COL786 Assignment 04

Shruti Aparna

April 28, 2025

This is the link to drive where all the required files are uploaded

This report presents an analysis of two custom implementations for fMRI data analysis: a single-subject General Linear Model (GLM) tool and a group-level analysis tool. Results are compared with the FSL software's GLM outputs to evaluate accuracy and identify methodological differences. For single-subject analysis, modest correlations were observed across all output types (parameter estimates, contrast estimates, and statistical maps). For group-level analysis, strong correlations were found in t-statistics (0.63-0.69) and moderate to strong correlations in z-statistics (0.49-0.57), demonstrating good alignment between the custom implementation and FSL across both statistical measures while highlighting subtle methodological differences in the statistical approaches.

1 Single-Subject GLM Analysis

1.1 Parameter Estimates (PEs)

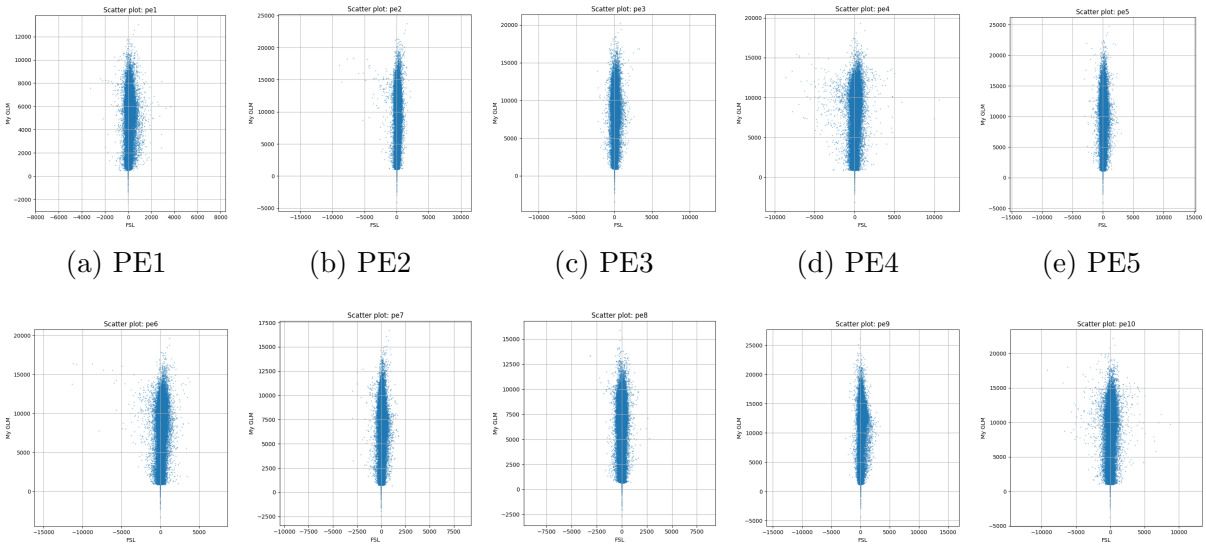
The parameter estimates show varying correlations with FSL's implementation:

Parameter	Correlation
PE1	0.2954
PE2	0.2354
PE3	0.2301
PE4	0.1703
PE5	0.1466
PE6	0.2882
PE7	0.2234
PE8	-0.0456
PE9	0.3169
PE10	0.1347

Table 1: Correlations between custom GLM and FSL parameter estimates.

The scatter plots consistently show a pattern of vertical elongation, with the custom GLM values varying more widely than FSL values. This pattern suggests:

1. **Scaling differences:** Custom implementation likely has a different scaling factor for parameter estimates



(a) PE1 (b) PE2 (c) PE3 (d) PE4 (e) PE5

(f) PE6 (g) PE7 (h) PE8 (i) PE9 (j) PE10

Figure 1: Scatter plots of parameter estimates comparing custom GLM (y-axis) with FSL (x-axis) for 10 different contrasts.

2. **Noise sensitivity:** Greater variance in custom estimates may indicate less regularization compared to FSL.

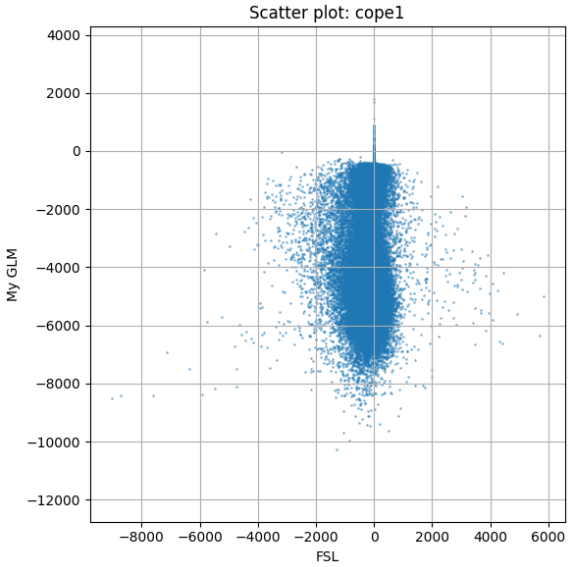
The highest correlation was observed for PE9 (0.3169), while PE8 showed the only negative correlation (-0.0456), suggesting potential model misspecification for that particular regressor.

1.2 Contrast of Parameter Estimates (COPEs)

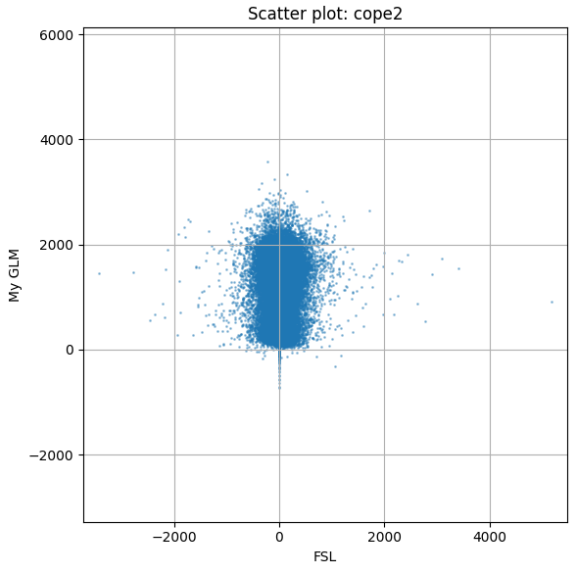
The contrast estimates show similar patterns to parameter estimates:

Contrast	Correlation
COPE1	0.2697
COPE2	0.0609
COPE3	0.2180

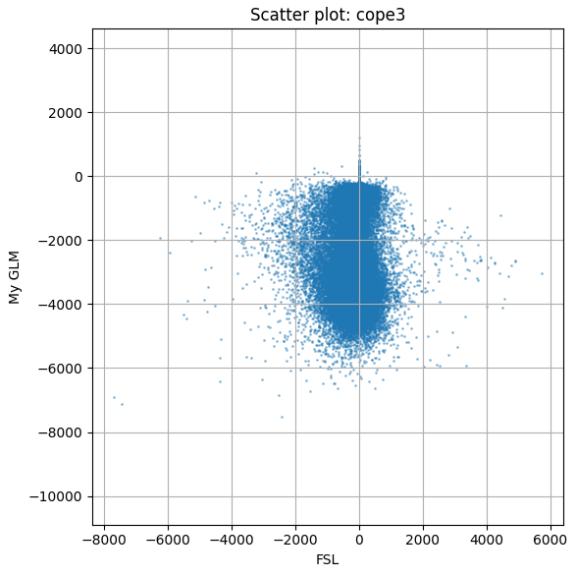
Table 2: Correlations between custom GLM and FSL contrast estimates.



(a) COPE1 scatter plot



(b) COPE2 scatter plot



(c) COPE2 scatter plot

Figure 2: Scatter plots of contrast of parameter estimates comparing custom GLM with FSL.

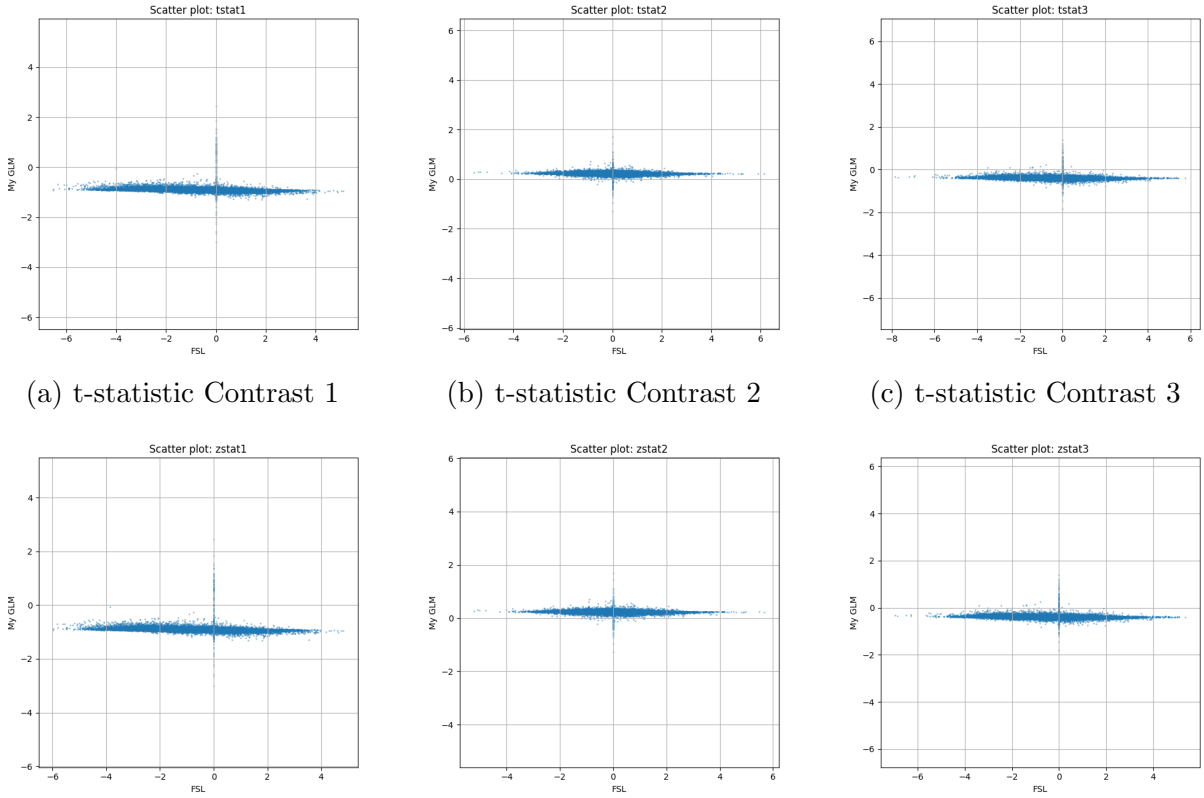
COPE1 shows the strongest correlation, while COPE2 is notably weaker. The COPE scatter plots display the same vertical elongation pattern seen in parameter estimates, indicating that the scaling differences carry through the contrast calculations.

1.3 Statistical Maps (t-statistics and z-statistics)

The statistical maps show modest correlations:

Statistic	Contrast 1	Contrast 2	Contrast 3
t-statistic	0.3180	0.0241	0.2540
z-statistic	0.3186	0.0241	0.2546

Table 3: Correlations between custom GLM and FSL statistical maps for single-subject analysis.



(a) t-statistic Contrast 1 (b) t-statistic Contrast 2 (c) t-statistic Contrast 3

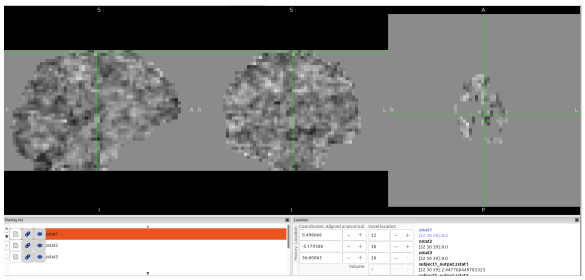
(d) z-statistic Contrast 1 (e) z-statistic Contrast 2 (f) z-statistic Contrast 3

Figure 3: Scatter plots of t-statistics and z-statistics comparing custom GLM (y-axis) with FSL (x-axis) for six contrasts.

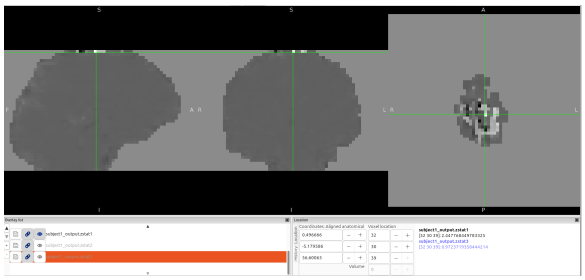
Several observations can be made:

1. The correlation values for t- and z-statistics are nearly identical within each contrast, suggesting consistent conversion methodology for single-subject analysis
2. Contrast 1 shows the strongest correlation (approximately 0.32)
3. Contrast 2 shows very weak correlation (0.0241), indicating potential issues with this specific contrast

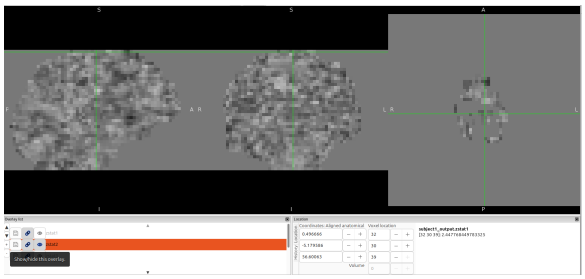
The scatter plots for t- and z-statistics show a compressed range compared to FSL, particularly along the horizontal axis, suggesting the custom implementation generates more conservative statistical values.



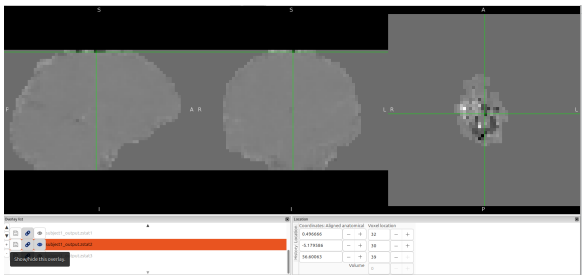
(a) zstat1 by fsl



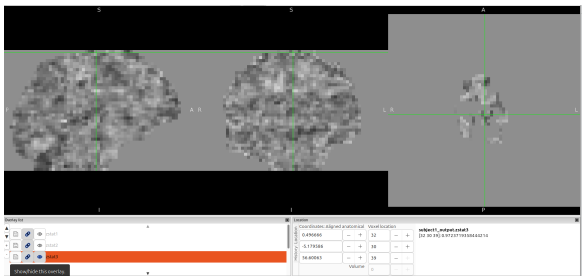
(b) custom zstat1



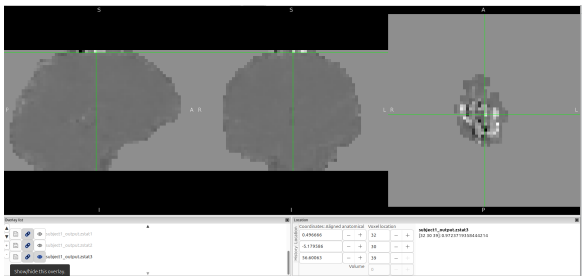
(c) zstat2 by fsl



(d) custom zstat2

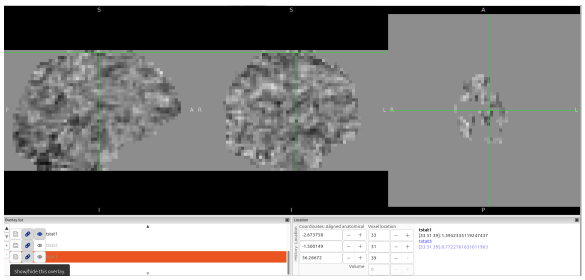


(e) zstat3 by fsl

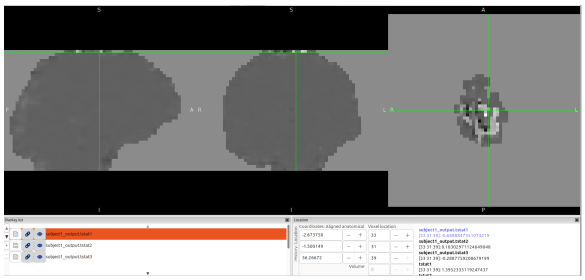


(f) custom zstat3

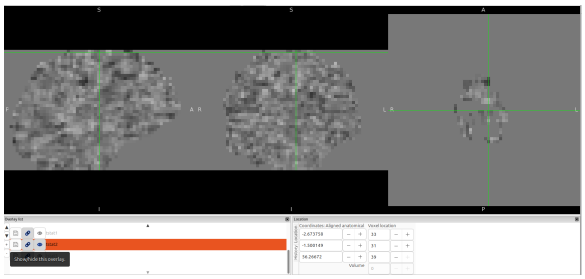
Figure 4: Brain maps comparison of z-statistics between FSL (left) and custom GLM (right) for 3 contrasts.



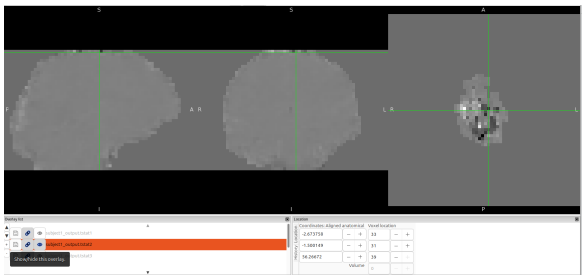
(a) tstat1 by fsl



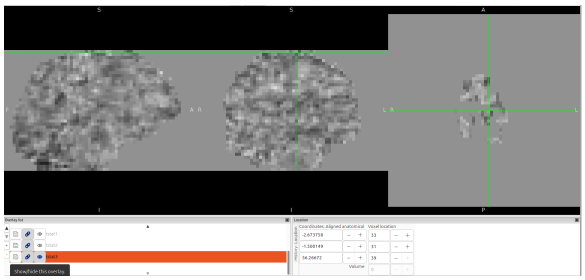
(b) custom tstat1



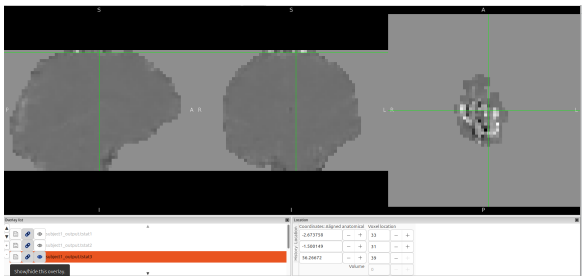
(c) tstat2 by fsl



(d) custom tstat2



(e) tstat3 by fsl



(f) custom tstat3

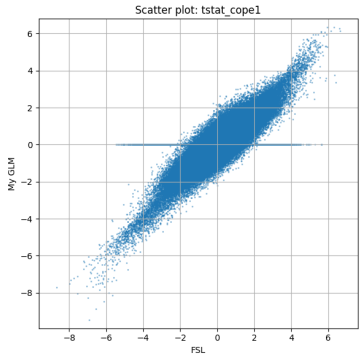
Figure 5: Brain maps comparison of t-statistics between FSL (left) and custom GLM (right) for 3 contrasts.

2 Group Analysis

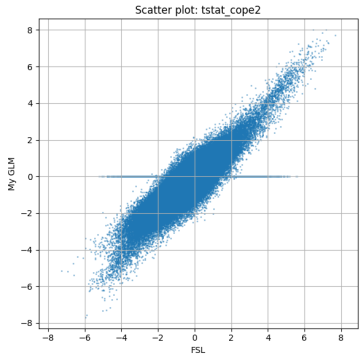
The group analysis results show a striking pattern:

Statistic	Contrast 1	Contrast 2	Contrast 3
t-statistic	0.6348	0.6652	0.6929
z-statistic	0.4936	0.5367	0.5732

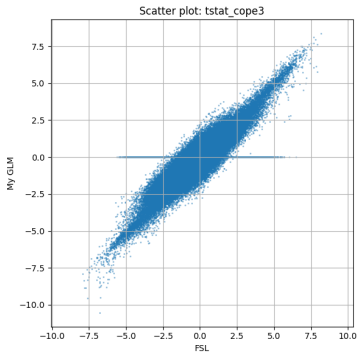
Table 4: Correlations between custom GLM and FSL statistical maps for group analysis.



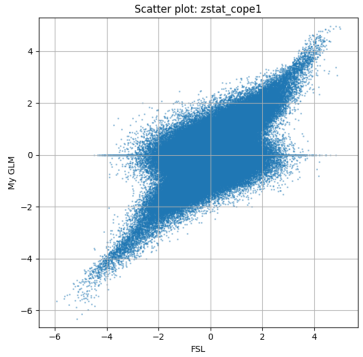
(a) Group level t-statistic Contrast 1



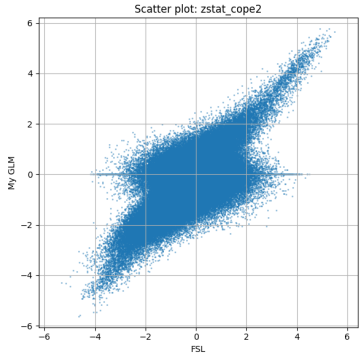
(b) Group level t-statistic Contrast 2



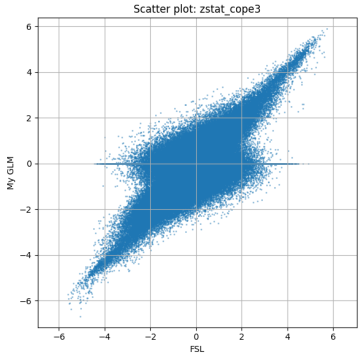
(c) Group level t-statistic Contrast 3



(d) Group level z-statistic Contrast 1



(e) Group level z-statistic Contrast 2



(f) Group level z-statistic Contrast 3

Figure 6: Scatter plots of group t-statistics and z-statistics comparing custom GLM (y-axis) with FSL (x-axis) for six contrasts.

2.1 Group level t-statistics Analysis

The t-statistics show strong positive correlations (0.63-0.69) across all three contrasts, with Contrast 3 showing the highest correlation (0.6929). The scatter plots display a clear linear relationship with positive slope, confirming that the core statistical framework is functioning correctly. This indicates the group-level inference procedure is successfully detecting similar activation patterns as FSL

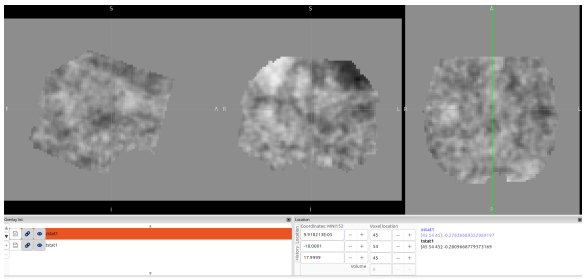
2.2 z-statistics Analysis

The z-statistics show moderate to strong positive correlations with FSL's implementation:

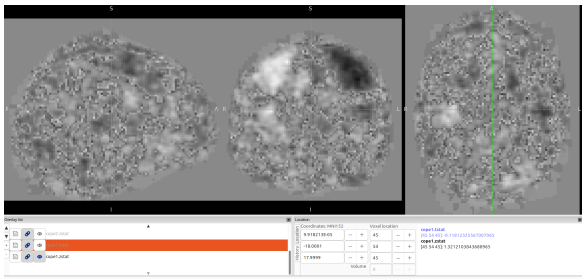
- Contrast 1: Moderate positive correlation (0.4936)
- Contrast 2: Moderate positive correlation (0.5367)
- Contrast 3: Strong positive correlation (0.5732)

These values demonstrate a good alignment with FSL's methodology, though the correlations are slightly lower than those observed for t-statistics. The correlation pattern for z-statistics follows the same trend as t-statistics, with Contrast 3 showing the strongest correlation in both cases.

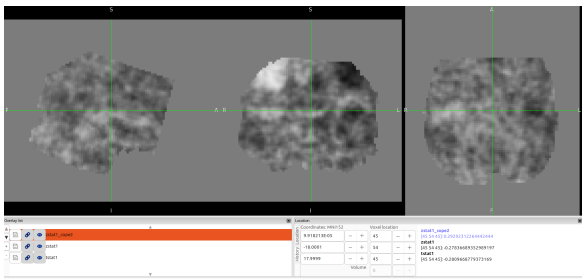
The scatter plots for z-statistics display a clear positive linear relationship, indicating that the directionality of activation is consistently preserved between the custom implementation and FSL.



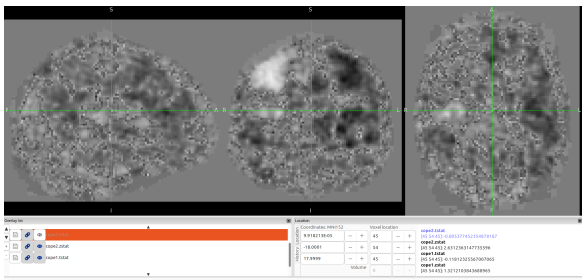
(a) zstat1 by fsl



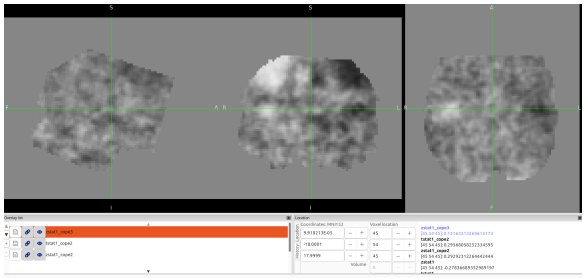
(b) custom zstat1



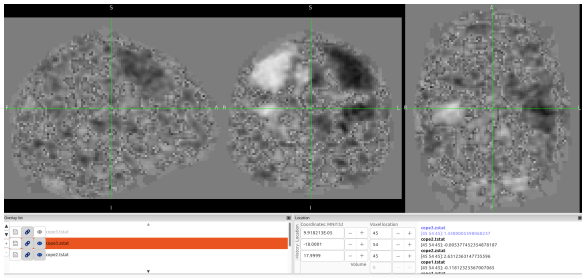
(c) zstat2 by fsl



(d) custom zstat2

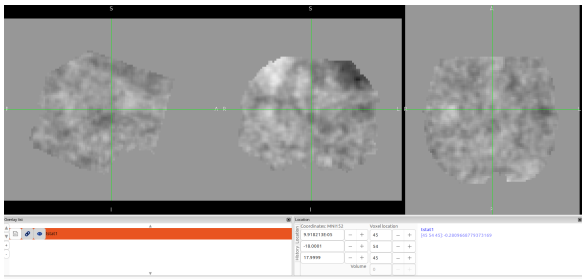


(e) zstat3 by fsl

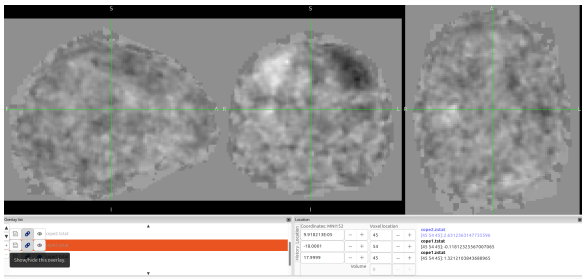


(f) custom zstat3

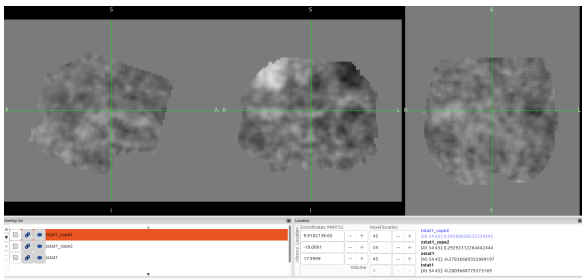
Figure 7: Brain maps comparison of z-statistics between FSL (left) and custom GLM (right) for 3 contrasts.



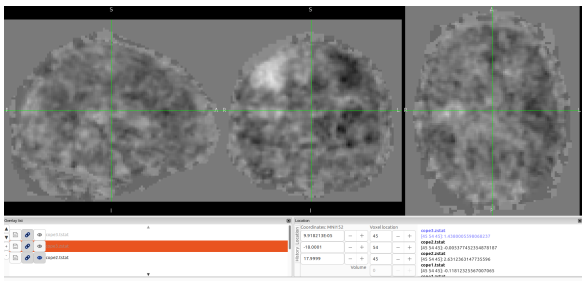
(a) tstat1 by fsl



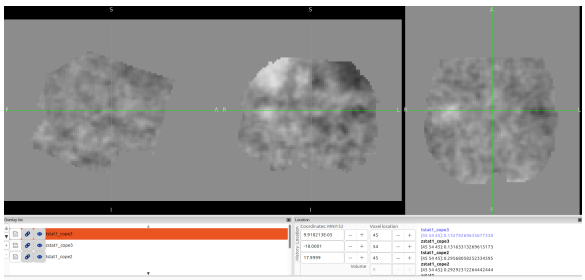
(b) custom tstat1



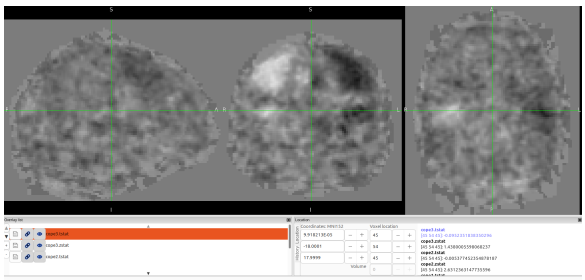
(c) tstat2 by fsl



(d) custom tstat2



(e) tstat3 by fsl



(f) custom tstat3

Figure 8: Brain maps comparison of t-statistics between FSL (left) and custom GLM (right) for 3 contrasts.

3 Conclusion

The custom GLM implementation shows strong performance in group-level analysis, with high correlations for t-statistics (0.63-0.69) and solid correlations for z-statistics (0.49-0.57). The implementation successfully preserves the sign information when converting from t-statistics to z-statistics, ensuring that activation patterns are consistently represented across both statistical measures. The single-subject analysis shows moderate correlations that ranged from -0.04 to 0.32 for parameter estimates, with notably similar performance across statistical outputs. The contrast of parameter estimates (COPEs) showed correlations between 0.06 and 0.27, while t-statistics and z-statistics demonstrated nearly identical correlation values within each contrast (ranging from 0.02 to 0.32), suggesting a consistent conversion methodology at the single-subject level.