

# Standard operating procedure for neonate quality assessment post-processing

DCAN Lab

# Quality Checking neonate neuroimaging data

## Executive Summary Overview

- T1 & T2 surface evaluation with Brain Sprite
- Functional Scan Images
- Reference Frame
- Motion Numbers and Grayordinates

## Structural Quality Assessment

- T1 to Atlas registration- outside of executive summary folder
- T1 & T2 grey matter and white matter surface delineation

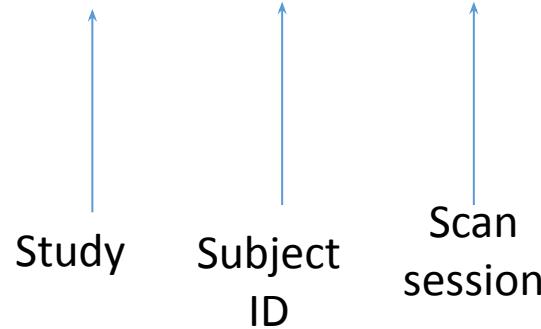
## Functional Quality Assessment

- BOLD alignment to T1- either in the executive summary or outside in the img folder

# How to get to executive summary files from a subject folder...

- Path to executive summary folder

- /processed/EXITO/sub-0001/ses-1234/files/summary\_DCANBOLDPROC\_v4.0.0/executivesummary



Should contain:

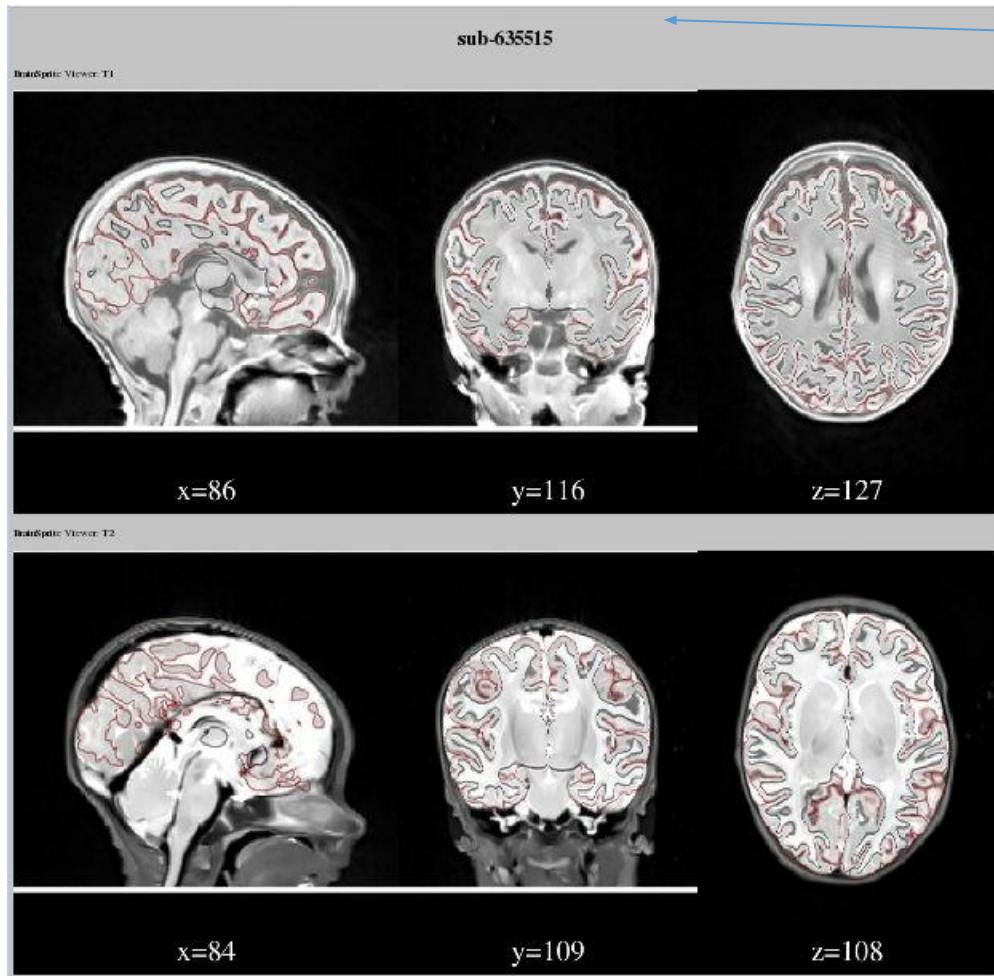
- .html file (open using firefox/ chromium)
- img folder (T1/atlas, T1/functional images)

# Executive Summary Overview

## QC Sheet column: Correct Executive Summary?

- Score as 1- if executive summary contains all the components it should
  - T1 surfaces in brain sprite
  - T2 surfaces in brain sprite
  - Functional data
  - Combined resting states' grayordinates and motion numbers pre- and post-regression
- Score as 0- if something is missing
  - Make note of what is missing in the executive summary comments column

Combined resting states' grayordinates and motion numbers pre- and post-regression



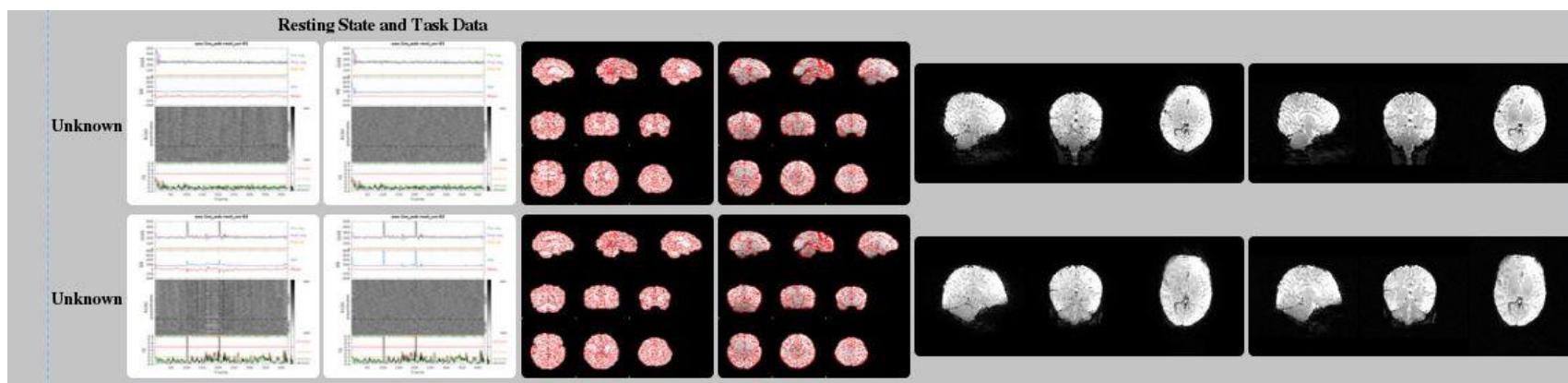
Subject ID

Structural Data

- BrainSprite Viewer
  - T1 & T2 Surfaces

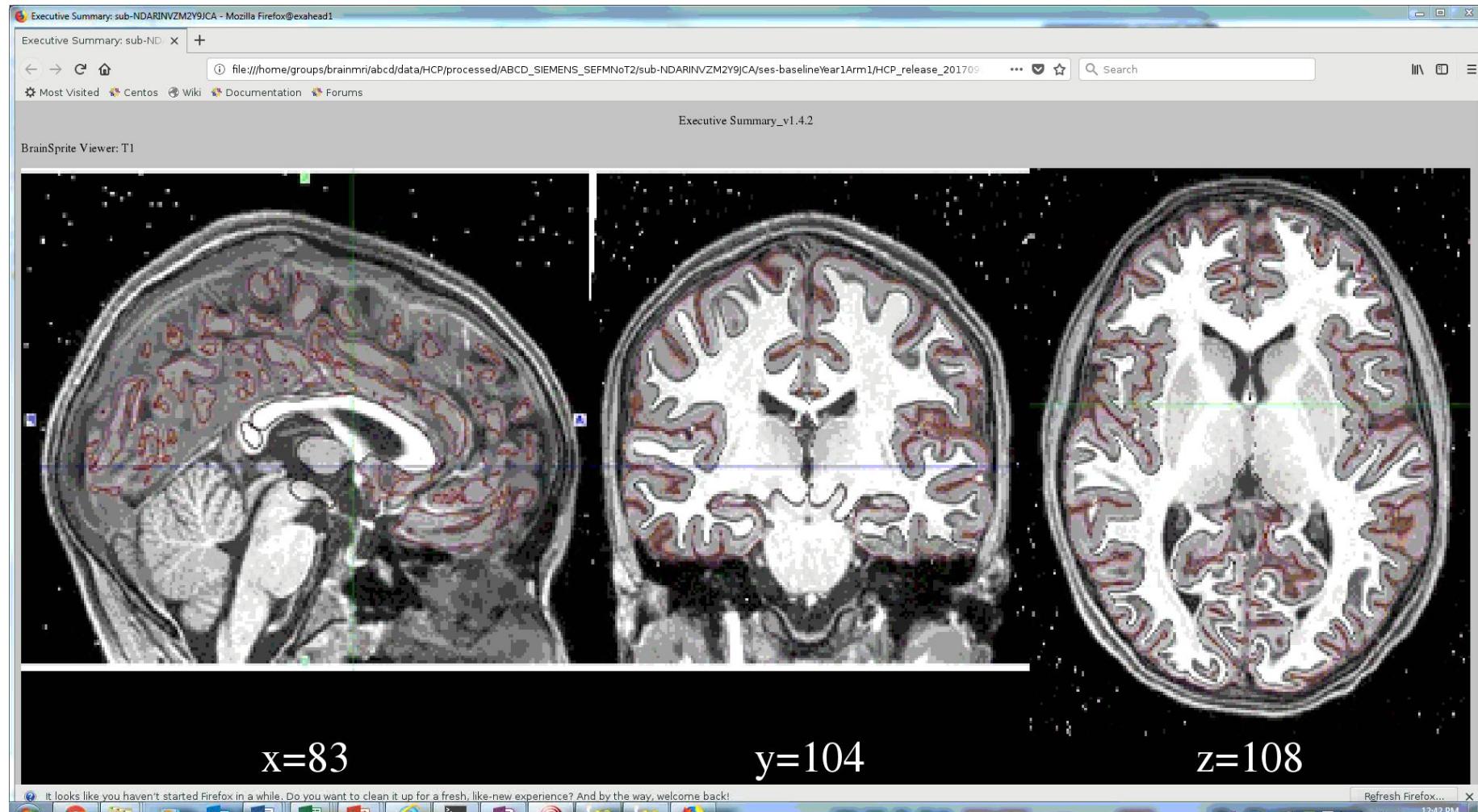
Functional Data

- 2 resting states
  - Rest in T1 image
  - Reference images per scan



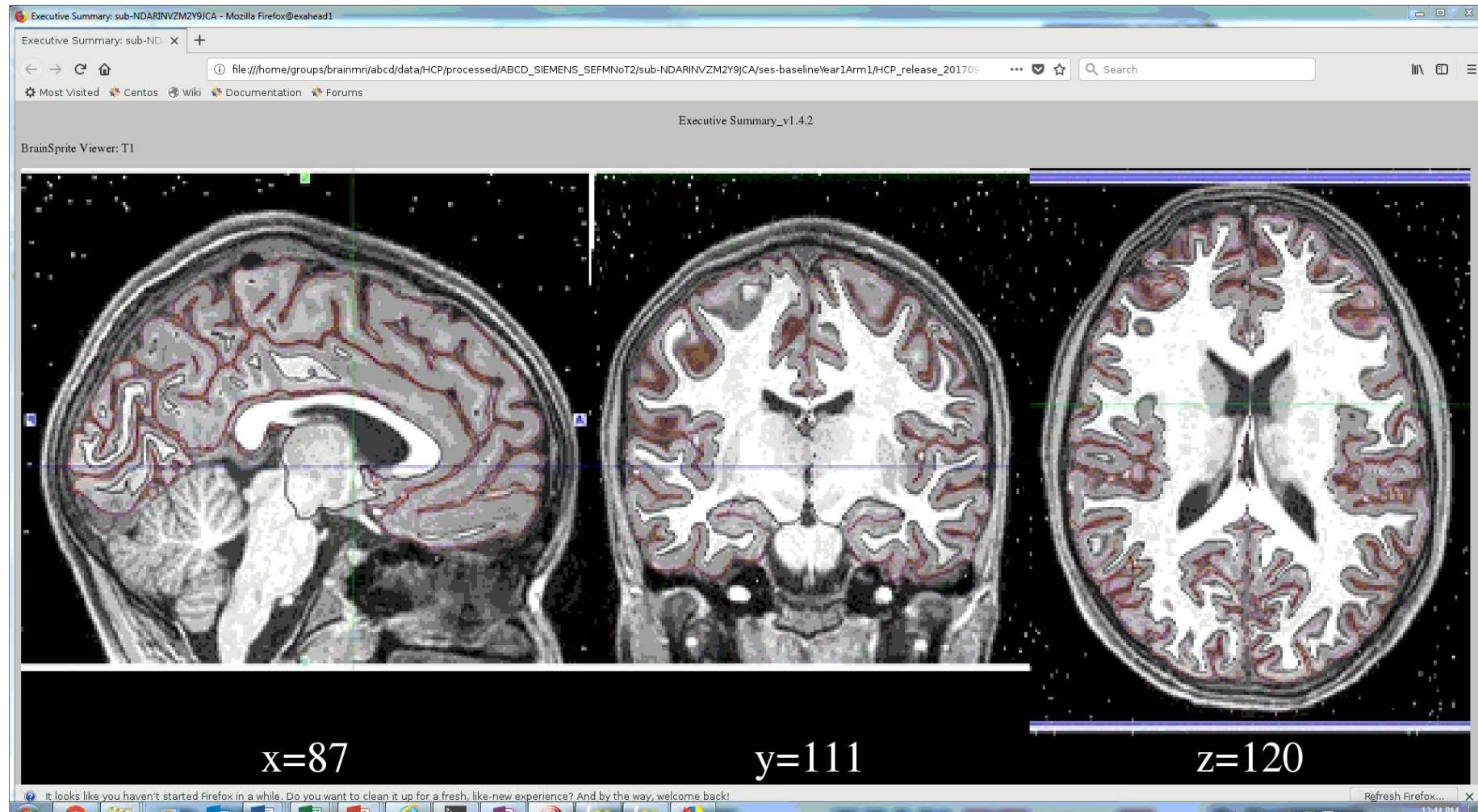
# Executive Summary: Structural Data

Indicates video on slide



To view the **sagittal X plane** move the cursor **left and right** on the **coronal Y plane** or **left and right** on the **axial Z plane**

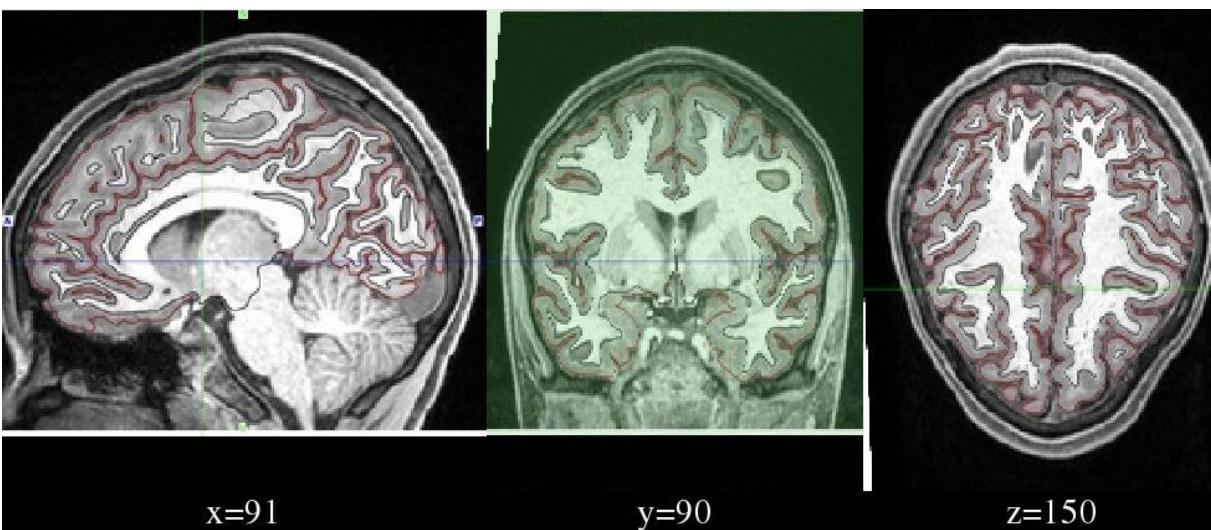
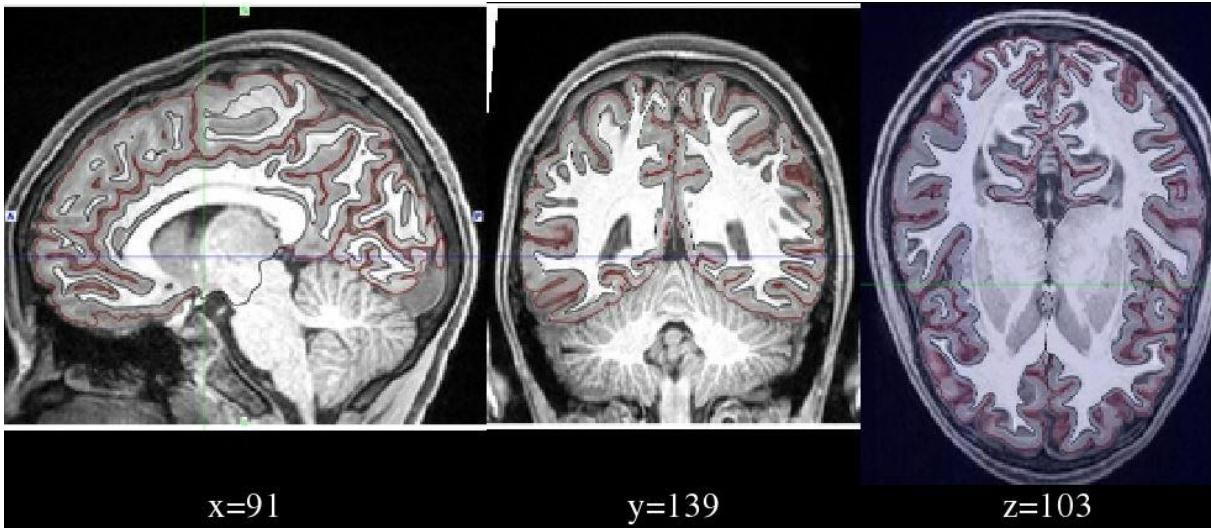
# Executive Summary: Structural Data



To view the **axial Z plane** move the cursor **up and down** on the **sagittal X plane** or **up and down** on the **coronal Y plane**

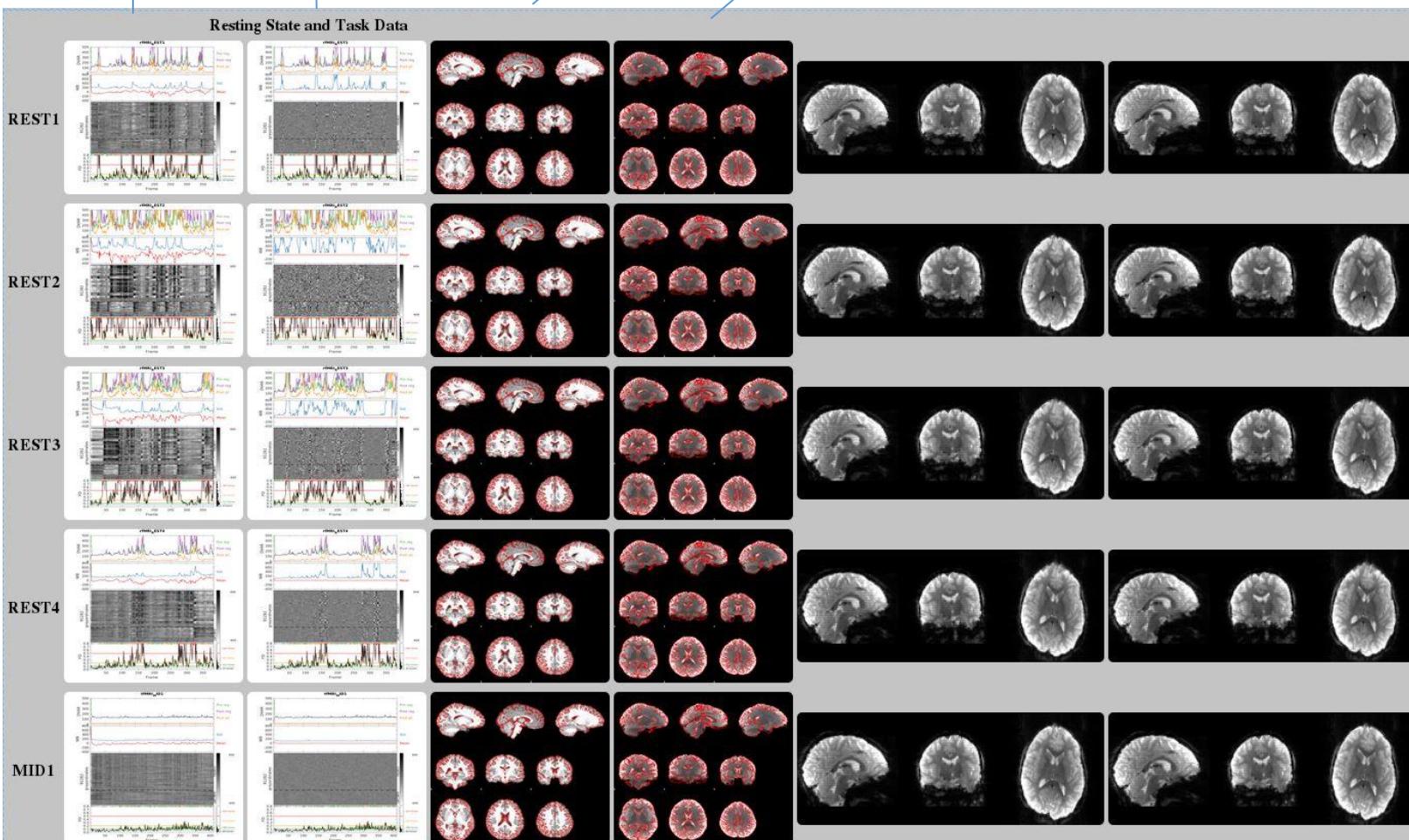
# Executive Summary: Brain Sprite Artifact

- For some subjects there are frames of the T1 that appear green or purple
- This is **not an artifact of the T1** but an unknown error from compiling the frames of the T1 into Brain Sprite
  - This has nothing to do with the quality of the scan and should be ignored during quality assessment



# Executive Summary: Functional Data

- Motion numbers and grayordinates post-regression
- Motion numbers and grayordinates pre-regression



- Functional scan overlaid onto T1
- T1 overlaid onto functional scan

- Reference images
  - SBRef (single band reference image) and 1<sup>st</sup> functional volume
  - Equivalent

# Structural Quality Assessment

# Structural QA

- **Do the surfaces delineate the gray and white matter?**
  - Common errors to look for to answer this question:
    - Blurriness
    - Ringing
    - Sawtooth Jags
    - Surfaces contain skull or dura
  - The presence of these errors does not automatically indicate the images are of poor quality – it is **to what extent these errors disrupt the delineation of the gray and white matter**
    - If errors persists in a particular region but is properly delineated after
      - 1-10 frames: QA = 1
      - >10 frames: QA = 2
    - If errors persists throughout the brain making the matter indistinguishable to delineate or does not capture a particular region
      - QA = 3

# Structural QA Scale

3

low quality

2

medium quality

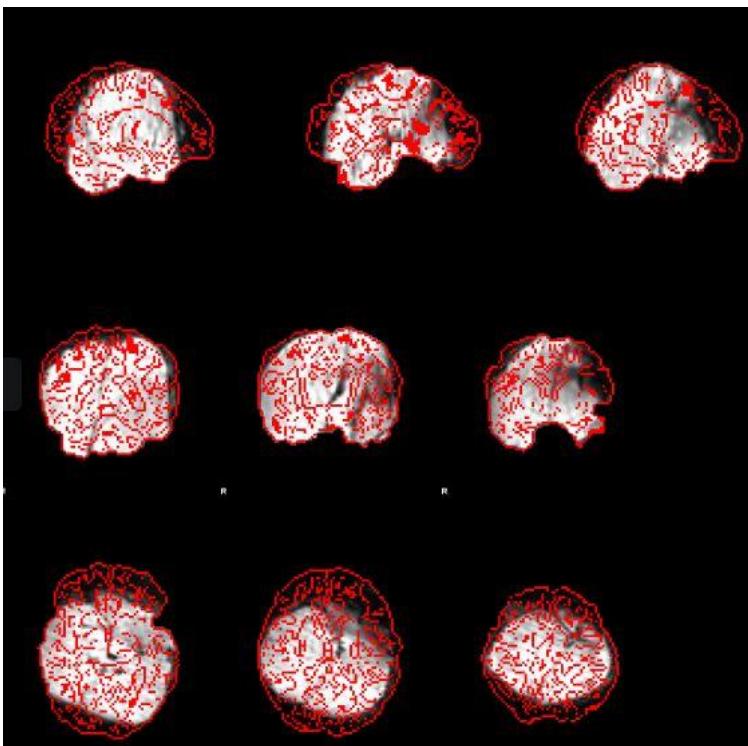
1

high quality

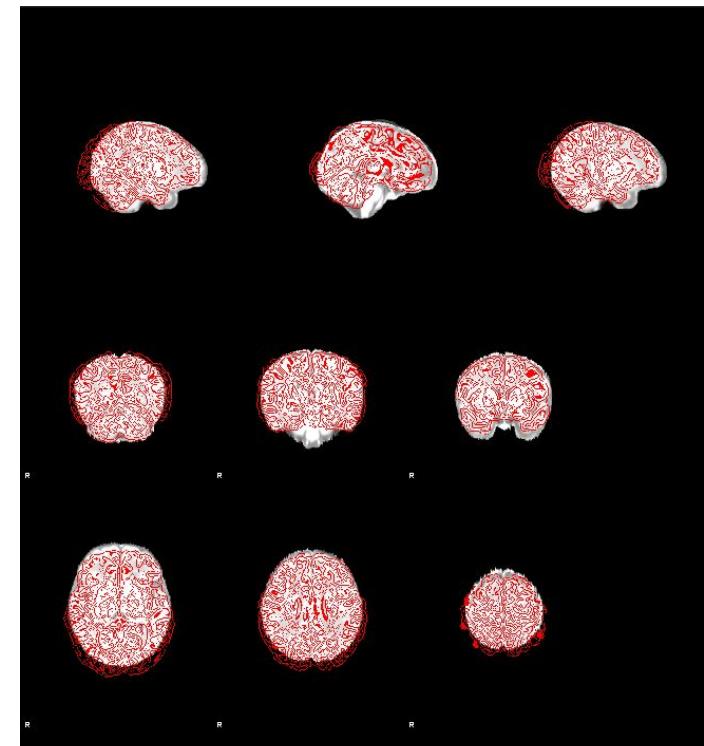
- Indistinguishable gyrus and sulcus
    - Blurriness
    - Ringing
  - GM and WM Surfaces poorly delineated throughout the brain
  - Surfaces overlap throughout brain
  - Surfaces go into the skull
- 
- Can distinguish gyrus and sulcus but doesn't fully delineate white and gray matter
    - Ringing
    - Blurriness
  - Sawtooth jags disrupt surface delineation >10 frames
  - If GM or WM are missing in a particular region they are captured in <10 frames
  - Surfaces overlap across one boundary for >10 frames
  - Surfaces go into dura
- 
- Clear image with distinctive gyrus and sulcus delineated by the surfaces
  - Ringing, sawtooth jags, and blurriness may be present but do not disrupt surface delineation
  - Captures matter in particular region in 1-10 frames

# Structural QA: Atlas registration

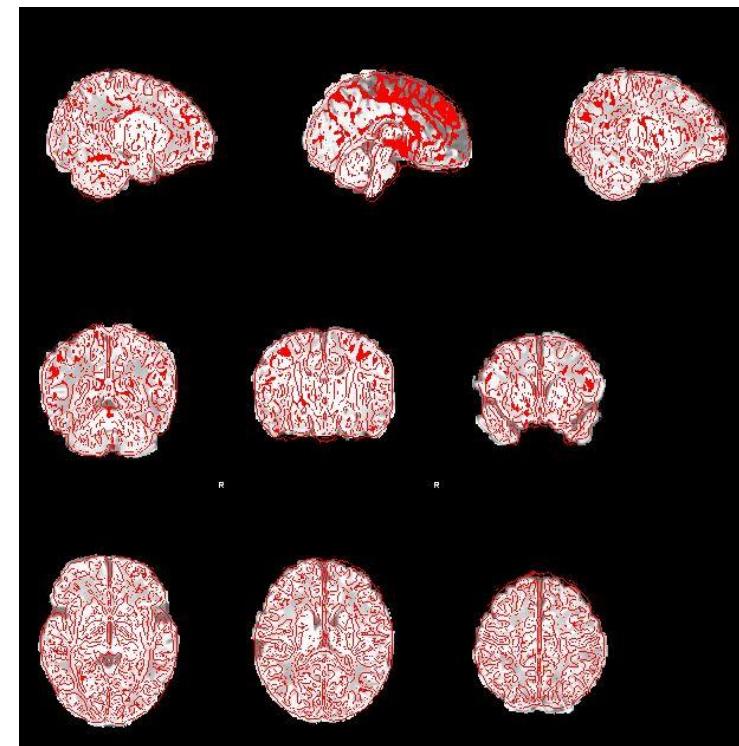
- In the executive summary folder there will be 2 images to quality assess in the img folder
  - These images are the T1 and atlas overlaid onto each other
    - Whichever image precedes the word “in” will be overlaid in red onto the other image
    - i.e. atlas in t1 contains the atlas overlaid in red over the subject’s T1
  - How well the T1 aligns with the atlas will signify the quality of atlas registration after processing
    - It is also useful in identifying any T1 distortions that will affect the structural and functional quality
    - Look at how well the T1 aligns with the inner boundary of the atlas



**3** Brain is upside down therefore it is impossible to register to atlas.



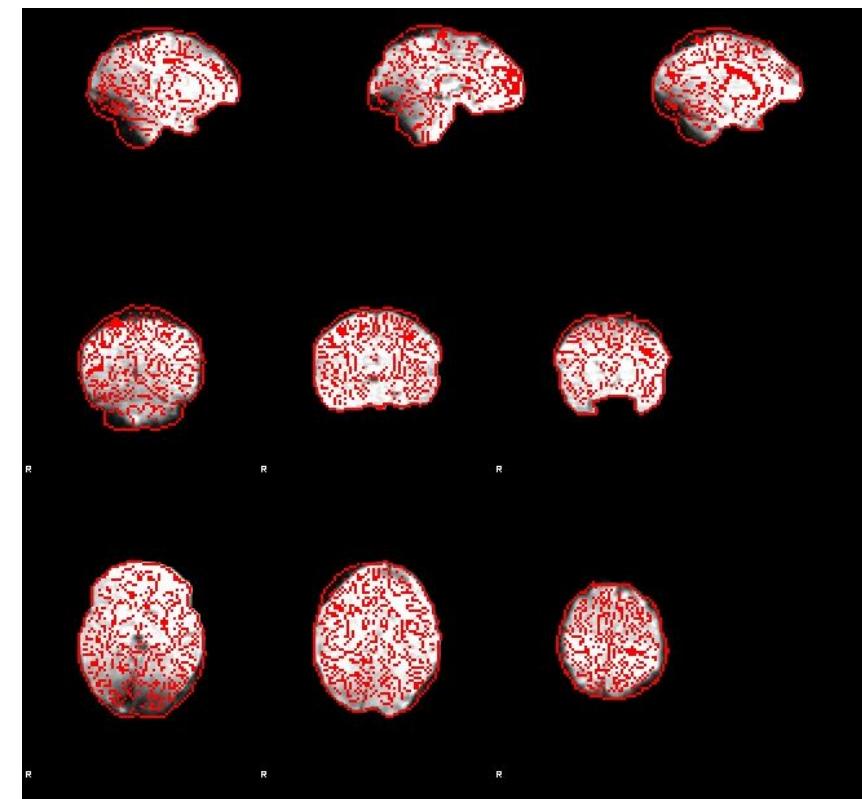
**2** Some regions slightly go outside and/or don't reach the boundaries of the atlas, which slightly disrupts the shape of the T1



**1** The alignment is accurate

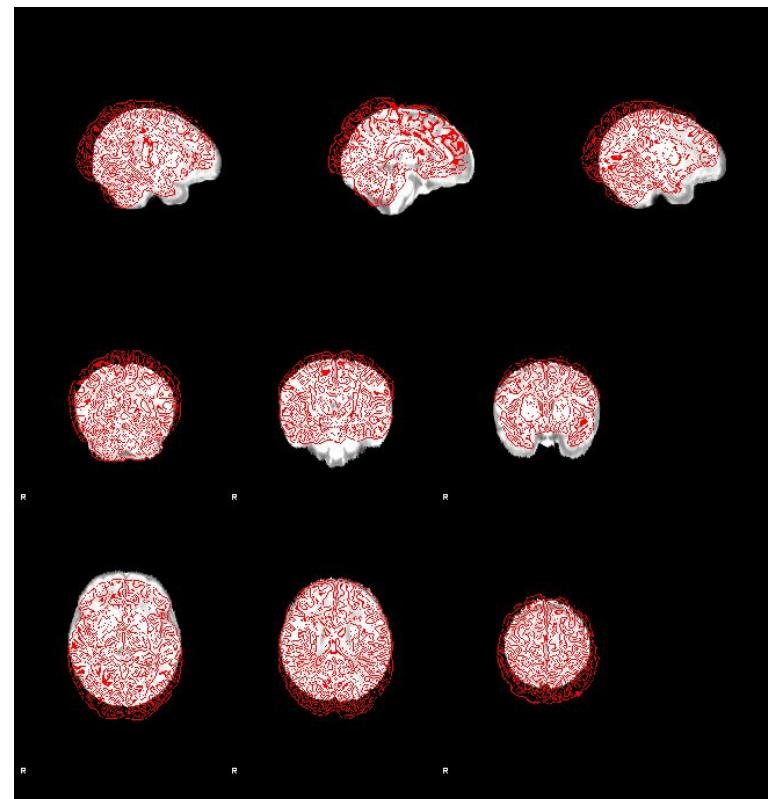
# Structural QA: Atlas registration

- The quality of the atlas registration depends on how well the T1 aligns to the boundaries of the atlas
  - The best way to evaluate the registration is by going back and forth between the 2 overlaid images



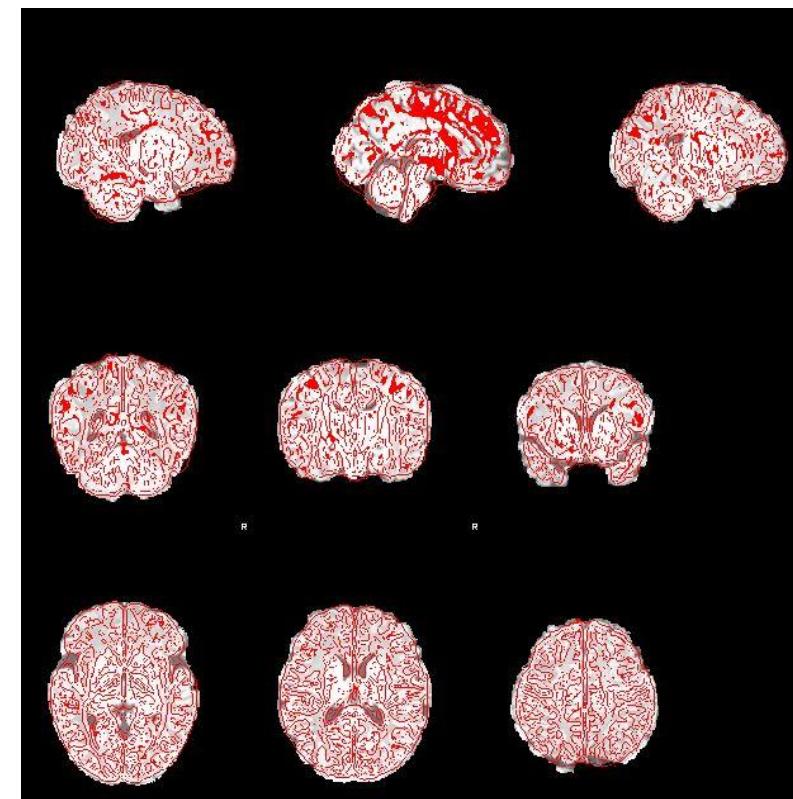
3

Poorly registers to the atlas throughout the brain, making the entire T1 appear warped



2

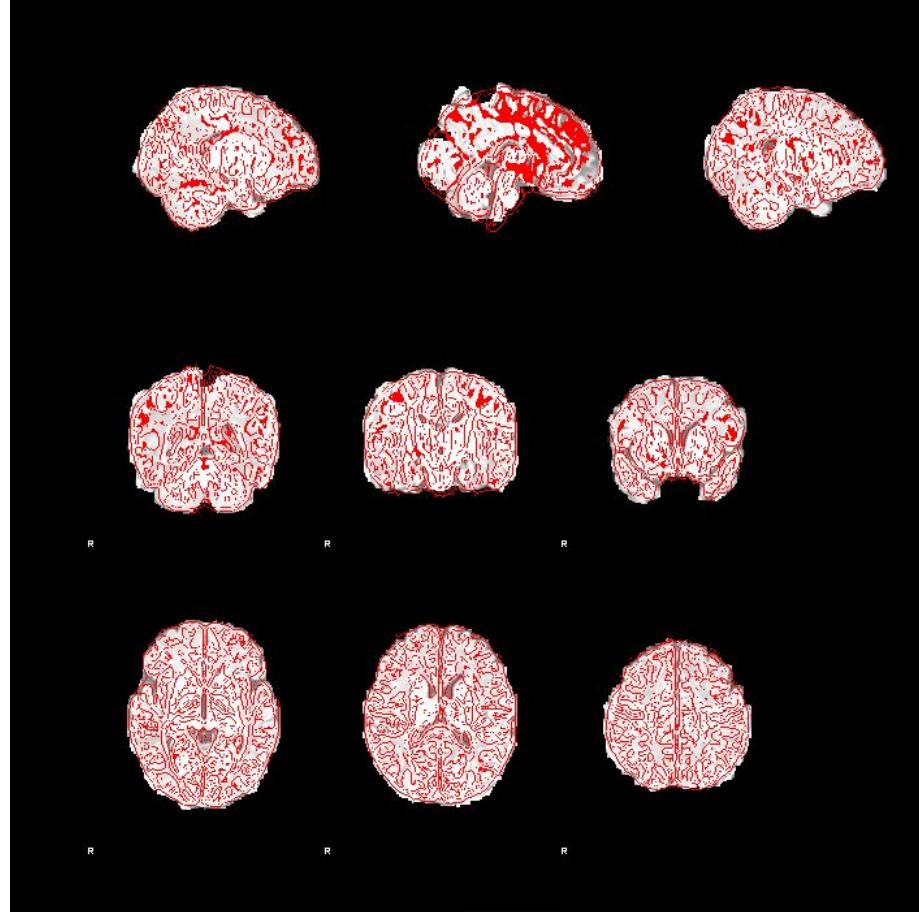
Some regions slightly go outside and/or don't reach the boundaries of the atlas, which slightly disrupts the shape of the T1



1

Some regions minimally go outside and/or inside the boundaries of the atlas, but the T1 maintains the overall shape of the atlas and is correctly aligned.

# Structural QA: Atlas registration Example



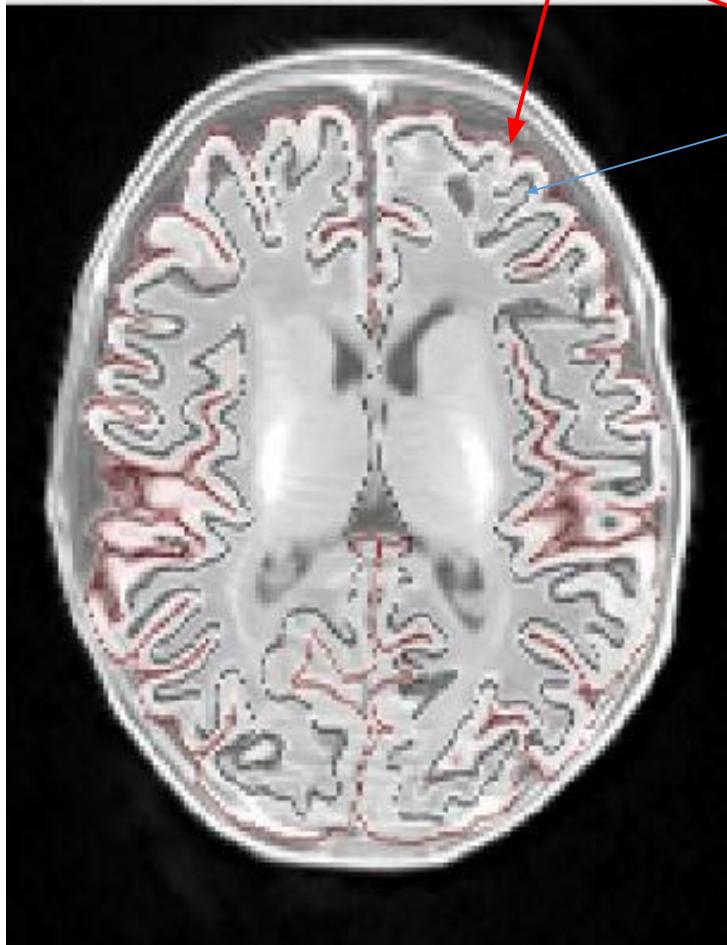
Atlas\_in\_t1.gif

2 - T1 looks like it is missing a giant chuck out of the superior parietal lobe

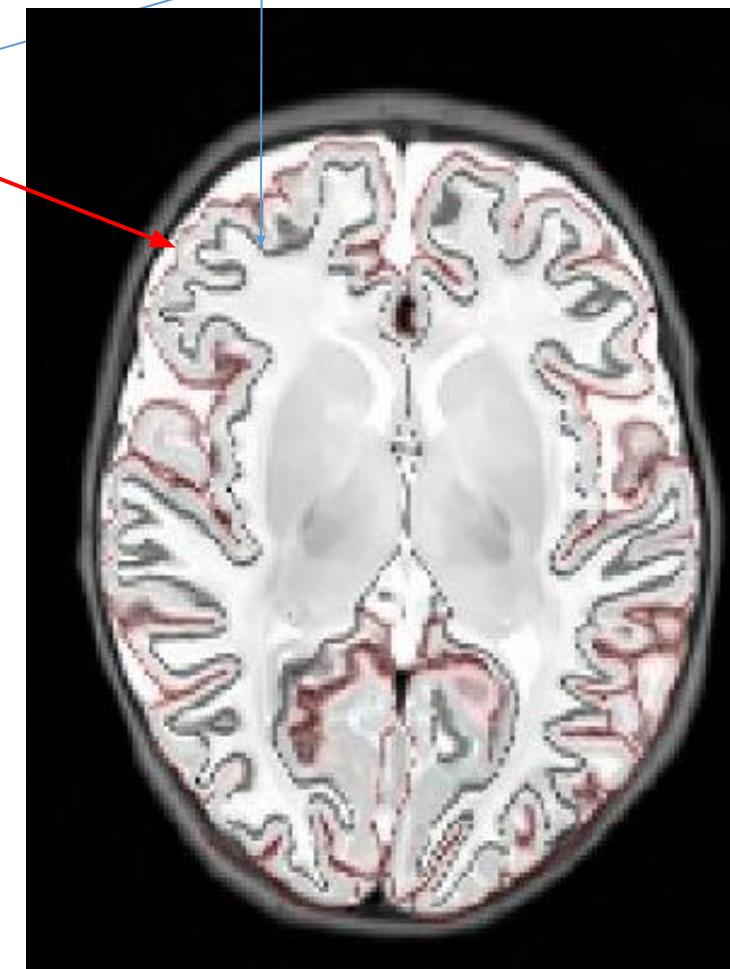
# Structural QA: General guidelines

- In the Executive Summary Folder, open executive summary .html file and go through each of the planes to view the segmented T1 and T2
- The most important question of structural quality assessment is: **Do the surfaces delineate the gray and white matter?**
  - Gray matter is delineated by **red lines** and white matter is delineated by **black lines**.

T1 Surfaces

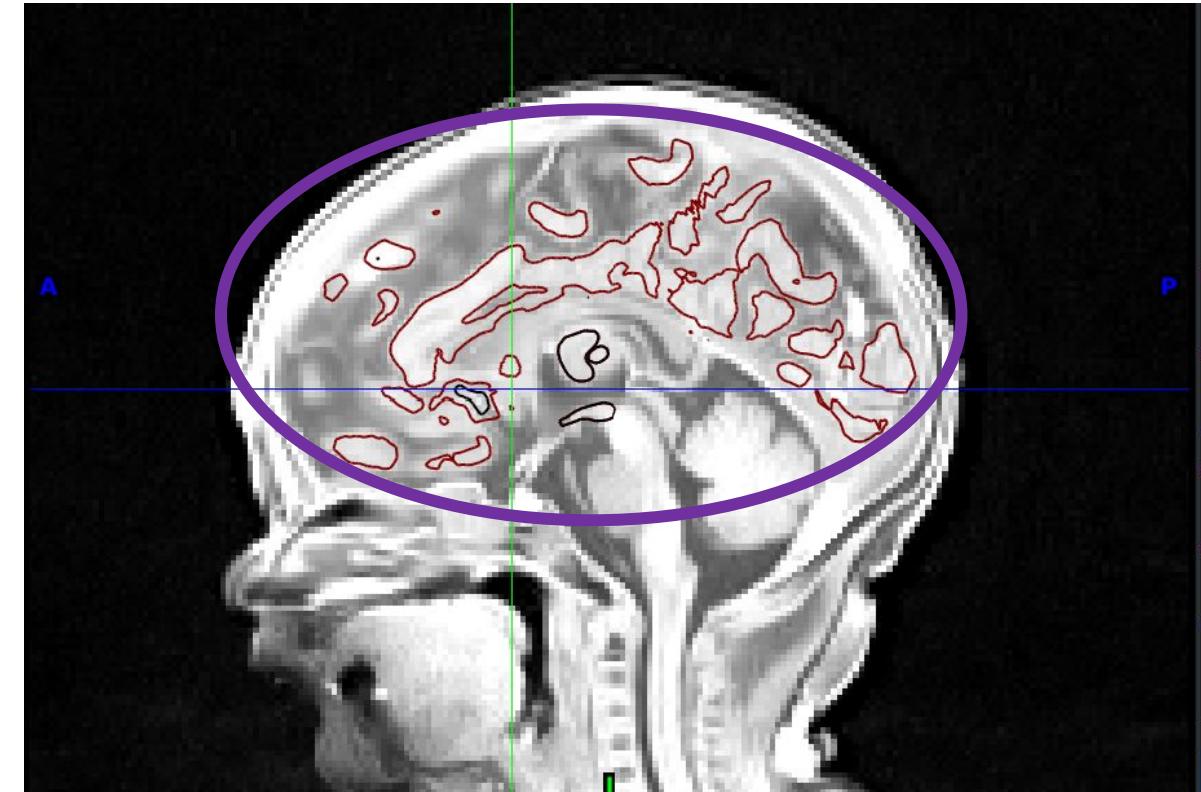
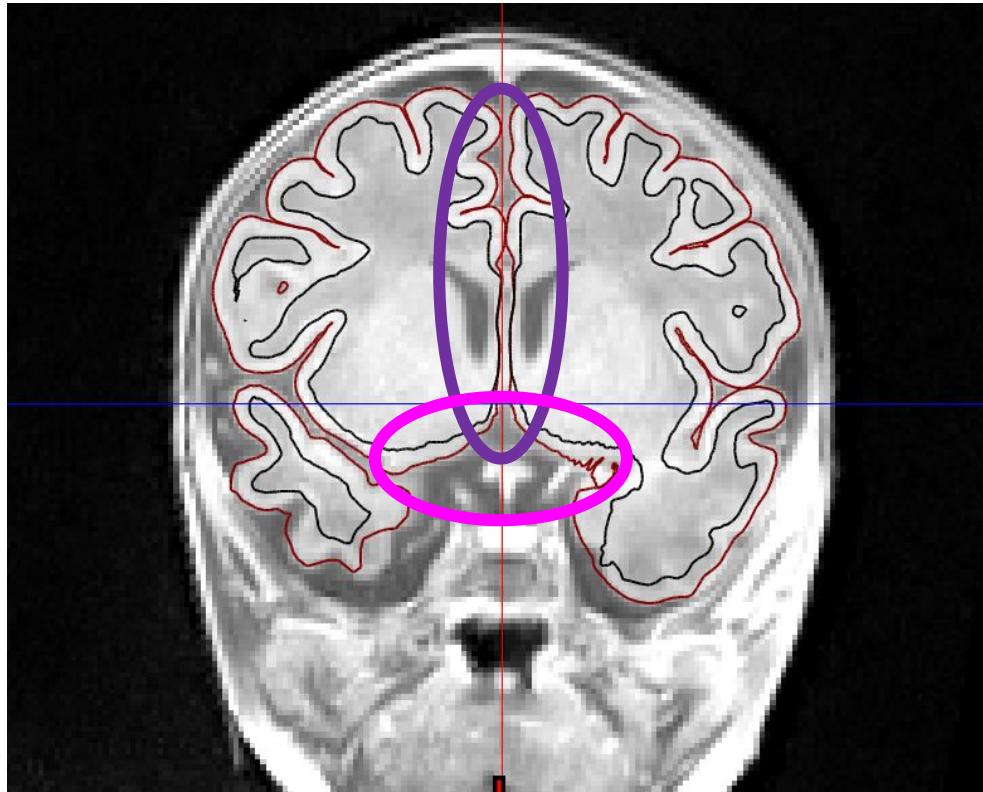


T2 Surfaces



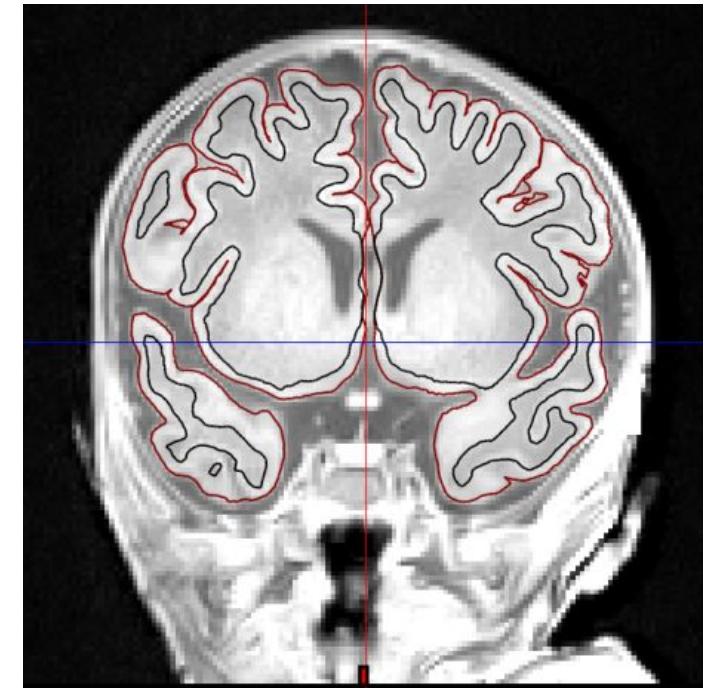
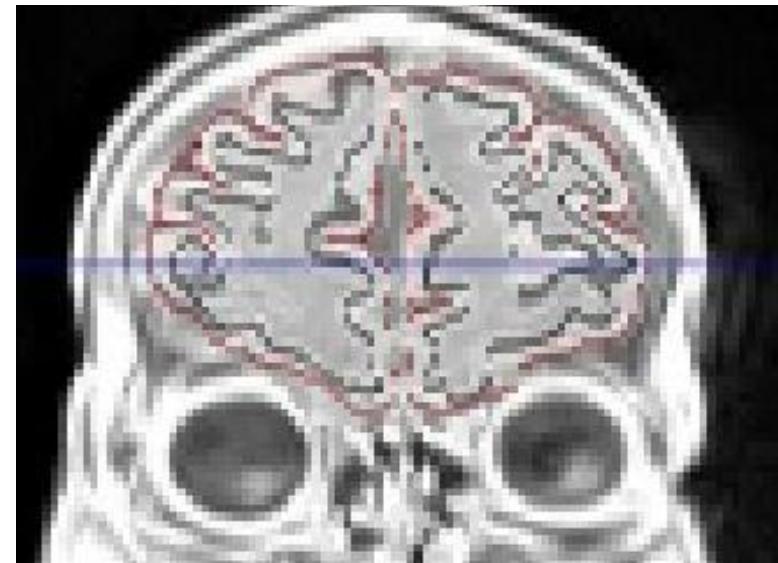
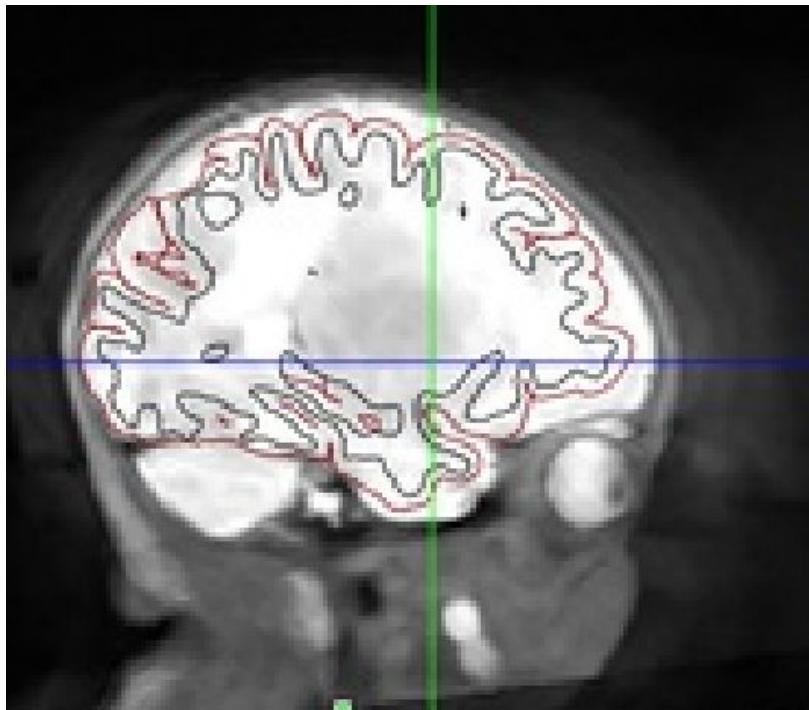
# Structural QA: Regions to disregard

- When assessing the delineation of white and gray matter ignore:
  - **Subcortical regions** like the one highlighted between the temporal lobes in the coronal view
    - The HCP pipeline specifies subcortical regions through a separate process from cortical regions and quality assessment is only concerned with the delineation of white and gray matter in cortical regions
  - **Midline** in the axial view and coronal view



# Structural QA: Blurriness

- **Blurriness** is the result of **small movements** in the scanner, or can result from **partial volumes** (i.e. one voxel captures multiple tissue types leading to blurriness in the data)



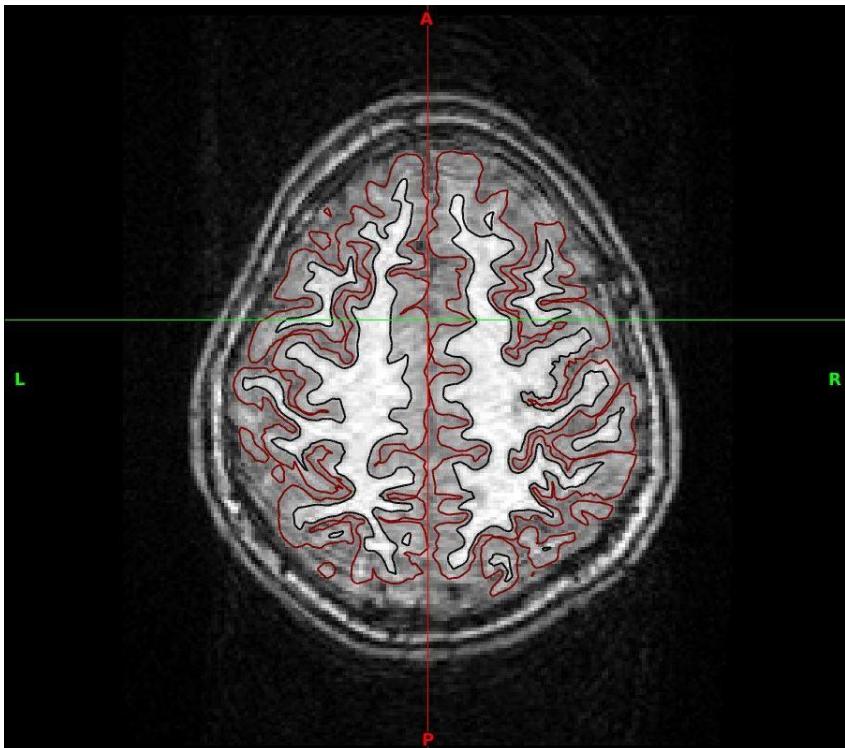
**3** Blurriness makes it difficult to distinguish and delineate gyrus and sulcus throughout the brain

**2** Blurry image but can distinguish gyrus and sulcus that are captured by the segmentations – **need to see if persists throughout frames**

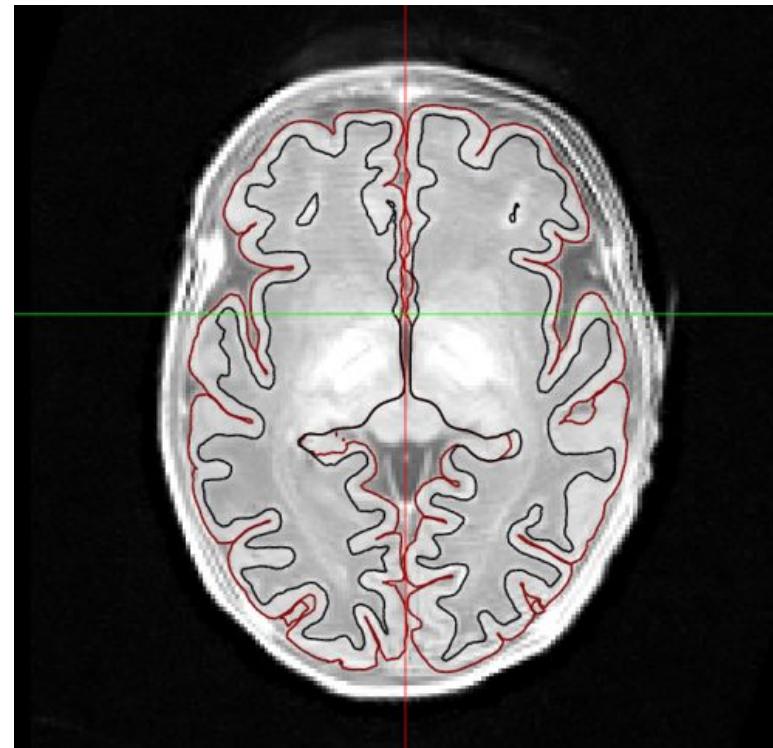
**1** Slightly blurry image with distinctive gyrus and sulcus captured by the segmentations

# Structural QA: Ringing

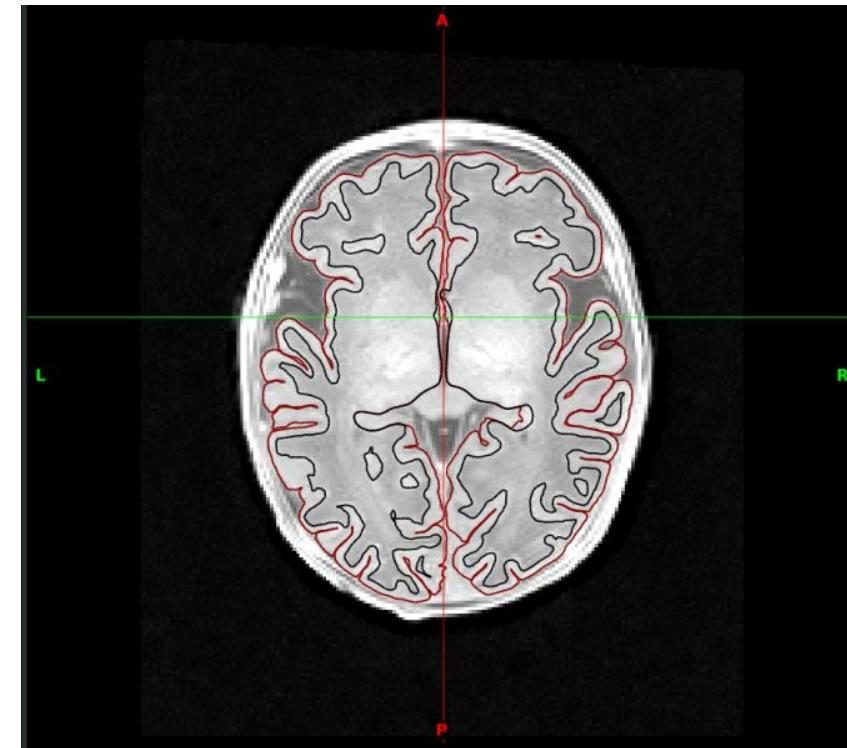
- **Ringing (striations/ stripy-ness)** results from systematic motion by the subject and can be problematic because it can disrupt the ability to delineate surfaces because the segmentation will follow the ringing artifact



**3** Ringing makes gyrus and sulcus indistinguishable



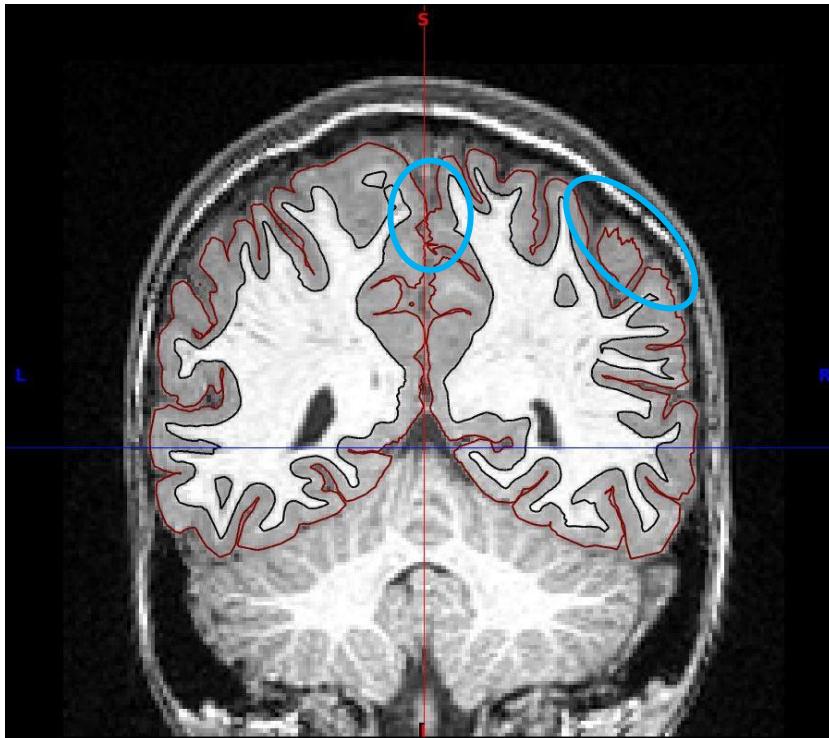
**2** Ringing is present, but can distinguish gyrus and sulcus that are mostly captured by the segmentations but misses a few sections – **need to see if this persists throughout frames**



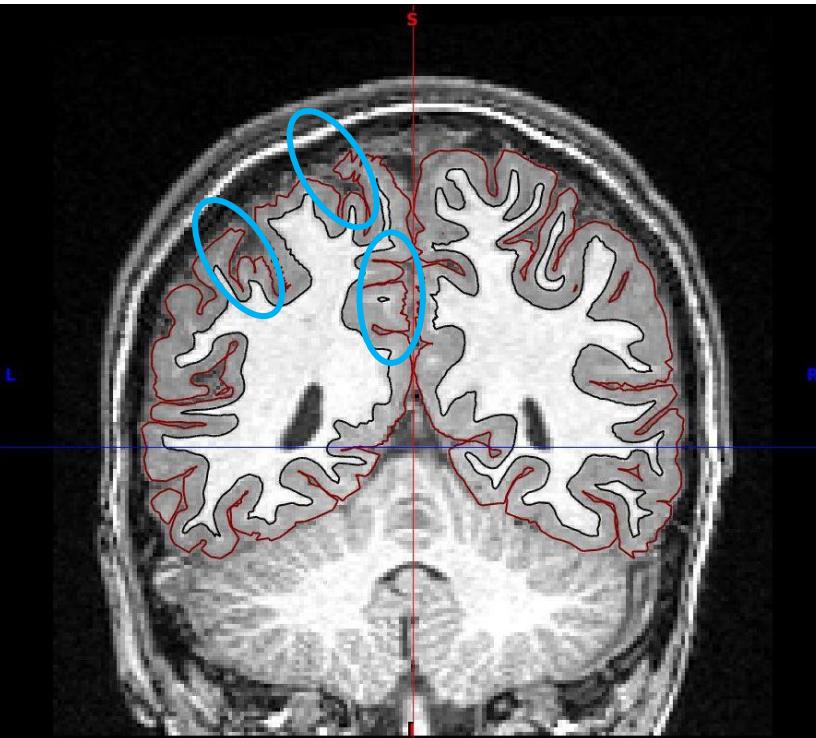
**1** Ringing is present, but does not disrupt the delineation of white and gray matter

# Structural QA: Sawtooth Jags

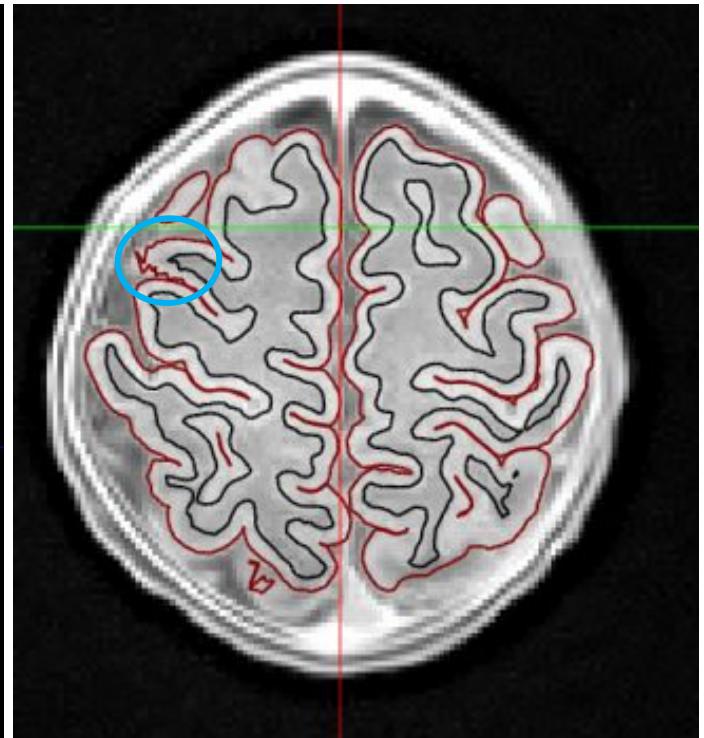
- **Sawtooth Jags** are artifacts that indicate motion, but their presence in one frame will **not** automatically demonstrate low image quality, but signals that the **subsequent frames need to be observed** to see if the sawtooth jag dissipates. They are less common in infants than adolescents.



Sawtooth jags slightly disrupts the surfaces from delineating the edge of gray matter

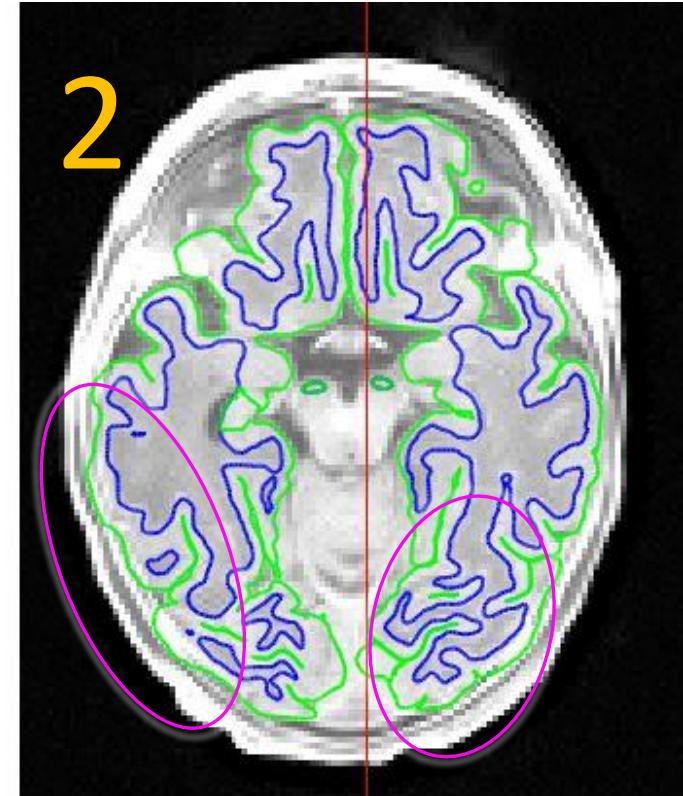


Multiple sawtooth jags indicates that the artifacts may persist in subsequent frames and disrupt the delineation of the surfaces

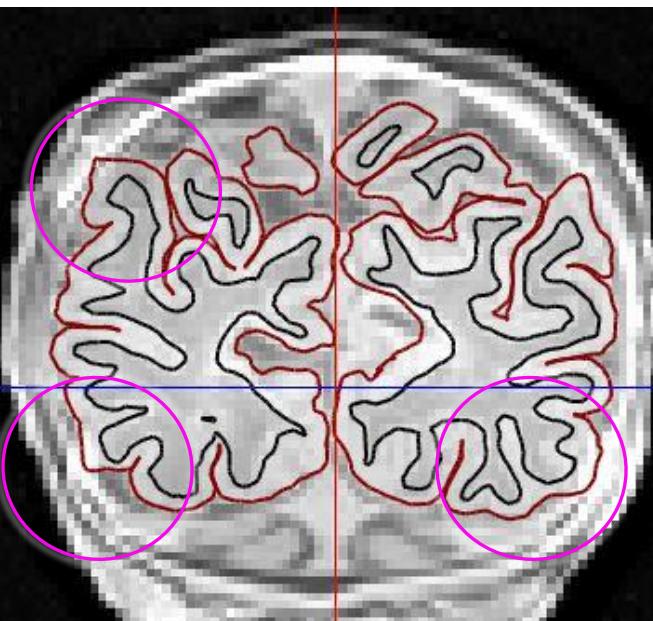


Small sawtooth jags that still appear to follow the gyrus and sulcus are acceptable

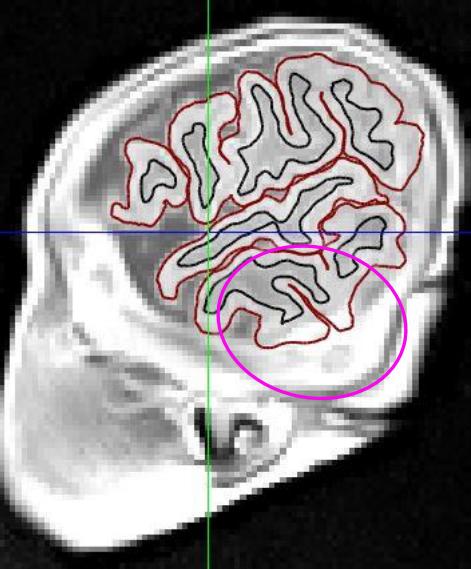
# Structural QA: Surfaces contain non-brain tissue (dura/skull)



2



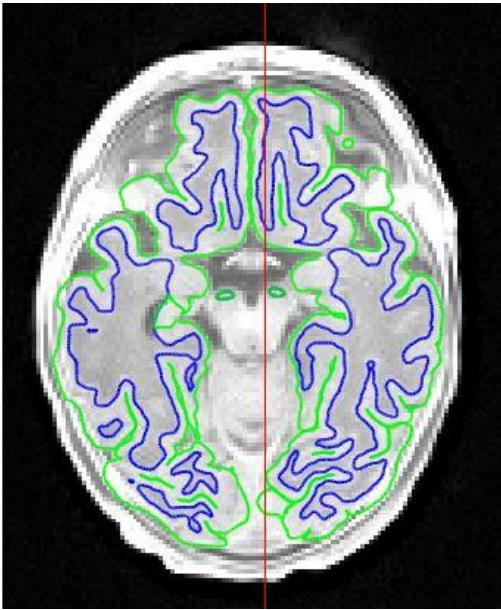
1



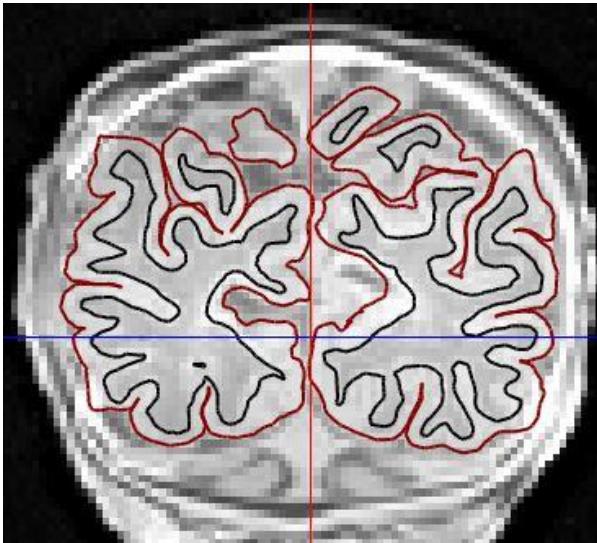
- Sometimes surfaces will capture non-brain tissue (dura mater/ skull)
- When this happens the QA score is based on to what extent the non-brain tissue disrupts the delineation of the grey and white matter
- **When the surface goes into non-brain tissue throughout brain, but surfaces are otherwise well delineated QA: 2**
- If the non brain tissue disrupts surface delineation QA: 3

# Structural QA: Non-brain tissue Examples

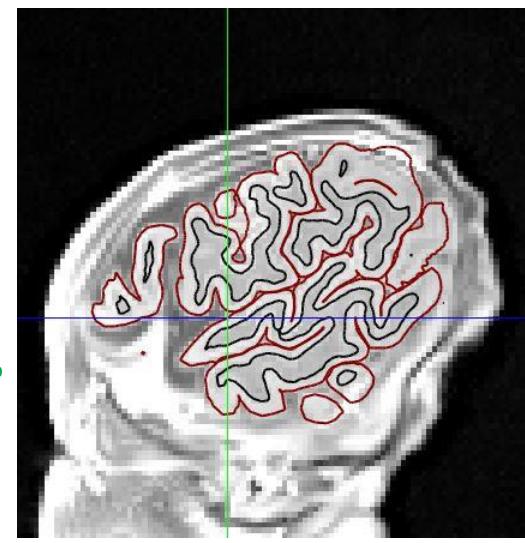
1



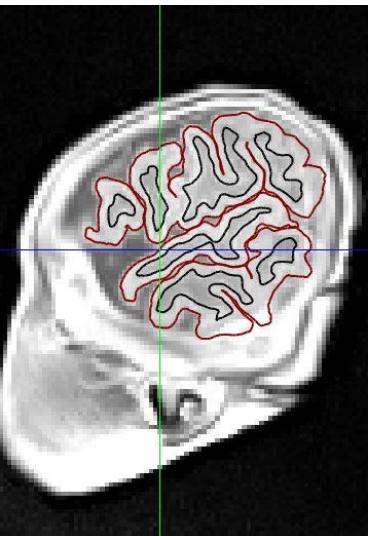
1



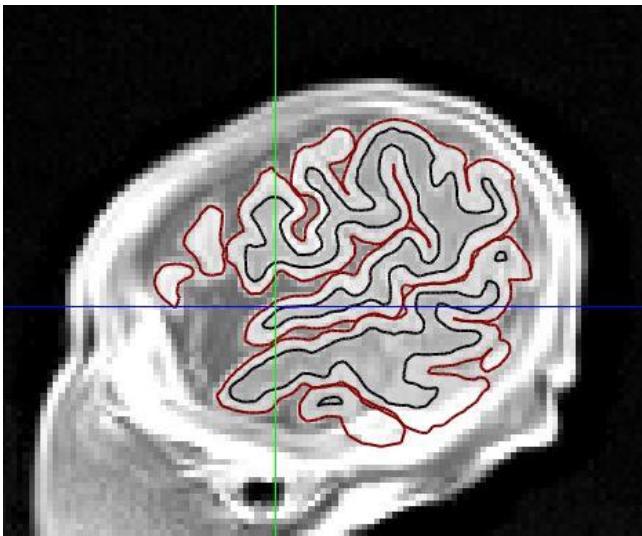
1



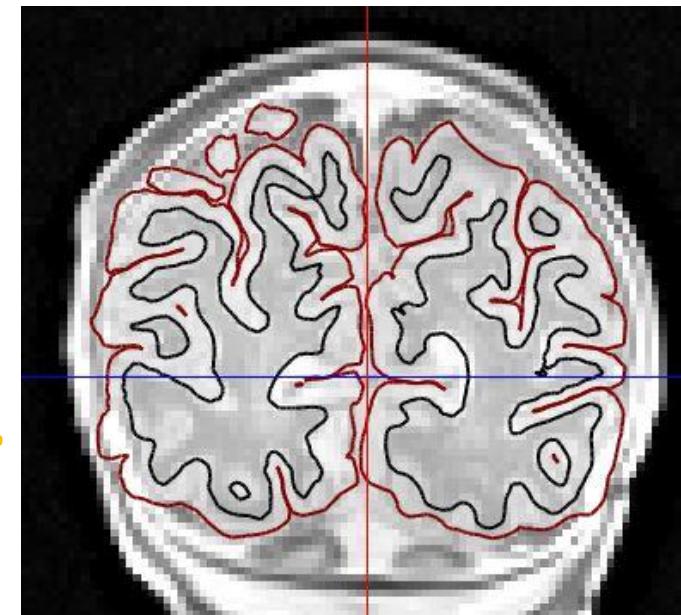
1



2



2



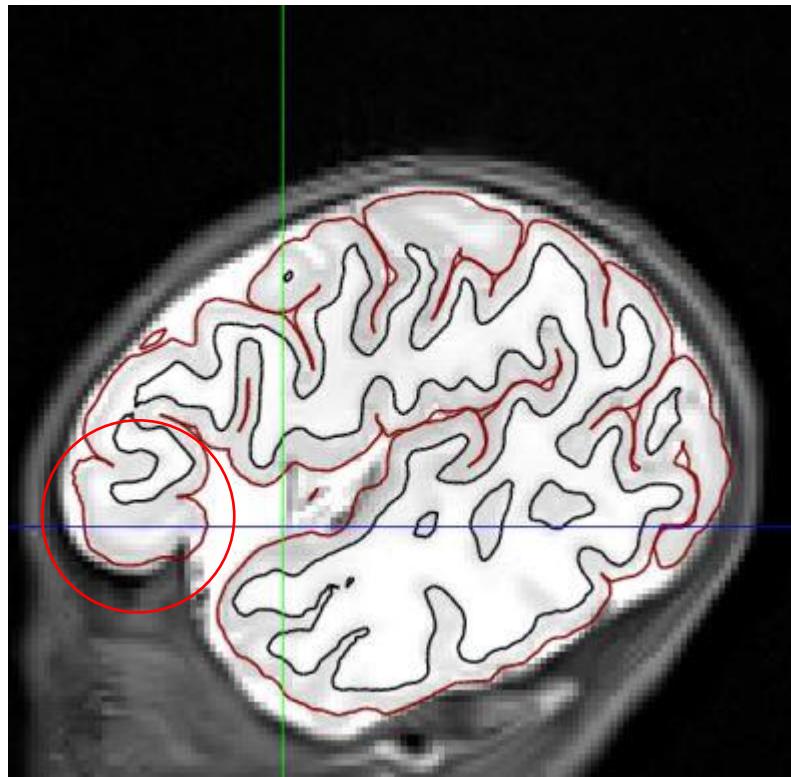
# Structural QA: Boundary issues – Overlapping surfaces



- Overlap occurs when the **white matter** and **gray matter** surfaces cross over one another
- If this error is corrected in
  - 1-10 frames QC: **2**
  - > 10 frames, throughout the brain, or crosses more than one boundary QC: **3**

# Structural QA: Examples

- Does the segmentation delineate the gray and white matter?



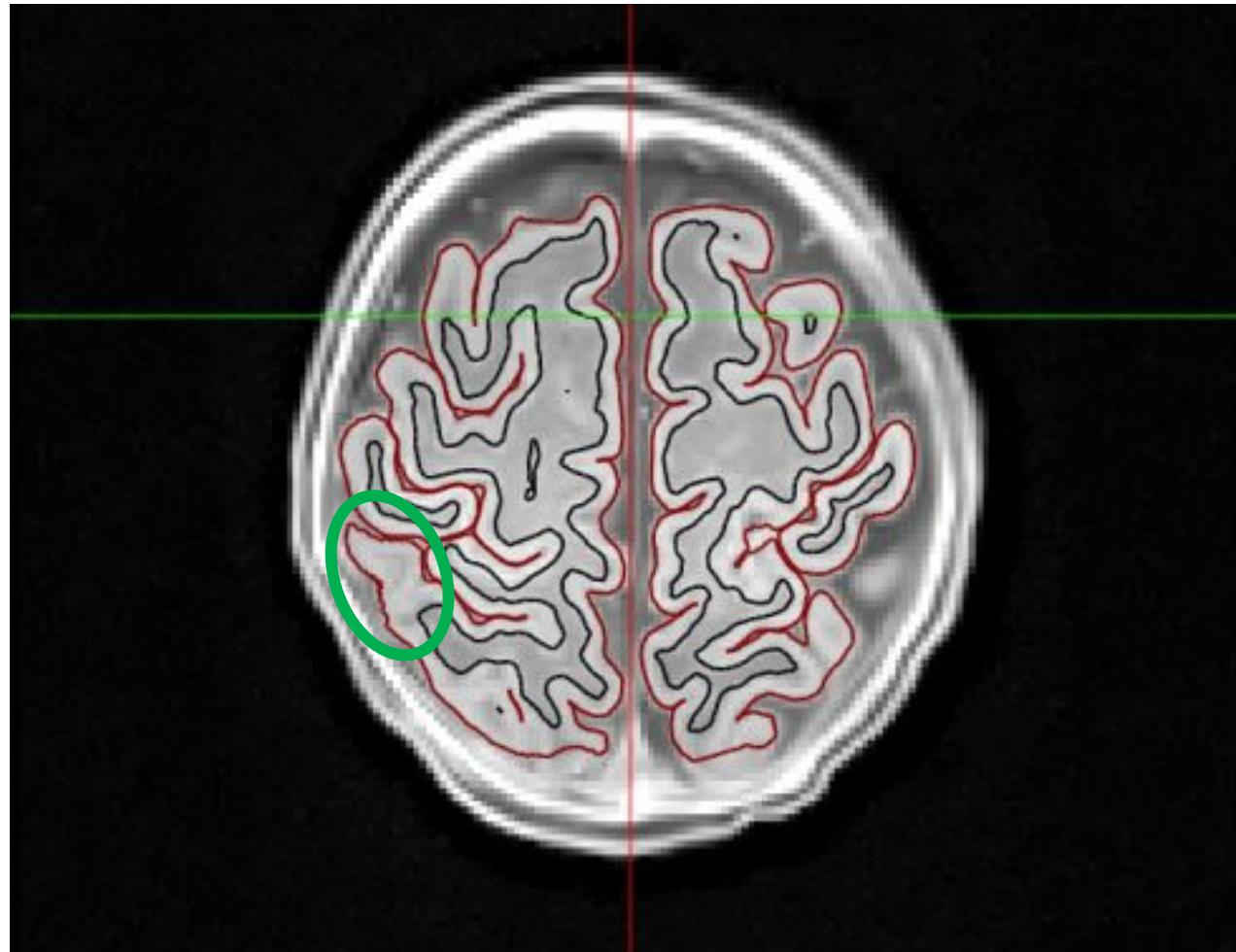
NO

- A. Poorly delineates gray matter
- B. Present in portion of the brain (< 10 slices)

QA: 2

# Structural QA: Examples

- Does the segmentation delineate the gray and white matter?

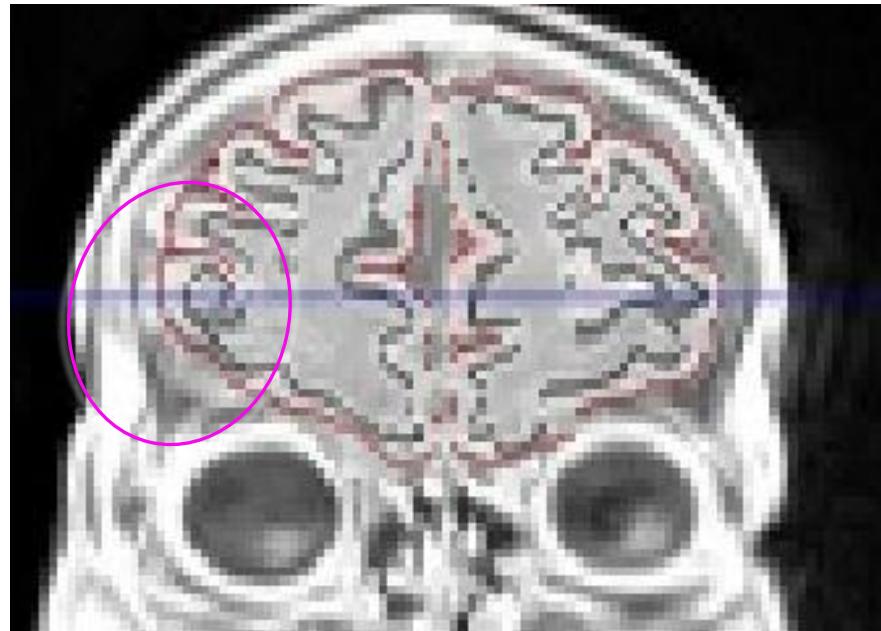


YES

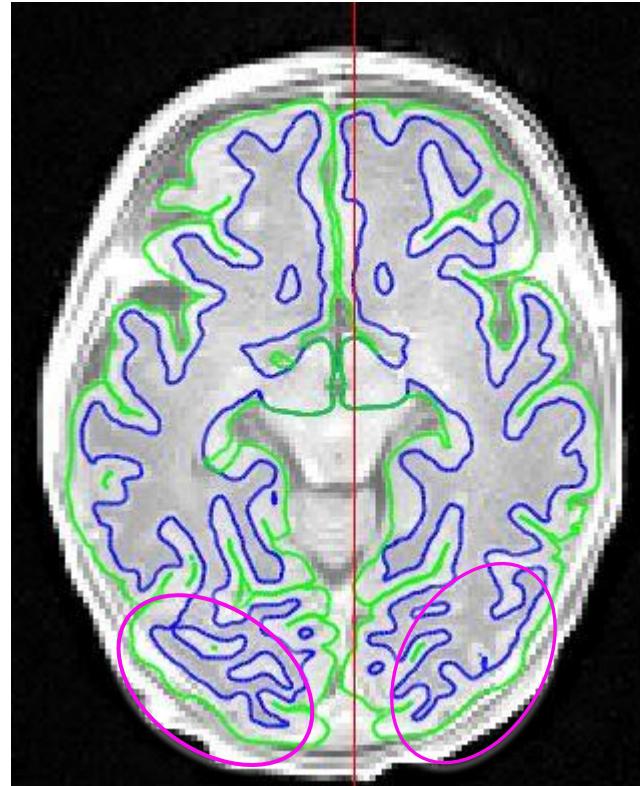
- A. Clear delineation of gray and white matter
- B. Some areas of gray matter missed
  - Look at neighboring slices to confirm that it captures the gray matter in <10 frames

QA: 1

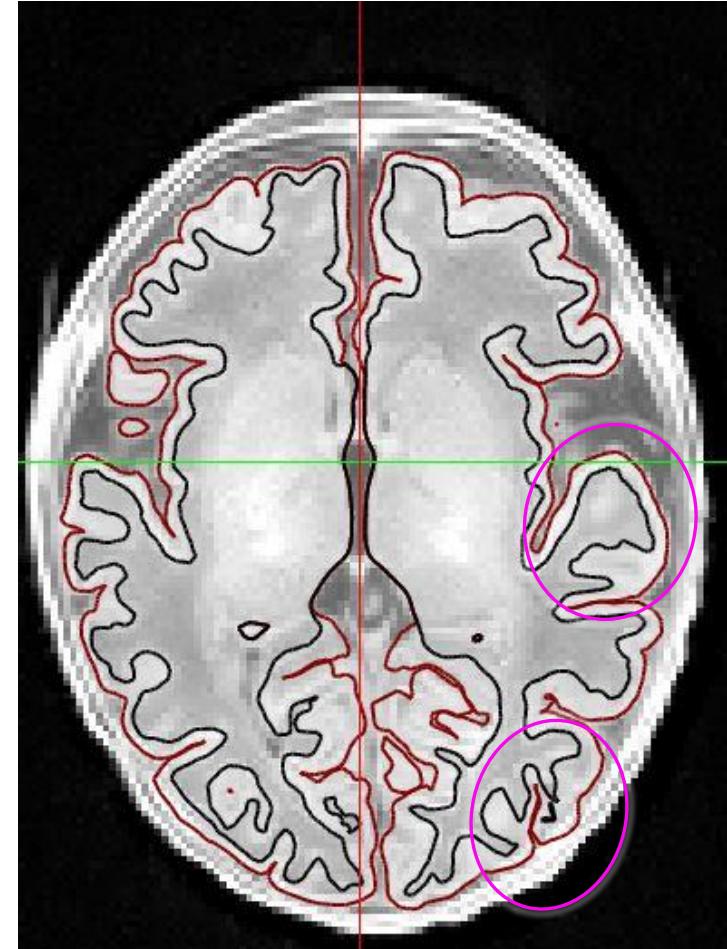
# Structural QA: Examples



2 Surfaces are not capturing a small amount of grey matter- this error does not persist throughout the brain



1 Surfaces capture a small amount of non-brain tissue , but WM and GM are otherwise well delineated



2 Surfaces capture a small amount of non-brain tissue and some WM is missing , but WM and GM are otherwise well delineated

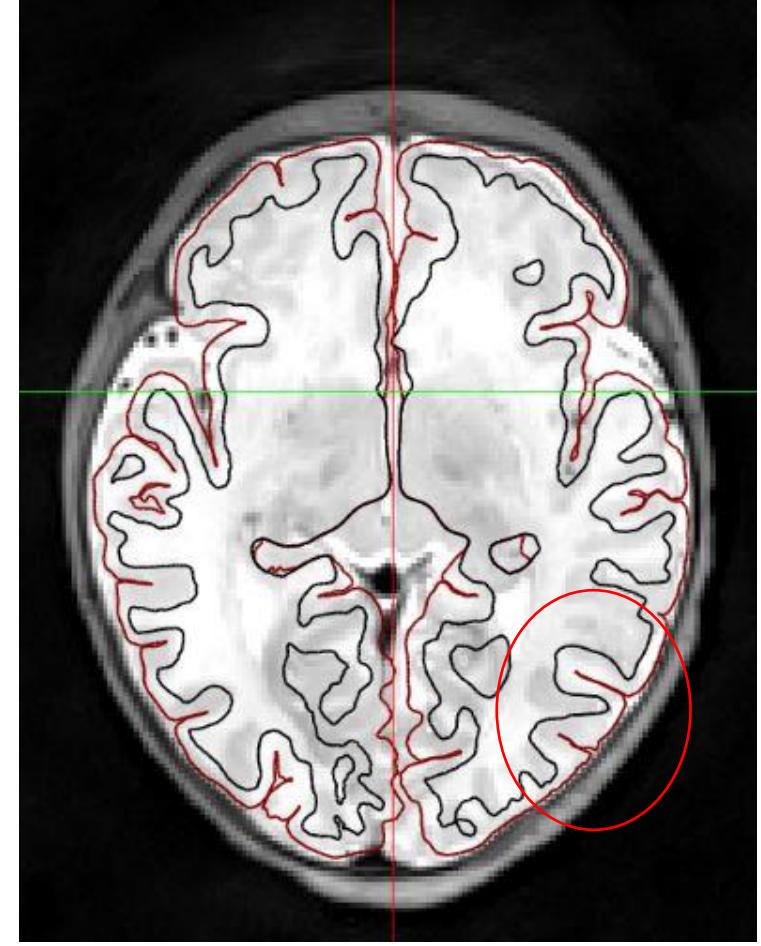
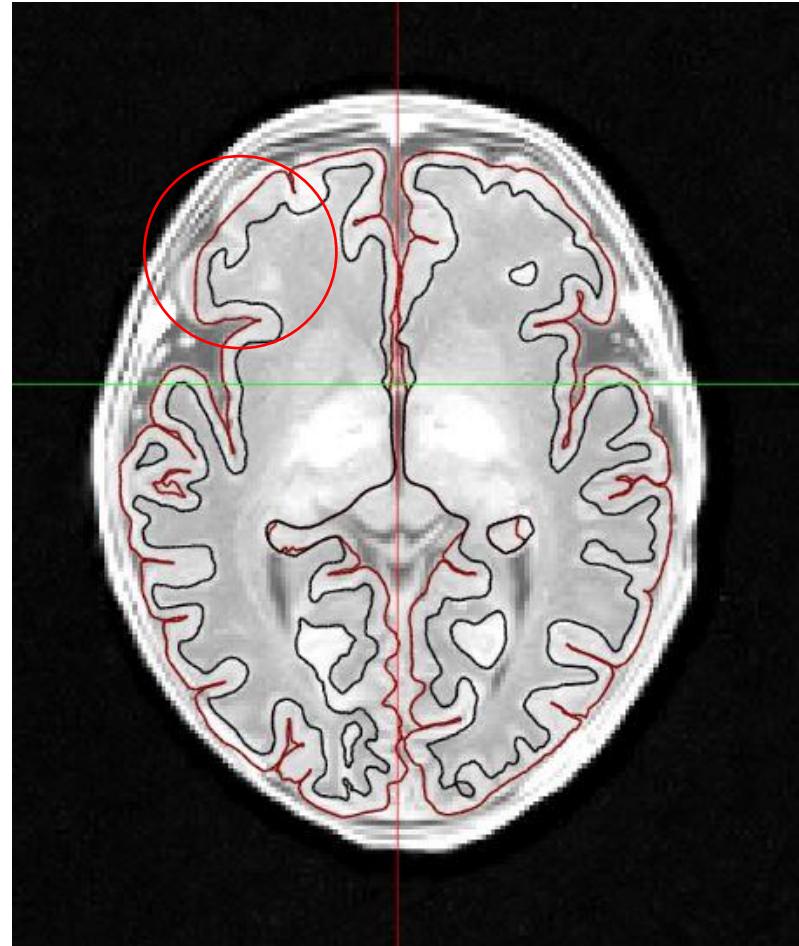
# Structural QA: Examples

- Does the segmentation delineate the gray and white matter?

NO

- A. Poor delineation of gray and white matter throughout the brain

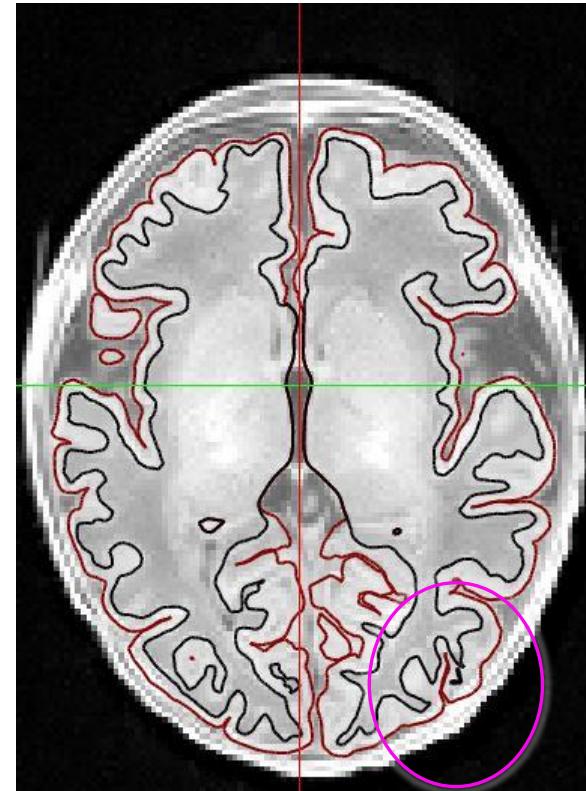
QA: 3



# Structural QA: Examples

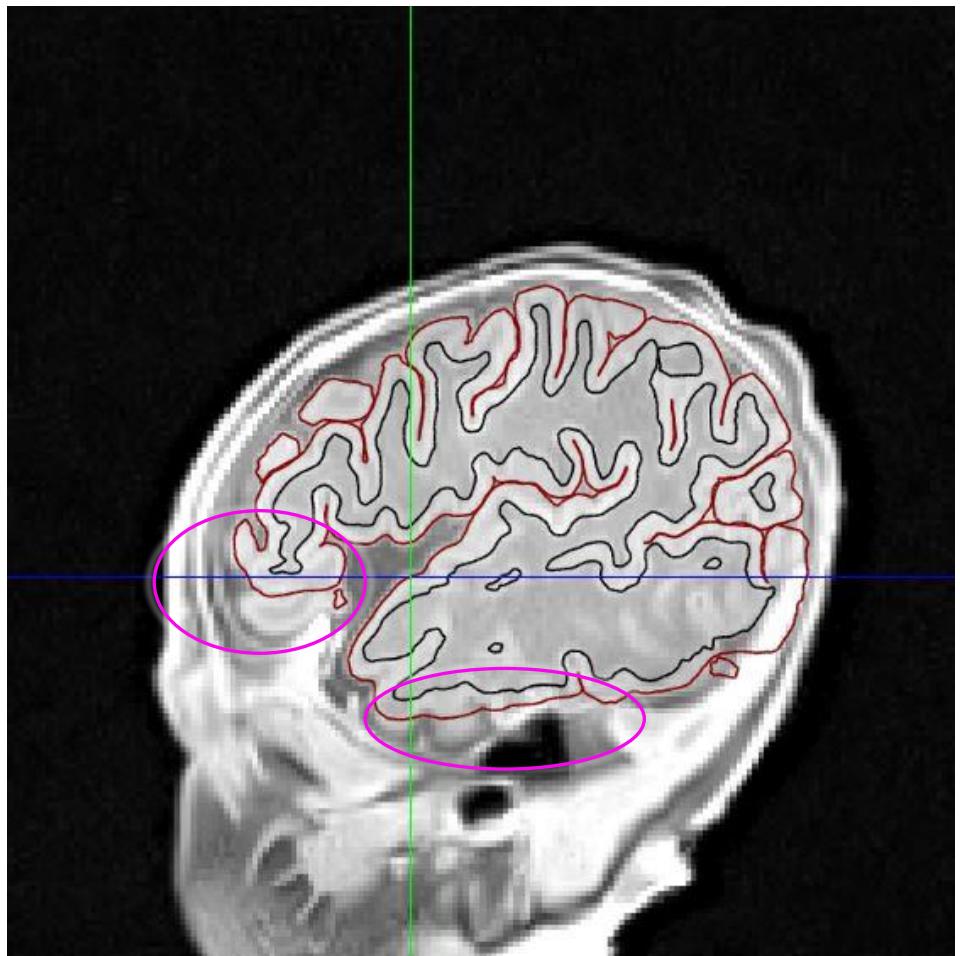


**2** - GM captures some dura- issue persists  
for > 10 slices, but isn't present throughout  
brain

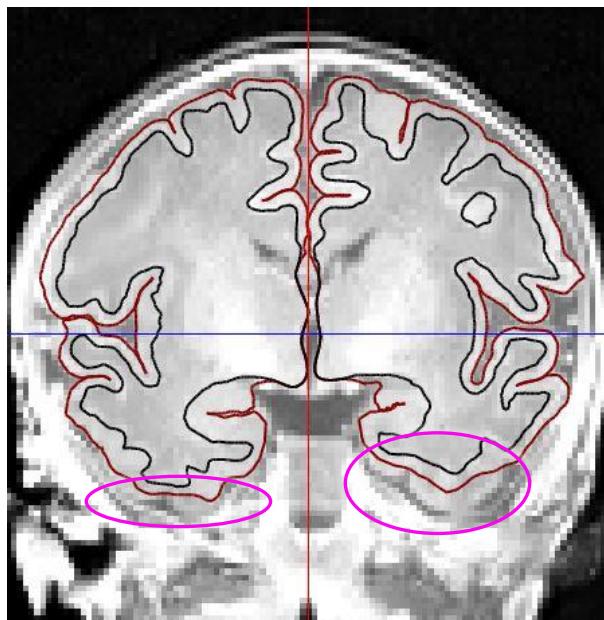


**1** - GM captures a small amount of dura,  
sawtooth present- issue persists for < 10 slices

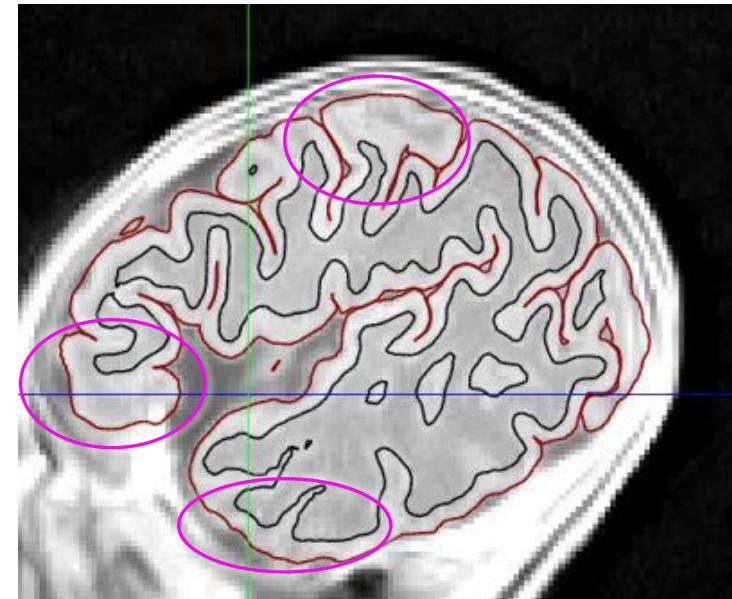
# Structural QA: Examples



**3** Missing prefrontal and temporal GM and WM throughout brain



**2** Missing some GM and WM in the temporal lobe- issues persists for < 10 slices



**2** Missing WM surfaces in the prefrontal, superior parietal, and temporal lobes- issues persists for < 10 slices

# Functional Quality Assessment

# Functional QA

- **Viewing functional data**
  - If functional data is not present in the executive summary use the "eog" command to view the following files in the img folder
    - I.e. sub-00001\_ses-151331\_task-rest\_run-01\_desc-**T1InTask.gif** & sub-00001\_ses-151331\_task-rest\_run-01\_desc-**TaskInT1.gif**
    - Goal: to examine how well the resting state functional data aligns to the structural T1 data
- **Does the structural and functional data align?**
  - Common errors to look for to answer this question:
    - Field of view cut-offs
      - This appears as cerebellum/ occipital dropout
    - Signal Dropout
      - Common regions:
        - Frontal
        - Temporal
        - Superior parietal
  - The presence of these errors does not automatically indicate the images are of poor quality – **it is to what extent these errors disrupt the alignment of the structural and functional data**

# Functional QA Scale

3

low quality

2

medium quality

1

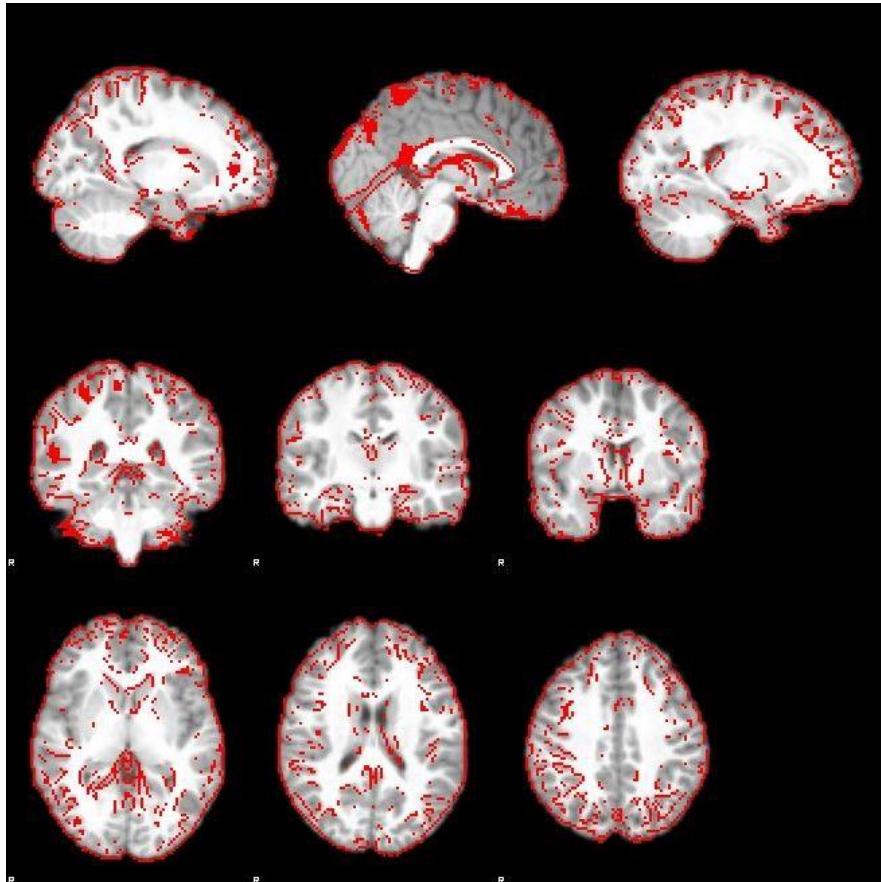
high quality

- Field of view error is significant
    - > 50% of cerebellum is cut off AND / OR other regions such as the temporal or frontal lobes are cut off
  - Signal drop out is significant (> 50%) in a particular region
  - Significantly poor alignment of functional data to structural data
  - Structural or functional data is missing
- Field of view error is slight
    - < 50% of the cerebellum is cut off, but no other regions
  - Signal drop out appears slightly (< 50%) in a particular region
  - Slightly poor alignment of functional to structural data
- Field of view error is minimal
    - < 10% of the cerebellum is cut off, but no other regions
  - Signal drop out is minimal (< 10%) in a particular region
  - Structural and functional data are well aligned

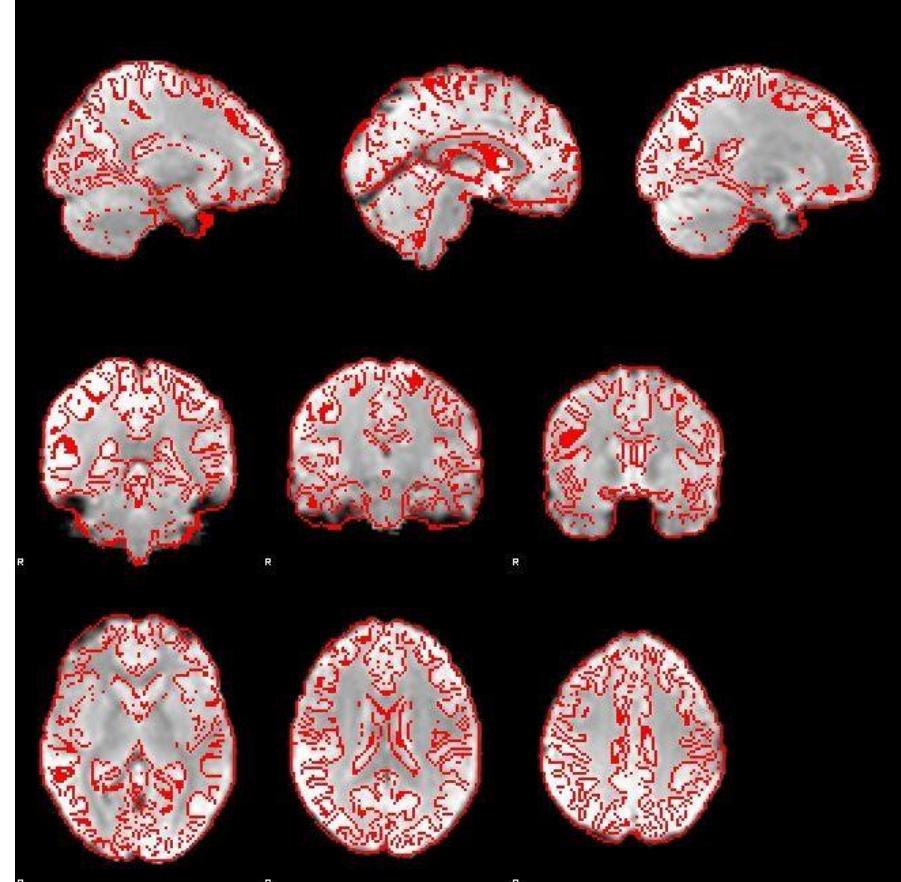
# Functional QA

- The most important question of functional quality assessment is: **Does the structural and functional data align?**

REST in T1



T1 in REST

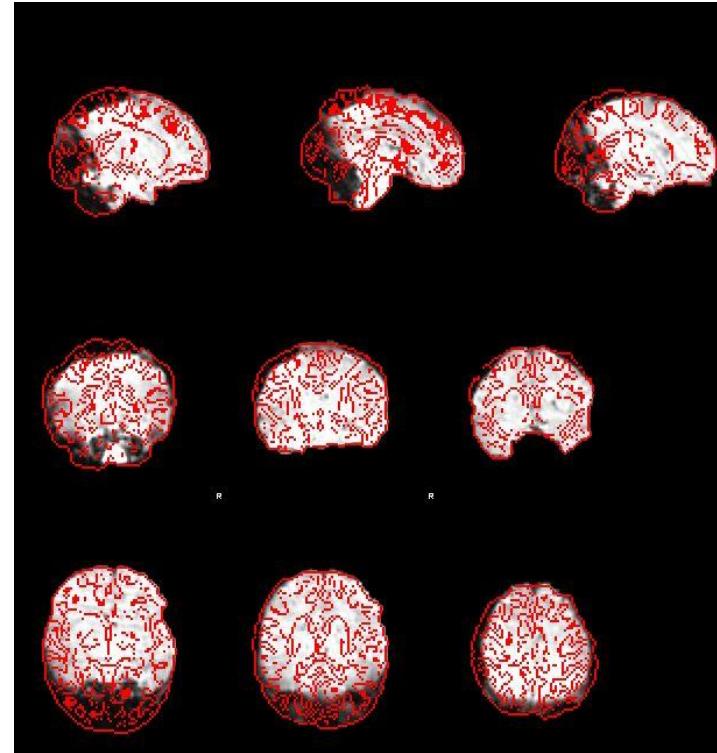
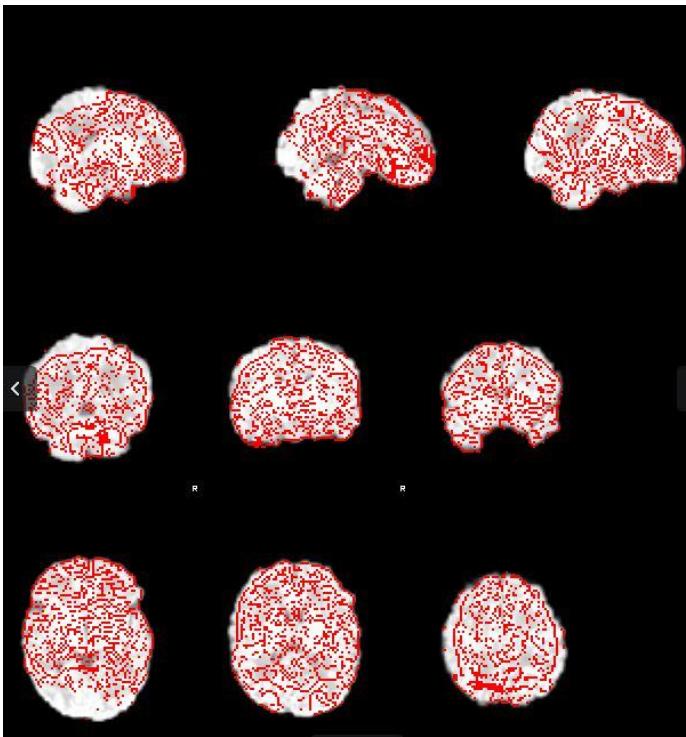


1

high quality

# Functional QA: Examples

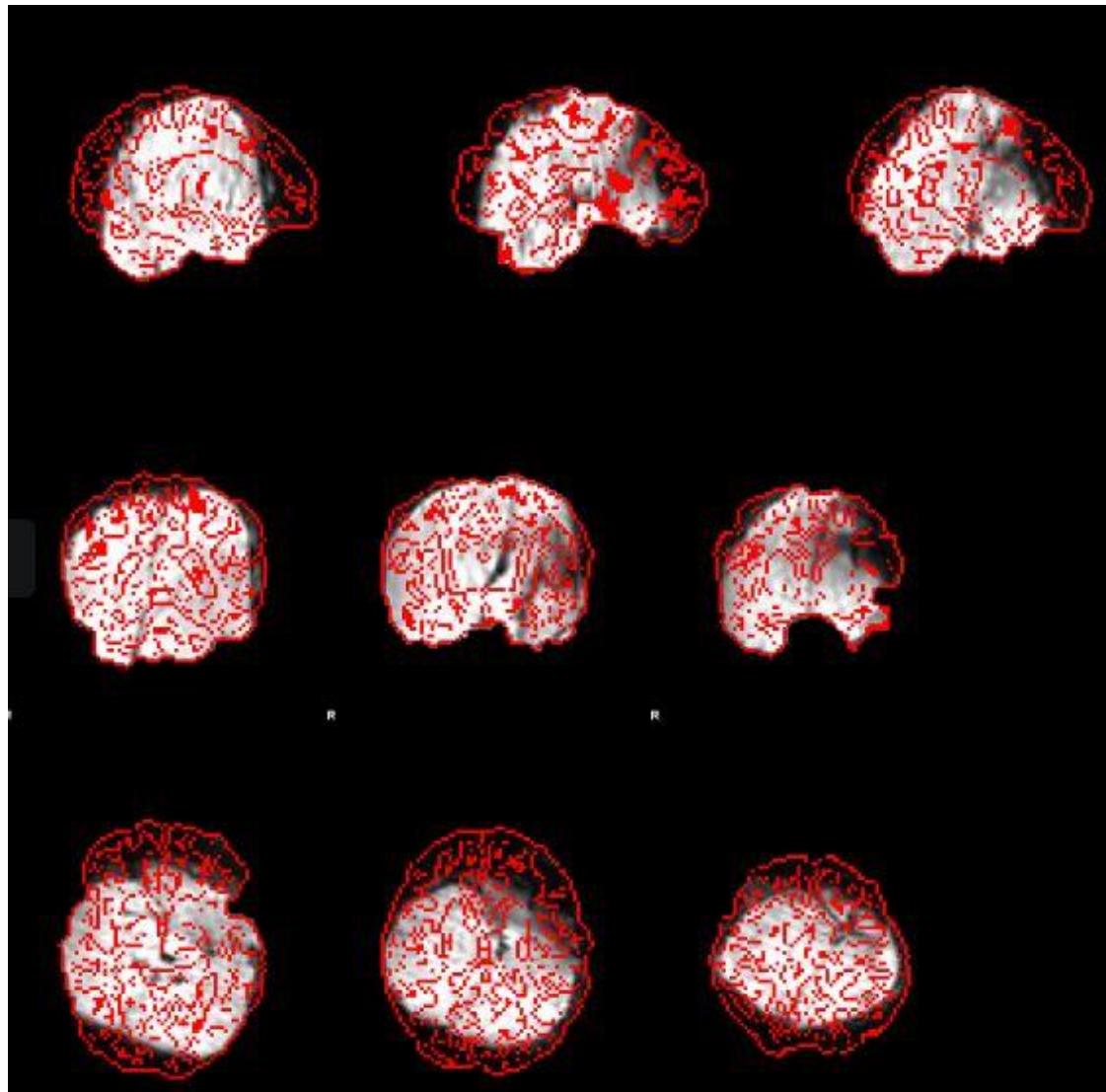
- Does the structural and functional data align?



3

Significantly cuts off the (> 50%) occipital lobe and superior parietal lobe

# Functional QA: Examples



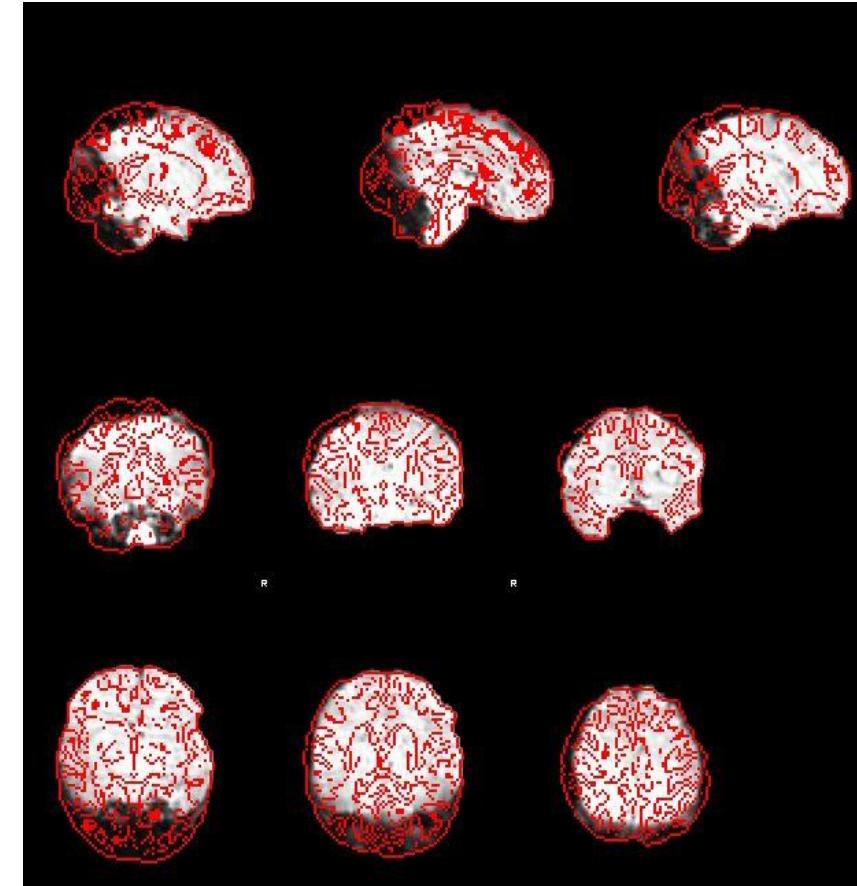
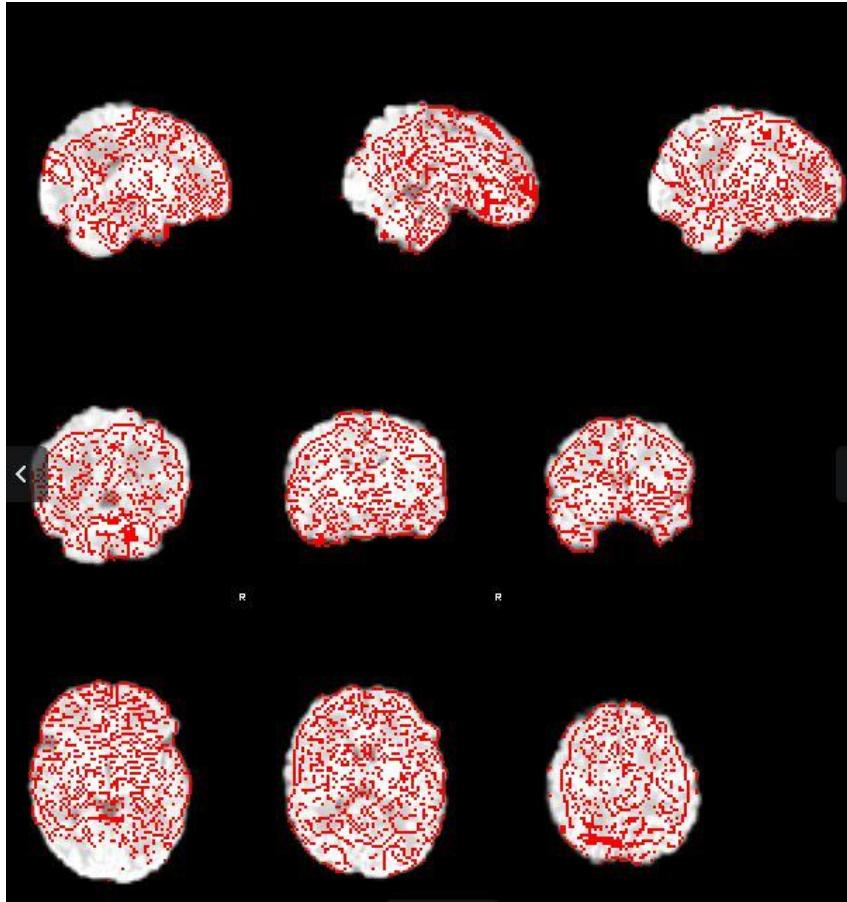
- Does the structural and functional data align?

3

Brain appears misaligned and there is significant dropout

# Functional QA: Examples

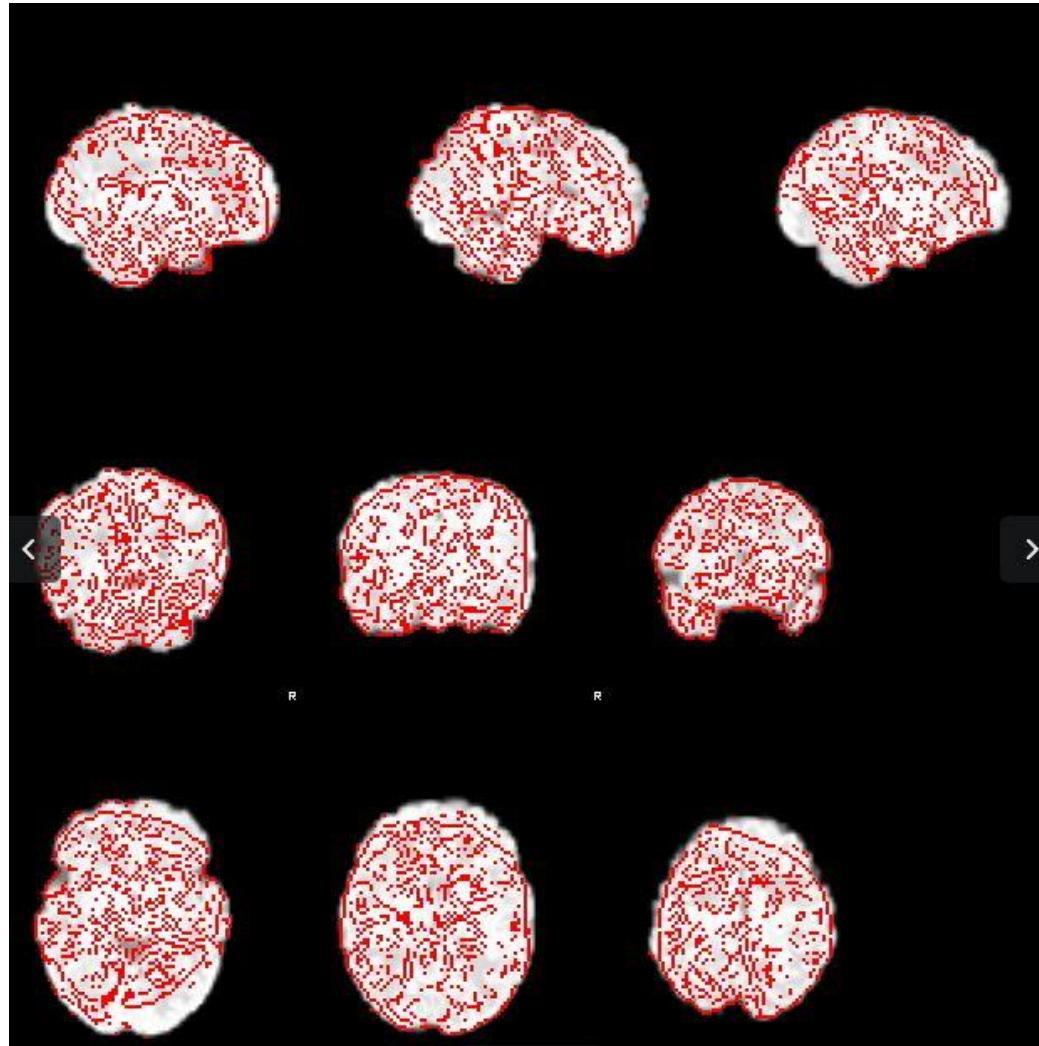
- Does the structural and functional data align?



3

Significantly ( $> 50\%$ ) cuts off the cerebellum, occipital lobe, superior parietal lobe and minimally ( $\leq 10\%$ ) cuts off the temporal lobes

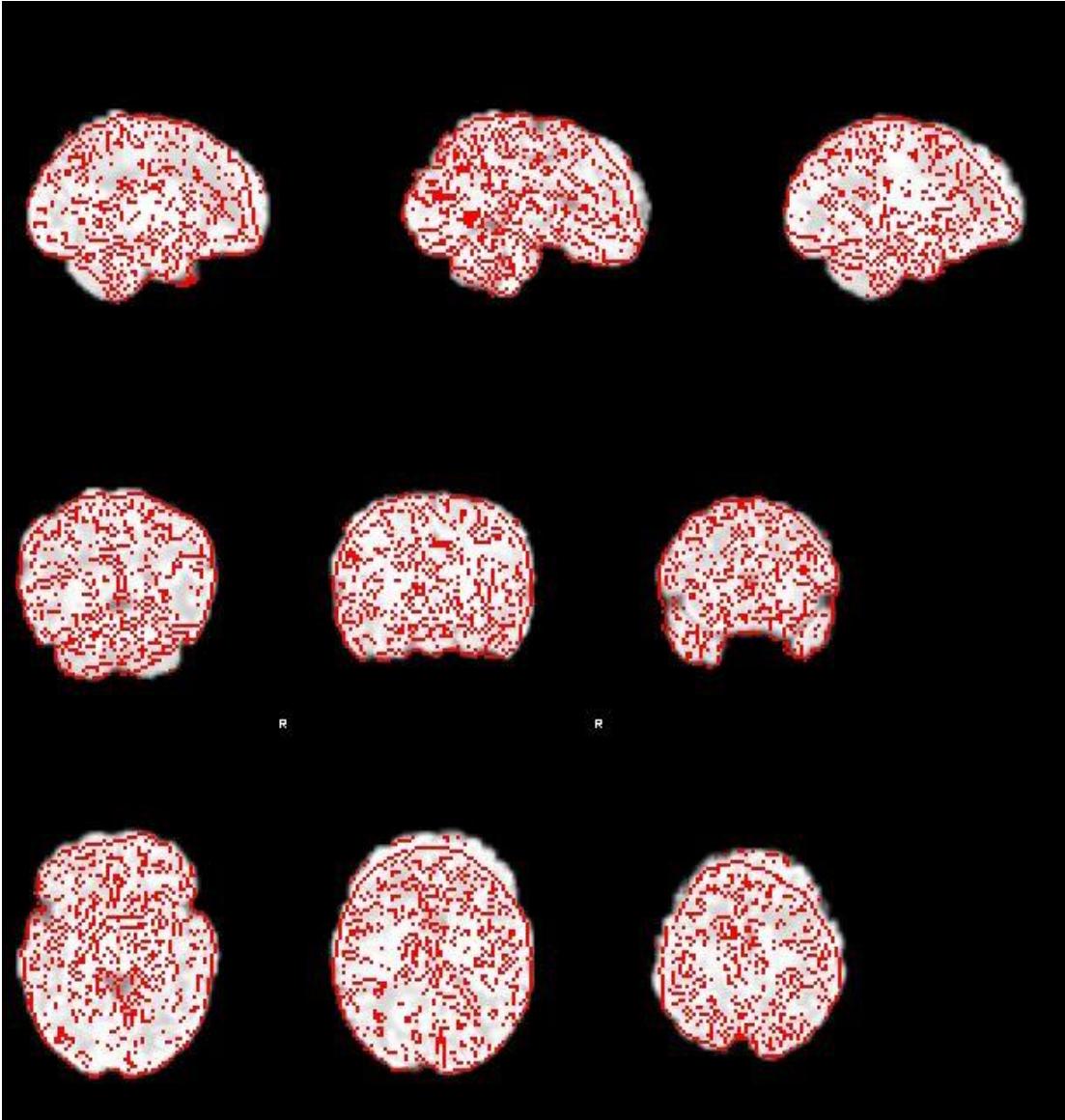
# Functional QA: Examples



3

Significantly ( $> 50\%$ ) cuts off the occipital lobe, and minimally ( $\leq 10\%$ ) cuts off the frontal lobe

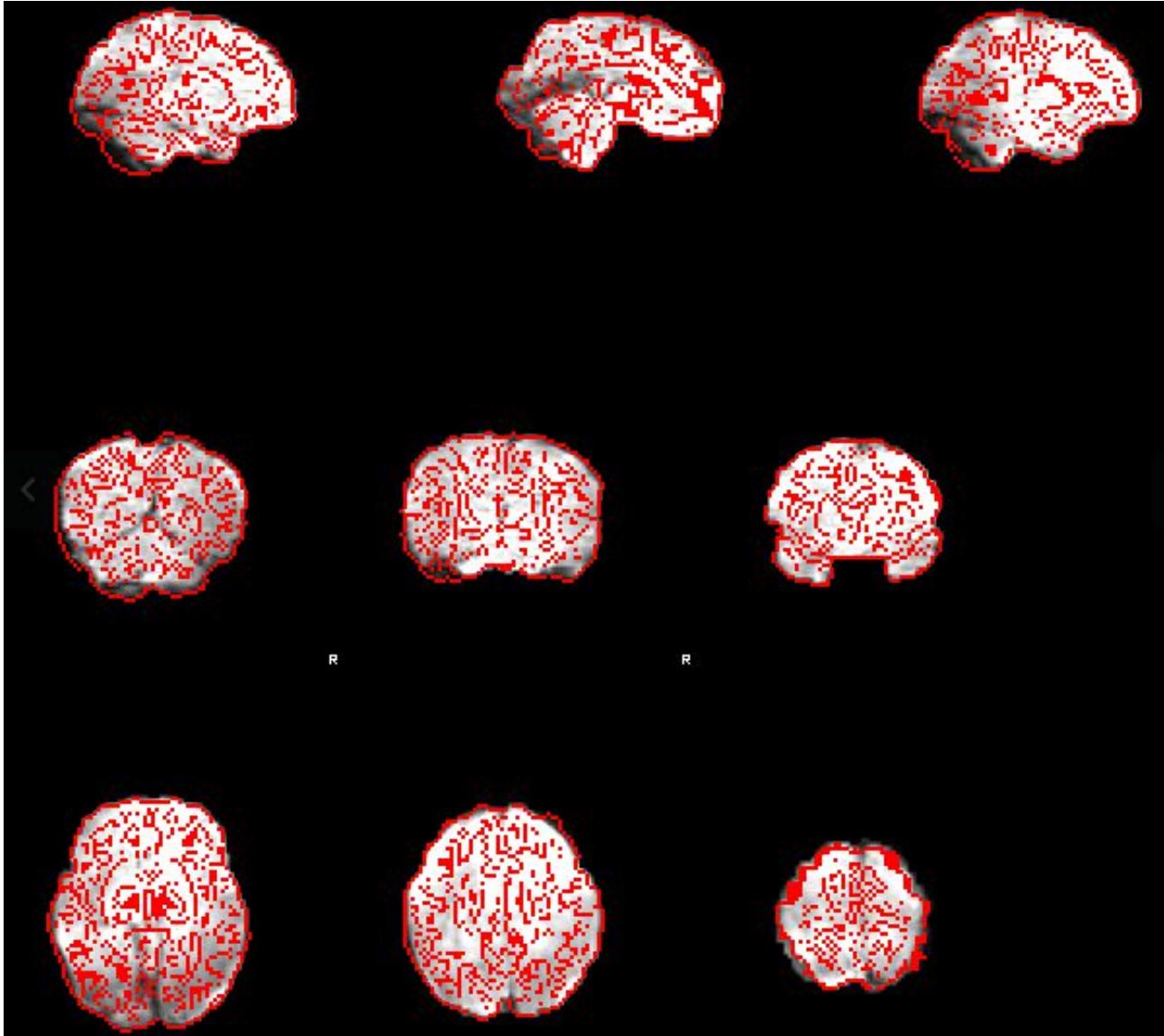
# Functional QA: Examples



- Does the structural and functional data align?

**3** Significant signal drop out appears (> 50%) in the frontal lobe and cerebellum

# Functional QA: Examples

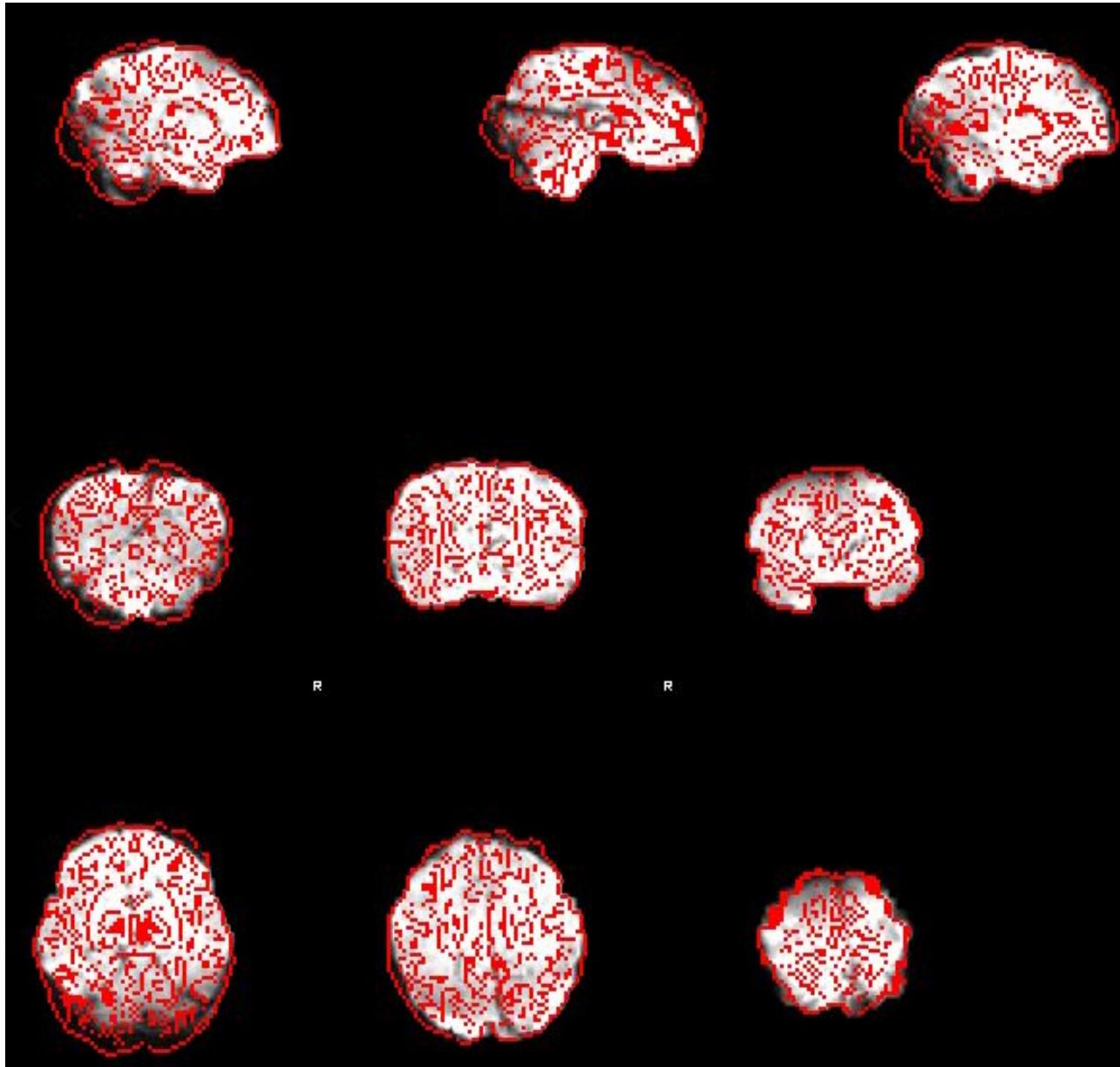


- Does the structural and functional data align?

1

Minimally ( $\leq 10\%$ ) cuts off part of the cerebellum but no other regions

# Functional QA: Examples



- Does the structural and functional data align?

2

Slightly ( $\leq 50\%$ ) cuts off part of the cerebellum, but no other regions

# QA Spreadsheet example

1	SUBJECT ID	SCANNER SITE	PATH	RATER	Does the executive summary contain everything it should?		Atlas to T1 registration quality		Surface delineation on T1 and T2 quality		Functional to structural data registration quality		
					correct executive summary	executive summary comments	atlas registration	atlas registration comments	T1	T1 comments	T2	comments	REST comments
2	SUBJECT1	SIEMENS	fiu	/PATH/TO/SUB ES	1		1	minimally goes outside boun	1	some jags but			1 REST4 warped t
3	SUBJECT2	GE	uwm	/PATH/TO/SUB ES	1		1	good registration	2	slight jags, m			2 slight prefronta
4	SUBJECT3	SIEMENS	musc	/PATH/TO/SUB ES	1		1	minimal protrusion	1	some jags but	2		2 minimal tempo
5	SUBJECT4	PHILIPS	uvm	/PATH/TO/SUB ES	1		1	good registration	1	good delineat	3		1 minimal FOV er
6	SUBJECT5	SIEMENS	fiu	/PATH/TO/SUB ES	1		2	misses part of occipital	2	poorly delinea			2 movement in SB
7	SUBJECT6	GE	uwm	/PATH/TO/SUB ES	1		3	brain smaller than atlas	3	poorly delina			3 superior pariet
8	SUBJECT7	PHILIPS	uvm	/PATH/TO/SUB ES	1		2	slight dropout in superior p	1	minimal ringi	3		1 slight prefronta
9	SUBJECT8	GE	uwm	/PATH/TO/SUB ES	1		1	minimally stays inside boun	1	minimally mis	3	skull, poor t2 reg	1 minimal tempo
10	SUBJECT9	PHILIPS	uvm	/PATH/TO/SUB ES	1		2	slightly inside boundaries	2	misses gray ir	3	misses complete GM	2 slight temporal
11	SUBJECT10	GE	uwm	/PATH/TO/SUB ES		0 missing REST4	3	significant protrusion	3	warped super	3	misses GM in super	3 0 temporal disto
12	SUBJECT11	SIEMENS	fiu	/PATH/TO/SUB ES	1		1	minimal protrusion	1	minimally mis	1		1 movement in SB
13	SUBJECT12	PHILIPS	uvm	/PATH/TO/SUB ES	1		1	good registration	1	minimal jags	3	lots of ringing	1 minimal prefron
14	SUBJECT13	PHILIPS	uvm	/PATH/TO/SUB ES	1		1	minimally goes outside boun	2	goes into dura	3	ringing, warping, se	2 slight temporal
15	SUBJECT14	SIEMENS	utah	/PATH/TO/SUB ES	1		1	good registration	2	poor delineat	3	goes into skull and	1 slight prefronta
16	SUBJECT15	GE	umich	/PATH/TO/SUB ES	1		2	slightly outside boundaries	1	minimally mis	3	ringing, goes into sk	1 slight temporal
17	SUBJECT16	SIEMENS	fiu	/PATH/TO/SUB ES		0 3 SSTs	1	good registration	1	some jags but	3	goes into dura and	1 minimal prefron
18	SUBJECT17	PHILIPS	vcu	/PATH/TO/SUB ES	1		2	slightly outside boundaries	1	good delineat	3	misses gyrus, goes i	2 movement in SB
19	SUBJECT18	GE	umich	/PATH/TO/SUB ES	1		2	slightly inside in frontal	2	goes into dura	3	ringing, misses GM	2 slight protru
20	SUBJECT19	SIEMENS	musc	/PATH/TO/SUB ES	1		3	warp in temporal	3	poorly delineat	3	completely misses l	3 temporal disto
21	SUBJECT20	GE	umich	/PATH/TO/SUB ES	1		1	good registration	1	minimally mis	3	goes into skull, sev	1 minimal prefron
22	SUBJECT21	PHILIPS	vcu	/PATH/TO/SUB ES		0 8 RESTs	1	minimal protrusion	1	some jags but	3	misses huge sector	1 minimal tempo
23	SUBJECT22	SIEMENS	musc	/PATH/TO/SUB ES	1		1	good registration	1	minimally mi	1	gyri smoothed over,	1 minimal FOV er
24	SUBJECT23	GE	uwm	/PATH/TO/SUB ES	1		2	misses part of frontal	3	temporal war	2	2 movement in SB	2 slight prefronta
25	SUBJECT24	GE	uwm	/PATH/TO/SUB ES	1		1	minimally goes outside boun	1	good delineat	1	completely misses b	2 slight prefronta
26	SUBJECT25	PHILIPS	vcu	/PATH/TO/SUB ES	1		1	good registration	1	minimally mi	3	ringing, gyri slightly	1 slight superior
27	SUBJECT26	SIEMENS	utah	/PATH/TO/SUB ES	1		1	minimal protrusion	1	minimal ringi	2	areas of poor GM st	1 movement in SB
28	SUBJECT27	SIEMENS	utah	/PATH/TO/SUB ES	1		3	warp in superior parietal	2	slightly misse	1		1 slight temporal
29	SUBJECT28	PHILIPS	vcu	/PATH/TO/SUB ES	1		2	misses part of temporal	1	minimal jags	1		2 significant FOV
30	SUBJECT29	PHILIPS	vcu	/PATH/TO/SUB ES		0 missing MID2	2	slight protrusion in right tem	1	some jags but	1		2 slight FOV error
31	SUBJECT30	GE	uwm	/PATH/TO/SUB ES	1		1	good registration	1	minimally mi	1		1 minimal tempo

# QA Spreadsheet to fill out

SUBID	QC using	Rater Initials	correct executive summary	comments	atlas registration	comments	T1	comments	T2	comments	REST1	REST2	REST3	REST4	comments
sub-198549	firefox														
sub-375518	firefox														
sub -439083	firefox														
sub-584381	firefox														
sub-00001	chromium-browser										ses-151331_REST1-	ses-151331_REST2-	ses-221338_REST1-	ses-221338_REST2-	
sub-00005	chromium-browser										ses-030914_REST1-	ses-030914_REST2-	ses-121356_REST1-	ses-121356_REST2-	
sub-00007	chromium-browser										ses-131356_REST1-	ses-131356_REST2-	ses-131356_REST3-	ses-131356_REST4-	
sub-00009	chromium-browser										ses-091330_REST1-	ses-091330_REST2-	ses-091330_REST3-	ses-091330_REST4-	
sub-00014	chromium-browser										ses-111350_REST1-	ses-111350_REST2-	ses-111350_REST3-	ses-131312_REST1-	
sub-00016	chromium-browser										ses-191314_REST1-	ses-191314_REST2-	ses-191314_REST3-	ses-211443_REST1-	
sub-00018	chromium-browser										ses-051311_REST1-	ses-051311_REST2-	ses-051311_REST3-	ses-051311_REST4-	

This is the QA spreadsheet you will be filling out

## Things to note:

- Column 2 indicates if firefox or chromium-browser should be used to open the executive summary
  - this is the .html file which contains the brain sprite surfaces- for QAing the grey matter/ white matter delineation
- Some subjects have wonky file names
  - The file names listed under REST# columns indicate the files you should open to QA functional to structural registration for these subjects