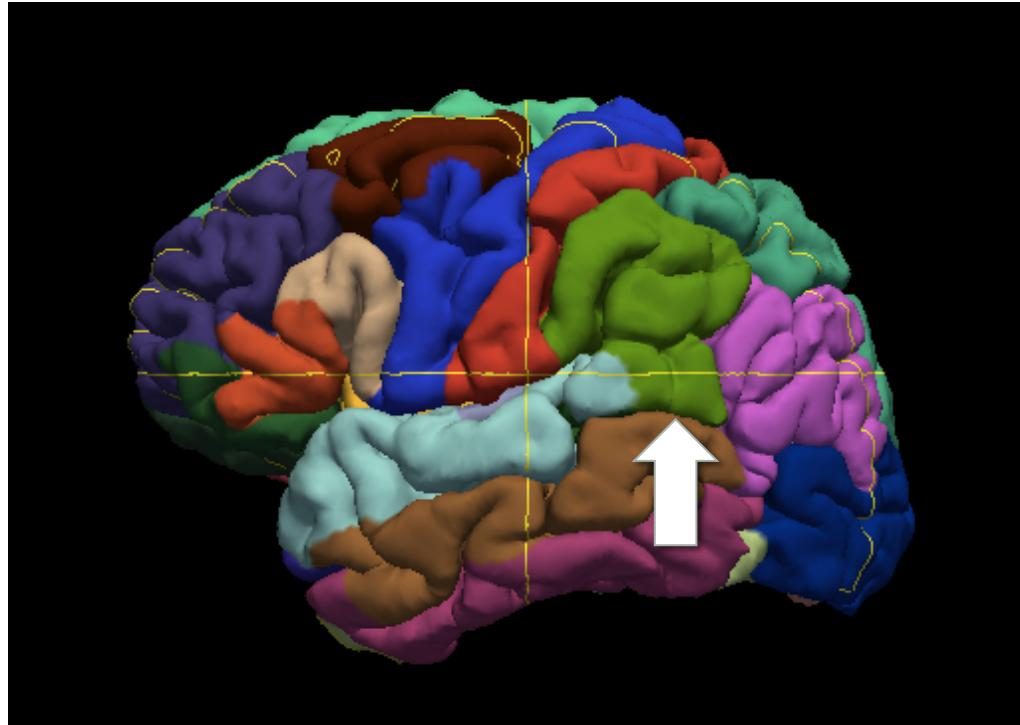
Fail BanksSTS + STG + MTG



Fail BanksSTS + MTG

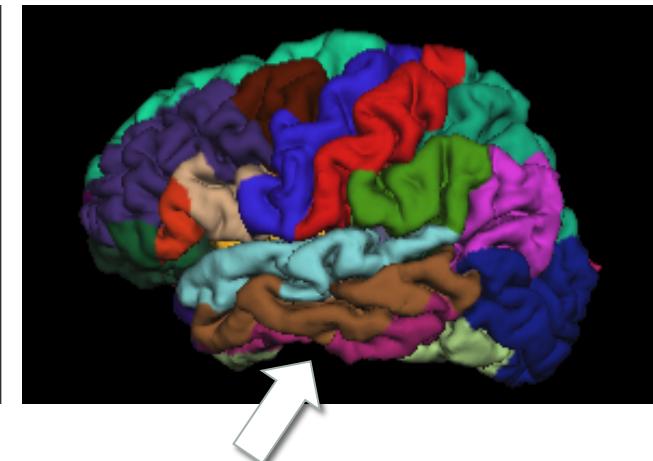
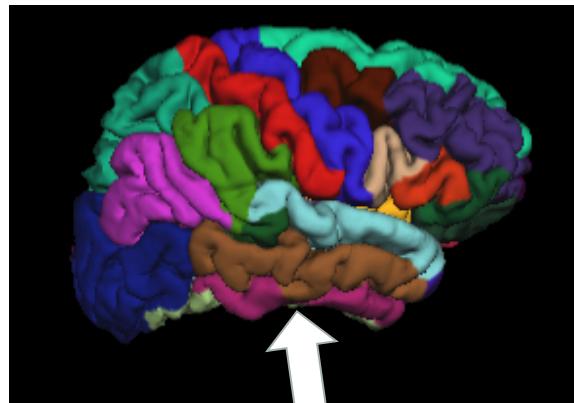
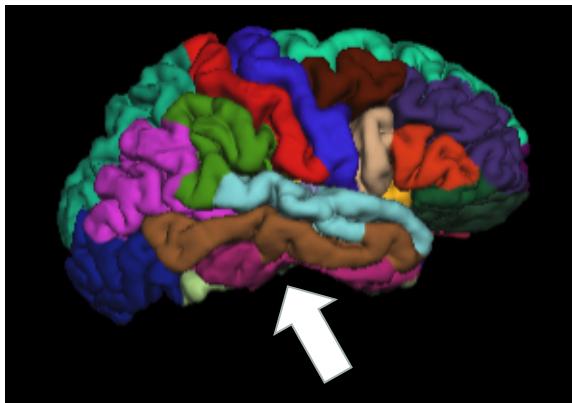
STG: superior temporal gyrus; MTG: middle temporal gyrus

# 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).
- List affected regions (L/R) in the QC spreadsheet

# Be aware: middle/inferior temporal gyrus



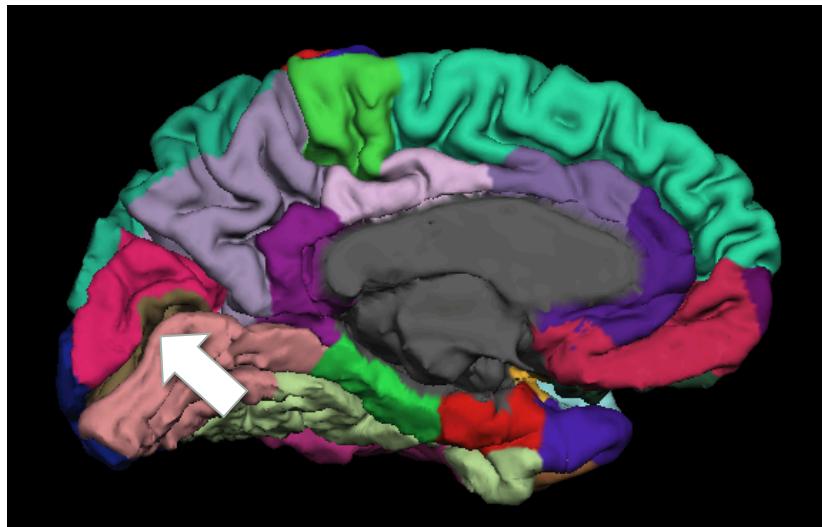
- When the middle temporal gyrus looks as if it covers the inferior temporal gyrus, this is usually due to the rotation angle of the brain and is probably Okie Dokie (Pass).
- It is considered normal when the middle and inferior temporal gyri are somewhat overlapping on each other as in the above examples (see examples of non-continuous inferior temporal sulcus).

## 3 External QC - mid saggital view

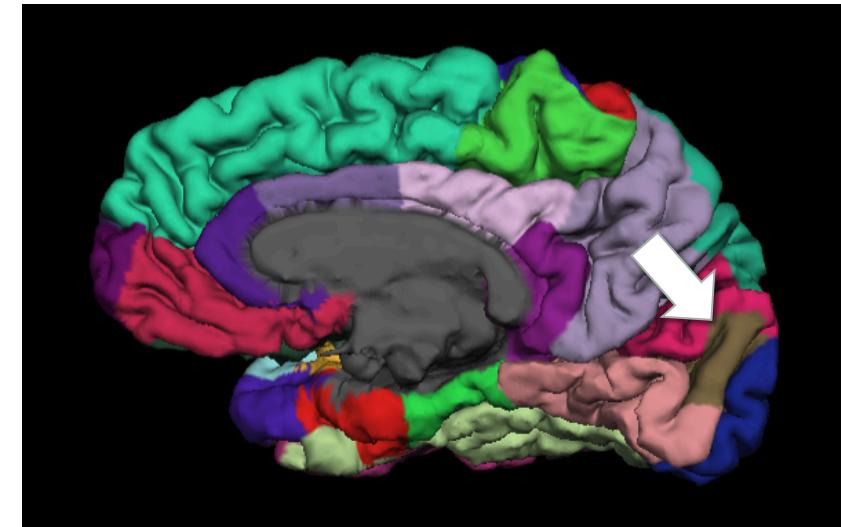
- Pericalcarine overestimations
- ERC / parahippocampal underestimations
- Paracingulate
- Superior parietal overestimation

# Pericalcarine Overestimations

**GOOD**



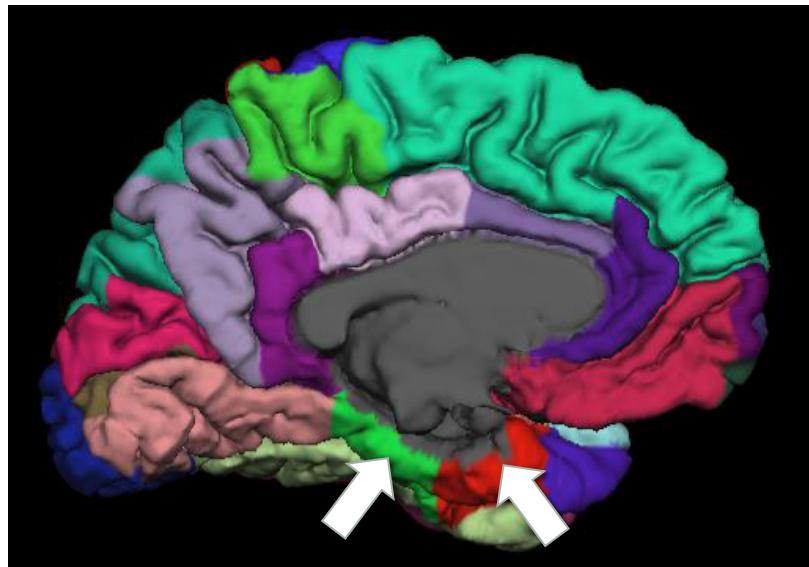
**BAD**



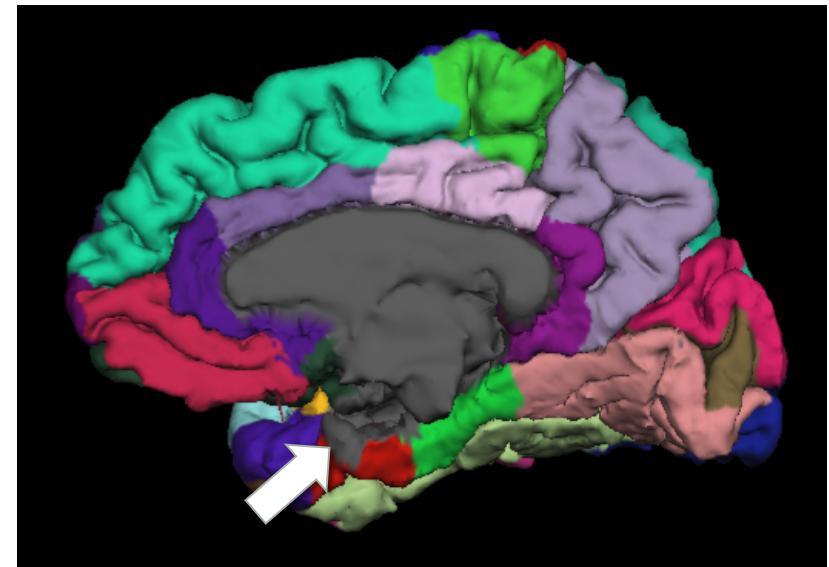
- Segmentation confined to calcarine sulcus
- Segmentation overestimates pericalcarine region
- List affected regions (above: pericalcarine, lingual, and cuneus regions) in QC spreadsheet

# Parahippocampal (green) and entorhinal cortex (ERC) (red) underestimations

A

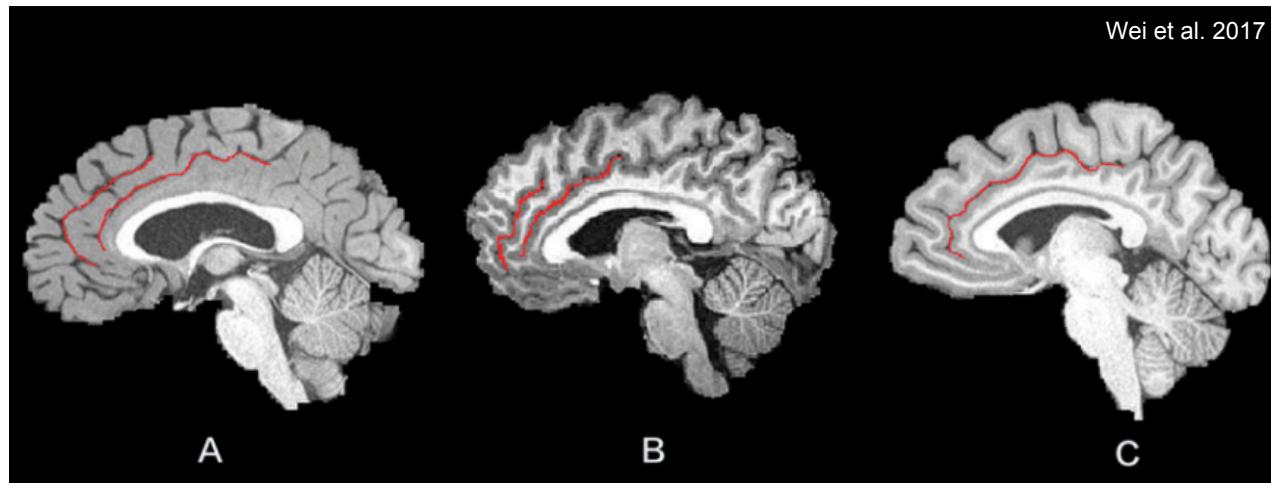


B

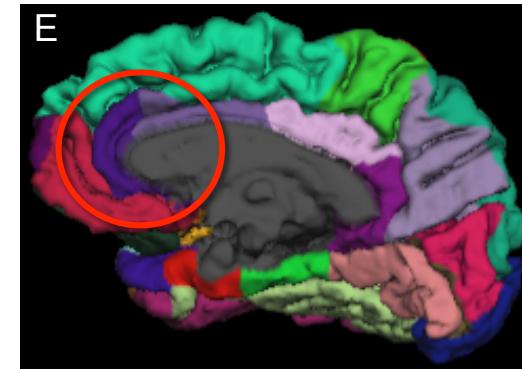
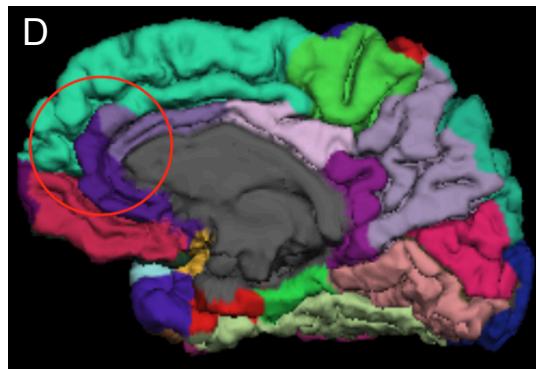


- List segmentation of the entorhinal cortex and parahippocampal gyrus as fail (L, R, or R/L) when >50 % of the region is underestimated
- So: example A = pass; example B = fail (ERC)

# Paracingulate cortex issues



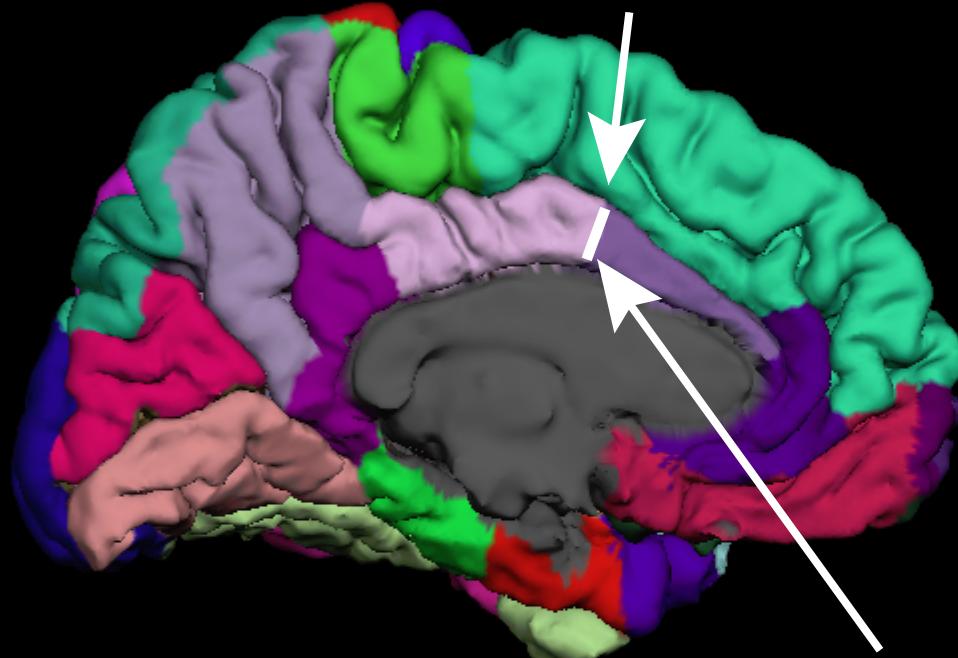
- A paracingulate sulcus (PCS) is present in 30–60% of cases and is more frequently found in the left hemisphere (A and B). This can cause segmentation problems in the cingulate and surrounding regions.



- In subjects with prominent paracingulate sulcus (example D, E), portions of the cingulate may be underestimated while superior frontal regions may be overestimated.
- Guideline to determine whether a prominent paracingulate sulcus is present: when the cingulate continues past the border caudal anterior /posterior cingulate (midwaypoint), but is labeled as superior frontal (see example next page)

## Paracingulate cortex - another example

Cingulate continues after midway point, but is labeled superior frontal

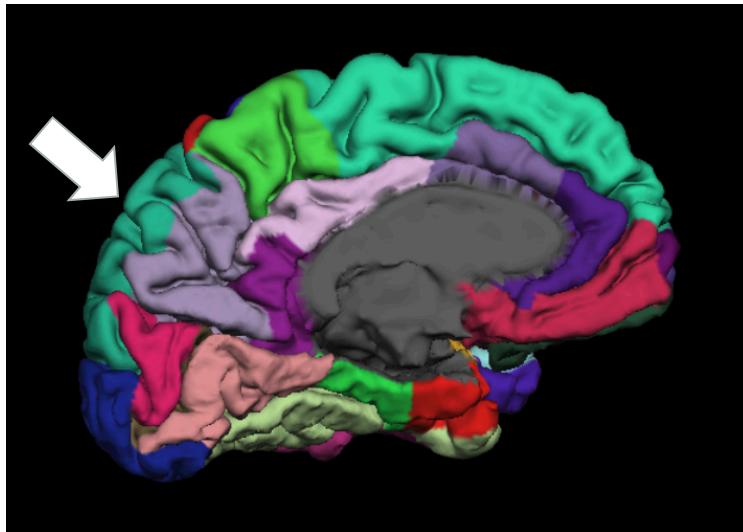


Midway point

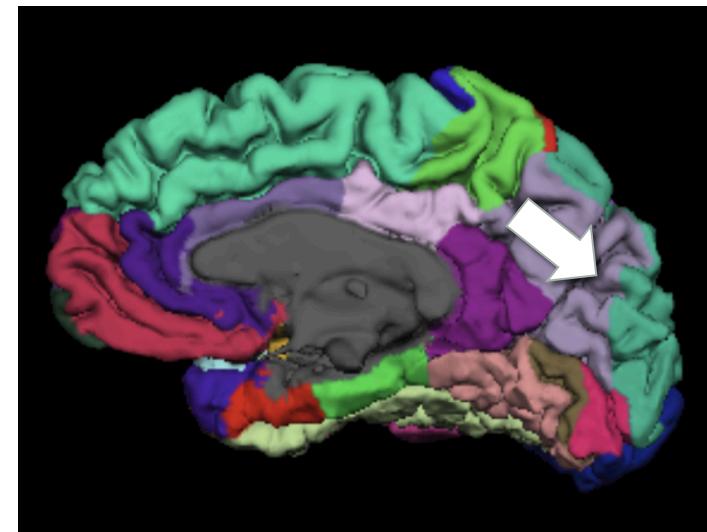
Prominent paracingulate that was mislabeled as the superior frontal cortex

# Superior Parietal Overestimation

**Normal**



**Overestimation**



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

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