

Assignment-3(COL786)

(Entry No:-2020CSY7576, Shivansh Chandra Tripathi)

1) First Level Analysis

Preprocessing and registration

a)Brain Extraction all anatomical images were brain extracted before the first level analysis in `feat_gui` using the Brain Extraction Tool, all these images were used during registration of the bold images. The Bold images were brain extracted as well before feeding in `feat_gui` during first level analysis.

b)Spatial smoothing using 4mm FWHM.

c)Temporal Filtering using 100s high pass filter cutoff.

d)Motion Correction using the MCFLIRT motion correction tool.

e)Linear Registration using the standard 2mm MNI brain template.

Generating Contrasts

The 8 Explanatory Variables are used: (The two extra EVs `audio_computation` and `video_computation` given in Assignment-3 weren't used in contrasts hence not considered)

EV1- audio left hand

EV2- audio right hand

EV3- audio sentence

EV4- horizontal checkerboard

EV5- vertical checkerboard

EV6- video left hand

EV7- video right hand

EV8- video sentence

The number of inputs in first level analysis was 30 which generated 30 “*.feat” files after `feat_gui` was run.

2) Higher Level Analysis

The 30 lower level feat directories were fed to the feat_gui for higher level analysis and the contrast is set to study the mean group effect of the lower level contrasts as depicted in the figure below:

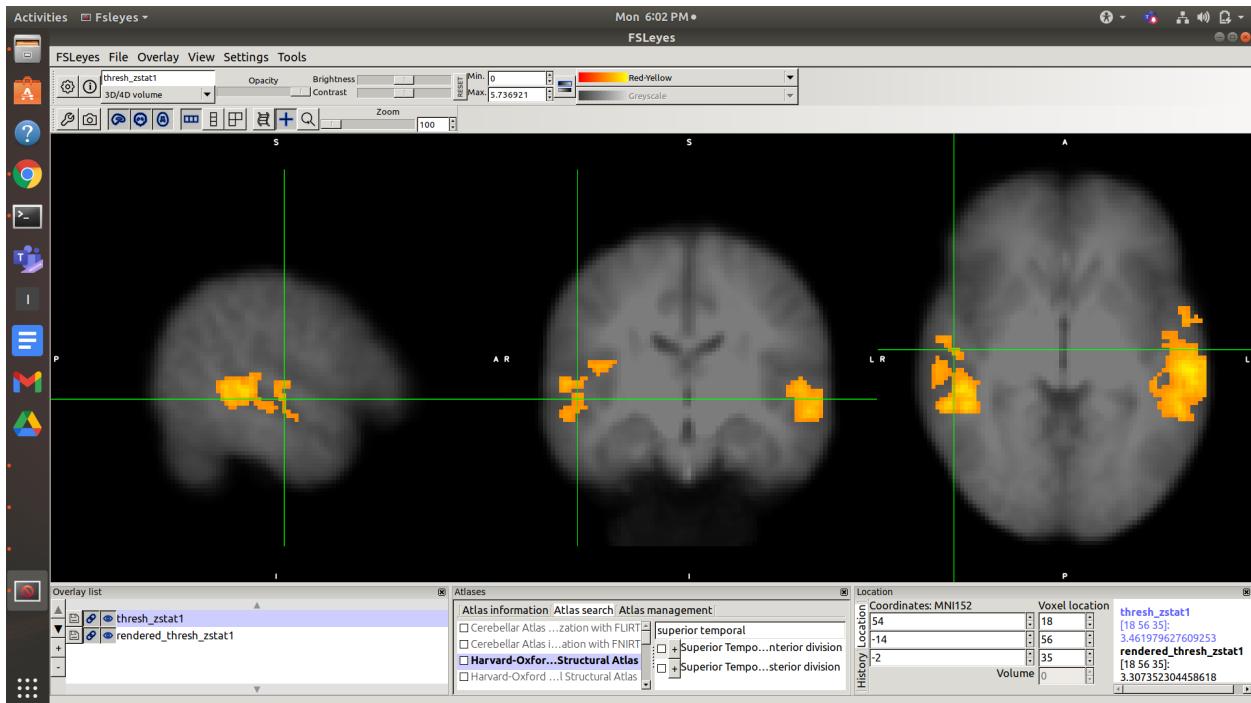
| EVs Contrasts & F-tests | | |
|-------------------------|---|-----|
| | Number of main EVs | 1 |
| | Number of additional, voxel-dependent EVs | 0 |
| Paste | Group | EV1 |
| Input 1 | 1 | 1 |
| Input 2 | 1 | 1.0 |
| Input 3 | 1 | 1.0 |
| Input 4 | 1 | 1.0 |
| Input 5 | 1 | 1.0 |
| Input 6 | 1 | 1.0 |
| Input 7 | 1 | 1.0 |
| Input 8 | 1 | 1.0 |
| Input 9 | 1 | 1.0 |
| Input 10 | 1 | 1.0 |
| Input 11 | 1 | 1.0 |
| Input 12 | 1 | 1.0 |
| Input 13 | 1 | 1.0 |
| Input 14 | 1 | 1.0 |
| Input 15 | 1 | 1.0 |
| Input 16 | 1 | 1.0 |
| Input 17 | 1 | 1.0 |
| Input 18 | 1 | 1.0 |
| Input 19 | 1 | 1.0 |
| Input 20 | 1 | 1.0 |
| Input 21 | 1 | 1.0 |
| Input 22 | 1 | 1.0 |
| Input 23 | 1 | 1.0 |
| Input 24 | 1 | 1.0 |
| Input 25 | 1 | 1.0 |
| Input 26 | 1 | 1.0 |
| Input 27 | 1 | 1.0 |
| Input 28 | 1 | 1.0 |
| Input 29 | 1 | 1.0 |
| Input 30 | 1 | 1.0 |

| EVs Contrasts & F-tests | | |
|-------------------------|------------|-----|
| | Contrasts | 1 |
| | F-tests | 0 |
| Paste | Title | EV1 |
| C1 | group mean | 1 |

The average activations of the following contrasts are shown below(using an atlas to find a particular location):

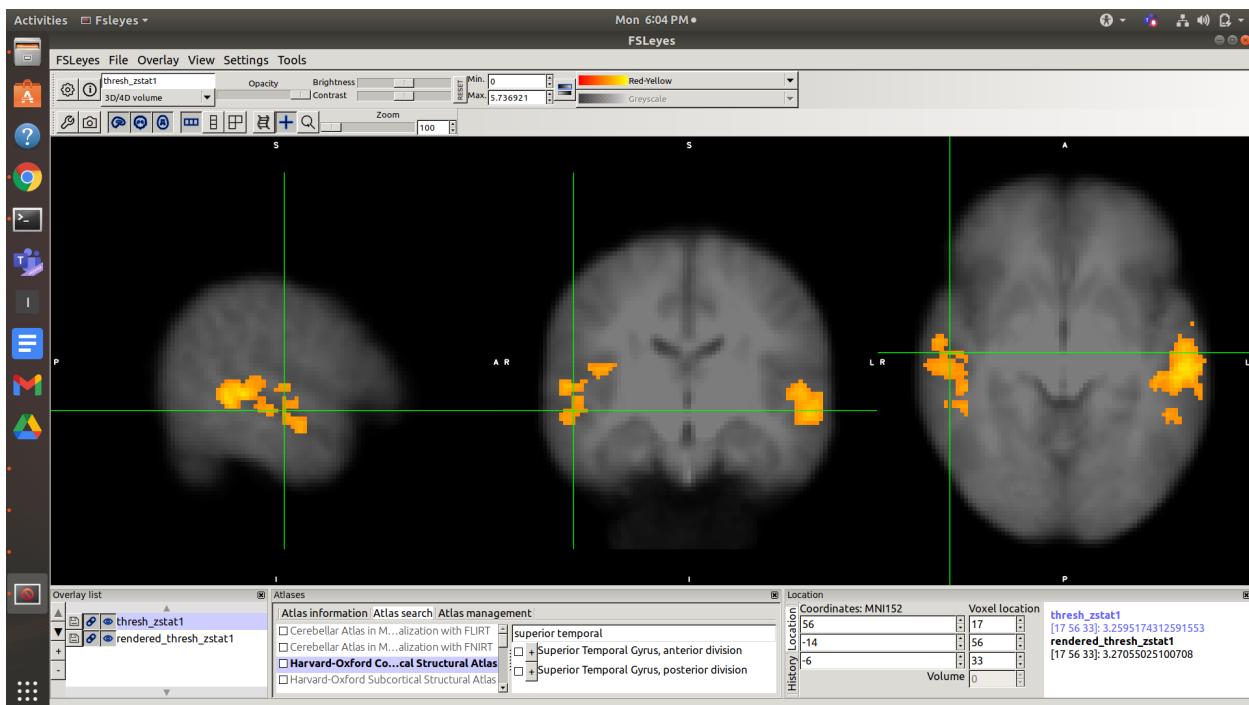
a)video sentences- checkerboard (EV8 - EV4 - EV5)

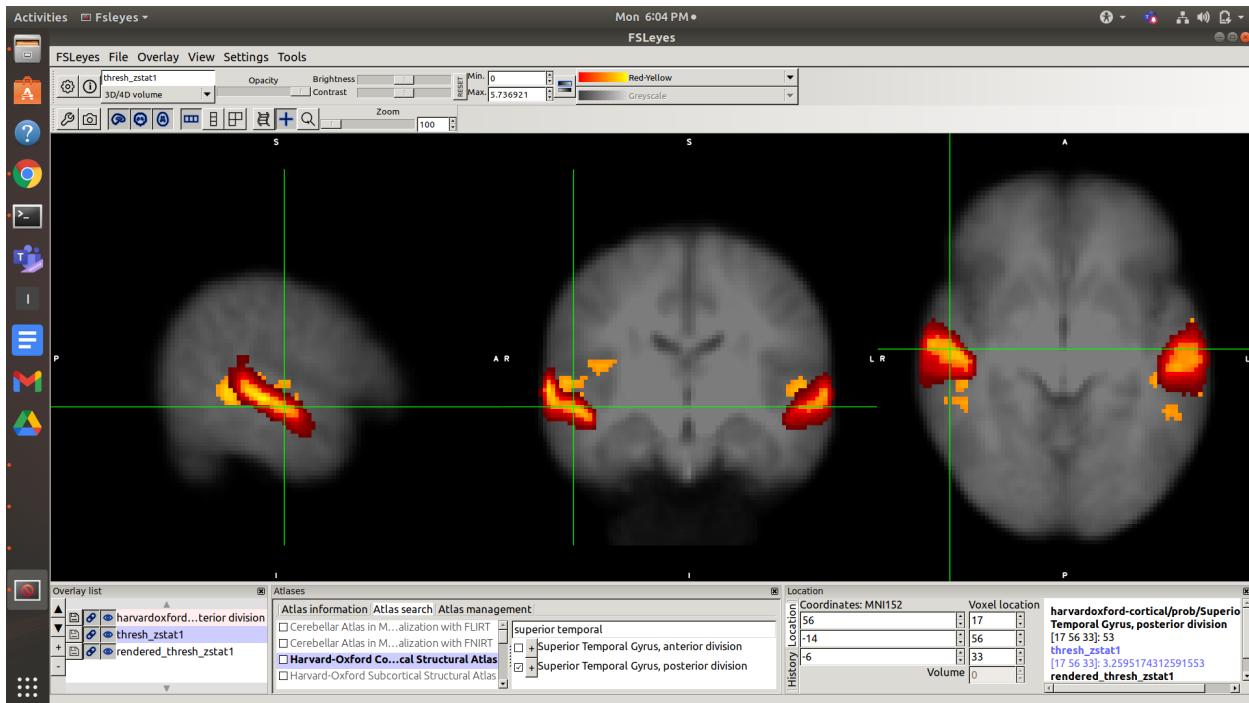
Superior temporal gyrus, anterior division



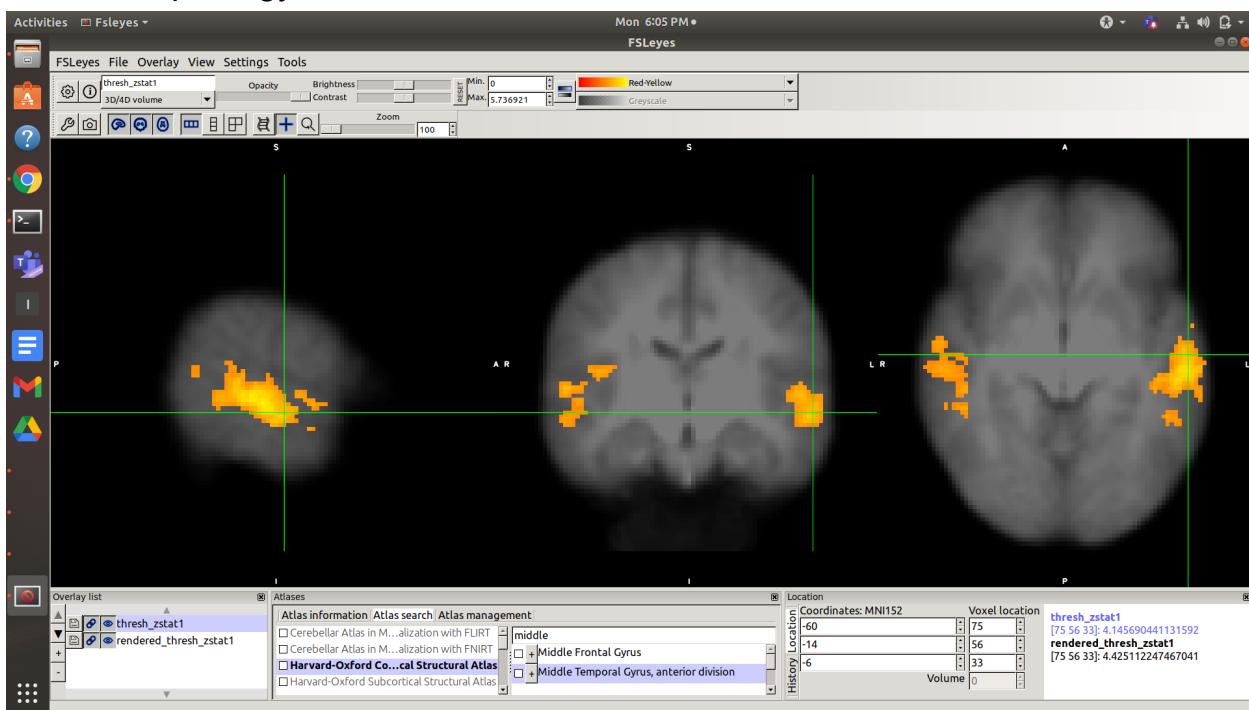


Superior temporal gyrus, posterior division



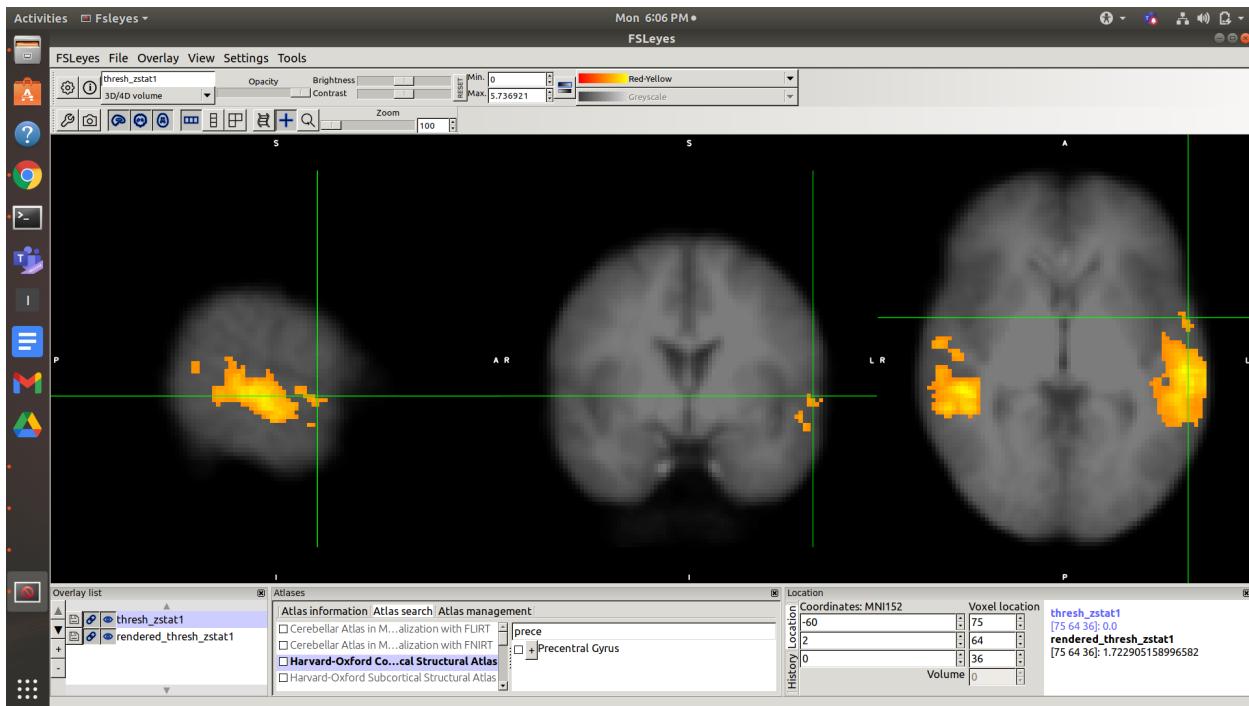


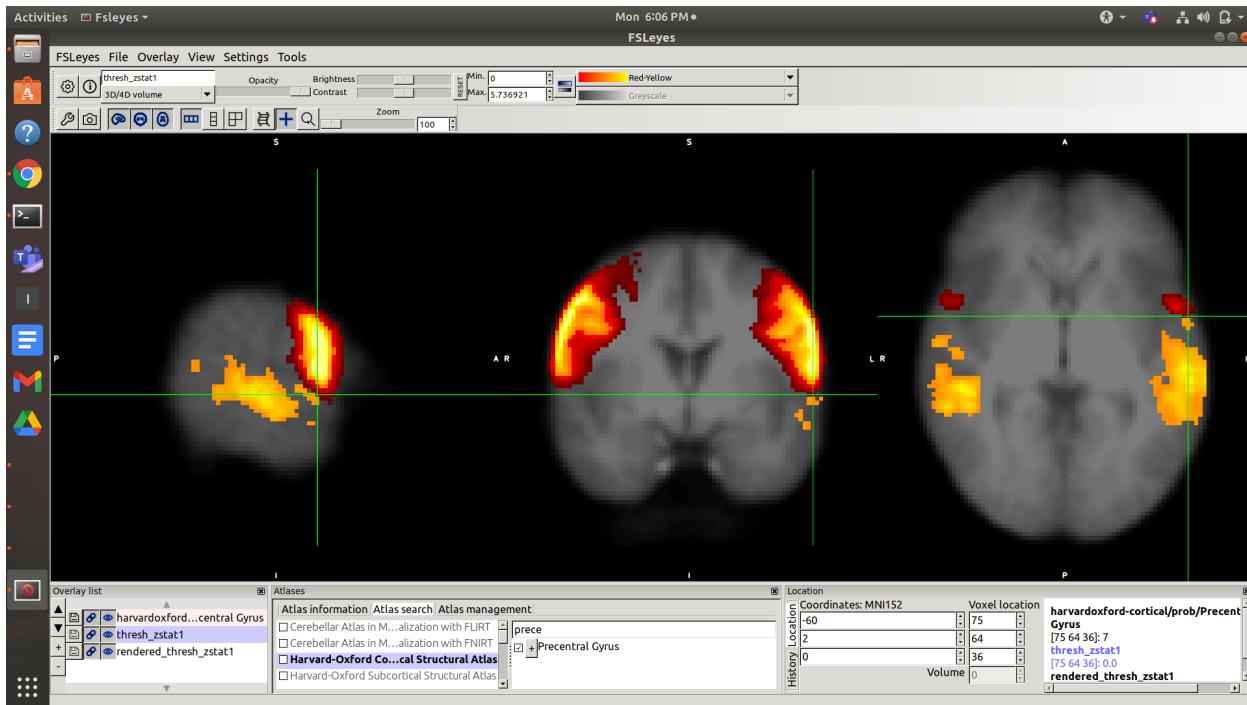
Middle temporal gyrus, anterior division



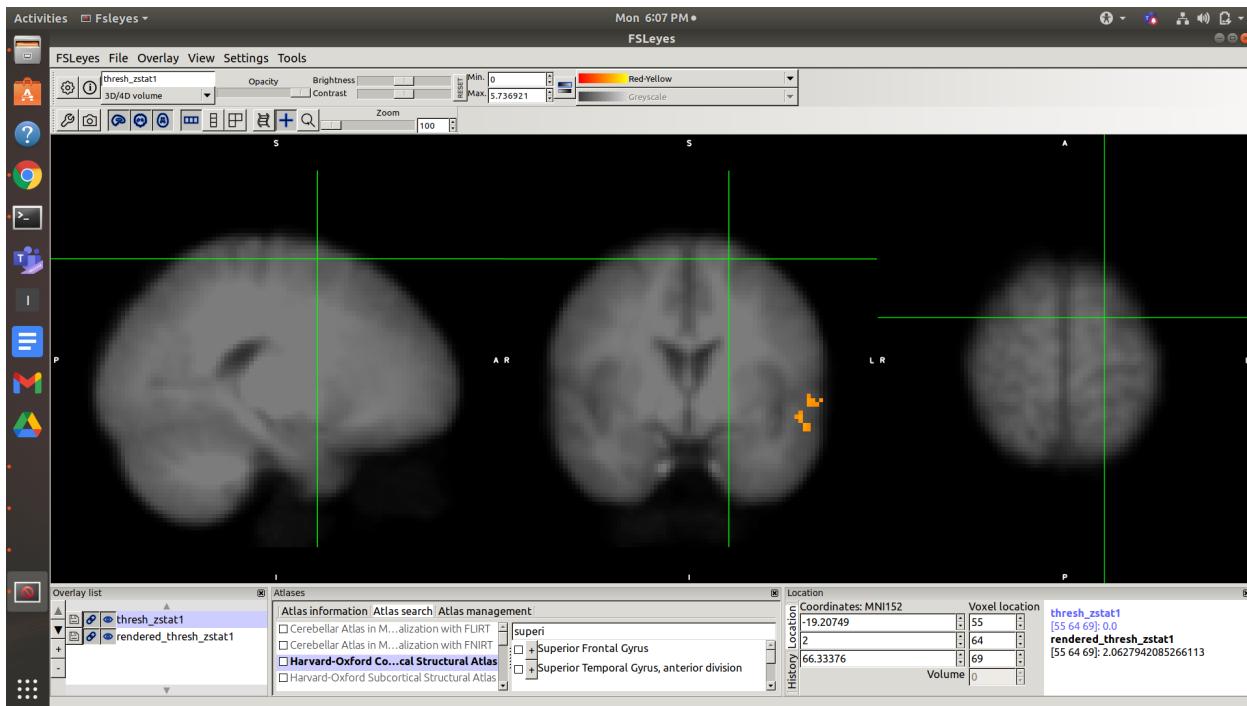


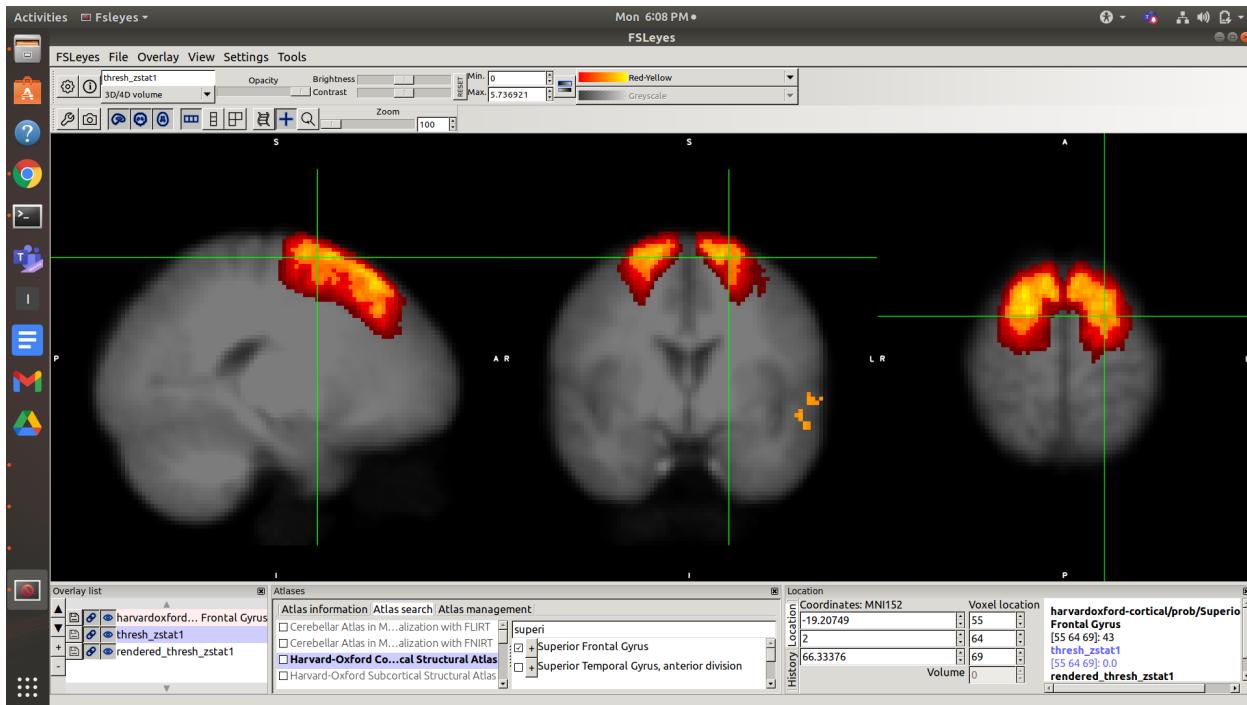
Precentral gyrus



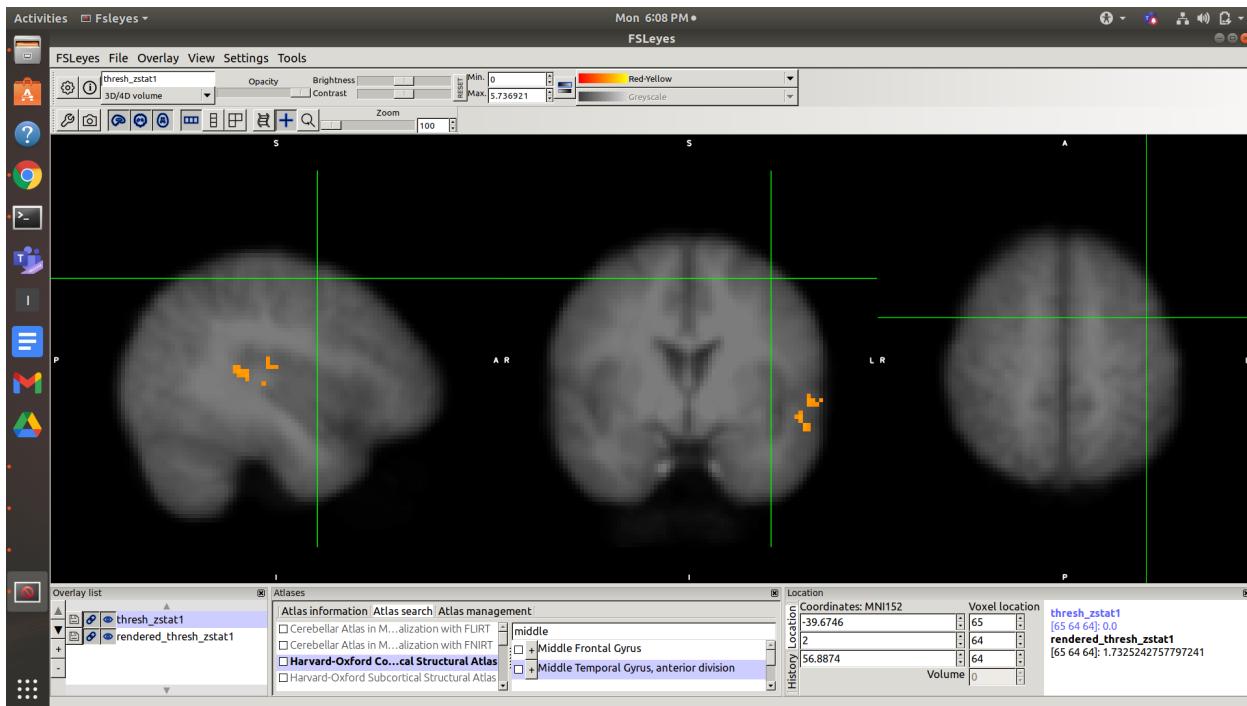


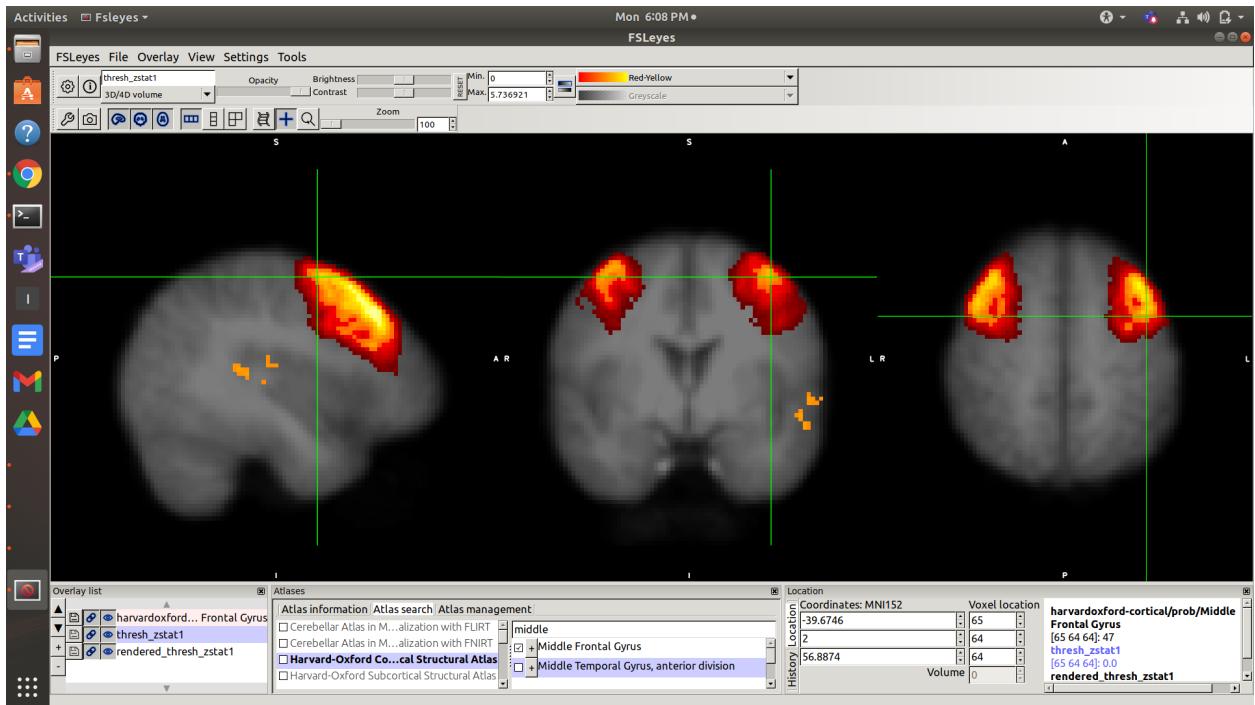
Superior frontal gyrus





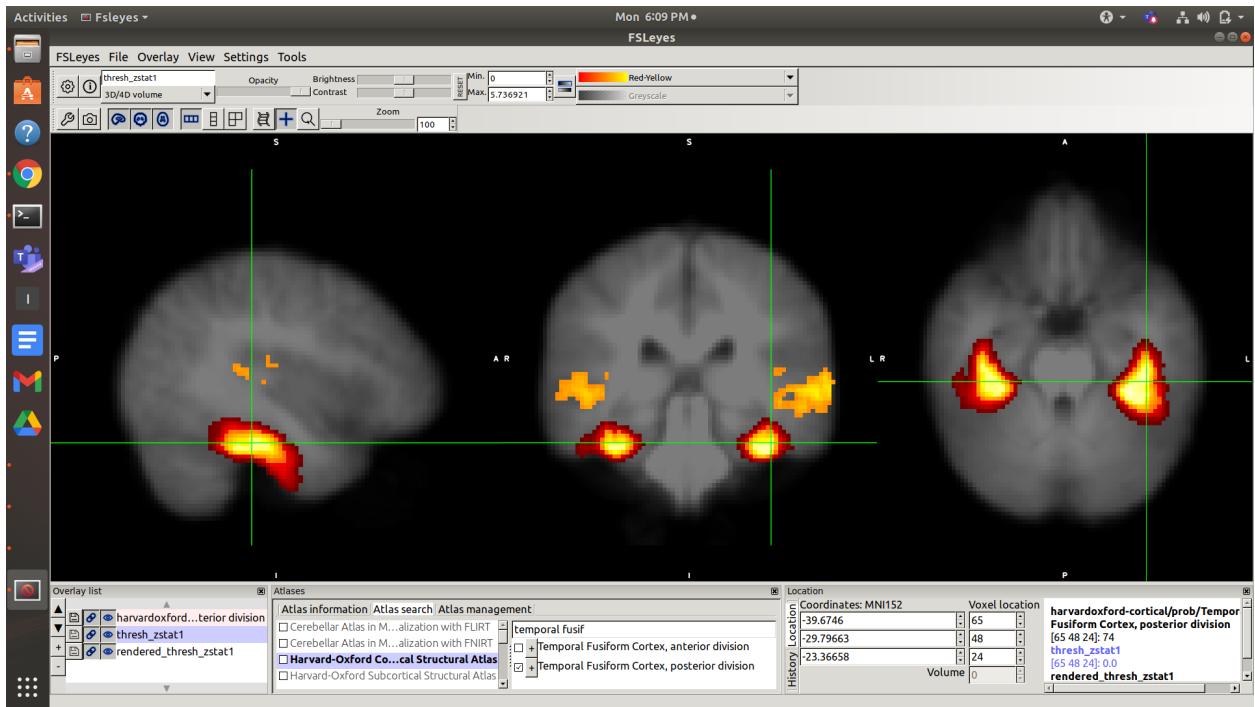
Middle frontal gyrus





Temporal fusiform cortex, posterior division



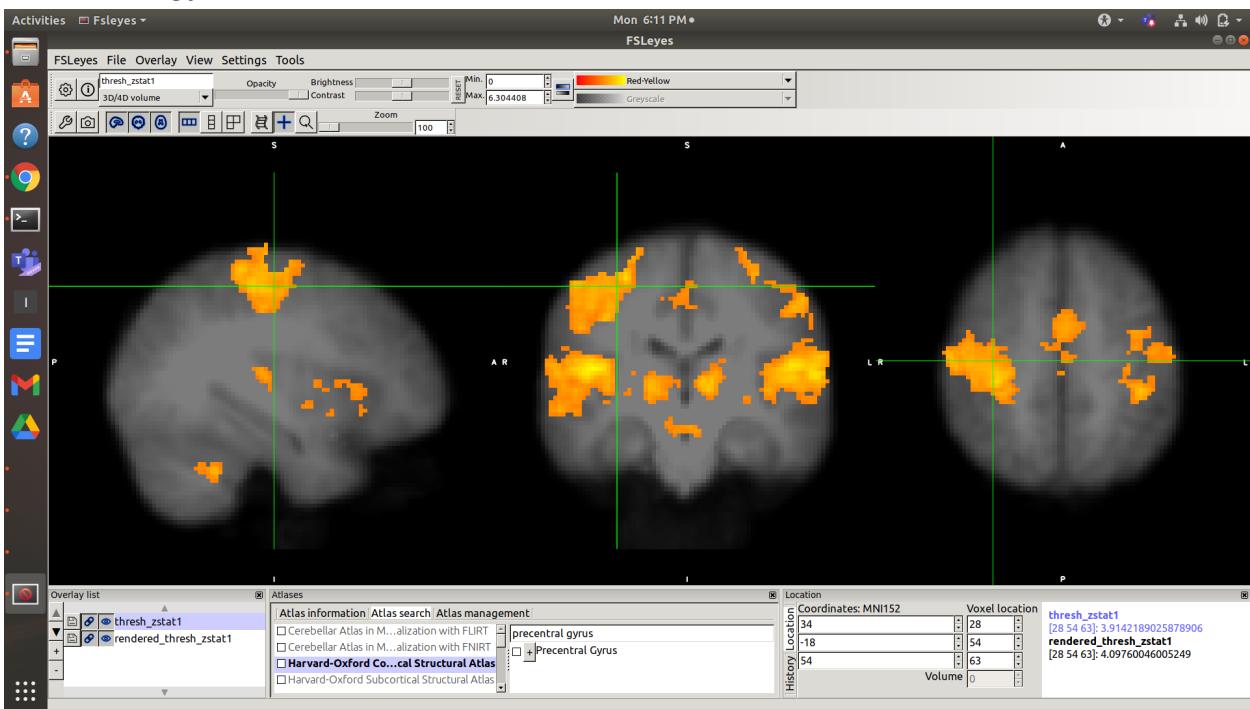


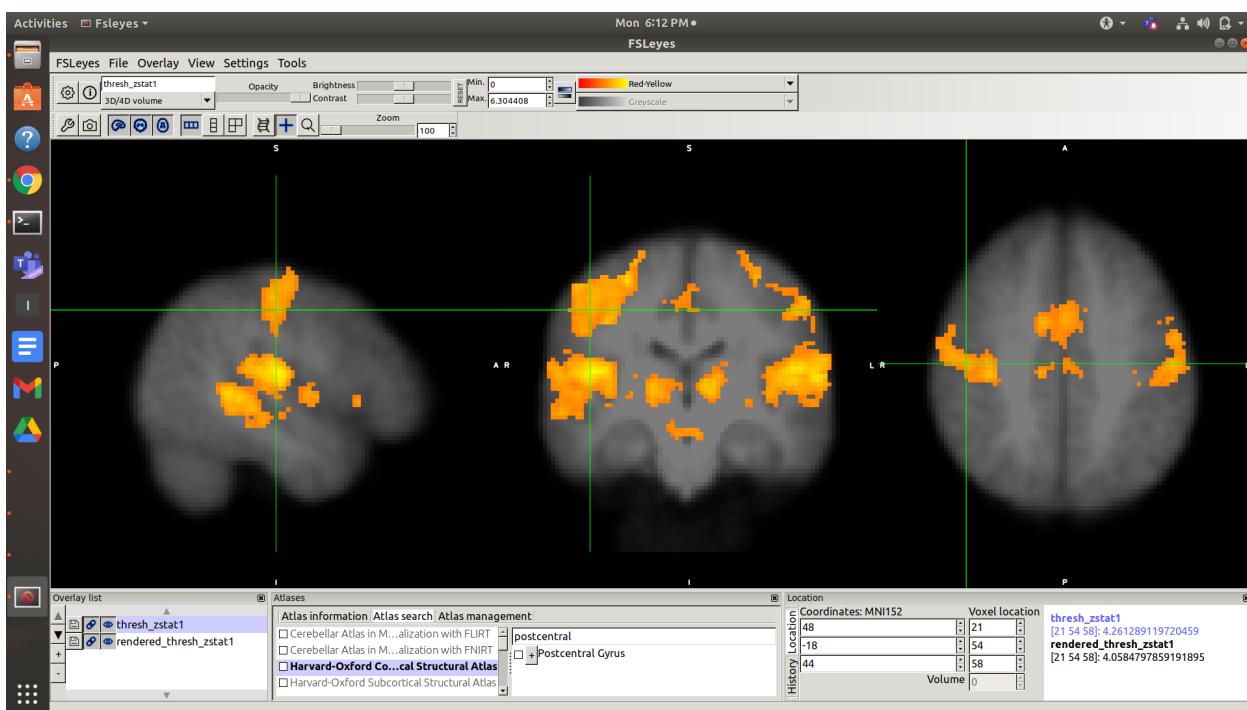
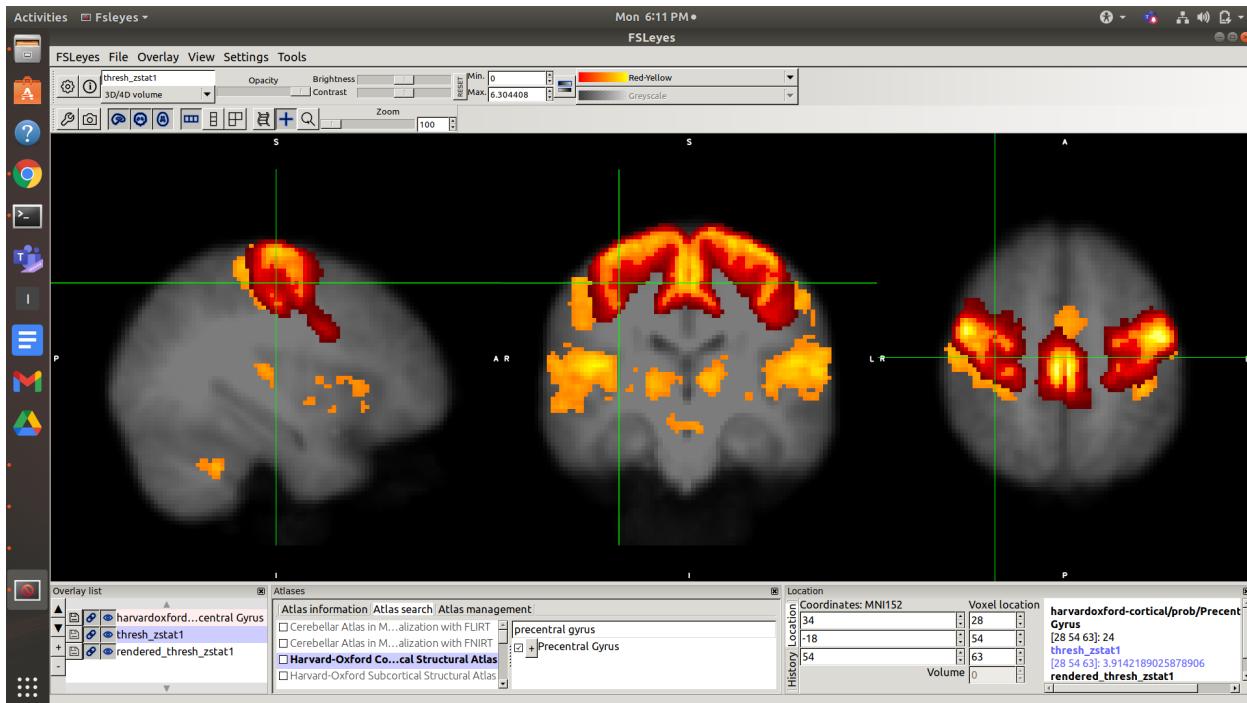
Right hippocampus

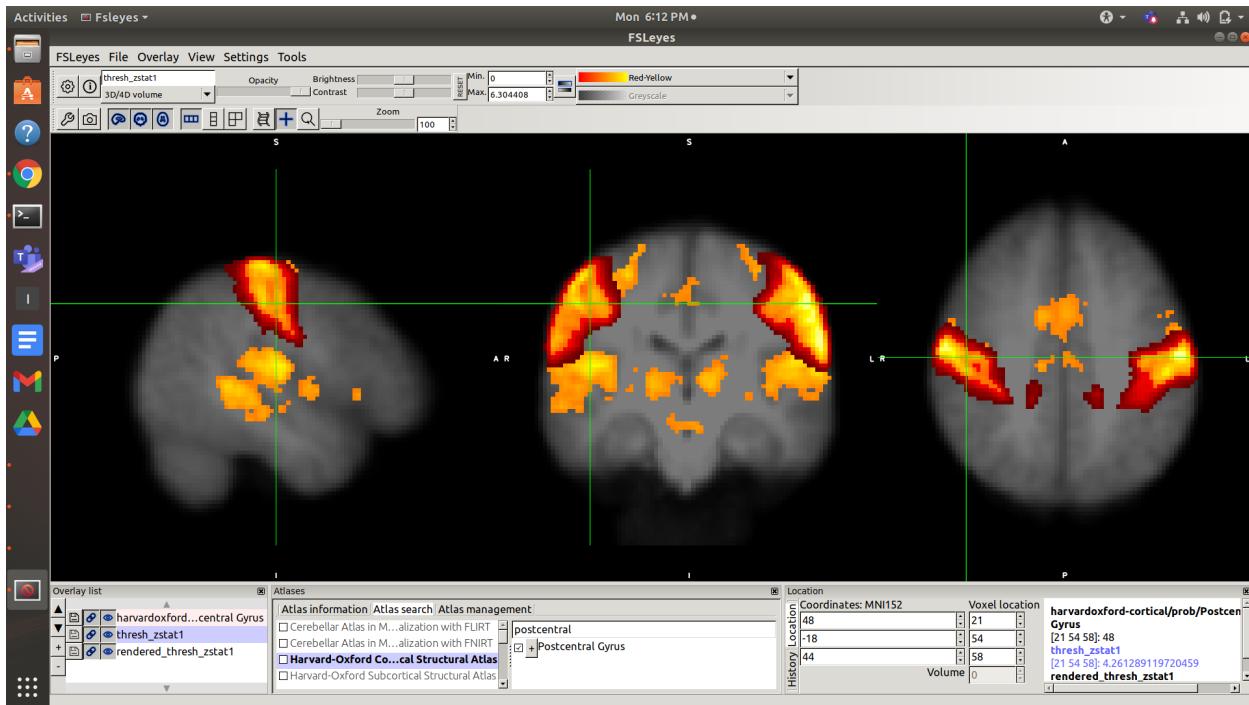


b)video left motor- checkerboard (EV6 - EV4 - EV5)

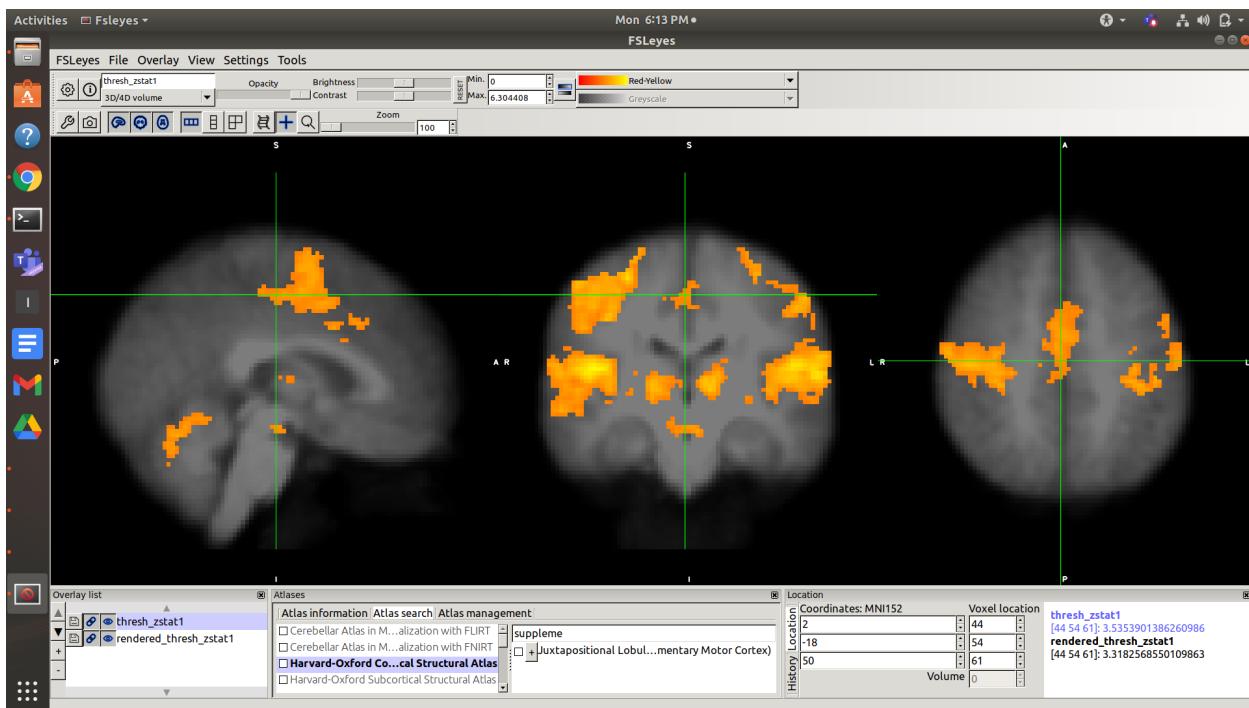
Precentral gyrus



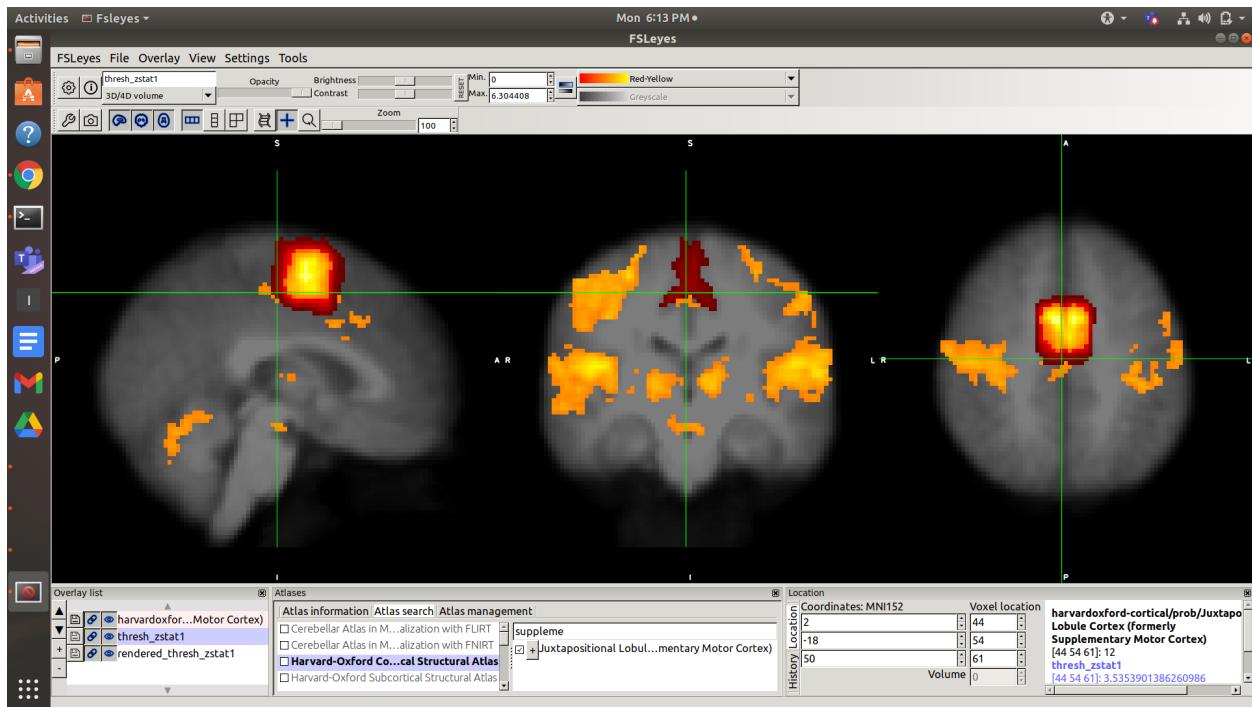




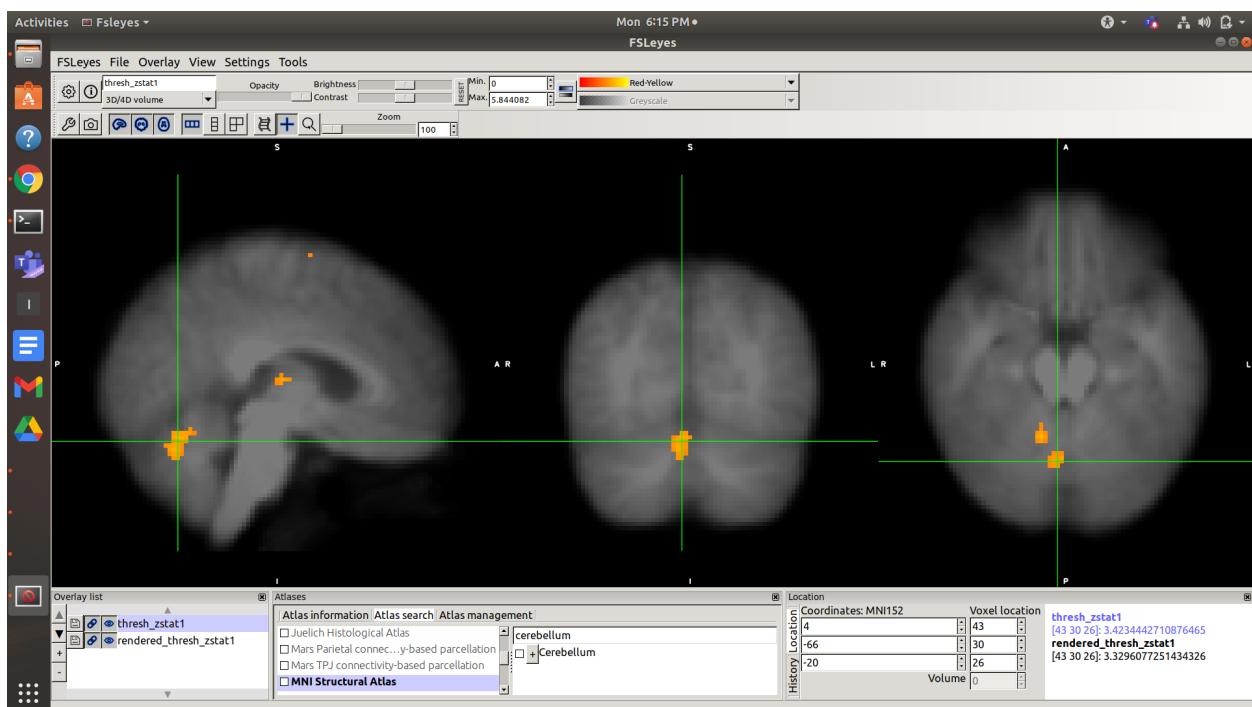
Postcentral gyrus



Supplementary motor cortex



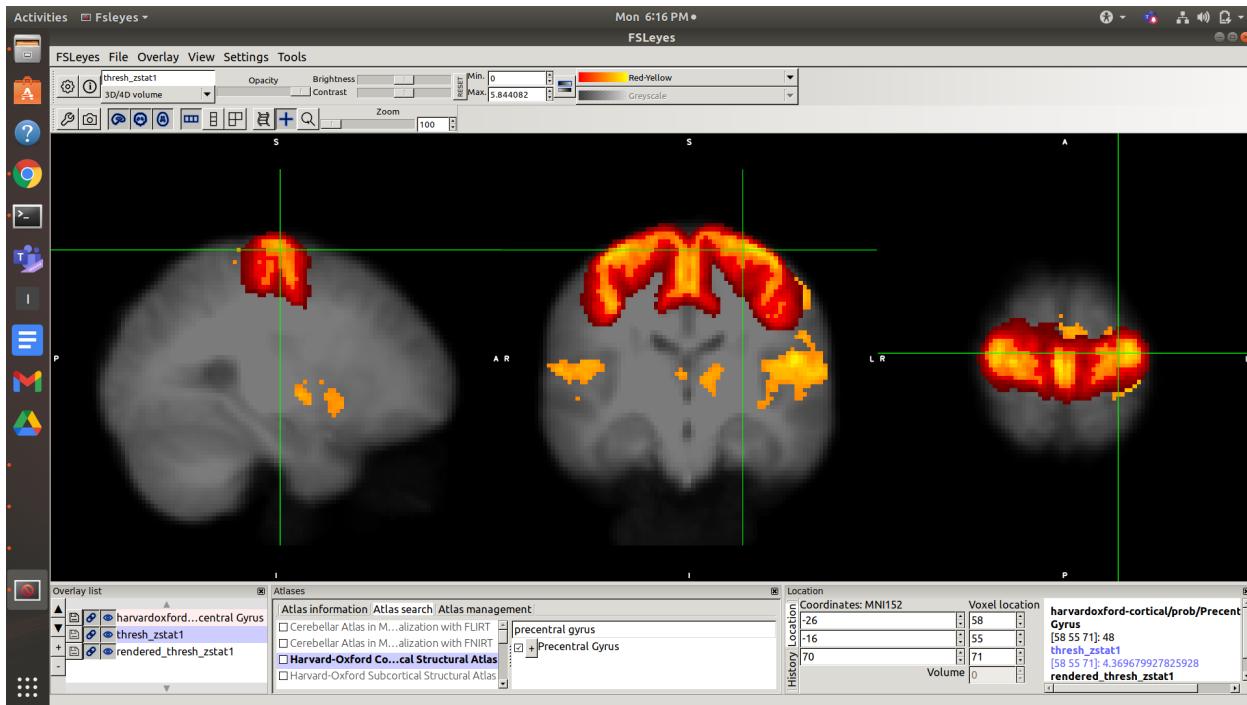
c)video right motor- checkerboard (EV7 - EV4 - EV5)
cerebellum



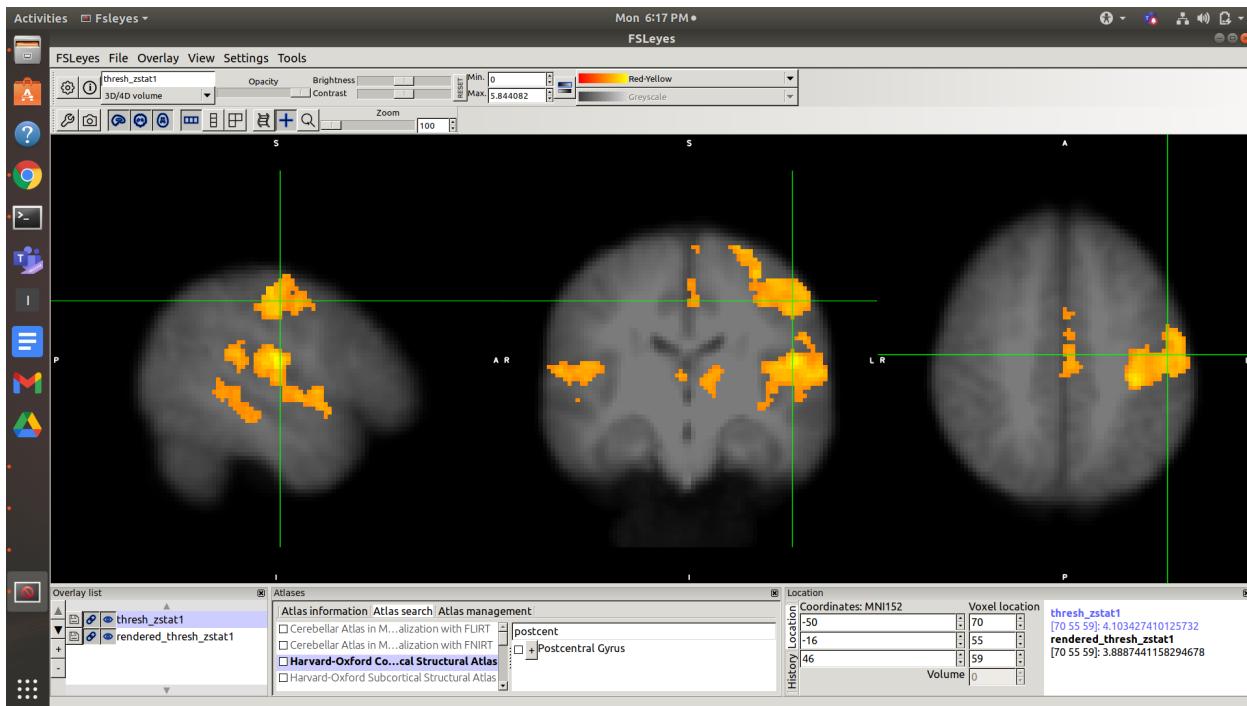


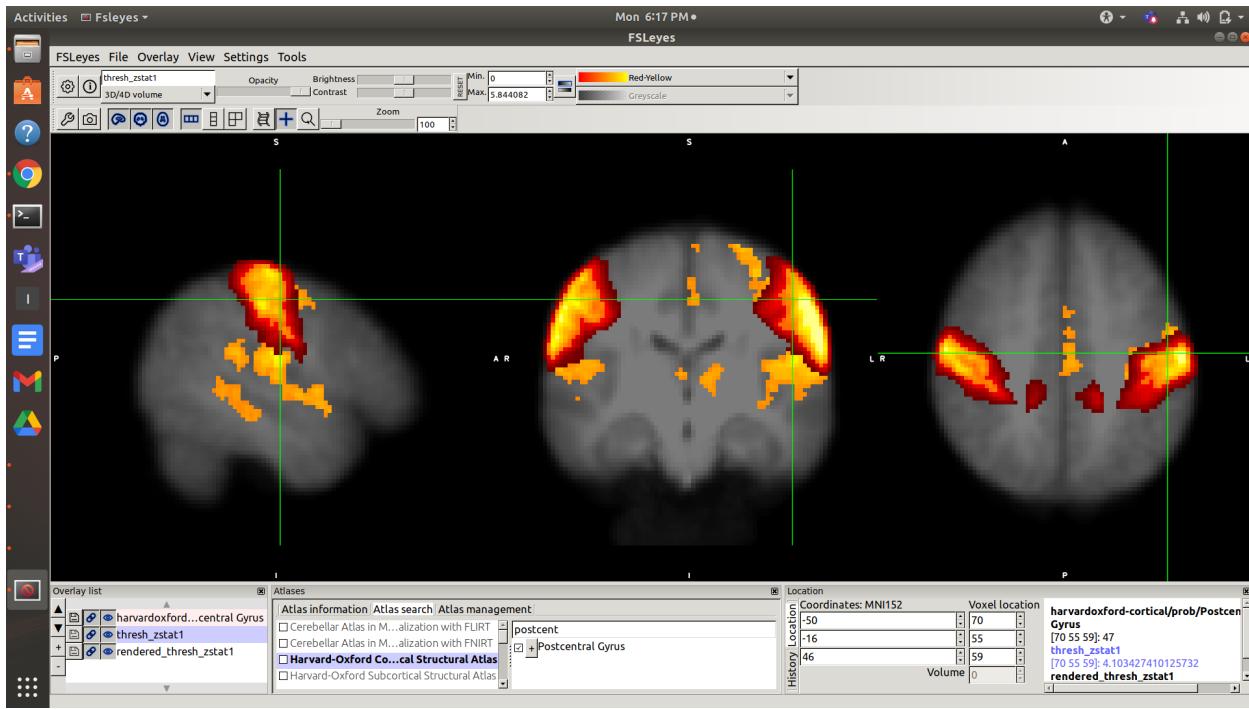
Precentral gyrus



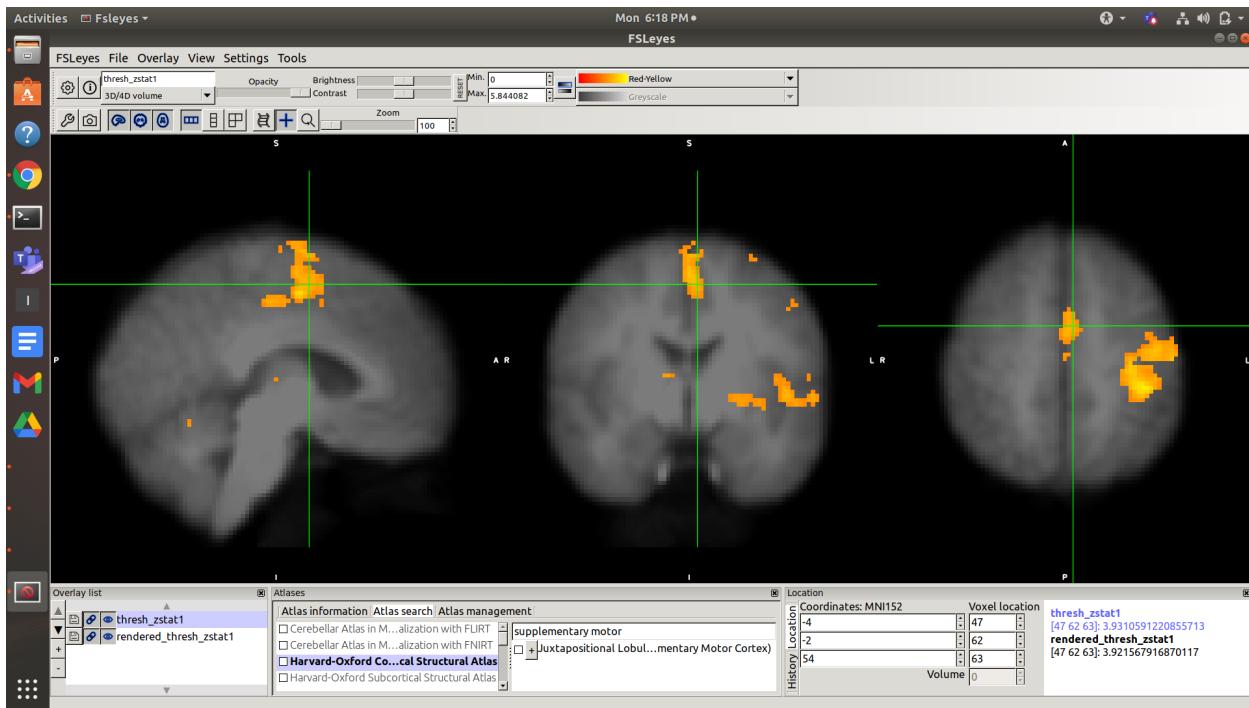


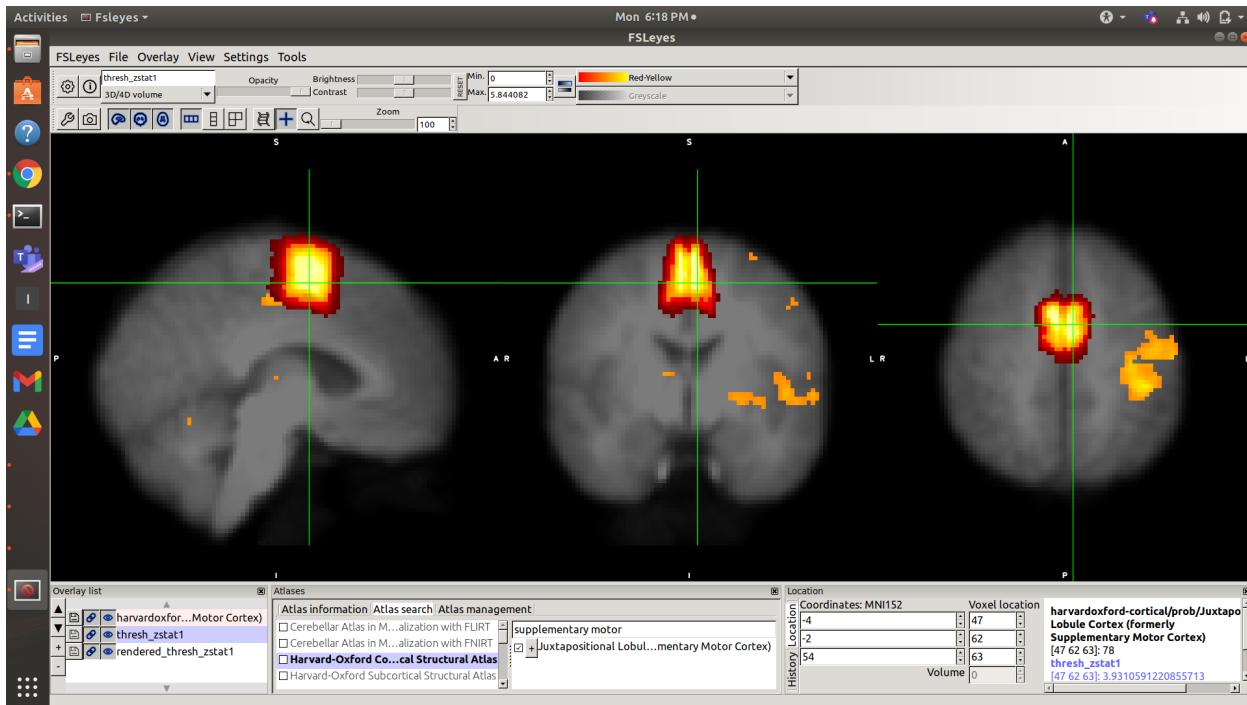
Postcentral gyrus





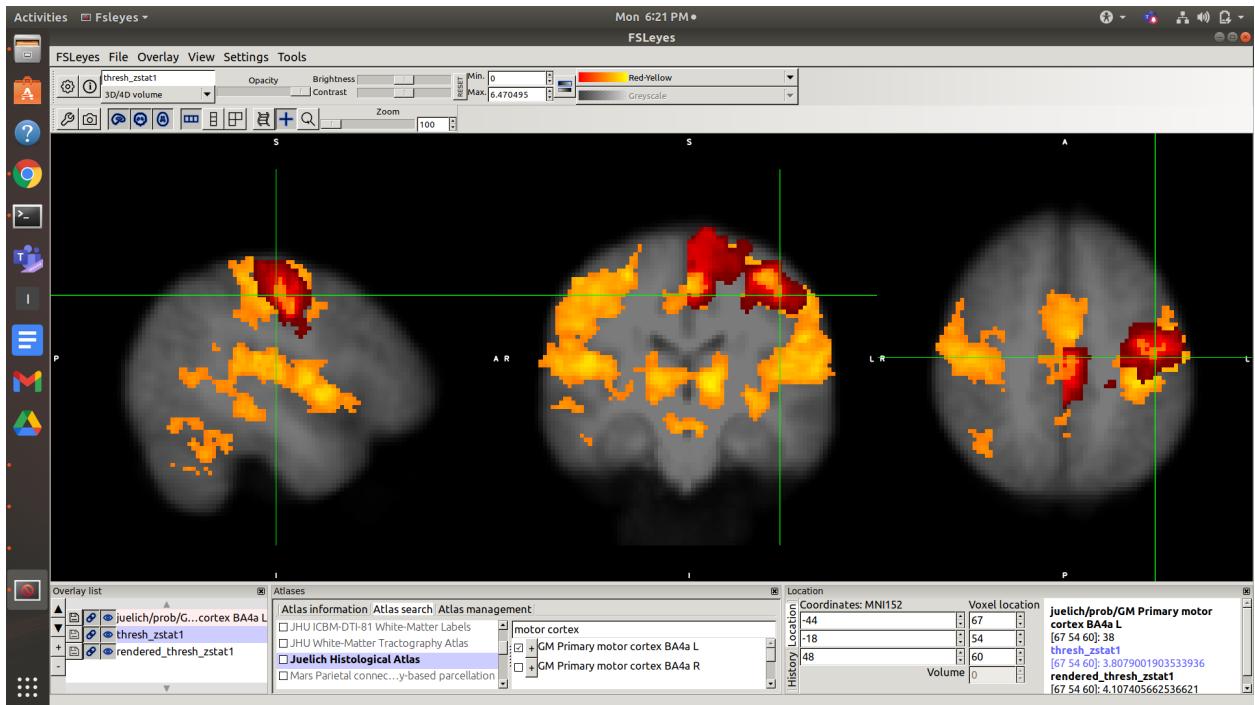
Supplementary motor cortex



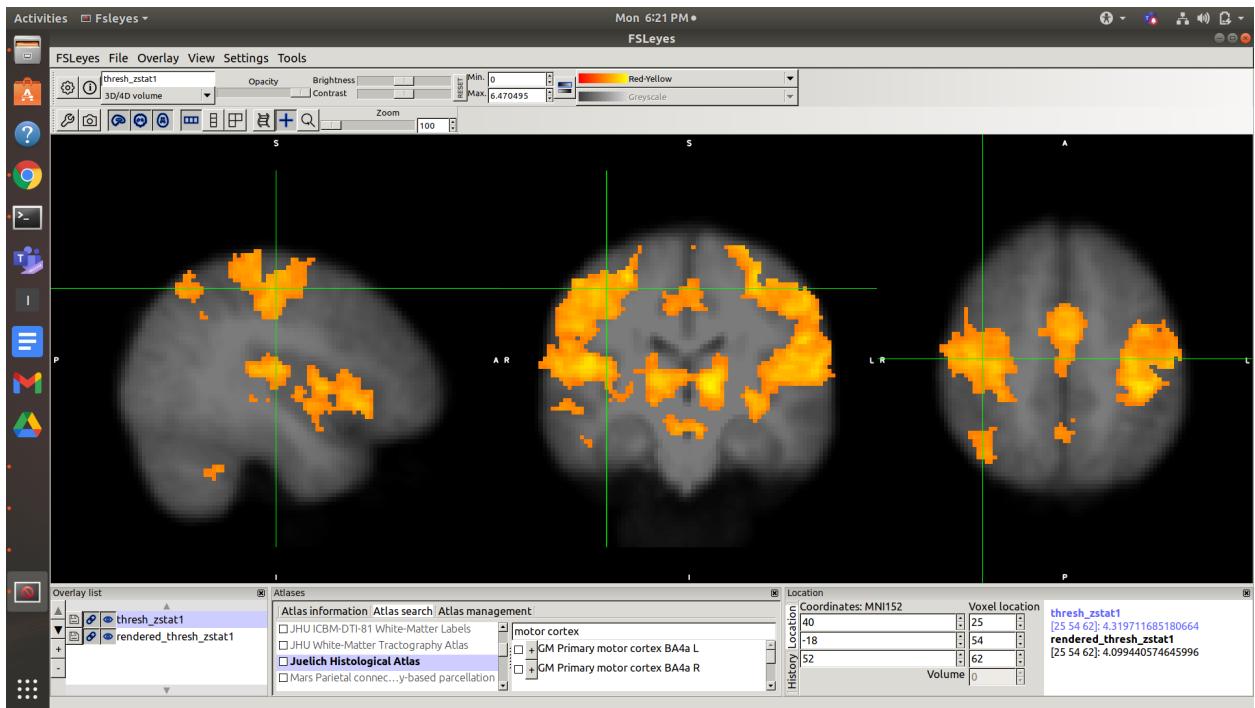


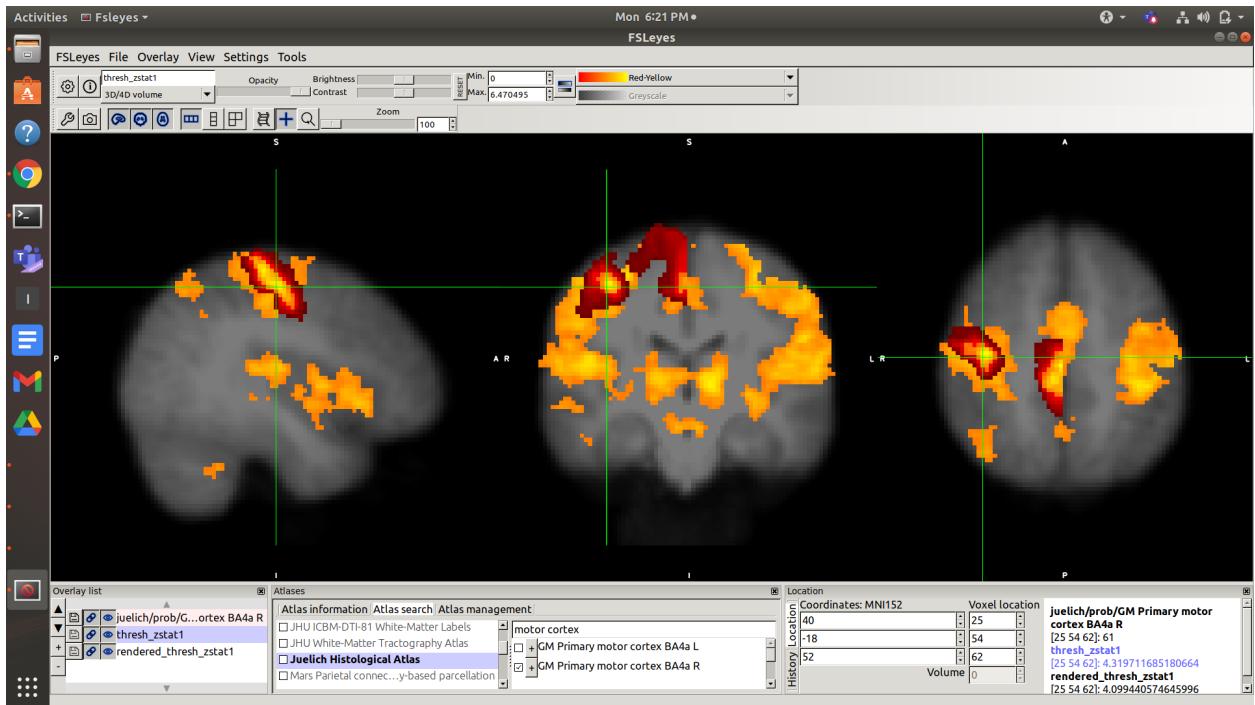
d)video motor- checkerboard (EV6 + EV7 - EV4 - EV5)

GM primary motor cortex R

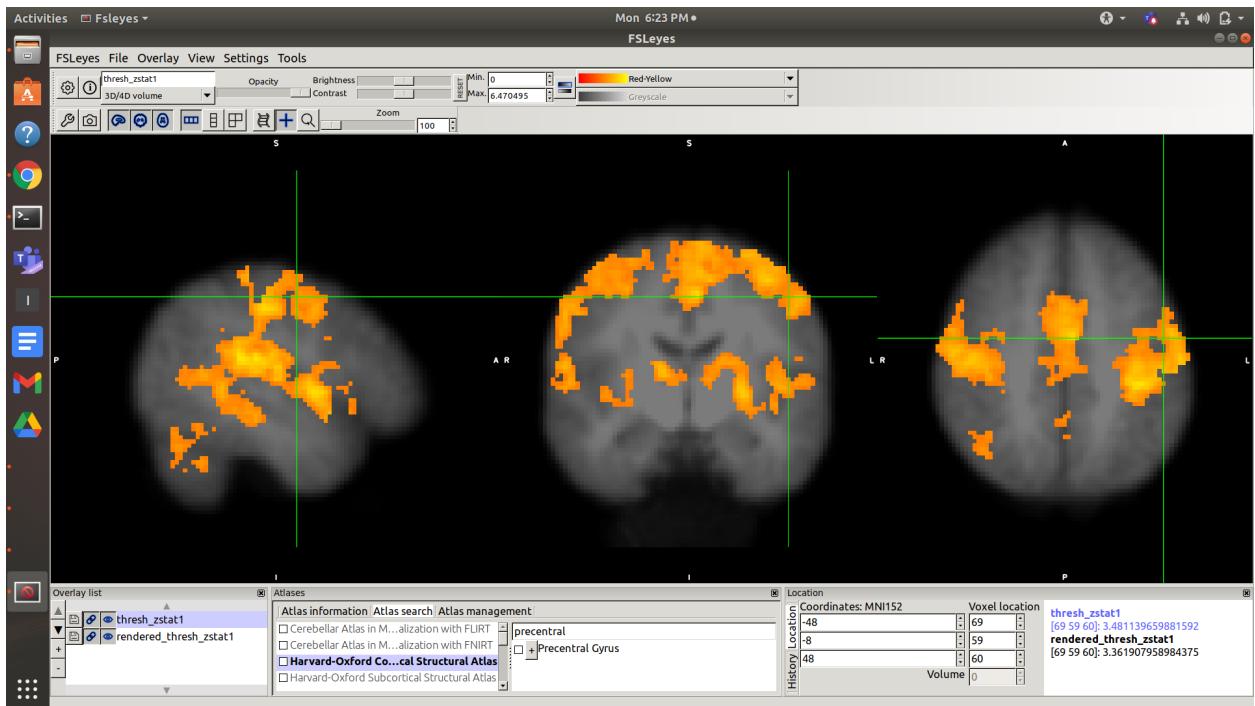


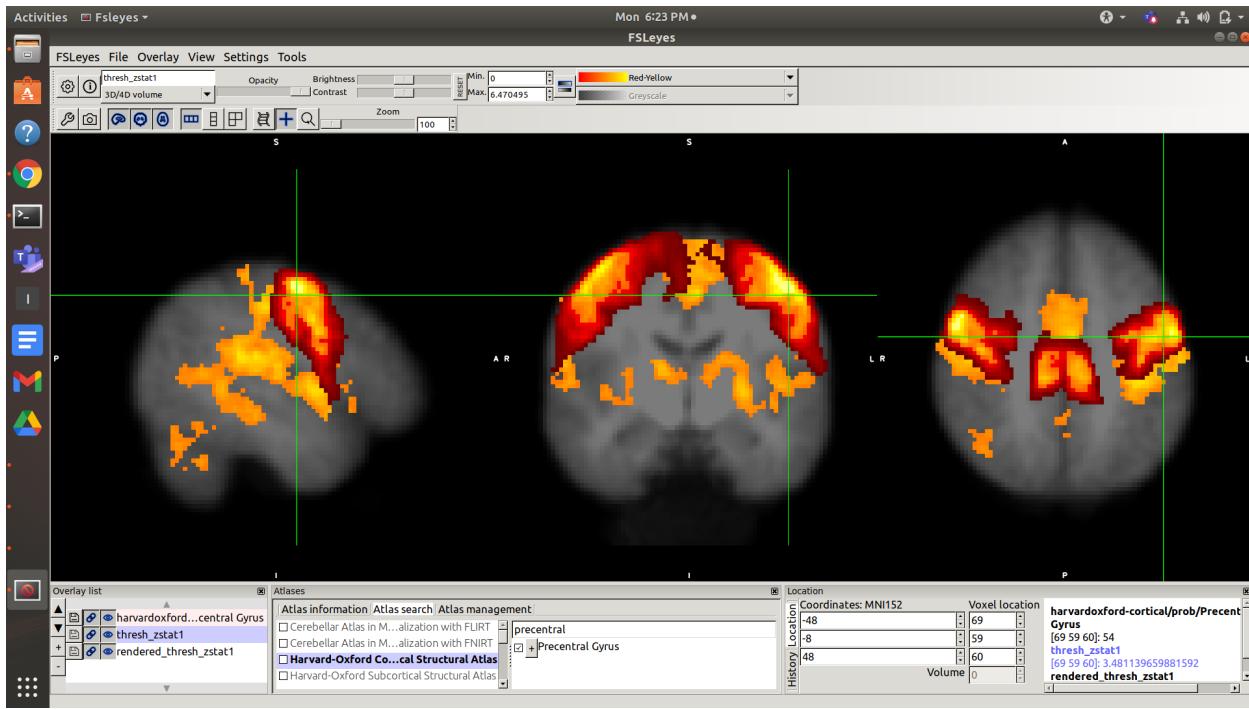
GM primary motor cortex L



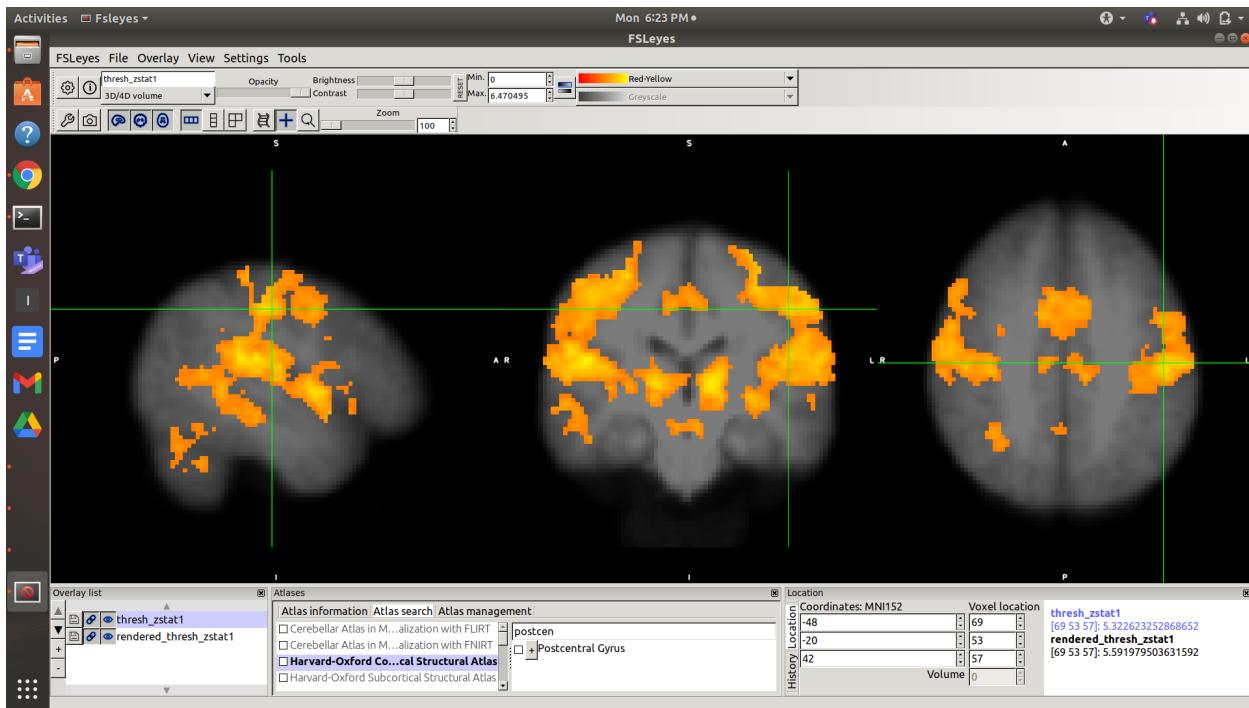


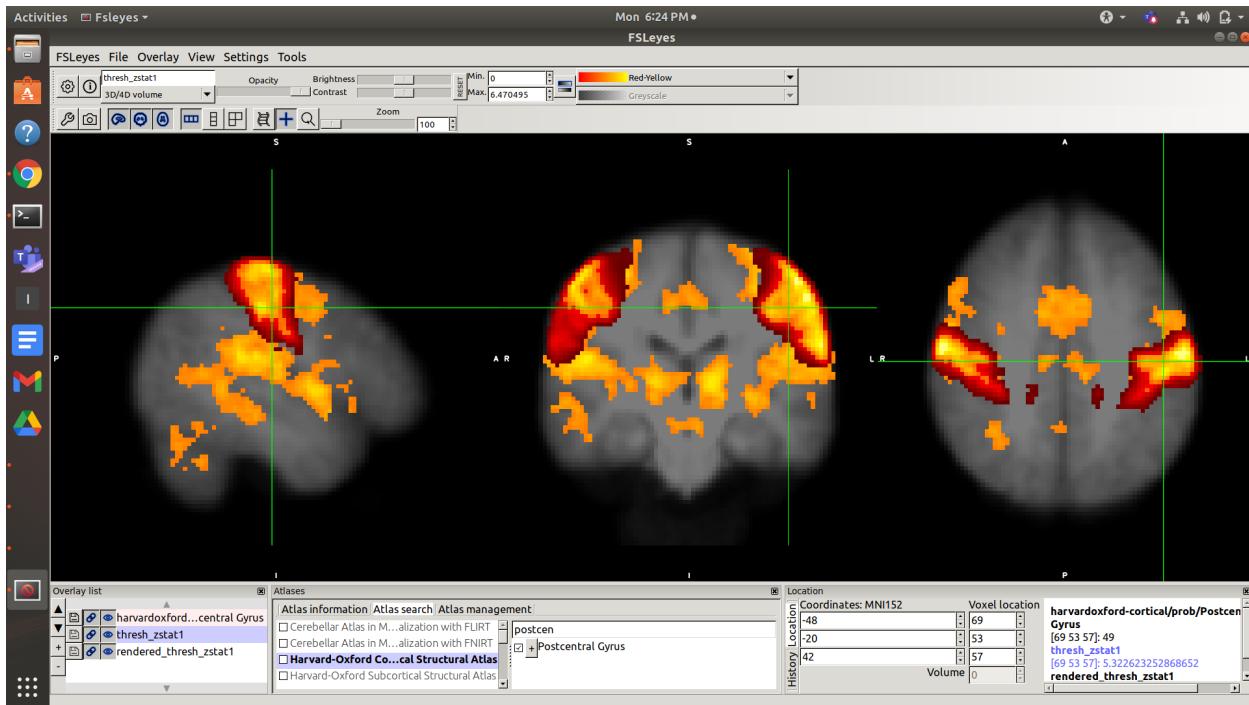
Precentral gyrus



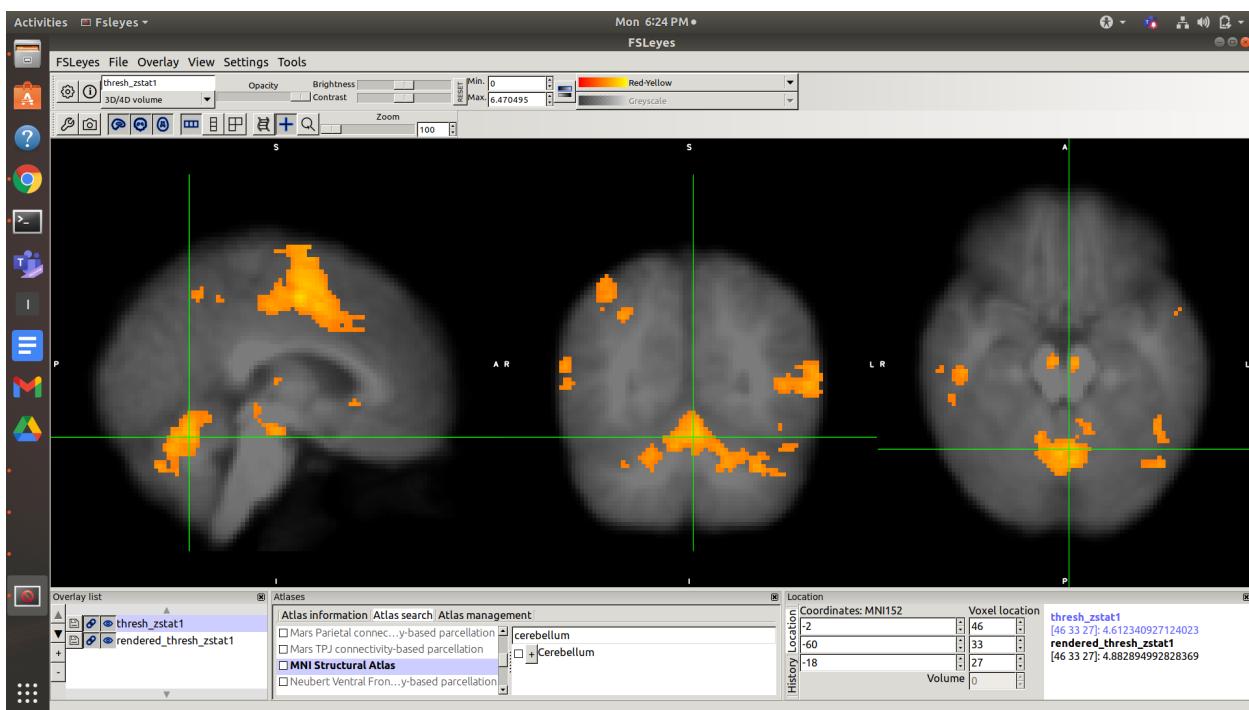


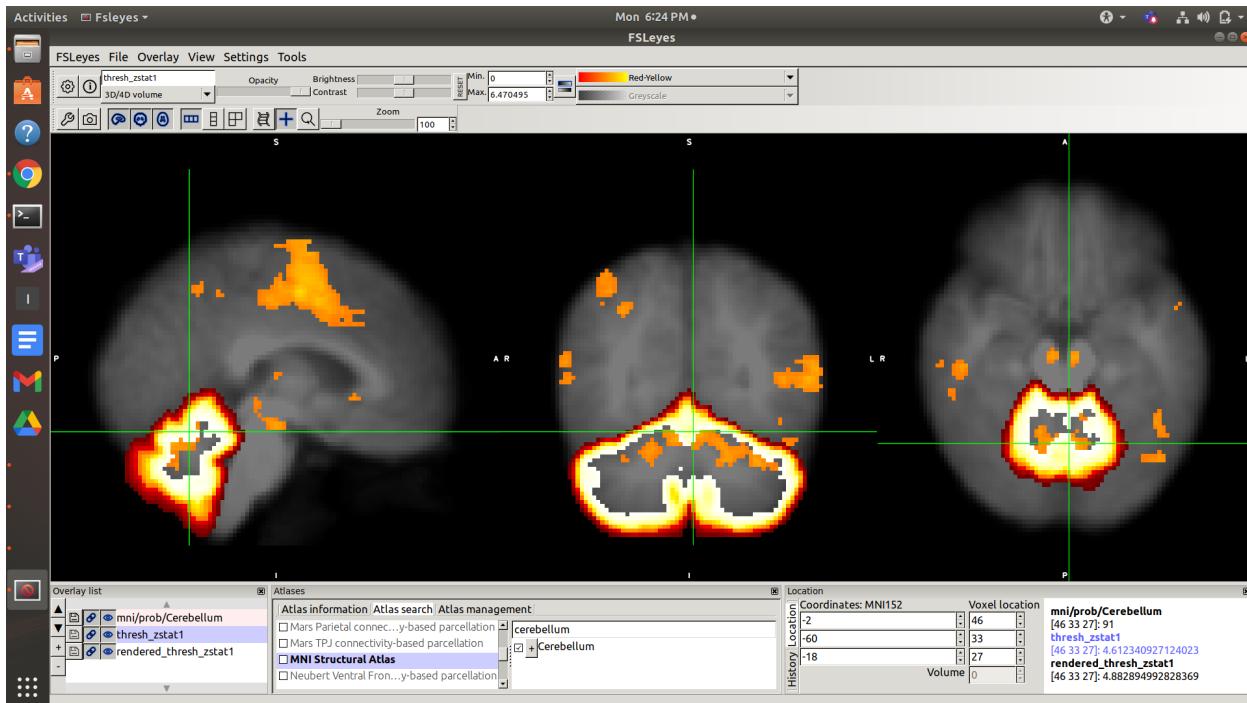
Postcentral gyrus



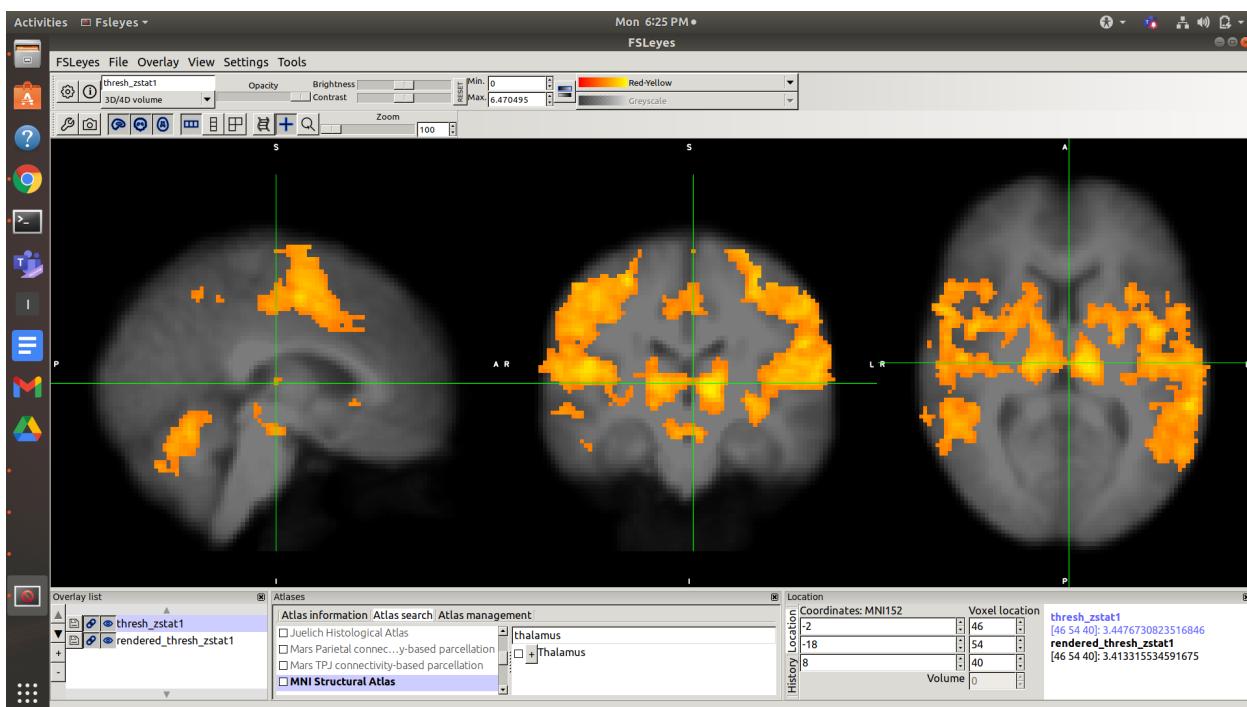


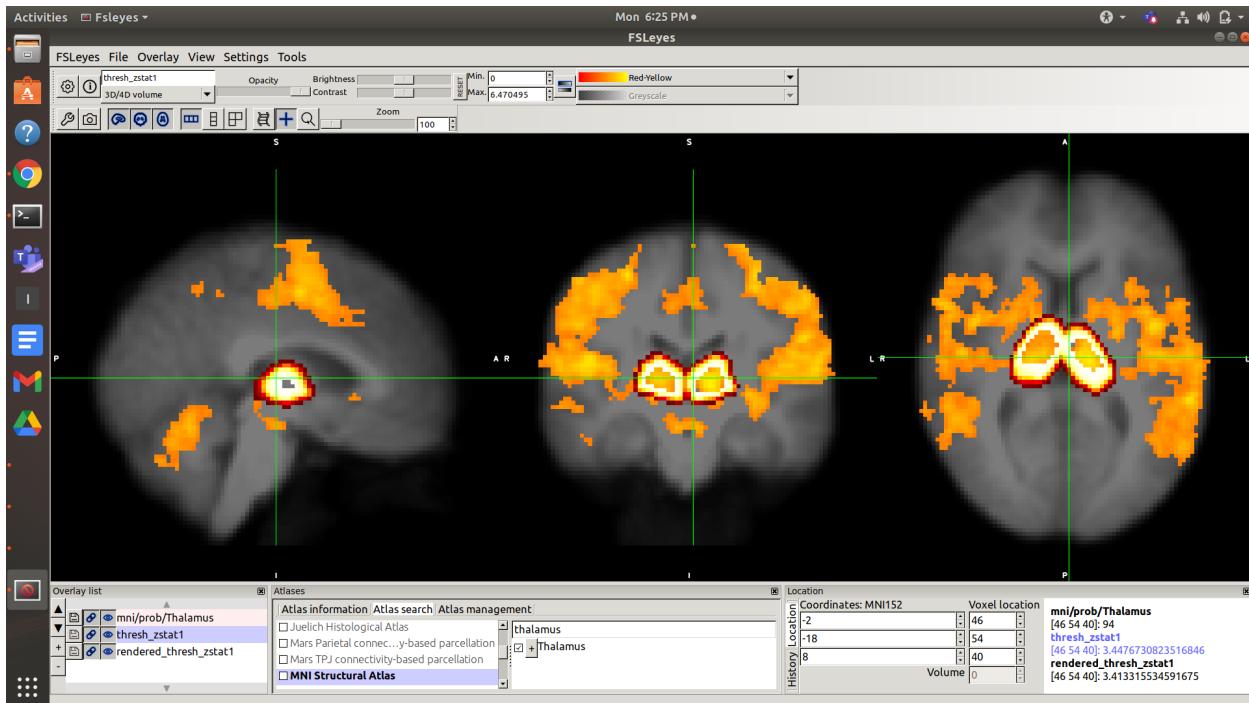
Cerebellum



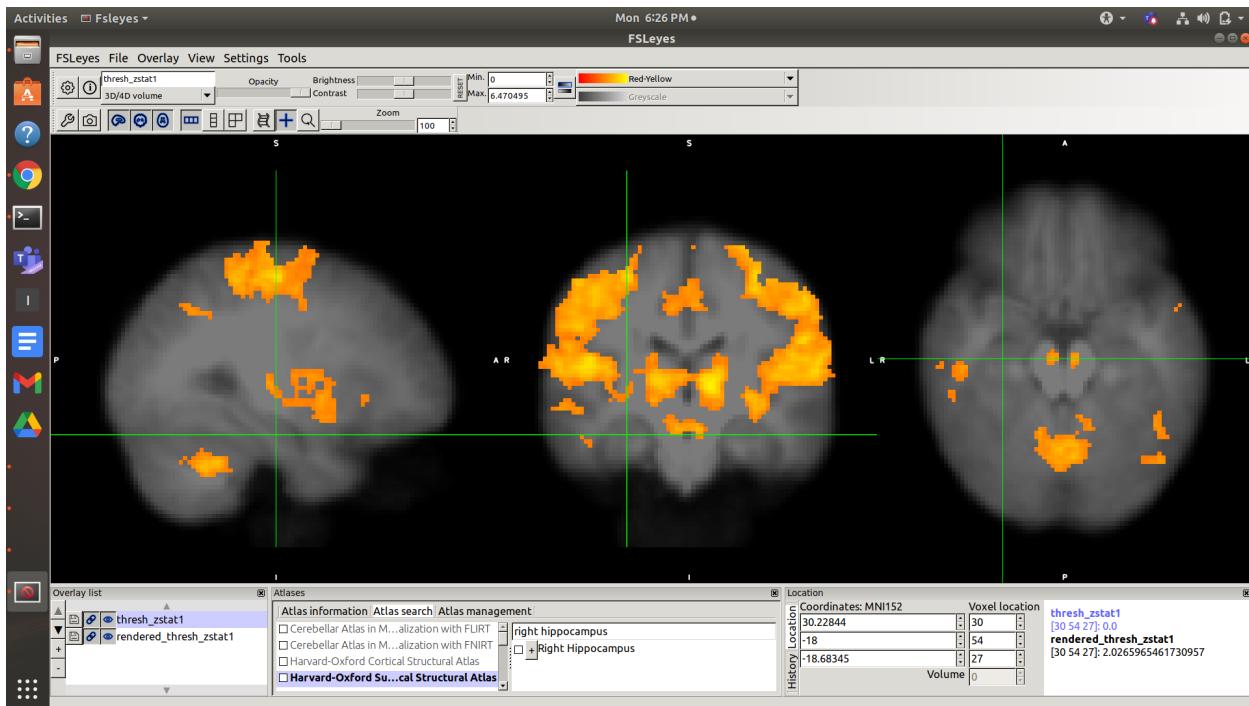


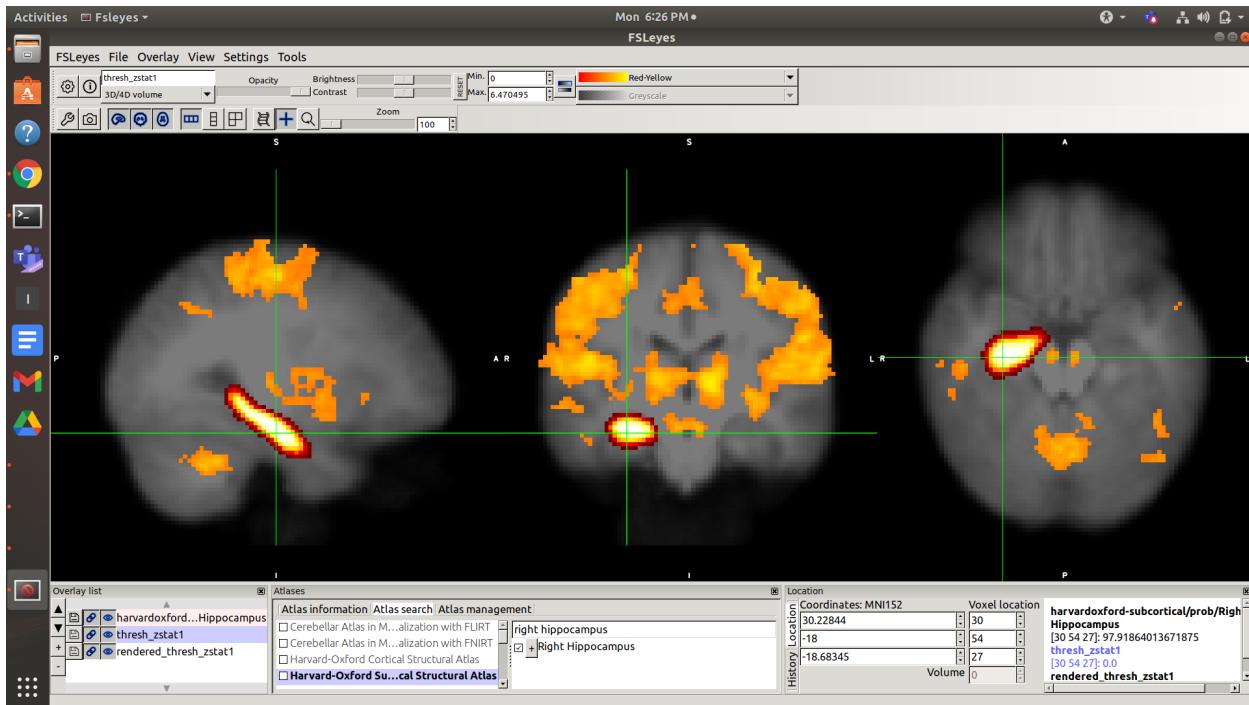
Thalamus





Right hippocampus

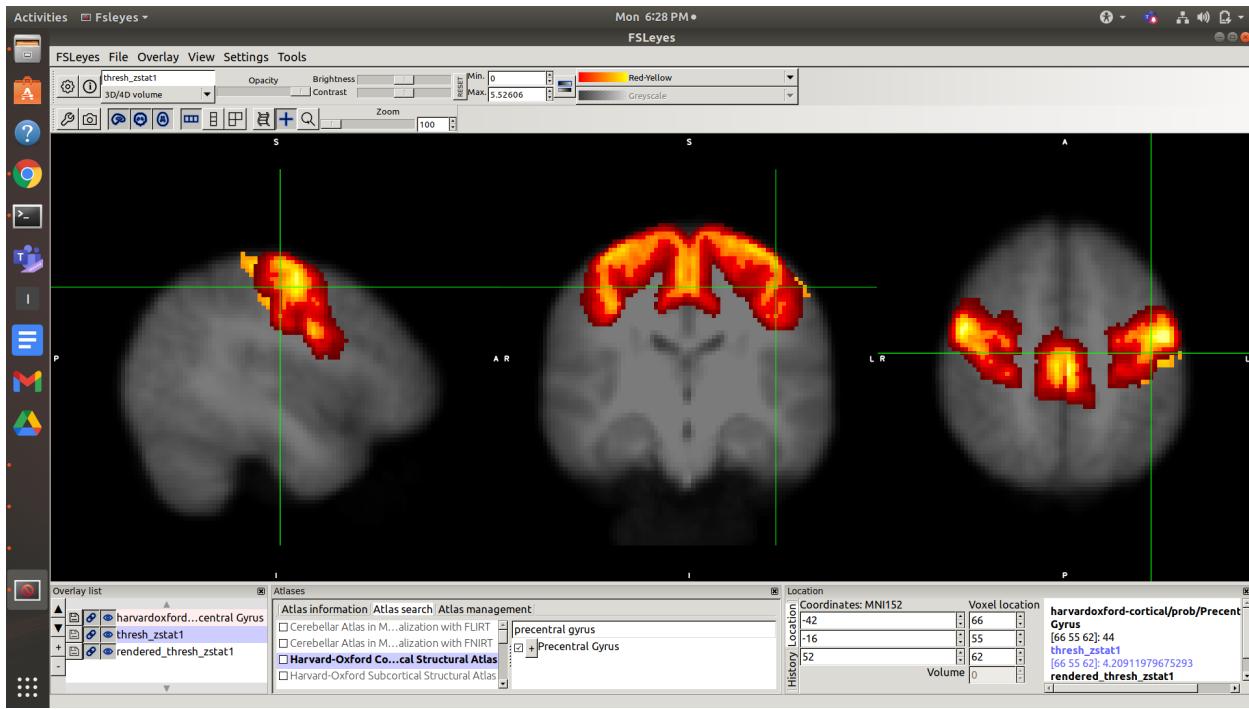




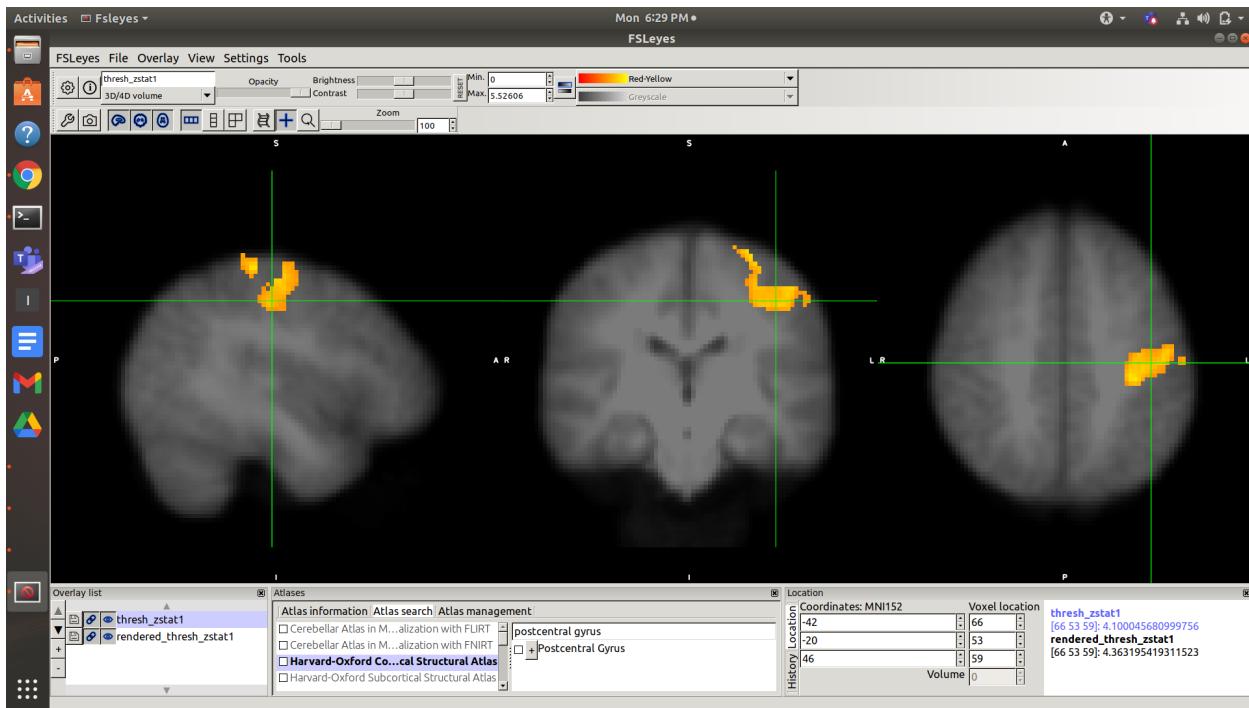
e)(video+audio)right motor- (video+audio)left motor (EV2+EV7 - EV1 - EV6)

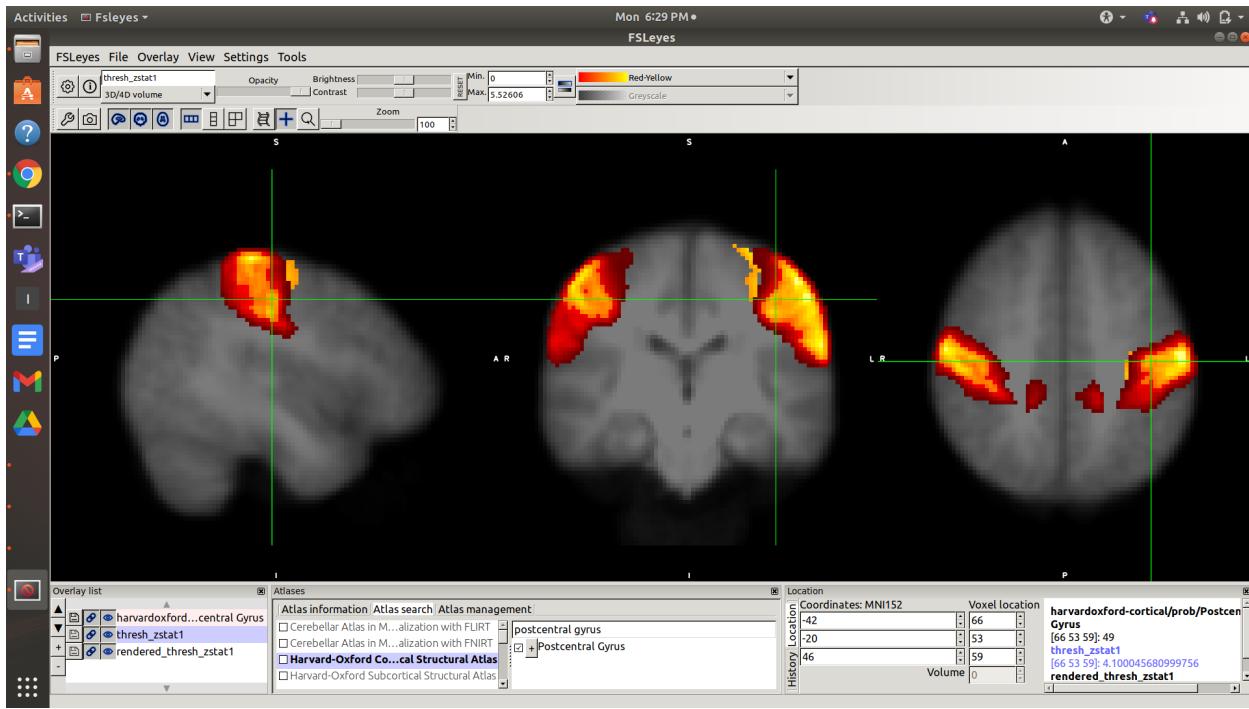
Precentral gyrus





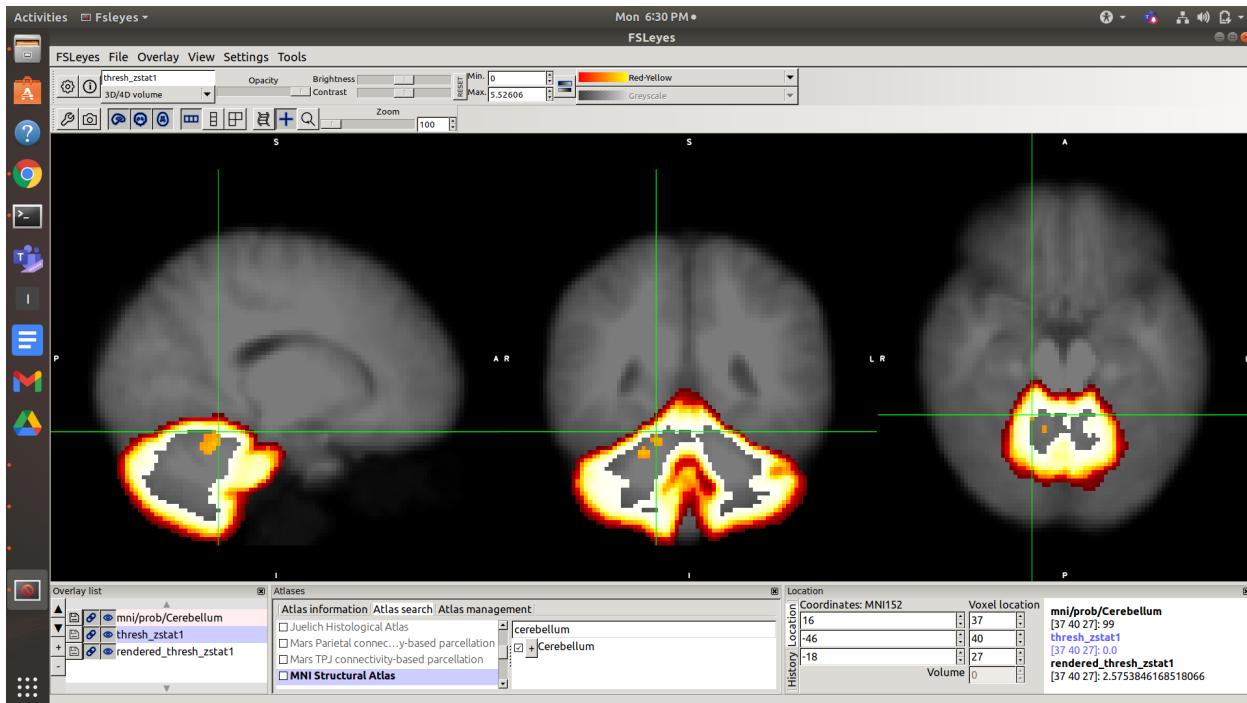
Postcentral gyrus





cerebellum

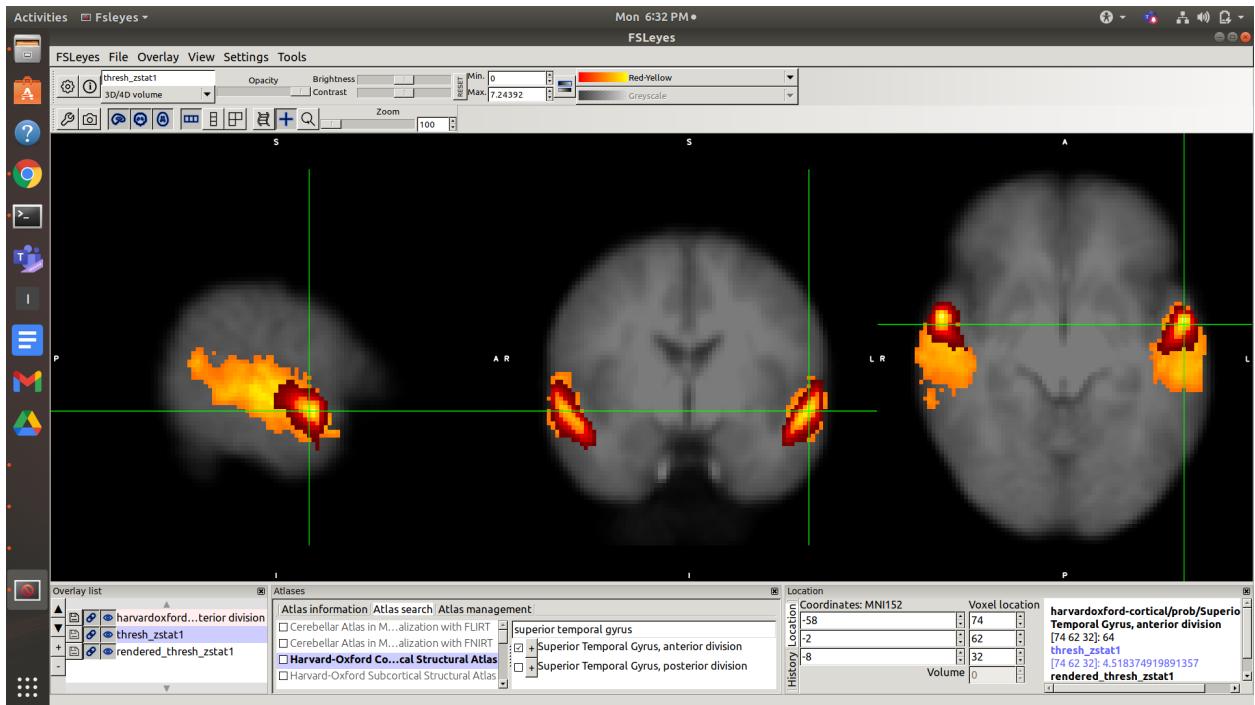




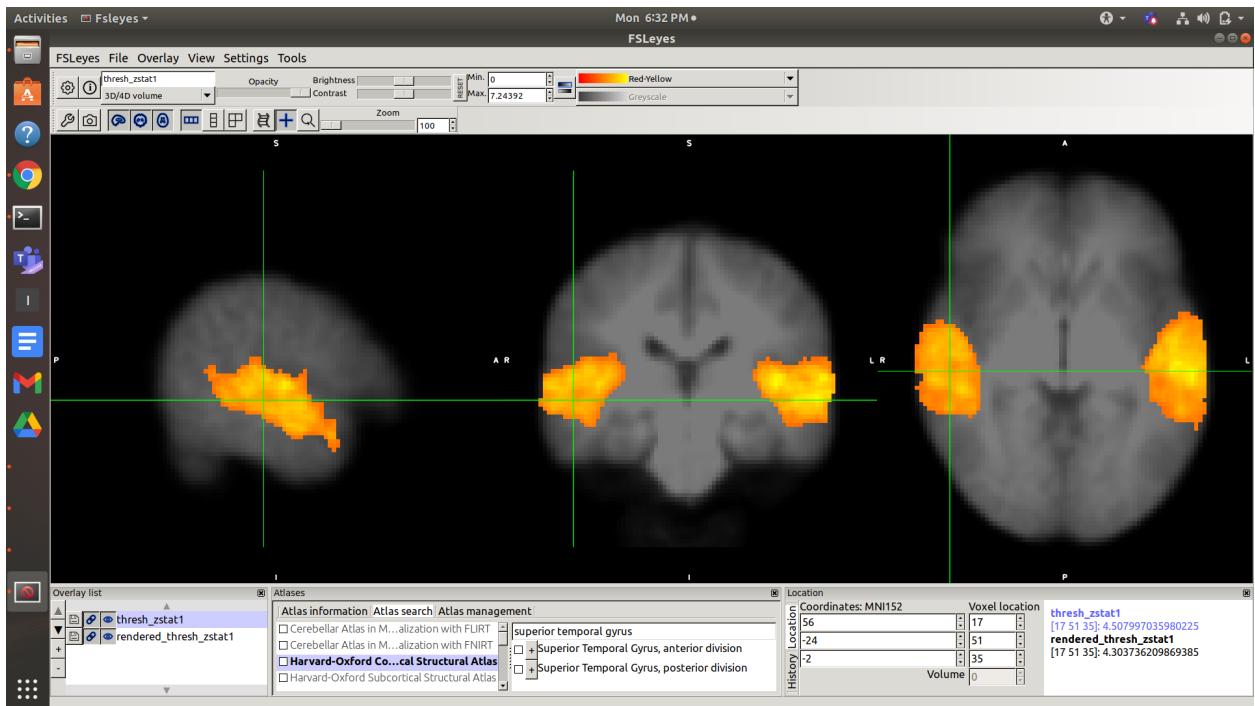
f)(video+audio)sentences- checkerboard (EV3+EV8 - EV4 - EV5)

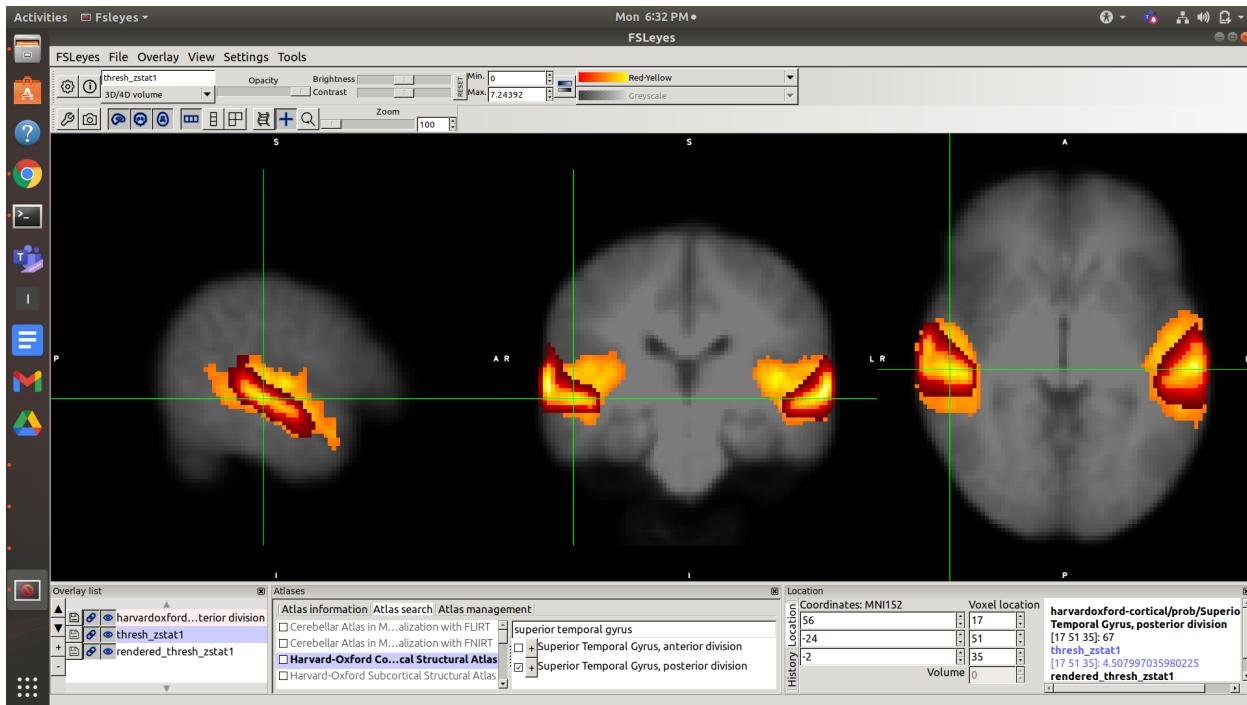
Superior temporal gyrus, anterior division





Superior temporal gyrus, posterior division





Middle temporal gyrus, anterior division



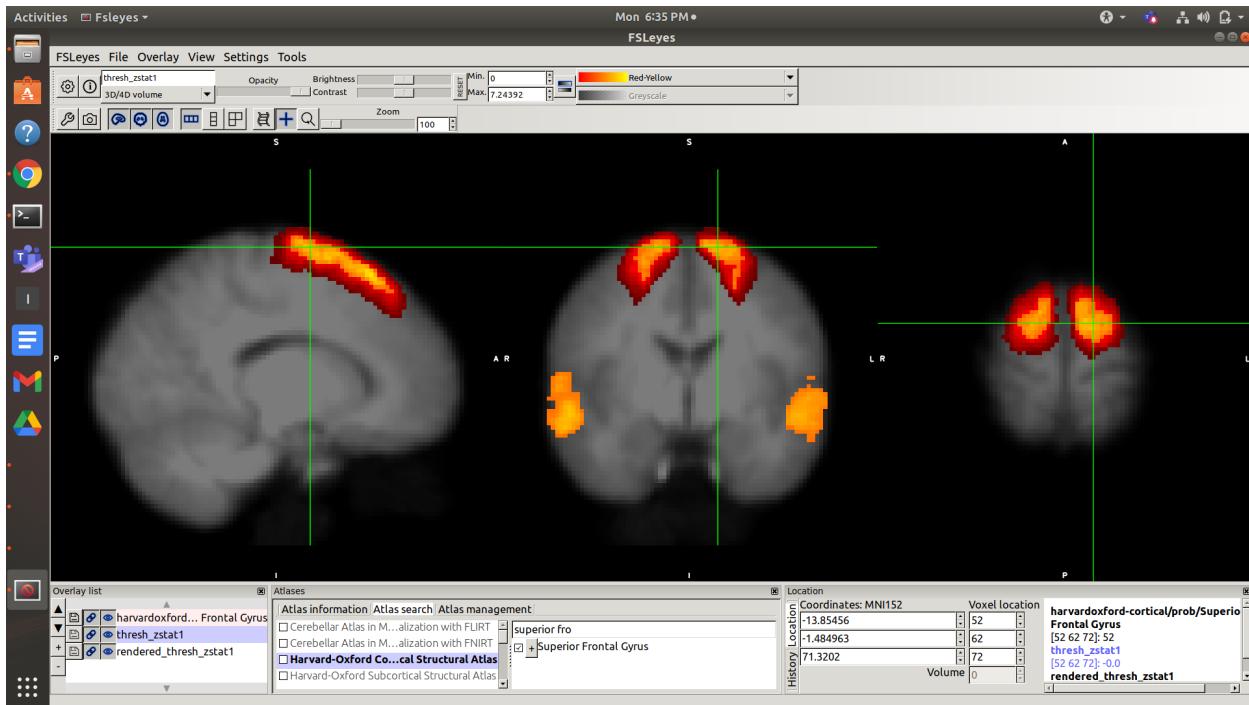
Middle temporal gyrus, posterior division



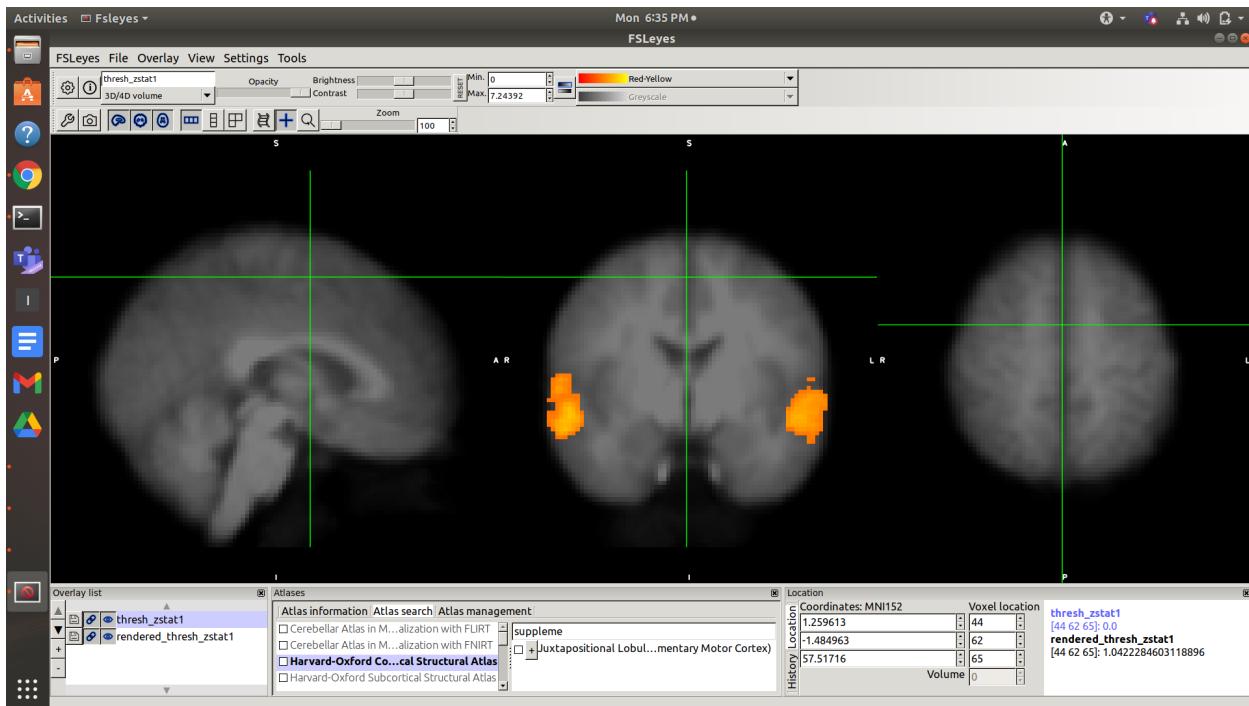


Superior frontal gyrus



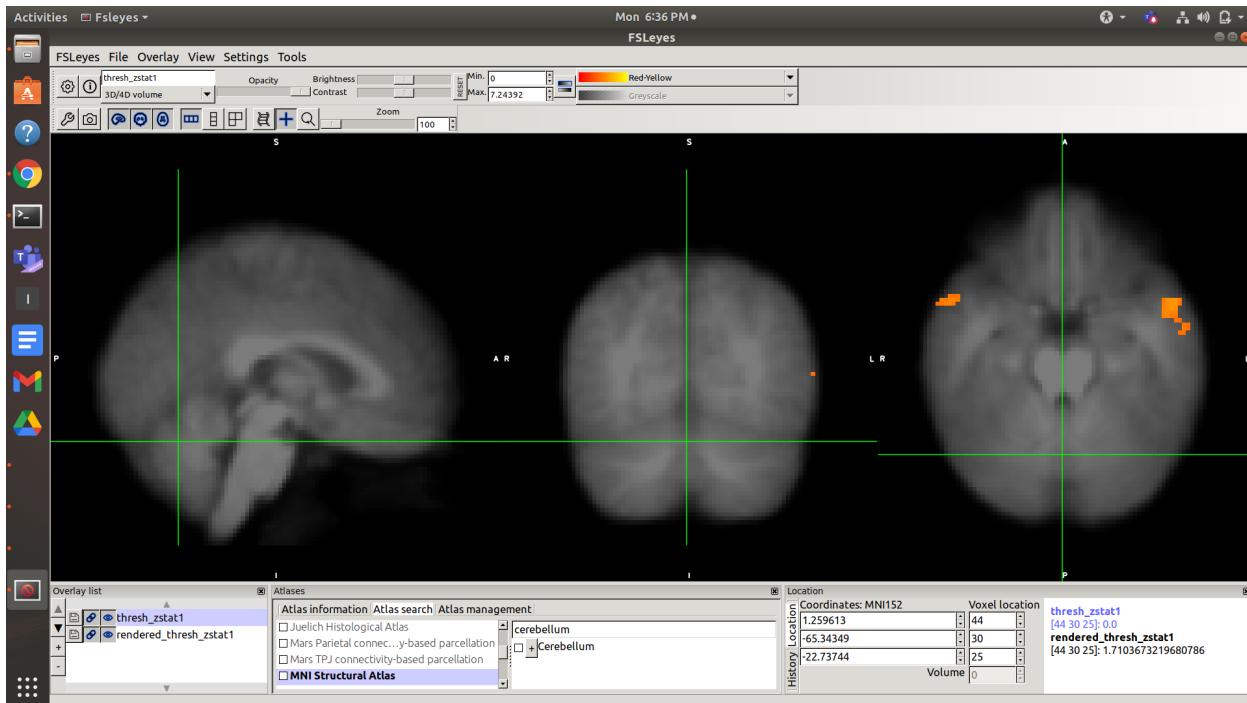


Supplementary motor cortex





cerebellum



| Brain area | x-coordinate | y-coordinate | z-coordinate | T value |
|--|--------------|--------------|--------------|---------|
| Sentences reading-checkerboards | | | | |
| Superior temporal gyrus, anterior division | 54 | -14 | -2 | 3.89 |
| Superior temporal gyrus, posterior gyrus | 56 | -14 | -6 | 3.62 |
| Middle temporal gyrus, anterior division | -60 | -14 | -6 | 4.9 |
| Precentral Gyrus | -60 | 2 | 0 | 3.19 |
| Video left motor-checker board | | | | |
| Precentral gyrus | 34 | -18 | 54 | 4.54 |
| Postcentral gyrus | 48 | -18 | 44 | 5.08 |
| Supplementary motor cortex | 2 | -18 | 50 | 4.00 |
| Video right motor-checker board | | | | |
| cerebellum | 4 | -66 | -20 | 3.84 |
| Precentral gyrus | -26 | -16 | 70 | 5.26 |
| Postcentral gyrus | -50 | -16 | 46 | 4.83 |

| | | | | |
|---|-----|-----|-----|------|
| Supplementary motor cortex | -4 | -2 | 54 | 4.57 |
| Video motor-checker board | | | | |
| GM primary motor cortex R | -40 | -18 | 52 | 4.58 |
| GM Primary motor cortex L | -44 | -18 | 48 | 4.38 |
| Precentral gyrus | -48 | -8 | 48 | 3.92 |
| Postcentral gyrus | -48 | -20 | 42 | 7.02 |
| cerebellum | -2 | -60 | -18 | 5.67 |
| thalamus | -2 | -18 | 8 | 3.87 |
| (video+audio)right motor-(video+audio)left motor | | | | |
| Precentral gyrus | -42 | -16 | 52 | 5.00 |
| Postcentral gyrus | -42 | -20 | 46 | 4.82 |
| cerebellum | 16 | -46 | -18 | 3.00 |
| (video+audio)sentences-checkerboard | | | | |
| Superior temporal gyrus, anterior division | -58 | -2 | -8 | 5.5 |
| Superior temporal gyrus, posterior division | 56 | -24 | -2 | 5.49 |

| | | | | |
|---|----|-----|-----|------|
| Middle temporal gyrus, anterior division | 60 | 2 | -18 | 3.84 |
| Middle temporal gyrus, posterior division | 60 | -20 | -6 | 6.59 |

Important Observations:

The average activated regions of the 6 contrasts generated are shown in the above diagram and table. Since, the contrasts given in [1] is not exactly the same as our generated contrasts (except for video sentence - checkerboard) but are more or less similar to them, hence most of the activated regions comply with the literature or are close to. E.g., for Sentence reading - checkerboards superior temporal gyrus(anterior), superior temporal gyrus(posterior), middle temporal gyrus(posterior) and precentral gyrus were found to be active for our setup as well as in [1], the regions which were not active in ours but active in [1] are left hippocampus, lingual gyrus, thalamus, cerebellum, precuneus gyrus. Activation of superior temporal gyrus (it has the wernicke's area) indicates the comprehension of the sentence reading. The following regions for contrast1 weren't found active in the average activations as compared to single subject analysis in Assignment-2: Superior frontal gyrus, middle frontal gyrus, Temporal fusiform cortex(posterior division), Right Hippocampus indicating that these areas activated with subject specific conditions(or a disorder in special case) whereas superior temporal gyrus, middle temporal gyrus and precentral gyrus were activated in both indicating that these regions are actively involved in language comprehension(sentence reading) and least in visual activations(checkerboard), also evident from the Wernicke's area(responsible for language comprehension) located in these areas(usually in superior temporal gyrus, posterior division).

For contrast 2, motor cortex is active for visualizing the motor cortex actions in the video(through mirror neuron activations), this activation is represented in supplementary motor cortex bold signal, although vision is also active for this contrast but it is subtracted through the checkerboard excluding its activations.

For contrast 3, similar activations like 2 in supplementary motor cortex was found, since it is a symmetric action, except that we found cerebellum also active in this case, since cerebellum is responsible for complex coordinated movements. In contrast 2 as well, cerebrum might be active but couldn't capture due to some inherent error even on an average.

Both in contrast 2 and 3, precentral and postcentral gyrus were active indicating that some level of language comprehension was also involved since it was a video motor stimulus and not a direct motor action, so comprehending the video involved this.

For contrast 4, which is similar to contrast 2 and 3, hence similar regions are active plus we've thalamus, hippocampus and cerebellum activations indicating the motor movements being captured in long term memory and stored for future recalls in complex conditions. The right hippocampus wasn't active for contrast 4 in average analysis whereas it was activated in single subject analysis in Assignment-2 indicating that these aren't generalized regions for this contrast.

For contrast 5, activations of precentral, postcentral gyrus and cerebellum responsible for complex motor actions and language comprehension both through audio and video stimulus are found to be active.

For contrast 6, superior temporal gyrus(anterior and posterior), middle temporal gyrus(anterior and posterior) are active. Activations of different areas of temporal gyrus indicates the broca's and wernicke's area for sentence reading comprehension and regeneration of the language, with the audition stimulus as well. Motor areas are active because ears have muscular actions such as vibrations of eardrum or cilia movements or fluid moving across the inside of ear. The superior frontal gyrus, supplementary motor cortex and cerebellum weren't active in average activations in contrast 6 than they were in single subject analysis in Assignment-2, indicating that these are not generalized functional areas of the particular contrast.

Drive Link to all folders:

The link given below directs to a folder containing all the 30 “*.feat” directories inside each of S01, S02,S32. The directory “Higher_Level_Analysis.gfeat” contains the group activated contrasts analysis for the six contrasts, each in. cope1.feat, cope2.feat,.....cope6.feat.

https://drive.google.com/drive/folders/1k2Alglm_gfdIVrxpWsWPI0RcqP0rlh43?usp=sharing

References

- 1)– Pinel, P., Thirion, B., Meriaux, S., Jobert, A., Serres, J., Le Bihan, D., ... Dehaene, S. (2007). Fast reproducible identification and large-scale databasing of individual functional cognitive networks. *BMC neuroscience*, 8(1), 1-18.
- 2)Orfanos, D. P., Michel, V., Schwartz, Y., Pinel, P., Moreno, A., Le Bihan, D., Frouin, V. (2017). The brainomics/localizer database. *Neuroimage*, 144, 309-314.
- 3)For understanding mean group effect, the following link was also referred:
<https://fsl.fmrib.ox.ac.uk/fsl/fslwiki/GLM>