

# fMRISroke: A preprocessing pipeline for fMRI Data from Stroke patients

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## Software

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## Summary

Functional Magnetic Resonance Imaging (fMRI) is a widely used neuroimaging technique for the analysis of neural activity and functional connectivity. However, fMRI signal is inherently noisy and susceptible to various artifacts, compromising the accuracy and reliability of derived analyses. This becomes particularly critical when dealing with stroke patients, given the added complexity associated with their neurological condition. Specific preprocessing and denoising are integral steps to identify the nuisance sources and mitigate their effect on fMRI analysis. To address these considerations, we introduce fMRISroke, a functional magnetic resonance imaging (fMRI) data quality checks and preprocessing pipeline tailored specifically for stroke data. fMRISroke works as an add-on to typical preprocessing pipeline. Leveraging on a commonly used fMRI preprocessing tool outputs (fMRIPrep), fMRISroke generates new quality check plots, computes additional confounds, and executes confound regression (denoising), providing preprocessed fMRI ready for neural activity or connectivity analysis.

## Statement of need

Stroke, with its complex and varied impact on the brain's vascular supply, often results in damages that extend beyond the immediate lesion site, making functional connectivity analysis a promising tool to understand its immediate impact as well as network reorganizations during recovery.

However, while the Blood Oxygen Level Dependent (BOLD) signal obtained from fMRI data is typically mixed with non-neuronal sources of variability (Bianciardi et al., 2009) in healthy subjects it is even more true for stroke patients (Siegel et al., 2017), compromising the reliability of fMRI analyses and specifically Functional Connectivity (FC) analysis. Recognizing these challenges, it is highly recommended, notably by Siegel et al. (2017), to incorporate specific quality checks and strategies to address lesion-related confounds when working with stroke fMRI data.

Existing tools like fMRIPrep (Esteban et al., 2019) have streamlined most of the preprocessing steps; however, they lack specificity for fMRI data from stroke patients.

To this end, we propose fMRISroke, a fMRI preprocessing pipeline designed specifically for stroke data that builds on the output derivatives of fMRIPrep (Esteban et al., 2019) when a lesion mask is given. It provides an interface requiring minimal user input while delivering easily interpretable and comprehensive reports.

Concretely, novel quality checks include a hemodynamic lagmap. fMRISroke assesses hemodynamic lag using cross-correlation with the global gray matter signal (Siegel et al., 2016) using the rapidTide python library (Frederick et al., 2023). As stroke can introduce altered blood flow patterns a normal hemodynamic response cannot be assumed. (Siegel et al., 2016)

investigated temporal delays (lag) in resting state functional magnetic resonance imaging signals and found that significant hemodynamic lag was observed in 30% of sub-acute stroke patients and approximately 10% of patients at one-year post-stroke. Lags systematically alter measurements of functional connectivity from the affected nodes, and need to be taken into consideration when doing FC analysis (Siegel et al., 2017).

Additionally, signal in the lesion mask and signals in CSF and WM masks incorporating lesion masks are added to the confounds already computed by fMRIPrep along with new ICA-based confounds inspired by Yourganov et al. (2017) proposed method. In this paper the authors point out that the lesion introduces a particular artefact into the fMRI data which is not removed by standard preprocessing techniques. To mitigate this effect, they propose an ICA-based noise identification method. Independent components are calculated on the BOLD signal and those that overlap with the lesion (that is unlikely to include signal related to neuronal activity), are identified as potential noise components. Signals extracted from ICA components can be further regressed out from the fMRI data with a denoising procedure.

Finally supplementary outputs include the lesion mask in standardized space and multiple denoised fMRI as there is currently no consensus in the fMRI community on an optimal denoising strategy.

fMRISStroke pipeline is presented in more details in the following figure.

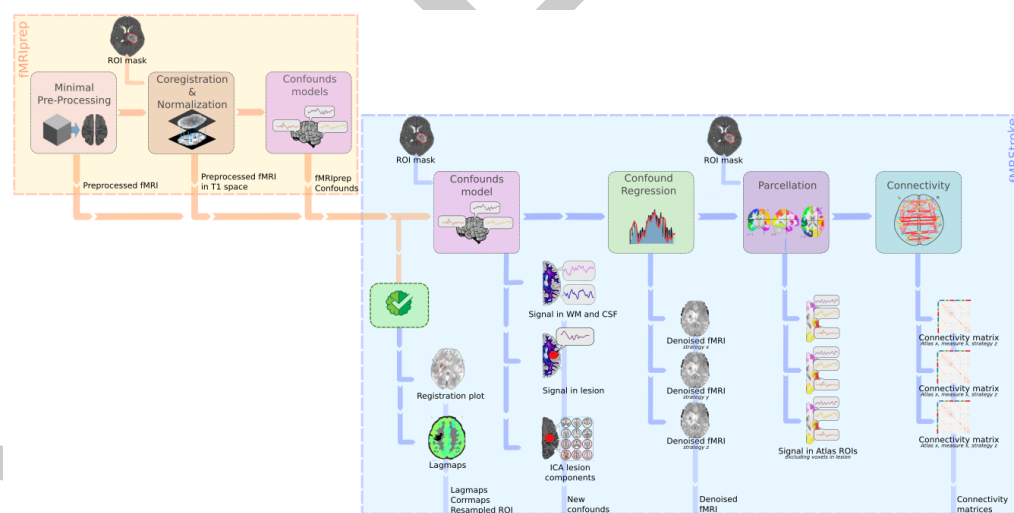


Figure 1: fMRISStroke pipeline.

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