Details About statistical analyses of MRI in Python Notebook:

The provided Jupyter notebook demonstrates how to perform statistical analysis on fMRI data using the General Linear Model (GLM) functionality from the **Nilearn** library. Below is a summary of the key steps and important information extracted from the notebook:

1. Data Setup and Visualization

- The notebook uses fMRI and anatomical images from subject sub-01 in the dataset ds000114.
    - **fMRI Image**: /data/ds000114/derivatives/fmriprep/sub-01/ses-test/func/..._desc-preproc_bold.nii.gz
    - **Anatomical Image**: /data/ds000114/sub-01/ses-test/anat/..._T1w.nii.gz
- After loading the images, the mean functional image and anatomical image are visualized using Nilearn's plotting functions.

2. Experimental Paradigm

- The experimental paradigm (timing of tasks) is defined by loading an events file (events.tsv), which contains task timings for "fingerfootlips" tasks.

3. GLM Analysis

- A FirstLevelModel object is created to perform the GLM analysis on the fMRI data. Key parameters include:
    - **TR (Repetition Time)**: 2.5 seconds
    - **Noise Model**: 'ar1'
    - **HRF Model**: 'spm'
- Confounds (e.g., motion correction parameters) are loaded from a confounds file and included in the model to account for noise.

4. Design Matrix

- The design matrix, which models the expected brain response during tasks, is computed and visualized. The first column corresponds to the "Finger" task.

5. Contrast Definition and Statistical Maps

- Contrasts are defined to compare different conditions (e.g., "active - Finger", "active - Foot"). These contrasts are used to compute effect size maps and z-score maps.

- Z-score maps are thresholded and visualized using both statistical thresholds (e.g., z > 3) and corrected thresholds (e.g., False Discovery Rate, Bonferroni correction).

6. Statistical Significance Testing

- Various methods for controlling false positives are demonstrated:
    - **False Positive Rate (FPR)**: Controls the chance of false detections.
    - **Bonferroni Correction**: A conservative method to control family-wise error rate.
    - **False Discovery Rate (FDR)**: Controls the proportion of false discoveries among detections.

7. Saving Results

- The effect size and z-score maps are saved as .nii.gz files.
- A table summarizing cluster information is generated and saved as a .csv file.

8. Group-Level Analysis

- After performing individual-level analysis for multiple subjects (sub-02 and sub-03), a group-level analysis is performed using a second-level model (one-sample t-test).

9. BIDS Integration

- The notebook demonstrates how to automate model creation for multiple participants using the BIDS standard with Nilearn's first_level_from_bids() function.

10. Evaluation of Models

- Residuals and predicted time series are extracted and compared against actual time series for peak voxels.
- The R-squared map is plotted to show how much variance in the data is explained by the GLM.

This notebook provides a comprehensive guide to performing statistical analyses on fMRI data, including individual-level GLM analysis, group-level analysis, thresholding methods, and BIDS integration, all using Nilearn's GLM functionality.