SBME 3038

Medical Equipment Design

Final report

Ziyad Hossam Masoud

Sec: 1

BN: 26

Under Supervision of Dr: Meena M. Makary

QC:

I did the Quality control manually/visually for the data and here are the results for just 2 subjects :

	Scan type	Motion Test	Quality test	Number of volumes	TR	Best BET threshold
Sub 1	run_1	Very simple motion can be seen between the last and first frame	Acceptable	146	2	0.2
	run_2	Like run_1 but less	Acceptable	146	2	
	T_1		Good with some white places near the neck			
Sub 2	run_1	No motion just eye blanking noticed	Acceptable	146	2	0.1
	run_2	Small neck rotation movement is noticed	Acceptable	146	2	
	T_1		Good with some white places under the eyes			

It can be noticed that the structural images T1 are high quality and there are some white places near the neck which by search I found that is fat tissue and the muscles.

Motion can be noticed most of the time between volume 0 and 146 where the visual difference is highly noticed.

The Number of volumes and TR are checked automatically by a bash script.

The best BET threshold is calculated after some trials to get the best one for each subject structural T1 image.

Sheet Link : this is for the full sheet for all subjects.

BET:

For the first 10 subject I do the BET manually to find out the best threshold for the while subject then I wrote a bash script to automate the process.

FEAT:

In this part start to do motion correction and registration on the MNI template but with many trials to show the difference when changing the parameters.

This process I do manually but also, I wrote a bash script to do that -just need before starting- the design.fsf file which provide the saved settings including the values of the different parameters and the preprocessing to apply.

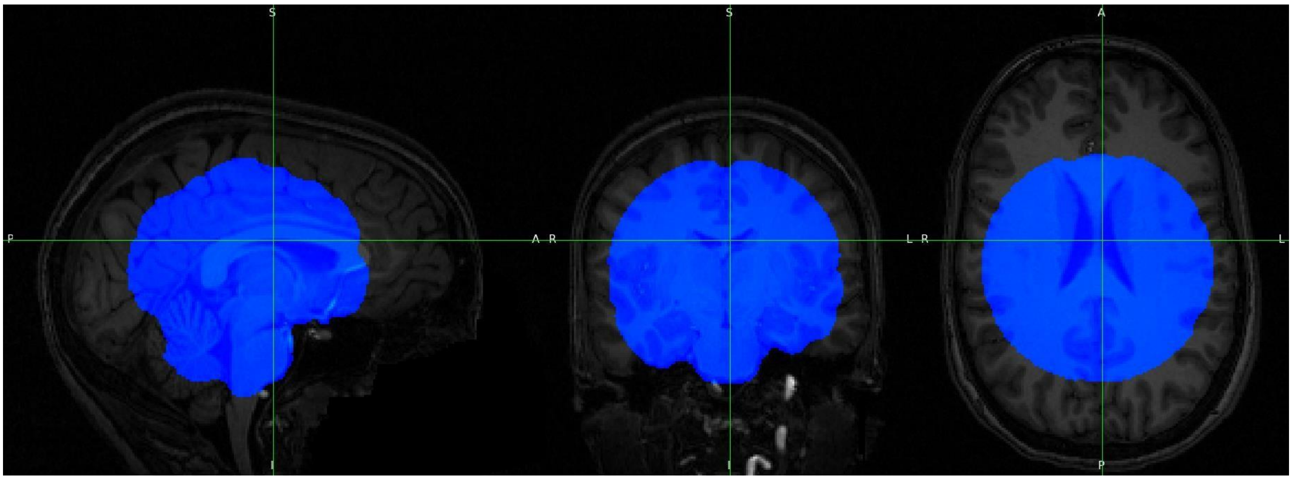
Automation part using Bash Scripts:

1. Automation checks of TR and Number of volumes.
2. Automation of BET using threshold.
3. Automation of FEAT.

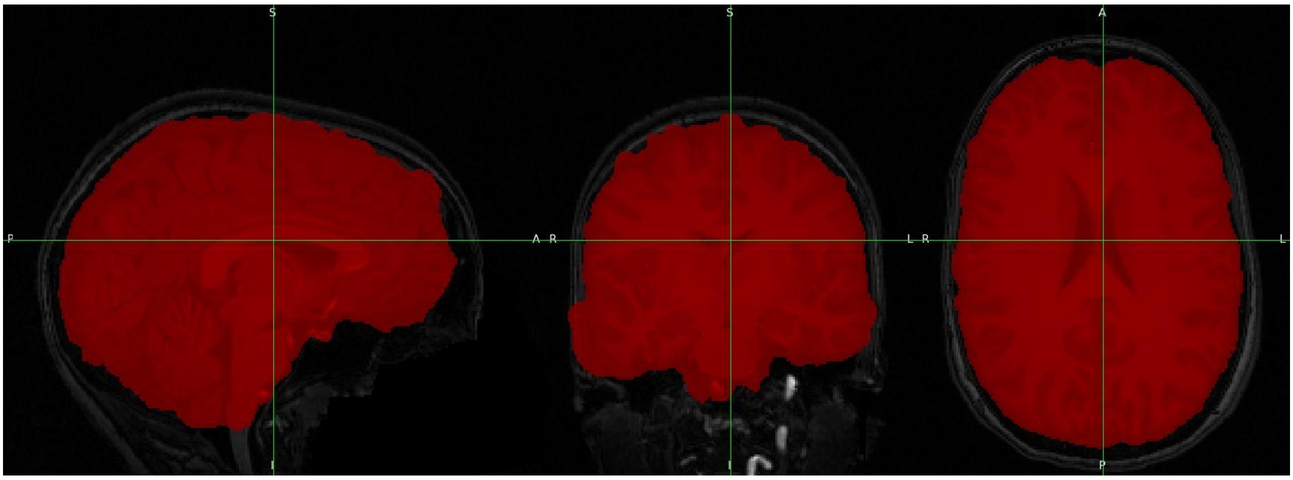
Exercises:

EX_1:

1. Sub_8 brain with threshold 0.9 :
   Many parts of the brain are removed duo to high threshold.

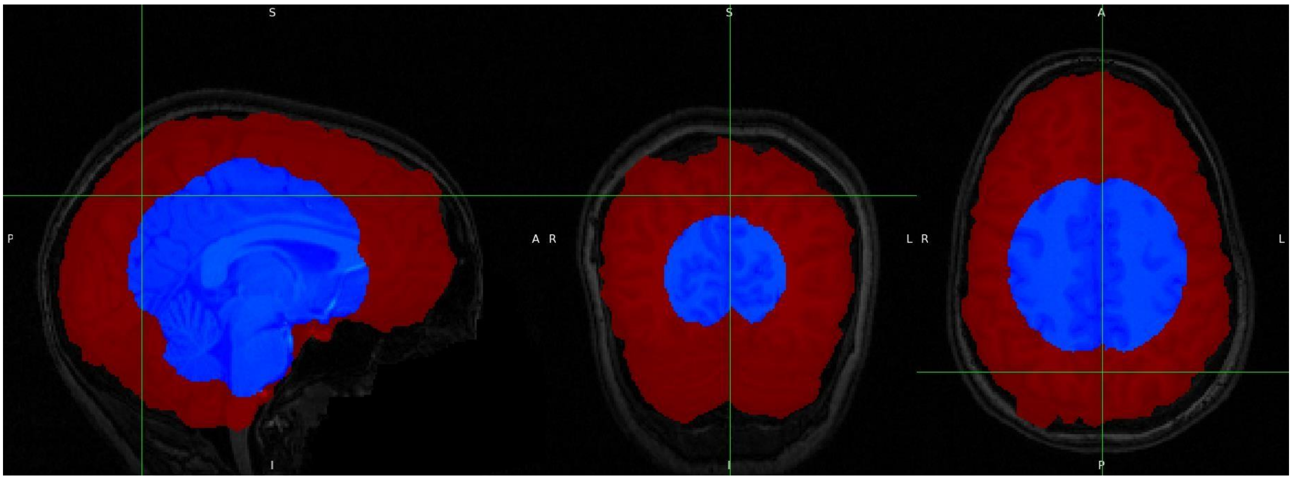


2. Sub_8 brain with threshold 0.1:



The brain is completely extracted without any missing parts.

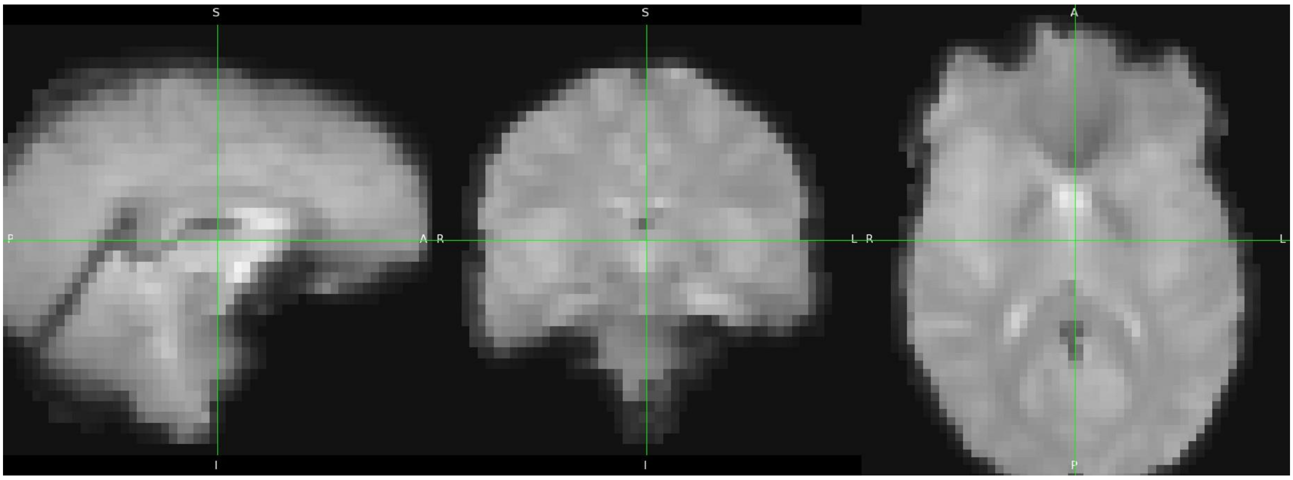
3. This the ovelay of the 2 images on the original image:



This shows the difference between them and the removed places.

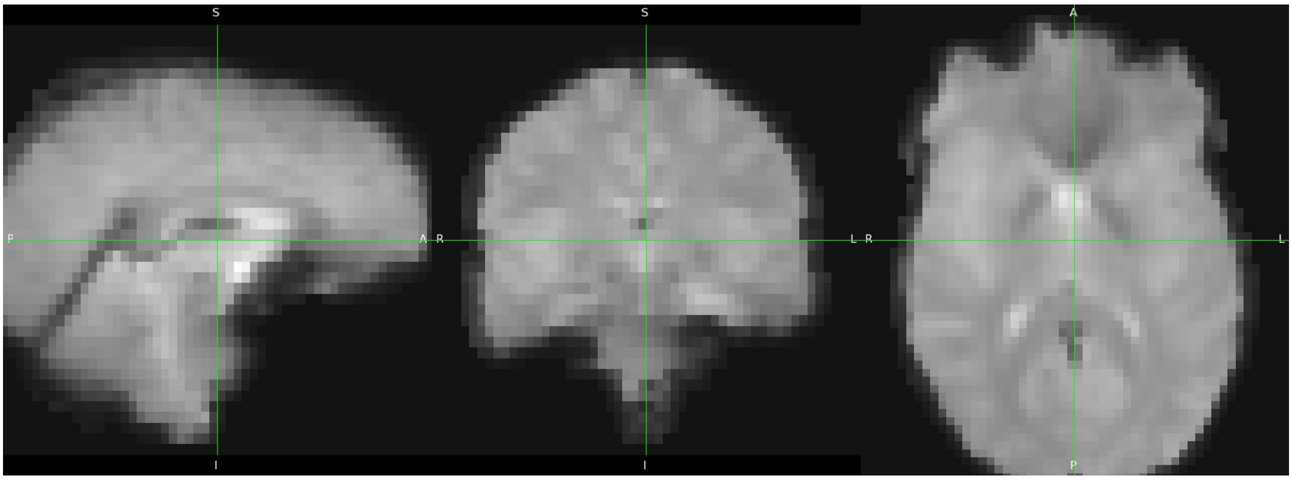
EX_2:

I do the FEAT with same parameters on 2 runs of the same subject but I noticed that the results are almost the same, but it differs in the report which shows in stats part that patient movement was higher in one of them than the other.



1. Sub_8 run 1 FEAT result:

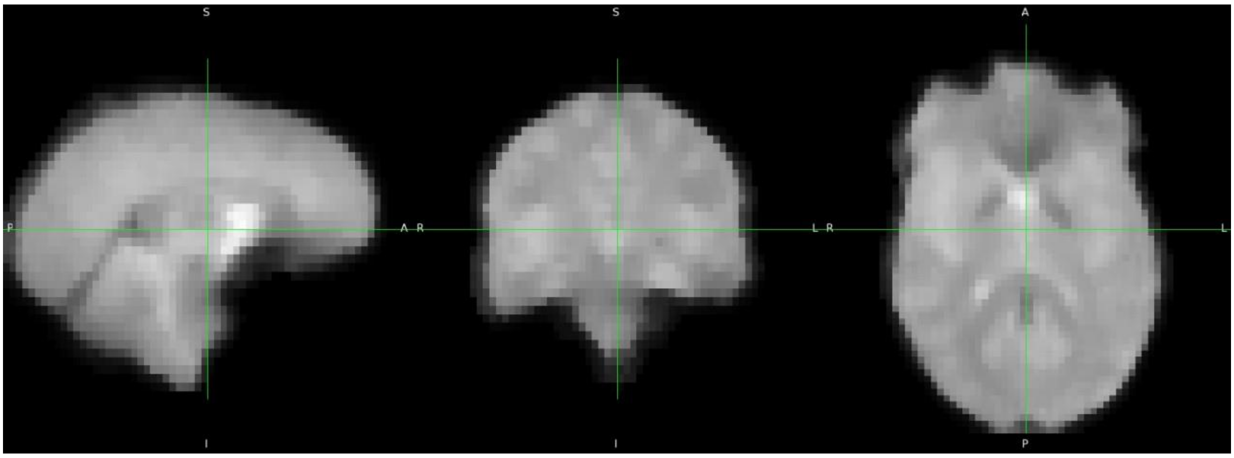
2. Sub_8 run 2 FEAT result:



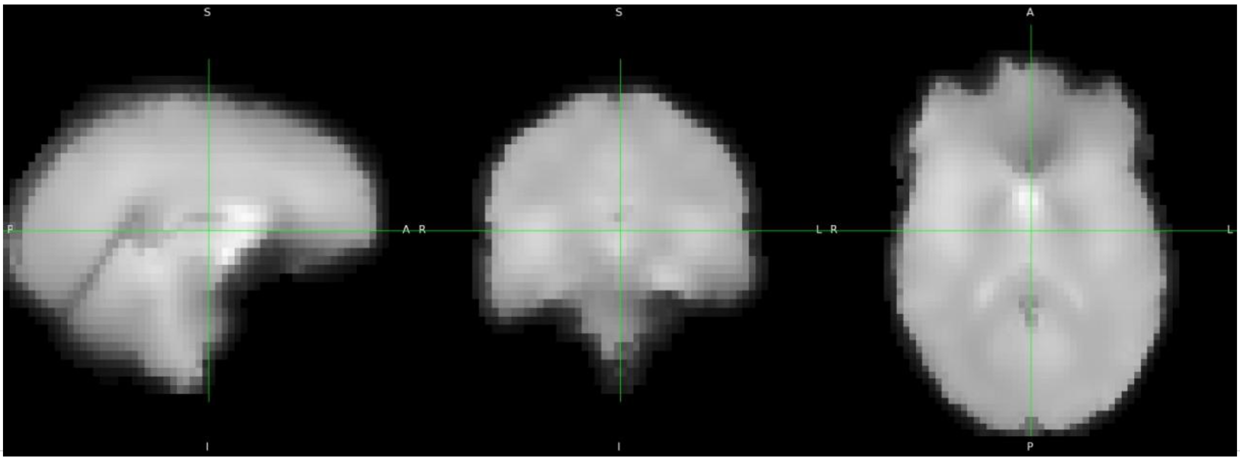
EX_3:

I do the preprocessing once using:

1. a 3mm smoothing kernel.



2. a 12mm smoothing kernel.



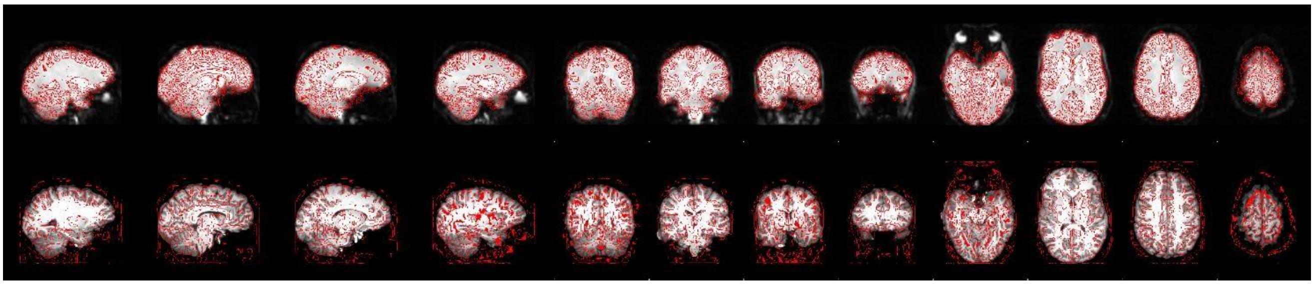
The main difference that can be noticed between the two images is the blur in the 12 mm kernel which cause more smoothing on the image which leads to lost information about specific voxels leads to low resolution image.

EX_4 & EX_5:

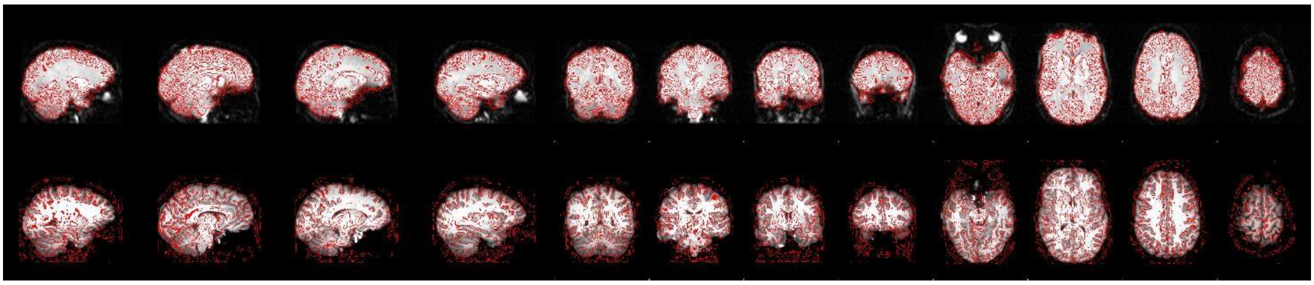
Using Motion correction with 12-DOF as reference and once with 3-DOF and other with BBR.

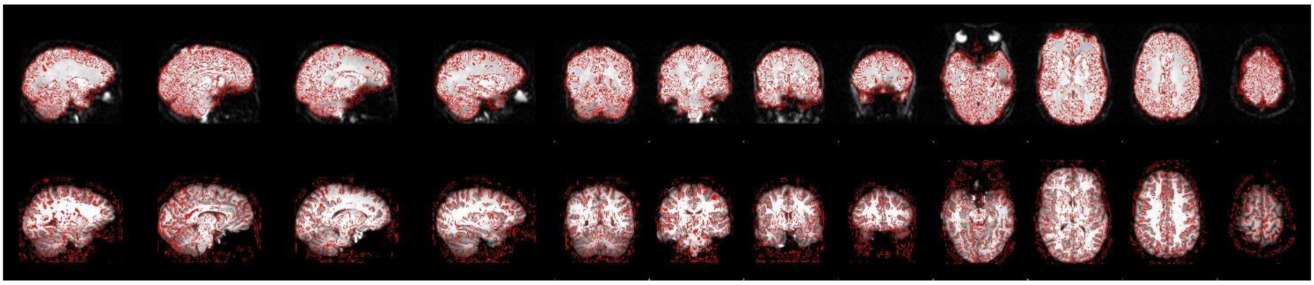
In the visual overlay of the 3 results there were no noticed difference, but it was shown in the fitting of the image on the registration process and there are also small differences in the video which show some motion in the 3-DOF which can be duo to rotation, shear or zoom.

1. 3-DOF report image of registration:



2. 12-DOF report image of registration:





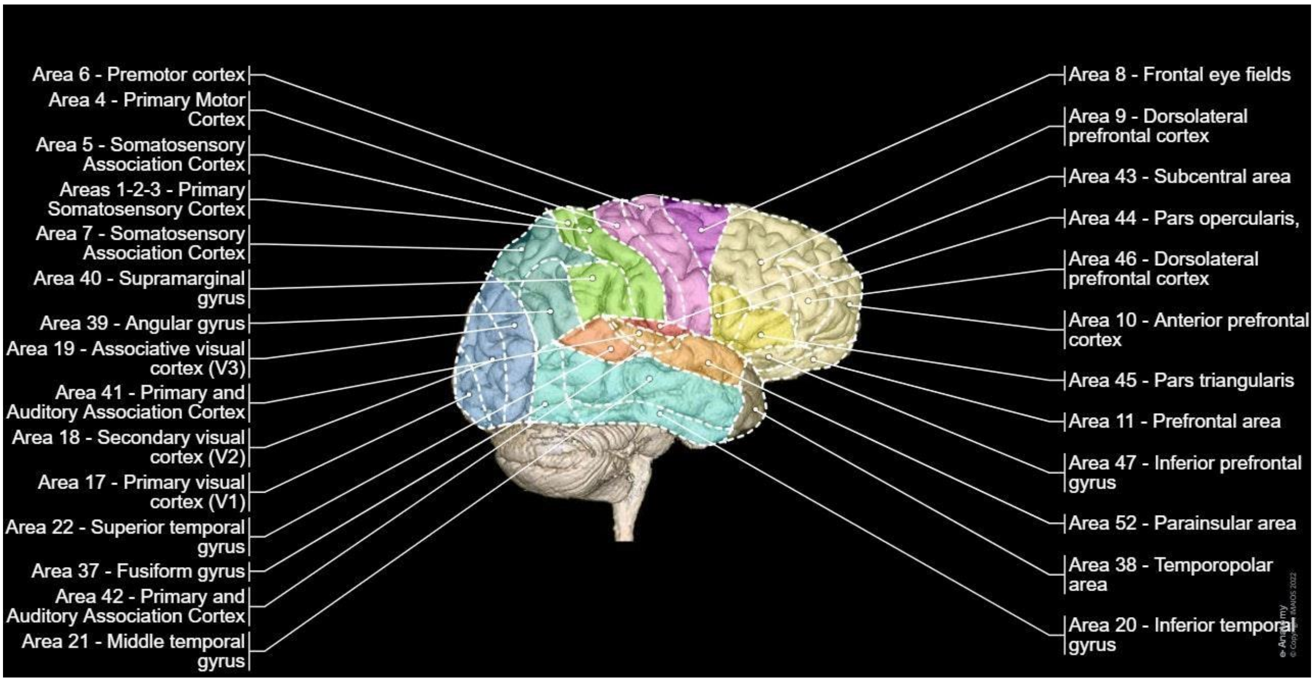
3. BBR report image of registration:

Neuroanatomy:

Introduction:

The human brain is a marvel of complexity, comprising various regions and structures, each contributing to different functions. In this report, we delve into the intricacies of brain anatomy, utilizing FSL software with MNI and Harvard Atlas to elucidate key regions and their functions.

Many regions and many functions the brain is responsible for so in this part I will using different FSL Atlases to show the specific region and its function.



I will divide it into subcategories of interest like: lobes, brainstem, deep brain structure & etc..

Lobes:

Region	Functions
Frontal Lobe	Executive functions such as decision-making, planning, and problem-solving.
	Personality expression and social behavior regulation.
	Working memory and attention control.
Parietal Lobe	Sensory perception.
	Spatial awareness.
	Somatosensory processing (including somatotopy).
Temporal Lobe	Auditory processing.
	Memory (particularly long-term memory).
	Language comprehension.
Occipital Lobe	Visual processing and perception.
	Integration of visual information.

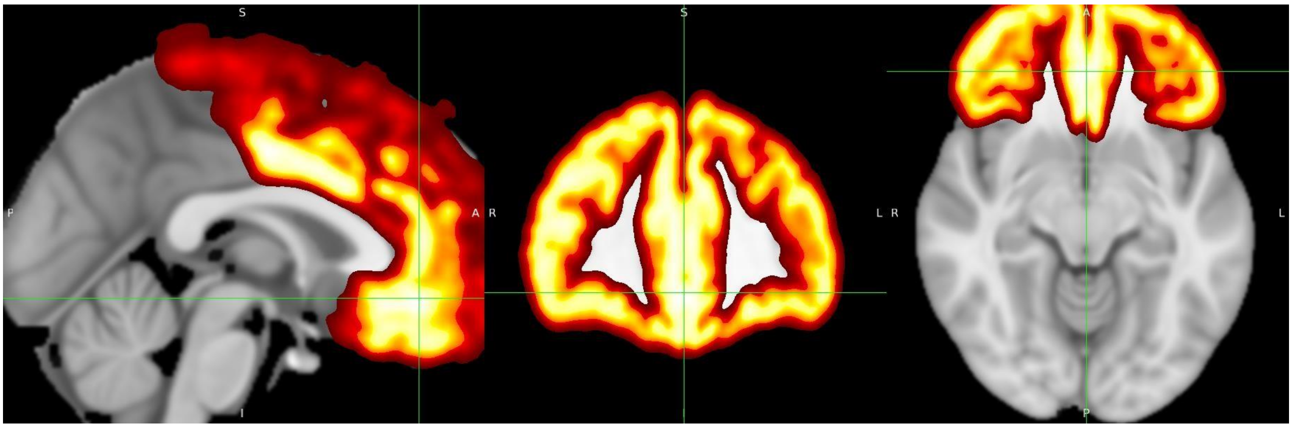


Figure 1: Frontal lobe.

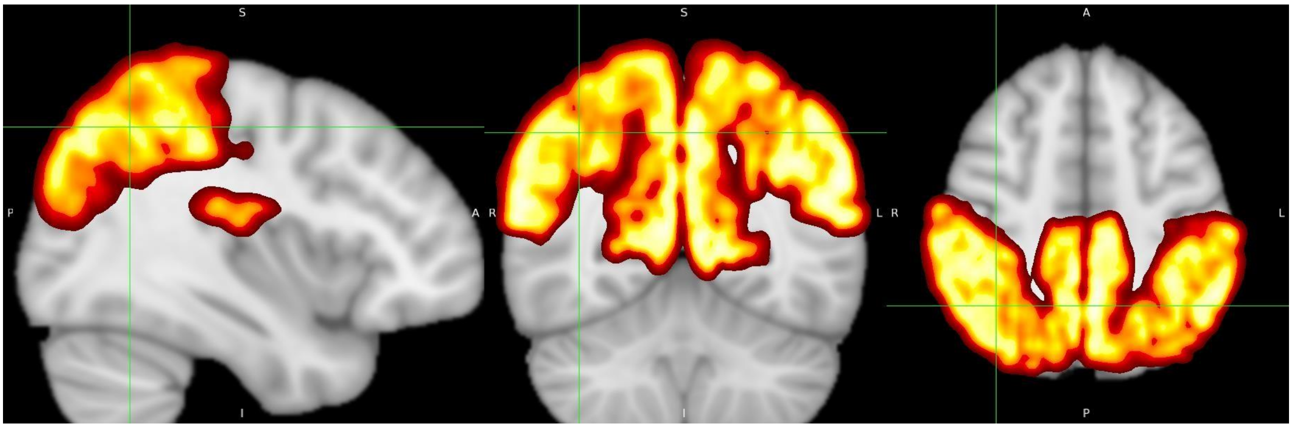


Figure 2: Parietal Lobe.

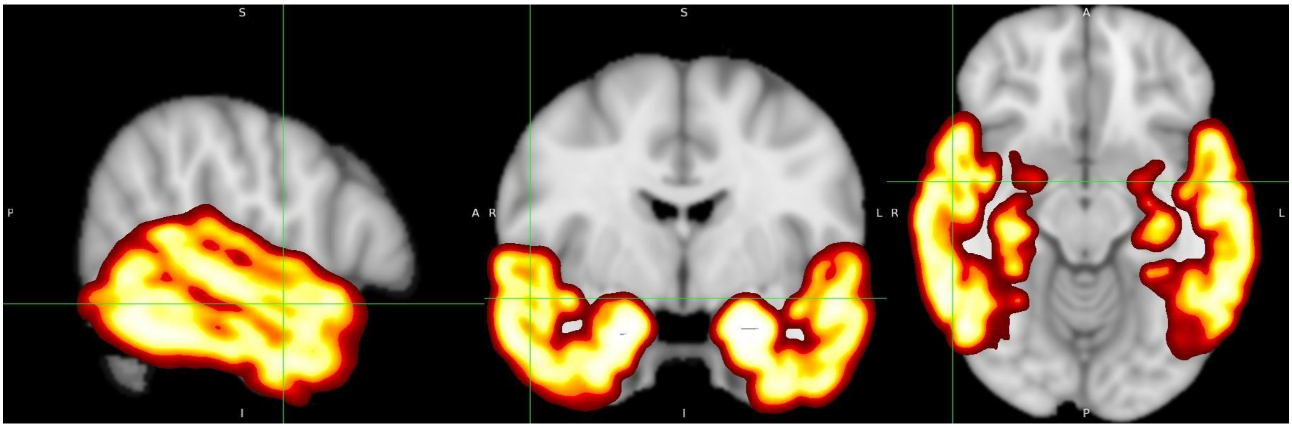


Figure 3: Temporal Lobe.

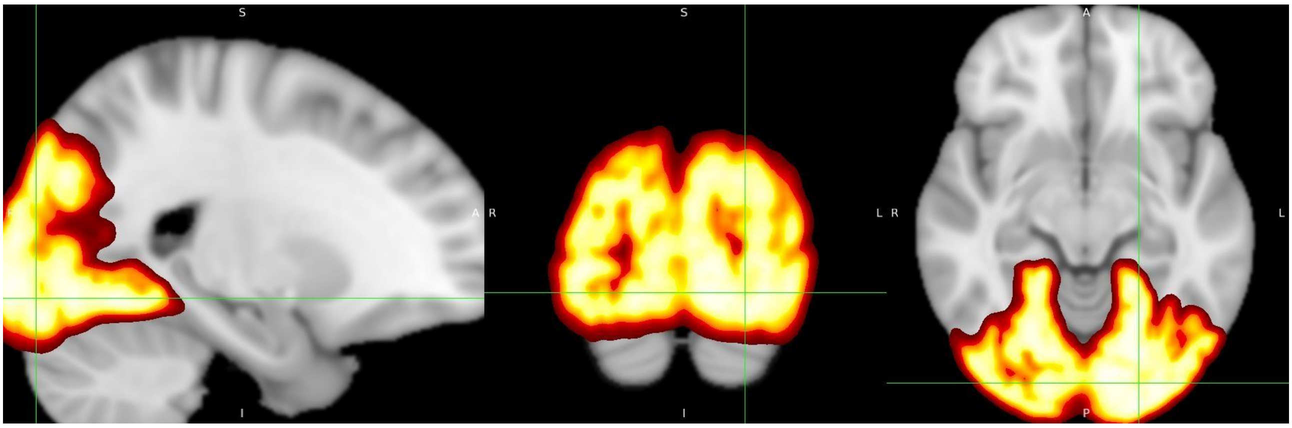


Figure 4: Occipital Lobe.

Brainstem

Pons	Relay sensory information between cerebrum and cerebellum.
	Regulation of sleep, respiration, and bladder control.
	Coordination of facial movements.
Medulla Oblongata	Control of autonomic functions such as heart rate and breathing.
	Coordination of swallowing and vomiting reflexes.
	Transmission of nerve signals between the brain and spinal cord.
Midbrain	Integration of sensory information and generation of motor responses.
	Regulation of visual and auditory reflexes.
	Control of movement and coordination.

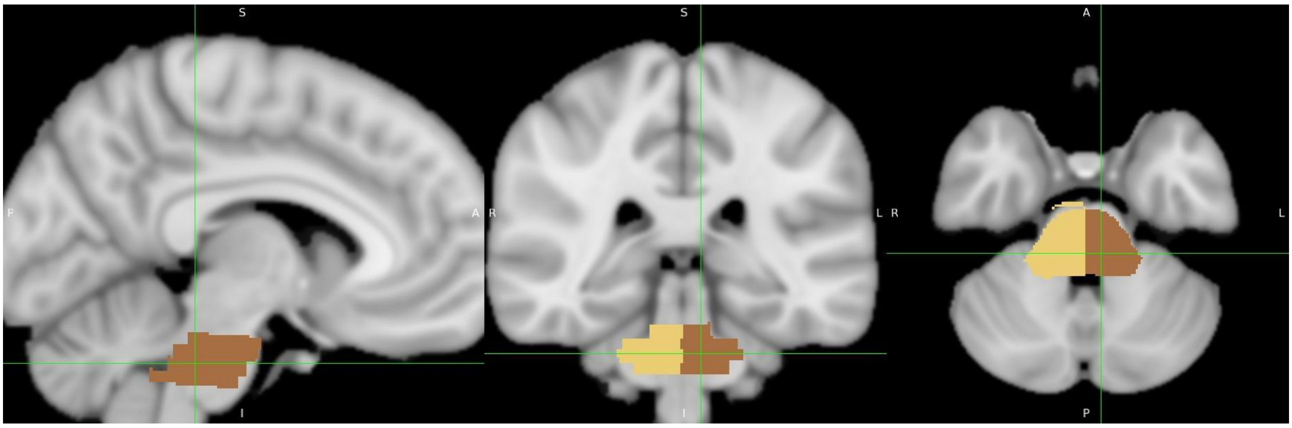


Figure 5: Pons.

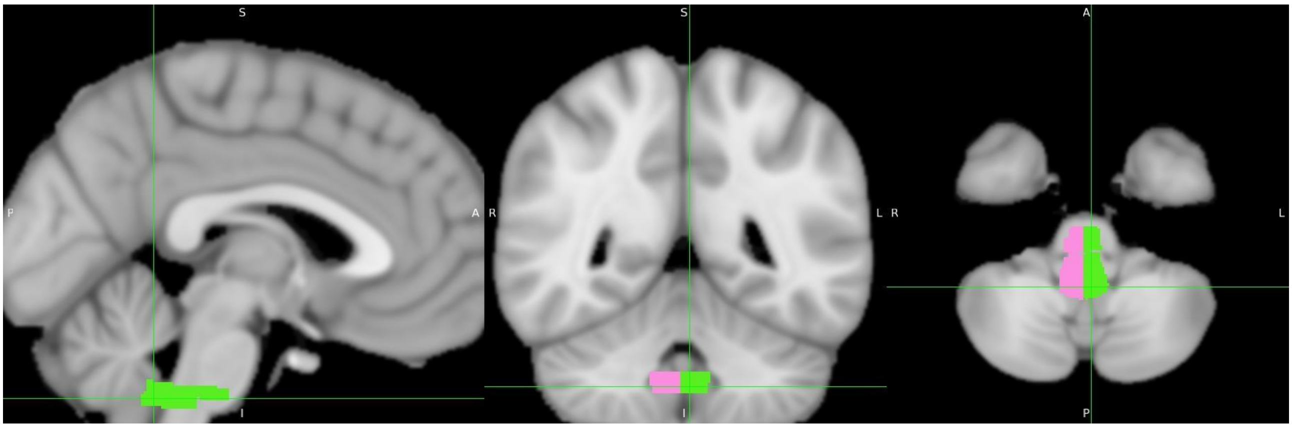


Figure 6: Medulla.

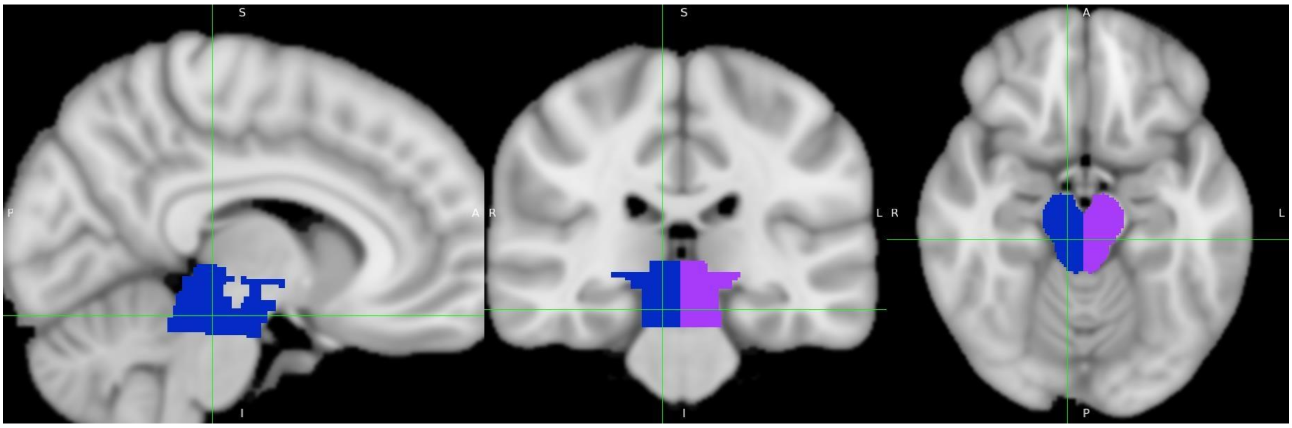


Figure 7: Midbrain.

Deep Brain Structures

Hippocampus	Formation of new memories and spatial navigation.
	Learning and memory consolidation.
	Emotional regulation and stress response.
Amygdala	Processing emotions, particularly fear and aggression.
	Modulating emotional responses and social behavior.
	Encoding emotional memories.

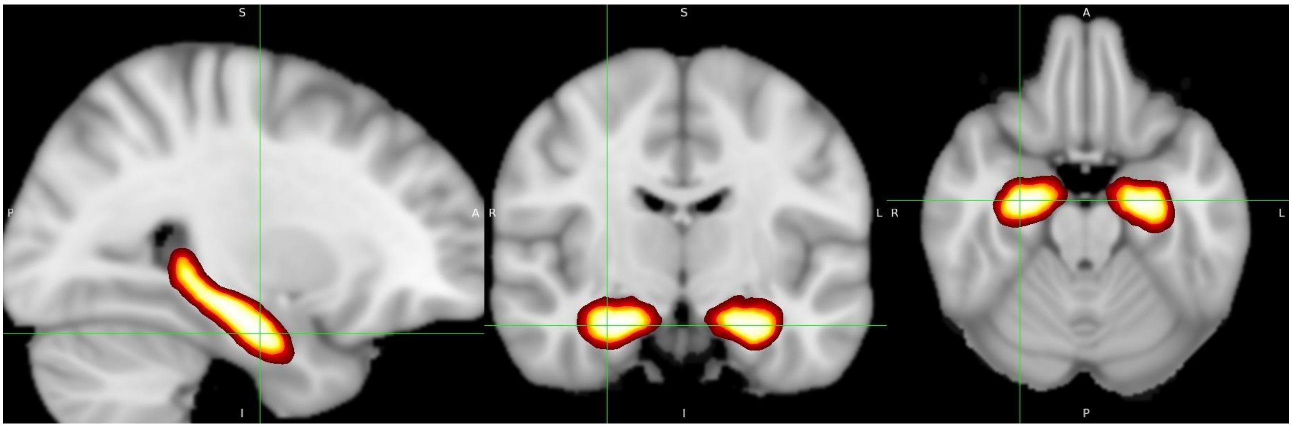


Figure 8: Hippocampus.

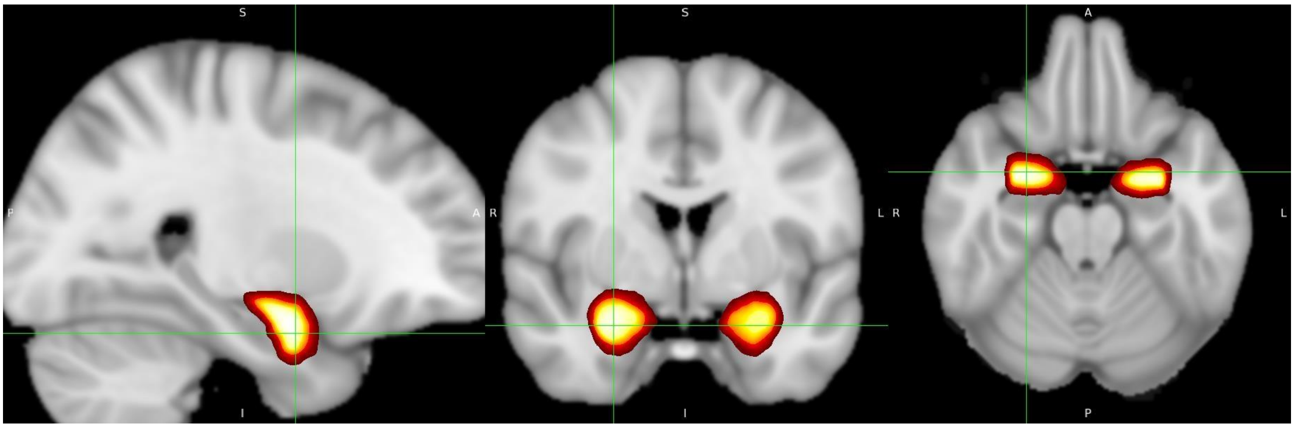


Figure 9: Amygdala.

Cerebellum and Insula

Cerebellum	Coordination of voluntary movements and balance.
	Motor learning and procedural memory.
	Cognitive functions such as attention and language.
Insula	Interoception and visceral sensation.
	Emotional processing and empathy.
	Autonomic regulation and homeostasis maintenance.

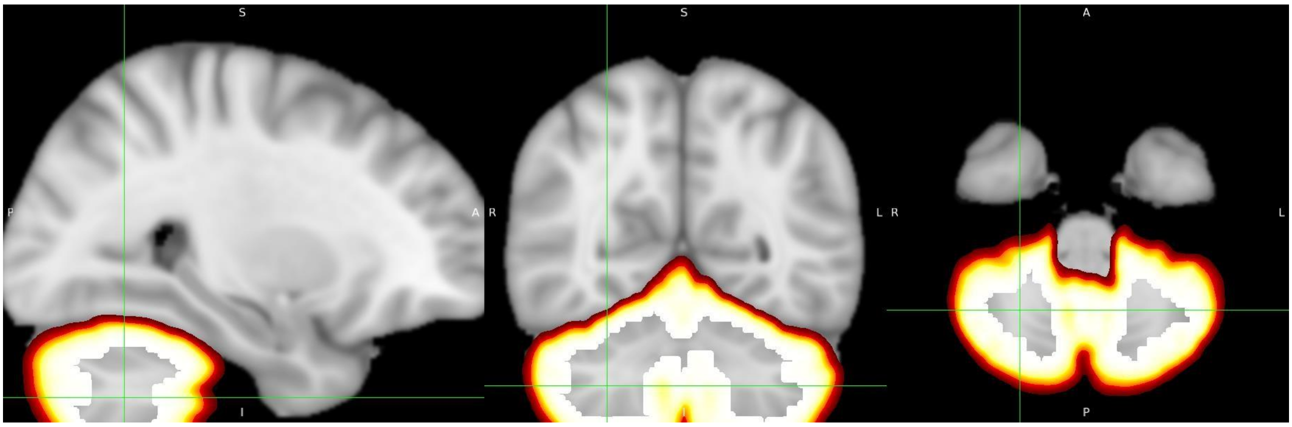


Figure 10: Cerebellum.

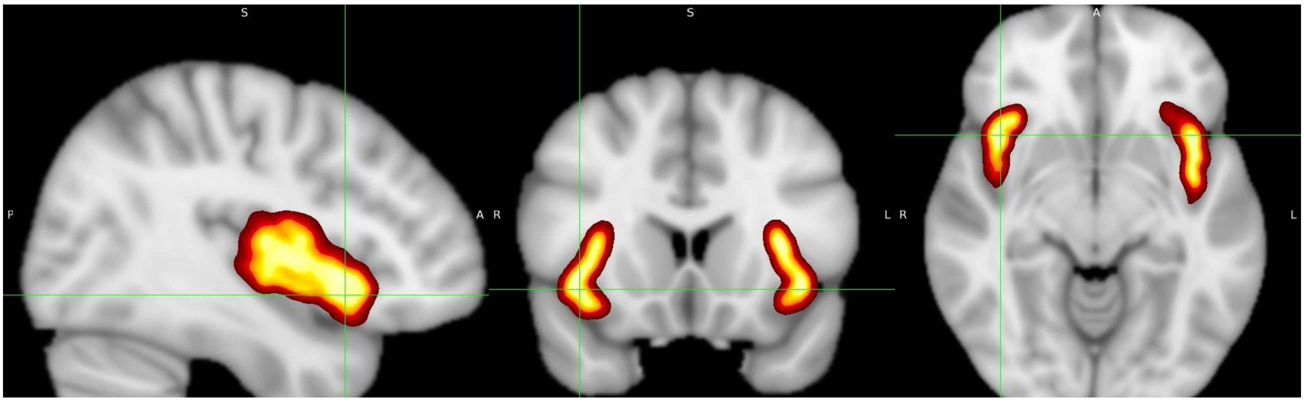


Figure 11: Insula.

Visual Cortex

Intracalcarine cortex	Primary processing of visual information.
	Initial visual perception and feature detection.
	Organization of retinotopic maps.

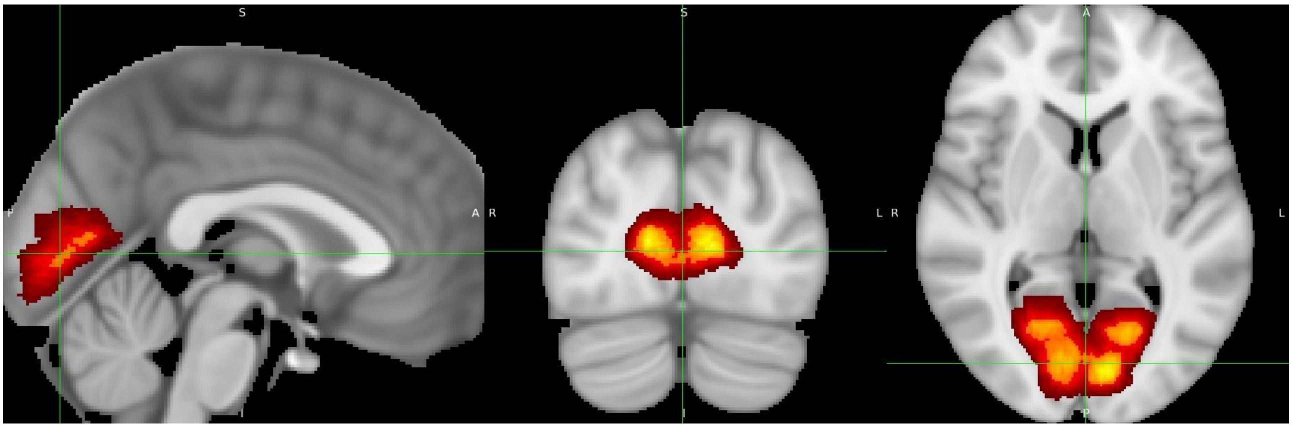


Figure 12: Intracalcarine cortex.

Conclusion:

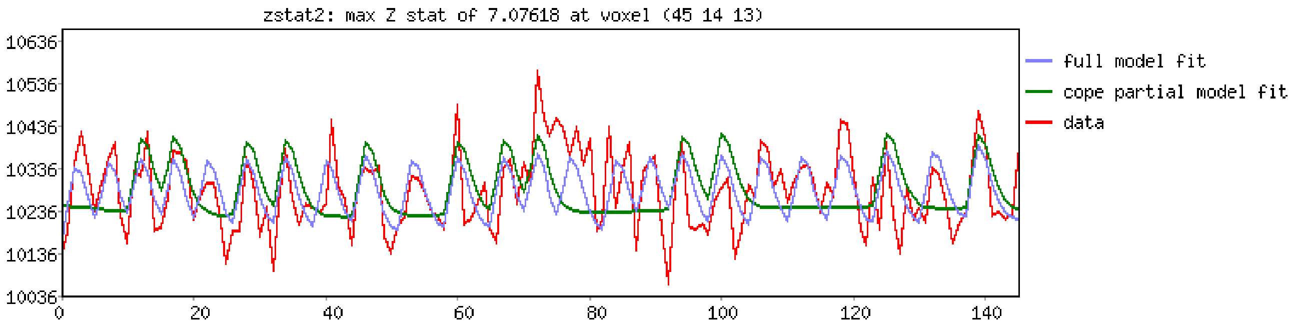
An in-depth understanding of brain anatomy and function is essential for unraveling the complexities of human cognition and behavior. By utilizing advanced imaging techniques like FSL with MNI and Harvard Atlas, researchers can explore brain regions and their functions with unprecedented detail, paving the way for advancements in neuroscience and clinical practice.

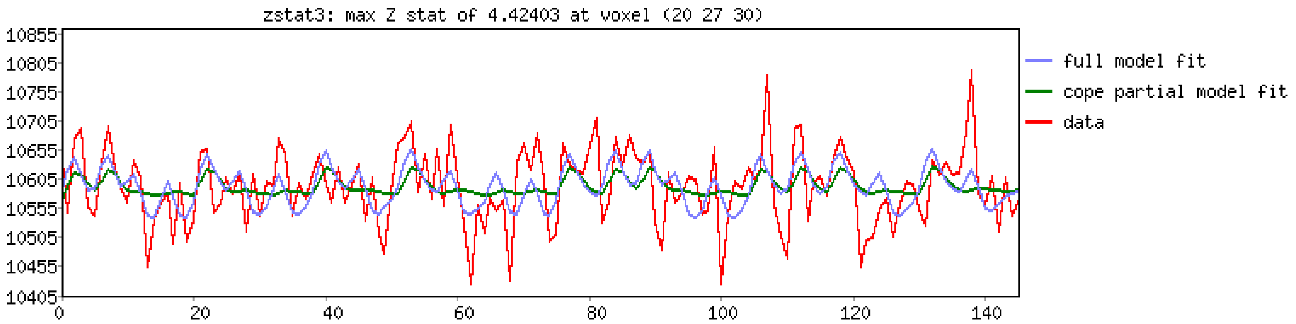
Statistics & Modeling:

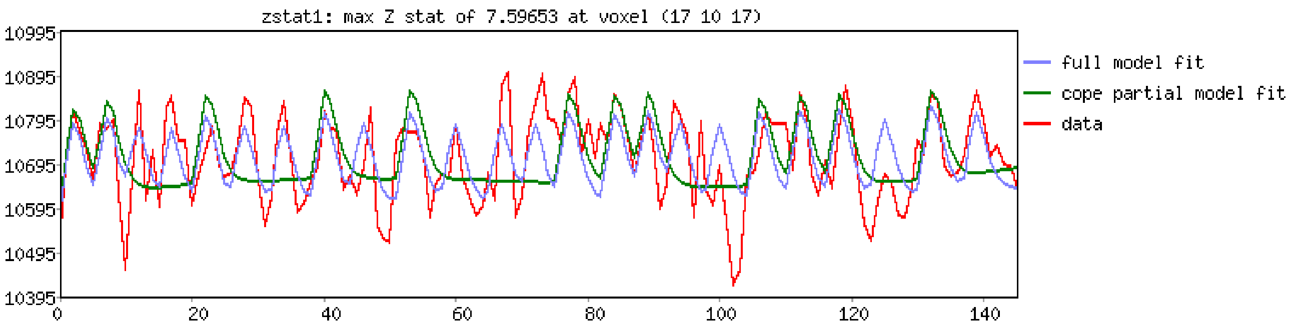
This is the last part in the preprocessing stat which we are going to model the regressors using GLM on the time-series FMRI to get the main parts of the brain which responsible of our task.

Sub-1:

Stats results:



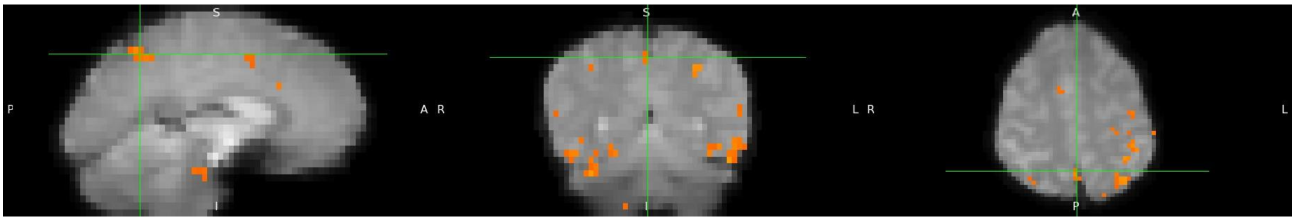




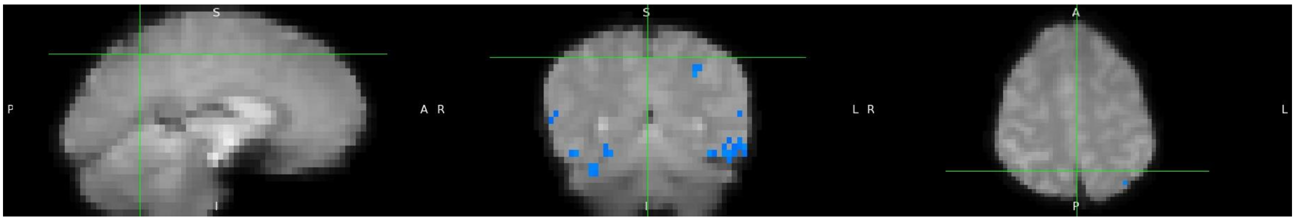
This shows the model of each contrast: incongruent, congruent and incongruent-congruent.

This shows COPE and the values for the whole time series

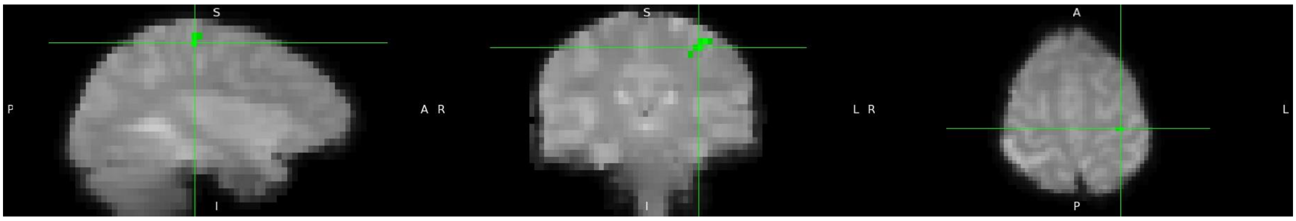
Events on filtered:



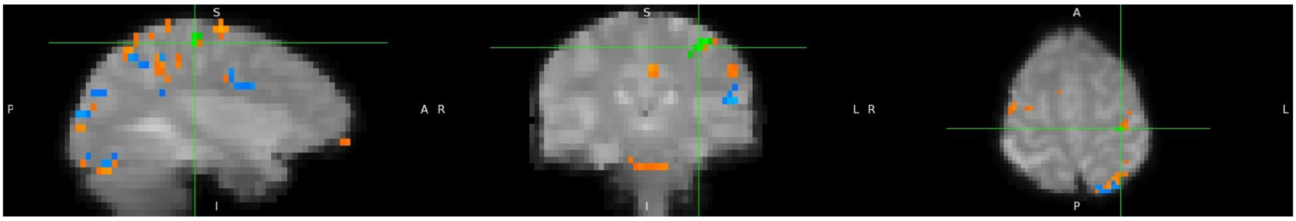
This shows the voxels most related with event 1 (incongruent)



This shows the voxels most related with event 1 (congruent)

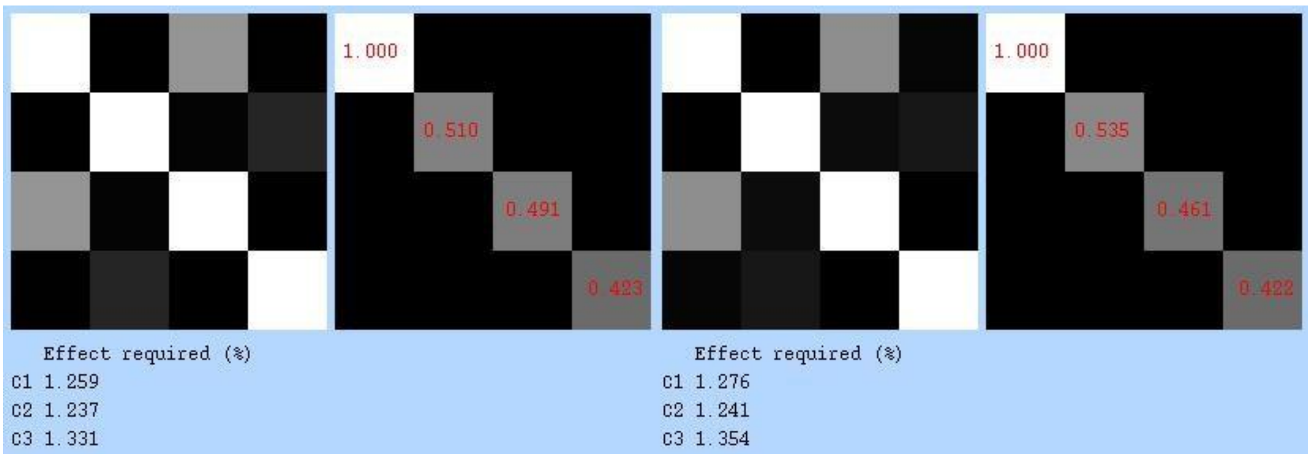


This shows the voxels most related with event 1 (incongruent)



This shows all of them together.

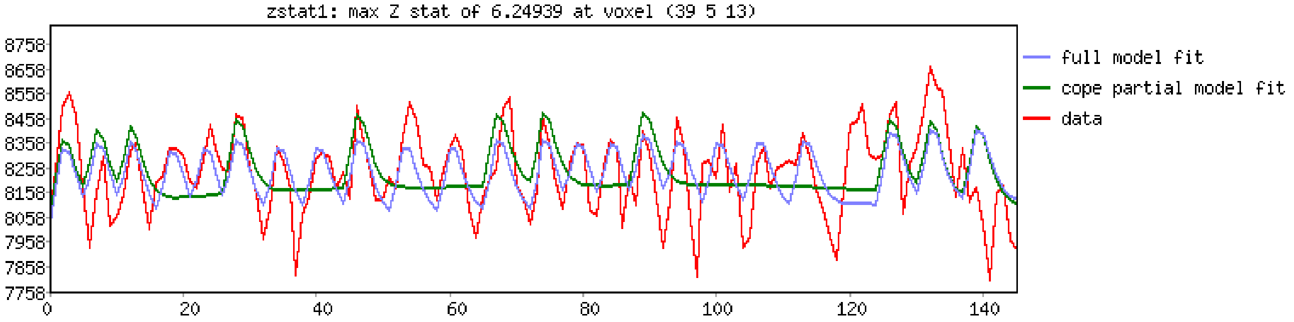
There are some shared voxels between the two events so in the 3rd contrast the marked voxels are rare.

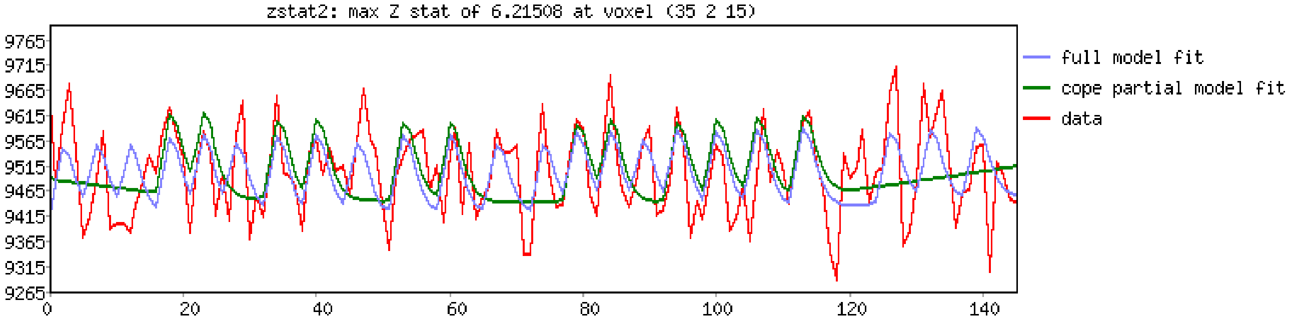


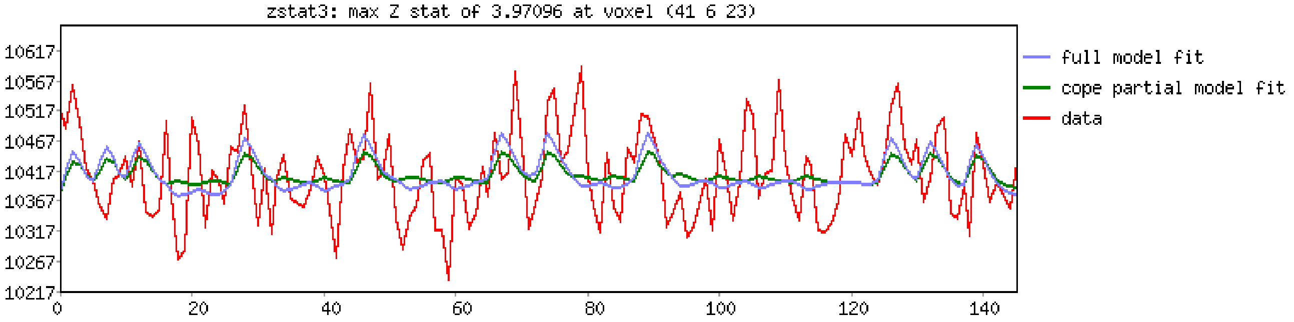
This is the cov matrix for run-1 and run-2 which is very similar and same response of the same subject.

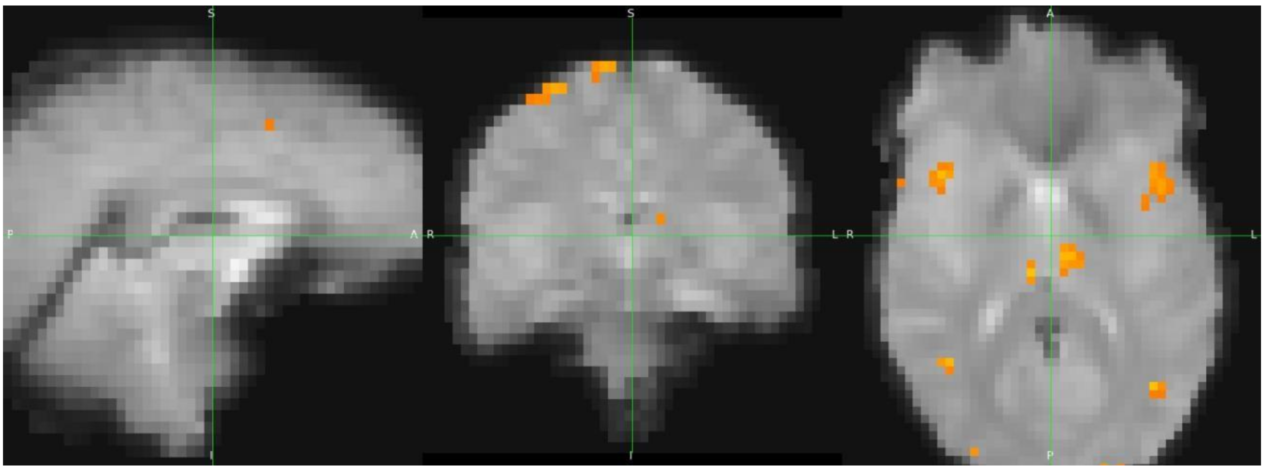
Sub-8:

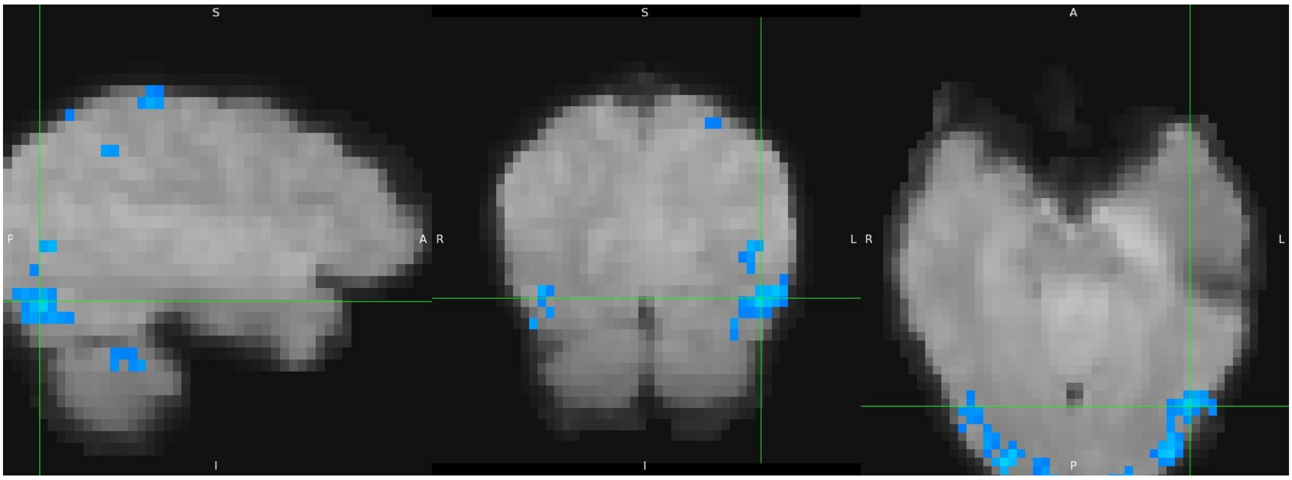
Almost the same response and result got form sub-8 and here its graphs and images:

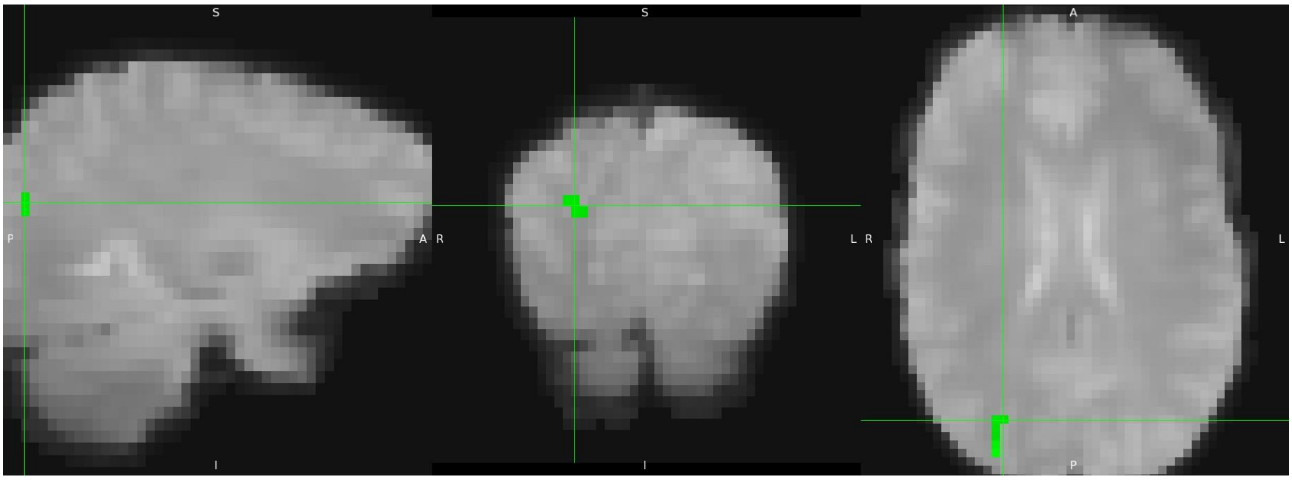


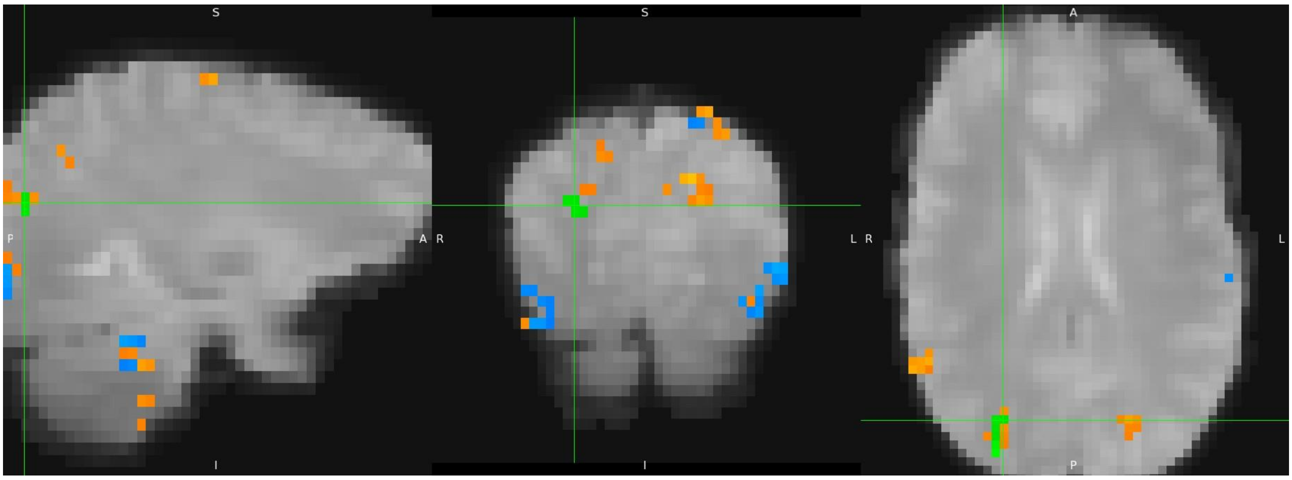




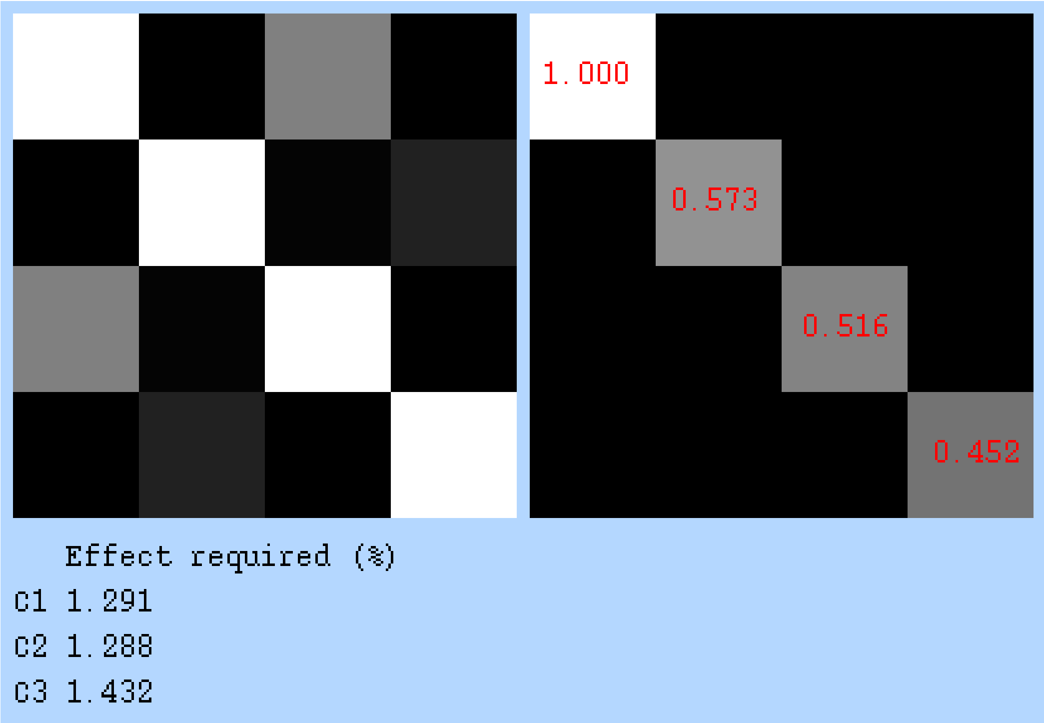








Not the same but the voxels are close.



The values are different but have the same range.

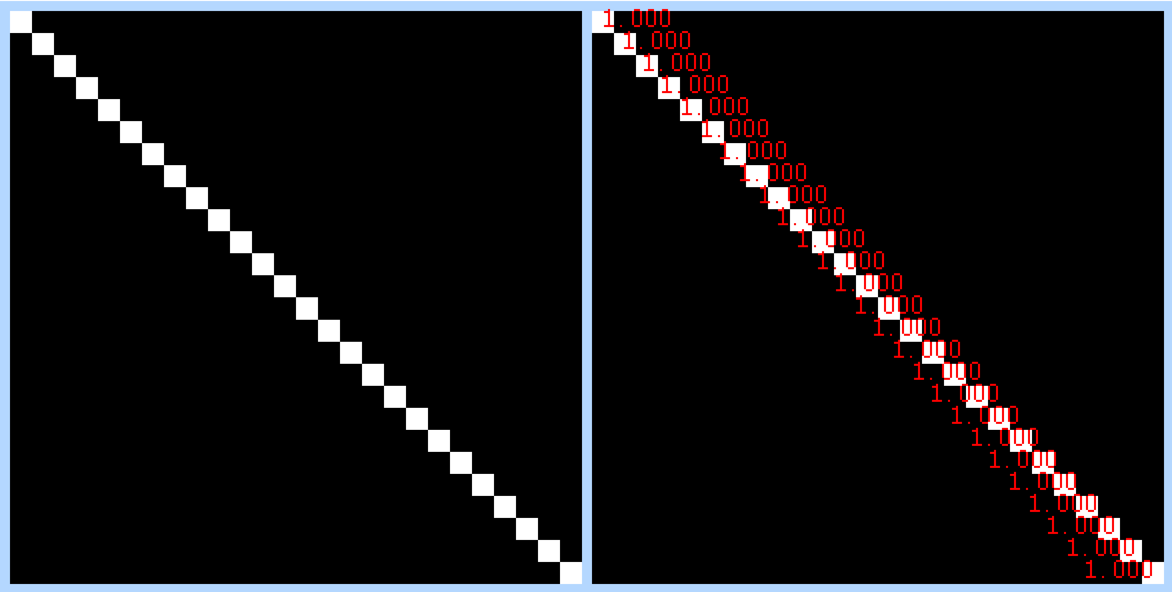
Scripting part:

After designing an fsf file to build first level analysis I start to do that for all subjects' data and for each run using bash scripting.

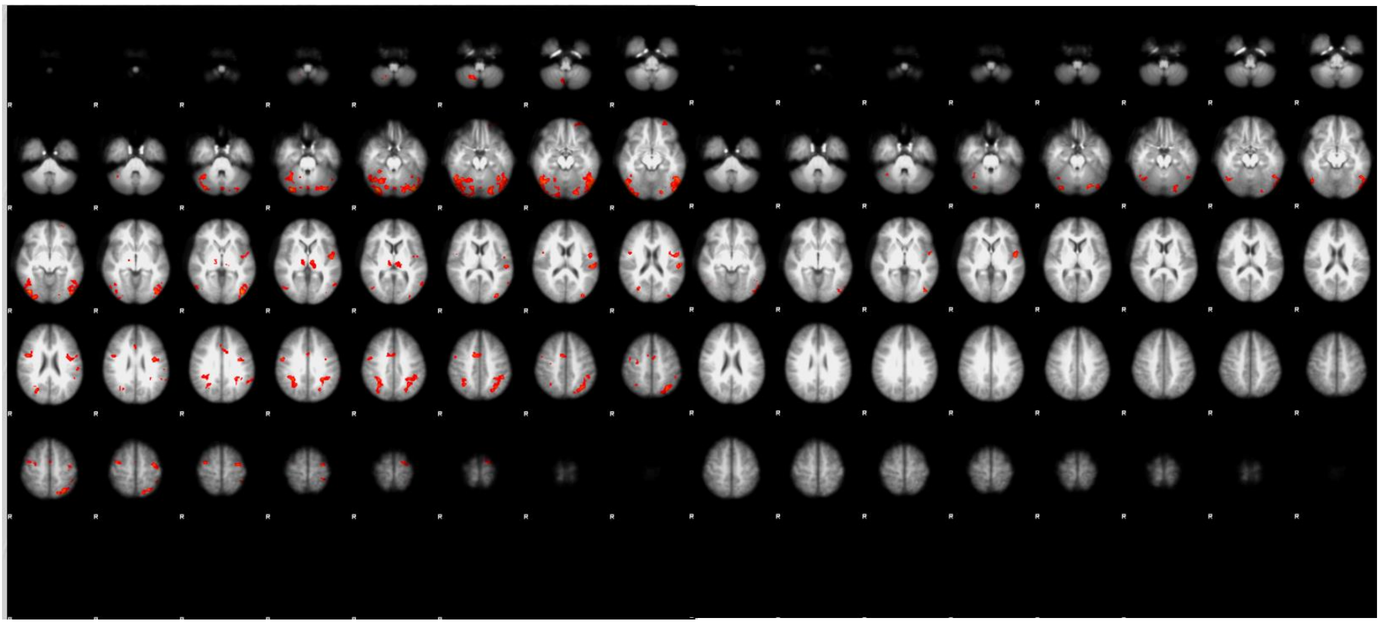
```
for i in `seq -w 2 26`
do

subj="sub-$i"

cd $subj

echo "Start working with $subj"

cp ../design_run1.fsf .
cp ../design_run2.fsf .

sed -i "s/sub-2/${subj}/g" design_run1.fsf
sed -i "s/sub-2/${subj}/g" design_run2.fsf

echo "===> Starting feat for run 1"
feat design_run1.fsf
echo "===> Starting feat for run 2"
feat design_run2.fsf

echo "--------------------------------------"

cd ..

done

echo "Finished...%100"
```

Second level analysis:

After running the bash script for all the data now we got 52 FEAT folders needs second level analysis, so I start doing that.

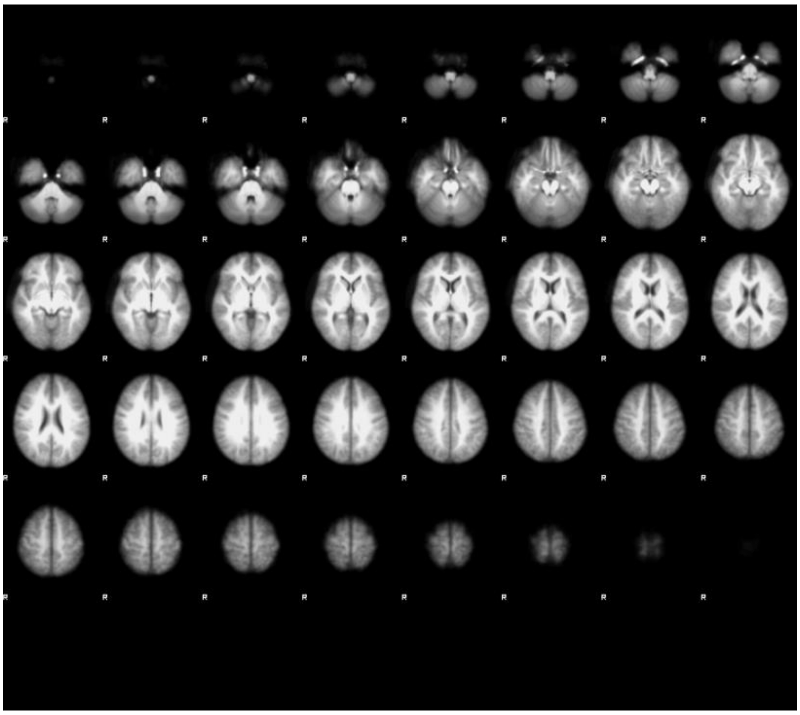


Here is the convolution matrix which was used to build the EVs and COPEs.

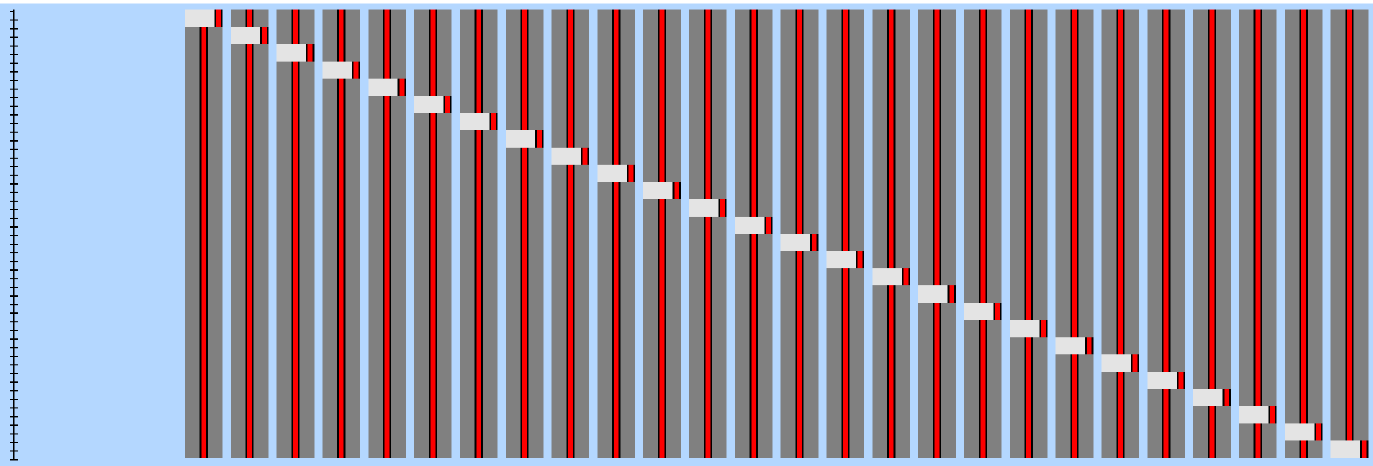


Result of incongruent and congruent events.

This for incongruent-congruent event which show that the response is very weak.



Here is the final EVs result matrix:



C1	group mean	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
C21		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
C22		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
C23		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
C24		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
C25		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
C26		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Third level analysis:

By do the 3rd level analysis with z_threshold = 3.1 and p = 0.05 the result is 7 clusters:

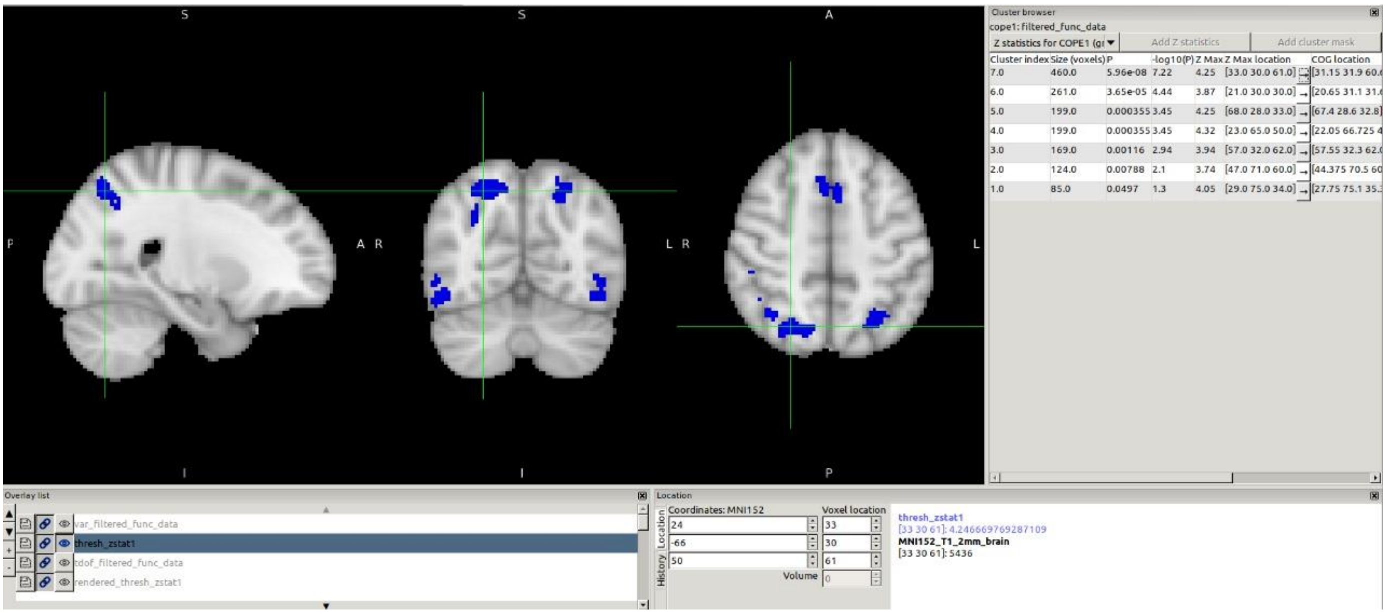
Cluster browser

cope1: filtered_func_data

Z statistics for COPE1 (group mean) | Add Z statistics | Add cluster mask

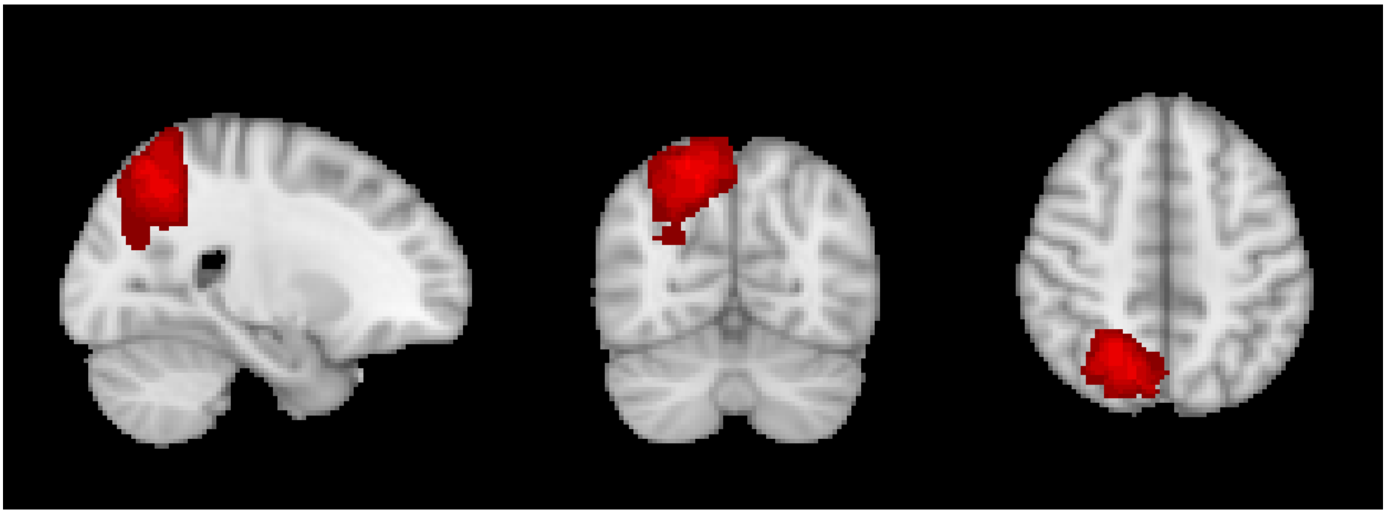
Cluster index	Size (voxels)	P	-log10(P)	Z Max	Z Max location	COG location	COPE Max	COPE Max location
7.0	460.0	5.96e-08	7.22	4.25	[33.0 30.0 61.0]	[31.15 31.9 60.6]	65.2	[38.0 28.0 63.0]
6.0	261.0	3.65e-05	4.44	3.87	[21.0 30.0 30.0]	[20.65 31.1 31.67]	61.3	[19.0 31.0 28.0]
5.0	199.0	0.000355	3.45	4.25	[68.0 28.0 33.0]	[67.4 28.6 32.8]	62.7	[68.0 28.0 29.0]
4.0	199.0	0.000355	3.45	4.32	[23.0 65.0 50.0]	[22.05 66.725 49.85]	57.6	[21.0 67.0 47.0]
3.0	169.0	0.00116	2.94	3.94	[57.0 32.0 62.0]	[57.55 32.3 62.05]	54.7	[59.0 31.0 62.0]
2.0	124.0	0.00788	2.1	3.74	[47.0 71.0 60.0]	[44.375 70.5 60.95]	56.1	[44.0 71.0 60.0]
1.0	85.0	0.0497	1.3	4.05	[29.0 75.0 34.0]	[27.75 75.1 35.39]	55.4	[29.0 75.0 34.0]

Then I used the biggest cluster to create the atlas and sphere mask for ROI part.



ROI analysis:

The Atlas Mask:

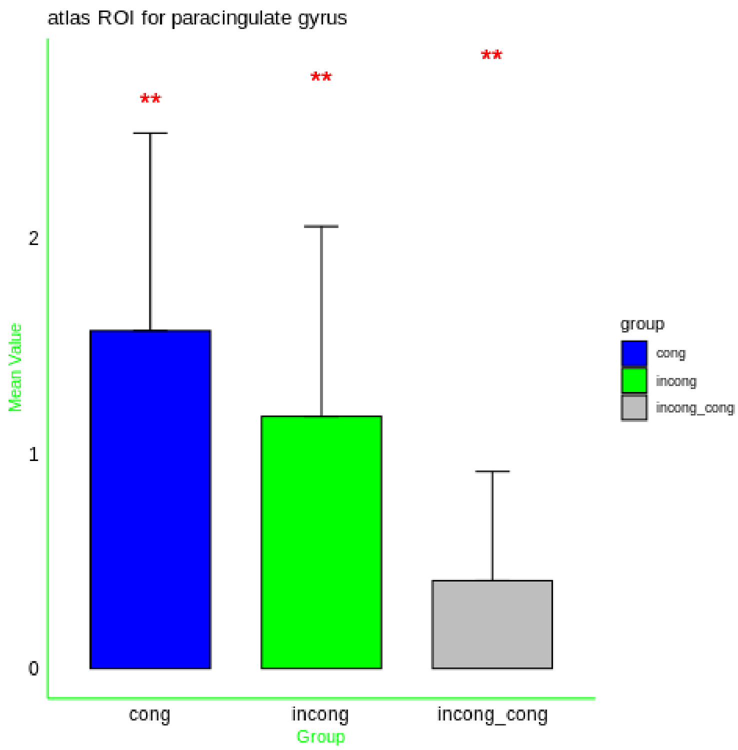


I used it to cover the biggest cluster which is at (33,30,60)

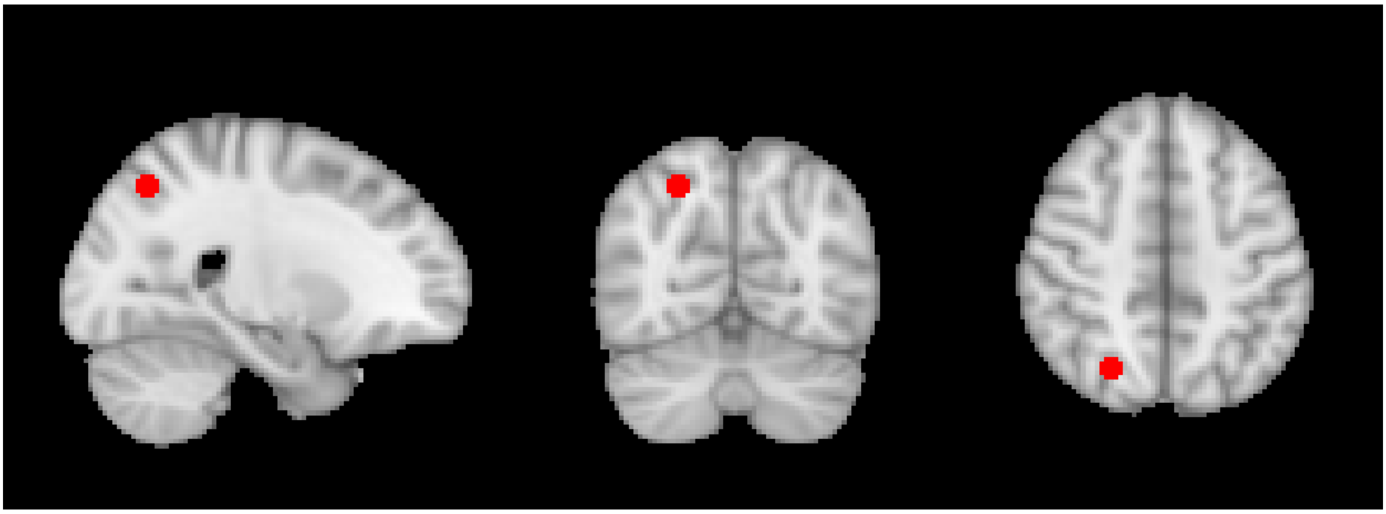
Here are the result using R for statistics:

The results are for each COPE of our 3 COPEs:

1. Incongruent
2. Congruent
3. Incongruent-congruent



The Sphere Mask:

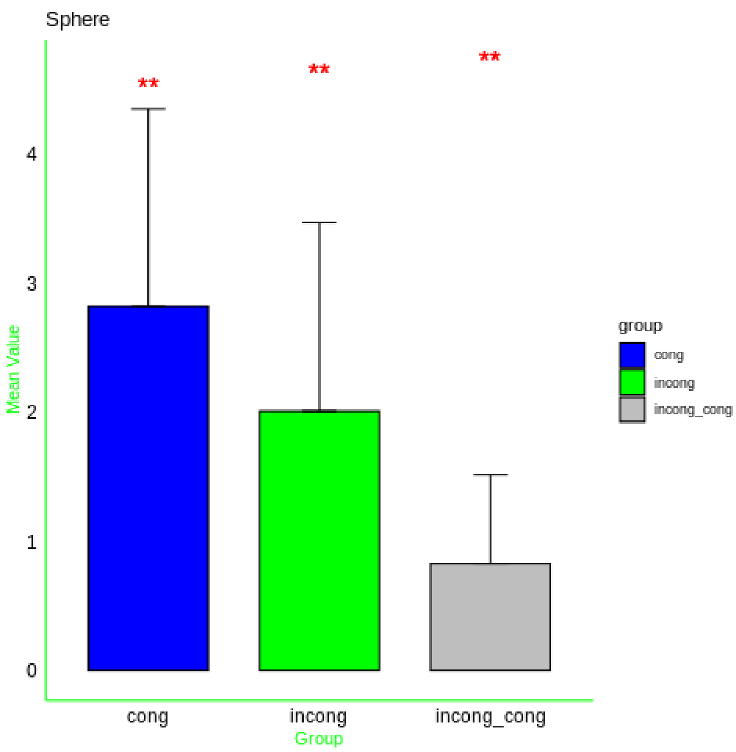


Also used to cover the biggest cluster at (33,30,60)

Here are the result using R for statistics:

The results are for each COPE of our 3 COPEs:

1. Incongruent
2. Congruent
3. Incongruent-congruent



Exercises:

When I do the 3rd level analysis using none thresholding in the post stat the whole clusters appears and the threshold file not be created

When we see COPE 3 we can know that the congruent task is a part of the incongruent task so there are many clusters in this COPE.

When I searched for the meaning of deactivation I found the following:

- <u>Resting-State Studies</u>: Deactivation patterns help in understanding the resting-state networks and their role in brain function.
- <u>Task-Based Studies</u>: Deactivation provides insights into which brain regions are being down-regulated to facilitate task performance.
- <u>Clinical Applications</u>: Abnormal patterns of deactivation (or lack thereof) can be indicative of various neurological or psychiatric conditions.
- Deactivation in fMRI images reveals important information about how the brain modulates its activity to optimize performance, manage resources, and maintain efficient functioning.

Conclusion:

The analysis of fMRI data from the flanker task revealed distinct brain activation clusters, each corresponding to different cognitive processes. The anterior cingulate cortex (ACC) showed increased activation during incongruent trials, indicating its role in conflict monitoring. The dorsolateral prefrontal cortex (DLPFC) was active in both trial types, reflecting its function in cognitive control. The posterior parietal cortex (PPC) and the supplementary motor area (SMA) were more active during incongruent trials and response execution phases, respectively, highlighting their roles in attention and motor planning. Lastly, the occipital cortex was engaged during visual processing stages, emphasizing its role in visual stimulus processing. These patterns demonstrate the dynamic engagement of brain regions in managing the task's cognitive demands.