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# **clpipe: A MRI Processing Pipeline for HPCs Documentation**

*Release .1*

**Cohen Lab at UNC-CH**

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## DOCUMENTATION

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clpipe was developed to streamline the processing of MRI data using the high performance cluster at University of North Carolina at Chapel Hill. It uses [fmriprep](#) for preprocessing fMRI data and implements a variety of additional processing steps important for functional connectivity analyses such as nuisance regression and filtering. Also included in clpipe are a variety of console commands for validation and checking the results of preprocessing. Please report any bugs, issues or feature requests on our [Github page](#).



## INSTALLATION

### 1.1 Python Environment Setup

If you have privileges to add python packages to a system, you can install the most recent version of clpipe with:

```
pip3 install --upgrade git+https://github.com/cohenlabUNC/clpipe.git
```

If you don't have access to the global library (perhaps you are just a user of an HPC), you can install a local copy by adding the `--user` flag:

```
pip3 install --user --upgrade git+https://github.com/cohenlabUNC/clpipe.git
```

Pip will automatically install all required Python package dependencies.

### 1.2 External Dependencies

If you don't already have a Singularity image of fMRIPrep, head over to their [site](#) and follow the directions. You will have to change the fMRIPrep image path in your configuration file.

Similarly, if you do not have a copy of the BIDS-validator Singularity image, you'll need to obtain [this image](#) as well:

Additionally, clpipe requires the following tools to be installed in order to run its postprocessing and analysis steps (UNC-CH Users - this is handled by the clpipe module):

- FSL (recommended v6.0.0 +)
- AFNI (recommended v20.0.00 +)
- R (v4.0.0 +)

### 1.3 A Note for UNC-CH Users

If you are a Longleaf user and a member of the hng posix group, clpipe has already been installed for you via the module system. Add the following line to your `~/.bashrc` file to include clpipe's modules:

```
module use /proj/hng/software/modules
```

You can then use the following to access the latest version of clpipe:

```
module add clpipe
```

You also already have access to the latest singularity images for both fmripred and the bids validator at `/proj/hng/singularity_imgs`, so there is no need to construct your own, unless you want a older version.

## 1.4 Batch Languages

clpipe was originally designed for use on the University of North Carolina at Chapel Hill's HPC, Longleaf, which uses the SLURM task management system. The way clpipe handles what batch language to use is through a set of batch configuration files. These files are not directly exposed to users, and modification of these directly is ill advised. For other institutions that use task management systems other than SLURM, get in touch with the package maintainers, and we would be happy to help setup a configuration file for your system. In coming versions of clpipe, functionality will be added to allow users to change the batch management system settings.



## PROJECT SETUP

clpipe contains a convenience command for setting up the directories and configuration files for a given neuroimaging project, in a way that makes it simple to change configuration option.

This command will create the necessary directory structures, as well as create a default configuration file with many directory fields already filled out. For example,

```
|-- analyses
|-- clpipe_config.json
|-- conversion_config.json
|-- data_BIDS
|   |-- CHANGES
|   |-- code
|   |-- dataset_description.json
|   |-- derivatives
|   |-- participants.json
|   |-- participants.tsv
|   |-- README
|   |-- sourcedata
|-- data_DICOMs -> /symlink/to/your/dicoms
|-- data_fmriprep
|-- data_postproc
|   |-- betaseries_default
|   |-- betaseries_noGSR
|   |-- betaseries_noScrub
|   |-- postproc_default
|   |-- postproc_noGSR
|   |-- postproc_noScrub
|-- data_ROI_ts
|   |-- postproc_default
|-- logs
|   |-- betaseries_logs
|   |-- DCM2BIDS_logs
|   |-- postproc_logs
|   |-- ROI_extraction_logs
|-- scripts
```

## 2.1 project\_setup

Set up a clpipe project.

```
project_setup [OPTIONS]
```

### Options

**-project\_title** <project\_title>

**Required**

**-project\_dir** <project\_dir>

**Required** Where the project will be located.

**-source\_data** <source\_data>

Where the raw data (usually DICOMs) are located.

**-move\_source\_data**

Move source data into project/data\_DICOMs folder. USE WITH CAUTION.

**-symlink\_source\_data**

Symlink the source data into project/data\_dicoms. Usually safe to do.

**-debug**

Flag to enable detailed error messages and traceback.

## CONFIGURATION FILES

Most command line functions in clpipe can take a configuration file in the ‘-configFile’ option. These configuration files are JSONs that contain all aspects of the preprocessing and postprocessing streams that you want applied to your dataset. To create a configuration file for your dataset use the following command

```
get_config_file -outputFile <adirectory/yourfilename>.json
```

This command will create a default configuration file with whatever name you specified. The default configuration file looks like this

```
{
  "ProjectTitle": "A Neuroimaging Project",
  "Authors/Contributors": "",
  "ProjectDirectory": "",
  "EmailAddress": "",
  "DICOMToBIDSOptions": {
    "DICOMDirectory": "",
    "BIDSDirectory": "",
    "ConversionConfig": "",
    "DICOMFormatString": "",
    "TimeUsage": "1:0:0",
    "MemUsage": "5000",
  },
  "CoreUsage": "2",
  "LogDirectory": "",
  "FMRIPrepOptions": {
    "BIDSDirectory": "",
    "WorkingDirectory": "",
    "OutputDirectory": "",
    "FMRIPrepPath": "/proj/hng/singularity_imgs/fmriprep_1.5.3.sif",
    "FreesurferLicensePath": "/proj/hng/singularity_imgs/license.txt",
    "CommandLineOpts": "",
    "TemplateFlowToggle": true,
    "TemplateFlowPath": "",
    "TemplateFlowTemplates": ["MNI152NLin2009cAsym", "MNI152NLin6Asym",
    ↪ "OASIS30ANTs", "MNIPediatricAsym", "MNIInfant"],
    "FMapCleanupROIs": 3,
    "FMRIPrepMemoryUsage": "20000",
    "FMRIPrepTimeUsage": "16:0:0",
    "NThreads": "8",
  },
  "LogDirectory": ""
},
```

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```

"PostProcessingOptions": {
    "TargetDirectory": "",
    "TargetSuffix": "space-MNI152Nlin2009cAsym_desc-preproc_bold.nii.gz",
    "OutputDirectory": "",
    "OutputSuffix": "",
    "ConfoundSuffix": "desc-confounds_regressors.tsv",
    "DropCSV": "",
    "Regress": true,
    "Confounds": ["trans_x", "trans_y", "trans_z", "rot_x", "rot_y", "rot_z",
        "csf", "white_matter", "global_signal", "a_comp_cor.*"],
    "ConfoundsQuad": ["trans_x", "trans_y", "trans_z", "rot_x", "rot_y", "rot_z",
↪ "",
        "csf", "white_matter", "global_signal"],
    "ConfoundsDerive": ["trans_x", "trans_y", "trans_z", "rot_x", "rot_y", "rot_
↪ z",
        "csf", "white_matter", "global_signal"],
    "ConfoundsQuadDerive": ["trans_x", "trans_y", "trans_z", "rot_x", "rot_y",
↪ "rot_z",
        "csf", "white_matter", "global_signal"],
    "FilteringHighPass": 0.008,
    "FilteringLowPass": -1,
    "FilteringOrder": 2,
    "OversamplingFreq": 4,
    "PercentFreqSample": 1,
    "Scrubbing": true,
    "ScrubVar": "framewise_displacement",
    "ScrubFDThreshold": 0.3,
    "ScrubAhead": 1,
    "ScrubBehind": 1,
    "ScrubContig": 2,
    "RespNotchFilter": true,
    "MotionVars": ["trans_x", "trans_y", "trans_z", "rot_x", "rot_y", "rot_z"],
    "RespNotchFilterBand": [0.31, 0.43],
    "PostProcessingMemoryUsage": "20000",
    "PostProcessingTimeUsage": "8:0:0",
    "NThreads": "1",
    "SpectralInterpolationBinSize": 5000,
    "BIDSValidatorImage": "/proj/hng/singularity_imgs/validator.simg",
    "LogDirectory": ""
},
"BetaSeriesOptions": {
    "TargetDirectory": "",
    "TargetSuffix": "preproc_bold.nii.gz",
    "OutputDirectory": "",
    "OutputSuffix": "betaseries.nii.gz",
    "ConfoundSuffix": "desc-confounds_regressors.tsv",
    "Regress": true,
    "NuisanceRegression": "QuadLagged",
    "WhiteMatter": true,
    "CSF": true,
    "GlobalSignalRegression": true,
    "FilteringHighPass": 0.008,

```

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```

    "FilteringLowPass": -1,
    "FilteringOrder": 2,
    "TaskSpecificOptions": [
        {
            "Task": "",
            "ExcludeColumnInfo": "trial_type",
            "ExcludeTrialTypes": ["block"]
        }
    ],
    "LogDirectory": ""
},
    "SUSANOptions": {
        "TargetDirectory": "",
        "TargetSuffix": "preproc_bold.nii.gz",
        "OutputDirectory": "",
        "OutputSuffix": "preproc_susan.nii.gz",
        "BrightnessThreshold": 500,
        "FWHM": 0,
        "MemoryUsage": "5000",
        "TimeUsage": "2:0:0",
        "NThreads": "4",
        "LogDirectory": ""
    },
    "ProcessingStreams": [
        {
            "ProcessingStream": "noGSR",
            "PostProcessingOptions": {
                "GlobalSignalRegression": false,
                "OutputDirectory": "",
                "OutputSuffix": ""
            },
            "BetaSeriesOptions": {
                "GlobalSignalRegression": false,
                "OutputDirectory": "",
                "OutputSuffix": ""
            },
            "SUSANOptions": {
                "OutputSuffix": "preproc_susan250.nii.gz",
                "BrightnessThreshold": 250
            }
        },
        {
            "ProcessingStream": "noScrub",
            "PostProcessingOptions": {
                "Scrubbing": false,
                "OutputDirectory": "",
                "OutputSuffix": ""
            },
            "BetaSeriesOptions": {
            },
            "SUSANOptions": {

```

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```
        }
    }

    ],
    "ROIExtractionOptions": {
        "TargetDirectory": "",
        "TargetSuffix": "",
        "OutputDirectory": "",
        "Atlases": ["power"],
        "RequireMask": true,
        "PropVoxels": 0.5,
        "MemoryUsage": "3000",
        "TimeUsage": "2:0:0",
        "NThreads": "1",
        "LogDirectory": ""
    },
    "RunLog": [],
    "BatchConfig": "slurmUNCCConfig.json"
}
```

All of these fields are required and have what the designers of clpipe consider to be reasonable defaults for processing. Additionally, users at UNC-CH on the Longleaf cluster with access to the HNG group should be able to use the default options with no change. Other users will have to modify several fields. We describe the various sections of the config now.

## 3.1 Header

- **ProjectTitle:** The title of your project. Not used in processing.
- **Authors/Contributors** Members of the project team. Not used in processing.
- **ProjectDirectory** Where the project is. Not used in processing.

## 3.2 FMRIPrep Options

- **FMRIPrepOptions:** Options regarding fMRIprep.
  - **BIDSDirectory:** Your BIDs formatted raw data directory. Use absolute paths if possible.
  - **OutputDirectory:** Where you want your preprocessed files to go. Use absolute paths
  - **WorkingDirectory** Where you want your working files to go. Use absolute paths. For Longleaf users, use `/pine/scr/<o>/<n>/<onyen>`, where `<onyen>` is your onyen, and `<o>` `<n>` are the first and second letters of your onyen respectively.
  - **FMRIPrepPath:** Where the fMRIprep Singularity image is.
  - **FreesurferLicensePath:** Where your Freesurfer license .txt file is.
  - **TemplateFlowToggle:** This flag activates the use of templateflow, which is used in later versions of FMRIPREP,
  - **TemplateFlowPath:** Where the templateflow template folder is located,

- **TemplateFlowTemplates:** Which templates (standard spaces) should clpipe download for use in templateflow?
- **FMapCleanupROIs:** How many timepoints should the fmap\_cleanup function extract from blip-up/blip-down field maps, set to -1 to disable.
- **CommandLineOpts:** Additional arguments to pass to FMRIPrep
- **FMRIPrepMemoryUsage:** How much memory in RAM each subject's preprocessing will use, in Mbs. Default is 20000Mb or 20Gb.
- **FMRIPrepTimeUsage:** How much time on the cluster FMRIPrep is allowed to use. Defaults to 16 hours.
- **LogDirectory:** Where cluster output files are stored.

### 3.3 Postprocessing Options

These are the processing options for function connectivity postprocessing only. Beta Series or GLM are separate option blocks. Note: These are the master options, and changes in `ProcessingStreams` are changes from the master options.

- **PostProcessingOptions:** Options for various postprocessing steps.
  - **TargetDirectory:** What directory holds your fMRIPrep preprocessed data.
  - **TargetSuffix:** What suffix do your preprocessed fMRI NiFTi files have? Default is preproc\_bold.nii.gz.
  - **OutputDirectory:** Where you want your postprocessed files to go.
  - **OutputSuffix:** What suffix do you want appended to your postprocessed files? Make sure to end it with .nii.gz.
  - **ConfoundSuffix:** What suffix does the confound regressors file have. Default is confound\_regressor.txt.
  - **Regress:** True/False. Do you want to perform nuisance regression on the data. Default True. For more info see Postprocessing/Nuisance Regression.
  - **RegressionParameters:** These are the headers for the various regression parameters in the fmriprep confound file. The defaults are for the latest fmriprep version. Change only if you are using a much earlier version of fmriprep.
  - **NuisanceRegression:** What type of nuisance regression do you want to perform. Default to QuadLagged (33 Parameter Regression). For more information see Postprocessing/Nuisance Regression.
  - **WhiteMatter:** True/False. Include mean whitematter signal into nuisance regression. Defaults to True.
  - **CSF:** True/False. Include mean cerebral spinal fluid signal into nuisance regression. Defaults to True.
  - **GlobalSignalRegression:** True/False. Include global signal into nuisance regression. Defaults to True.
  - **FilteringHighPass:** High pass frequency for filtering. Defaults to .08 Hz. For more information on filtering see Postprocessing/Frequency Filtering. Set to -1 to remove high pass filtering.
  - **FilteringLowPass:** Low pass frequency for filtering. Defaults to no filter (-1). For more information on filtering see Postprocessing/Frequency Filtering. Set to -1 to remove low pass filtering.
  - **FilteringOrder:** Order of filter. Defaults to 2. For more information on filtering see Postprocessing/Frequency Filtering.
  - **OversamplingFreq:** The oversampling frequency for the spectral interpolation. Defaults to 4. For more information on spectral interpolation see Postprocessing/Spectral Interpolation.

- **PercentFrequencySample**: Proportion (0 to 1, 1 being 100%) of spectrum to use in spectral interpolation. Defaults to 1. For more information on spectral interpolation see Postprocessing/Spectral Interpolation.
- **Scrubbing**: True/False. Use scrubbing. Defaults to true. For more information on scrubbing see Postprocessing/Scrubbing.
- **ScrubFDThreshold**: At what framewise displacement to scrub. Defaults to .3.
- **ScrubAhead**: If a timepoint is scrubbed, how many points after to remove. Defaults to 2.
- **ScrubBehind**: If a timepoint is scrubbed, how many points before to remove. Defaults to 2.
- **ScrubContig**: How many good contiguous timepoints need to exist. Defaults to 4.
- **PostProcessingMemoryUsage**: How much memory (RAM) per subject to request, in Mbs. Defaults to 20000Mb or 20Gb.
- **PostProcessingMemoryUsage**: How much time per subject to request. Format is Hours:Mins:Seconds. Defaults to 8 hours.
- **NThreads**: How many CPUs to request. Defaults to 1. Do not modify lightly.
- **SpectralInterpolationBinSize**: How many voxels per bin to work on in spectral interpolation. Increasing this reduces time but increases memory usage. Defaults to 5000.
- **BIDSValidatorImage**: Where the BIDS validator Singularity image is.
- **LogDirectory**: Where cluster output files are stored.

## 3.4 Beta Series Options

These options are for the beta series calculations. This is a complex method, please see DOCUMENTATION NOT COMPLETE, for implementation details.

- **BetaSeriesOptions** Options for various postprocessing steps.
  - **TargetDirectory**: What directory holds your fMRIPrep preprocessed data.
  - **TargetSuffix**: What suffix do your preprocessed fMRI NiFTi files have? Default is preproc\_bold.nii.gz.
  - **OutputDirectory**: Where you want your postprocessed files to go.
  - **OutputSuffix**: What suffix do you want appended to your postprocessed files? Make sure to end it with .nii.gz.
  - **ConfoundSuffix**: What suffix does the confound regressors file have. Default is confound\_regressor.txt.
  - **Regress**: True/False. Do you want to perform nuisance regression on the data. Default True. For more info see Postprocessing/Nuisance Regression.
  - **RegressionParameters**: These are the headers for the various regression parameters in the fmriprep confound file. The defaults are for the latest fmriprep version. Change only if you are using a much earlier version of fmriprep.
  - **NuisanceRegression**: What type of nuisance regression do you want to perform. Default to QuadLagged (33 Parameter Regression). For more information see Postprocessing/Nuisance Regression.
  - **WhiteMatter**: True/False. Include mean whitematter signal into nuisance regression. Defaults to True.
  - **CSF**: True/False. Include mean cerebral spinal fluid signal into nuisance regression. Defaults to True.
  - **GlobalSignalRegression**: True/False. Include global signal into nuisance regression. Defaults to True.



- **FilteringHighPass**: High pass frequency for filtering. Defaults to .08 Hz. For more information on filtering see Postprocessing/Frequency Filtering. Set to -1 to remove high pass filtering.
- **FilteringLowPass**: Low pass frequency for filtering. Defaults to no filter (-1). For more information on filtering see Postprocessing/Frequency Filtering. Set to -1 to remove low pass filtering.
- **FilteringOrder**: Order of filter. Defaults to 2. For more information on filtering see Postprocessing/Frequency Filtering.
- **TaskSpecificOptions**: A list of option blocks, one for each task you are interested in using beta series with.
  - \* **Task**: Task name, must match BIDS task- signifier.
  - \* **ExcludeColumnInfo**: The name of the column in the BIDS formatted events files that contain the information about the trials needed to be excluded from the beta series analysis. (for example, if you have events nested within blocks, then you would want to exclude the block “events”)
  - \* **ExcludeTrialType**: A list of trial types to exclude.
- **LogDirectory**: Where cluster output files are stored.

## 3.5 SUSAN Smoothing

- **SUSANOptions** Options for FSL’s SUSAN smoothing procedure
  - **BrightnessThreshold**: The voxel intensity threshold used to distinguish where to smooth. It should be above background level, but below the contrast between edges.
  - **FWHM**: The size of the smoothing kernel. Specifically the full width half max of the Gaussian kernel. Scaled in millimeters. 0 uses a 3x3x3 voxel smoother.

## 3.6 Processing Streams

- **ProcessingStreams**: A list of processing streams, consisting of the following:
  - \***ProcessingStream::** The name of the processing stream
  - \***PostProcessingOptions::** A list of options to overwrite.
  - \***BetaSeriesOptions::** A list of options to overwrite.

These options are for specific processing streams, and allow the user to overwrite the defaults.

## 3.7 ROI Extraction Options

### \***ROIExtractionOptions:** Options for ROI extraction

- **TargetDirectory**: What directory holds your fMRIPrep preprocessed data.
- **TargetSuffix**: What suffix do your preprocessed fMRI NiFTi files have? Default is preproc\_bold.nii.gz.
- **OutputDirectory**: Where you want your postprocessed files to go.
- **Atlases**: A list of atlas names. Please refer to the ROI extraction documentation for a full list of included atlases.

## 3.8 Other Options

- **RunLog:** This list contains a record of how a given configuration file is used.
- **BatchConfig:** What batch configuration file to use. For more information see For Advanced Users/Batch Configuration.

## DICOM TO BIDS CONVERSION

clpipe has several commands to facilitate the conversion of DICOM files into NiFTI files all in BIDS format. We use `dc2nifti`, which is a flexible system for converting DICOM files. It does require the creation of a configuration file, a JSON that directs the conversion. Below we have an example of what this might look like.

One important thing to note about using the main command is the need for a specifically formatted *dicom\_dir\_format* option. This is to appropriately map your dicom directories to subject/sessions. All subject session folders should be named the same way. A *dicom\_dir\_format* must contain at least {session} and can contain a {subject} formatting option. Two examples of a *dicom\_dir\_format* option are *{subject}\_{session}/*, which corresponds to the following structure:

```
dicom_data/
  S01_pre/
    scan1/
    scan2/
    scan3
  S01-post/
    scan1/
    scan2/
    scan3/
```

Alternatively, you can use *{subject}/{session}/*

```
data/
  S01/
    pre/
      scan1/
    post/
      scan1/
  S02/
    pre/
      scan1/
    post/
      scan1/
```

You can include other text in the formatting option, so that the program ignores that text. For example, *Subject-{subject}/* used on a dataset with *Subject-01* as a folder will determine the subject id to be *01* not *Subject-01*. Note that in all examples, there is a trailing forward slash.

Finally, instead of using the command line option, this DICOM format string can be specified in the clpipe configuration JSON.

The other important ingredient in converting your DICOMs to BIDS format is the conversion configuration. An example file is generated when you use the `project_setup` command. Below is a brief example:

```

{
  "descriptions": [
    {
      "dataType": "anat",
      "modalityLabel": "T1w",
      "customLabels": "",
      "criteria": {
        "SeriesDescription": "T1w_MPRAGE",
        "ImageType": ["ORIGINAL", "PRIMARY", "M", "ND", "NORM"]
      }
    },
    {
      "dataType": "anat",
      "modalityLabel": "T2w",
      "customLabels": "",
      "criteria": {
        "SeriesDescription": "T2_AX_struct"
      }
    },
    {
      "dataType": "func",
      "modalityLabel": "bold",
      "customLabels": "task-rest",
      "sidecarChanges": {
        "TaskName": "Resting State"
      },
      "criteria": {
        "SeriesDescription": "*_resting_AP*"
      }
    },
    {
      "dataType": "func",
      "modalityLabel": "bold",
      "customLabels": "task-gngreg",
      "criteria": {
        "SeriesDescription": "*_GNGregular*"
      }
    },
    {
      "dataType": "func",
      "modalityLabel": "bold",
      "customLabels": "task-gngrew",
      "criteria": {
        "SeriesDescription": "*_GNGreward*"
      }
    },
    {
      "dataType": "dwi",
      "modalityLabel": "dwi",
      "customLabels": "acq-APref",
      "criteria": {
        "SeriesDescription": "*p2_AP_TRACEW*"
      }
    }
  ]
}

```

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```

    },
    {
        "dataType": "dwi",
        "modalityLabel": "dwi",
        "customLabels": "acq-PAref",
        "criteria": {
            "SeriesDescription": "*p2_PA"
        }
    },
    {
        "dataType": "dwi",
        "modalityLabel": "dwi",
        "customLabels": "acq-AP",
        "criteria": {
            "SeriesDescription": "*p2_AP"
        }
    },
    {
        "dataType": "fmap",
        "modalityLabel": "epi",
        "criteria": {
            "SeriesDescription": "*_resting_PA*"
        },
        "intendedFor": [2,3]
    }
]
}

```

This configuration file looks for all scans that have “\_srt” anywhere in the SeriesDescription field of the header, converts them into NIFTI, labels them in the BIDS standards, and adds the custom label of *task-srt*. It does the same for anatomical scans with “MPRAGE” contained in the series description. Any header field in the dicoms can be used as criteria. If multiple scans meet the criteria, then they will be labeled *run-1*, *run-2*, ... in order of acquisition.

Note that for fieldmaps, one can use the “intendedFor” option to specify which BOLD images a fieldmap should be used for. There are two important points here. The first is that the “intendedFor” field is 0-indexed, in that 0 corresponds to the first entry in the conversion config, 1 corresponds to the second entry, etc, etc. In the example above, the fieldmap is intended for the resting state scan and the GNG regular scan. Additionally, the intended for field is not sensitive to multiple runs. For example, if there are 2 resting state scans, and therefore the file names look like “sub-9999\_task-rest\_run-01\_bold.nii.gz” and “sub-9999\_task-rest\_run-02\_bold.nii.gz” after conversion, the IntendedFor field in the fieldmap’s JSON will list “sub-9999\_task-rest\_bold.nii.gz” This is due to an issue with the dcm2bids package, and will result in the fieldmaps not being used. The workaround is to list each run explicitly in your conversion configuration, or to modify each fieldmap JSON after it is generated.

Finally, there are several varieties of fieldmaps allowable in the BIDS format, each needing a different set of conversion config entries. For a detailed look at these types, please see [the BIDS Specification](#).

## 4.1 Conversion Commands

To obtain the information from the header, dcm2bids has a handy helper function:

```
usage: dcm2bids_helper [-h] -d DICOM_DIR [DICOM_DIR ...] [-o OUTPUT_DIR]

optional arguments:
  -h, --help            show this help message and exit
  -d DICOM_DIR [DICOM_DIR ...], --dicom_dir DICOM_DIR [DICOM_DIR ...] DICOM files_
                        ↪directory
  -o OUTPUT_DIR, --output_dir OUTPUT_DIR
                        Output BIDS directory, Default: current directory

Documentation at https://github.com/cbedetti/Dcm2Bids
```

This command will create convert an entire folder's data, and create a temporary directory containing all the converted files, and more importantly the sidecar JSONs. These JSONs contain the information needed to update the conversion configuration file.

Once you have updated your conversion configuration file, you can convert your entire dataset with:

### 4.1.1 convert2bids

Convert DICOM files to BIDS format.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

```
> clpipe bids convert 123 124 125 ...
```

Available subject IDs are determined by the dicom\_dir\_format string.

```
convert2bids [OPTIONS] [SUBJECTS] ...
```

#### Options

**-config\_file, -c <config\_file>**

The path to your clpipe configuration file.

**-conv\_config\_file <conv\_config\_file>**

A conversion definition file, either a dcm2bids conversion config .json file or a heudiconv heuristic .py file.

**-dicom\_dir, -i <dicom\_dir>**

The folder where subject dicoms are located.

**-dicom\_dir\_format <dicom\_dir\_format>**

Format string which specifies how subjects/sessions are organized within the dicom\_dir. Example: {subject}\_{session}. See [https://clpipe.readthedocs.io/en/latest/bids\\_convert.html](https://clpipe.readthedocs.io/en/latest/bids_convert.html) for more details.

**-BIDS\_dir, -o <bids\_dir>**

The dicom info output file name.

**-overwrite**

Overwrite existing BIDS data?

**-log\_dir** <log\_dir>

Where to put your HPC output files (such as SLURM output files).

**-subject** <subject>

DEPRECATED: specify one subject to process - can give an arbitrary number of subjects as arguments now.

**-session** <session>

Specify the session to convert. Available sessions determined by the {session} placeholder given by dcm\_dir\_format.

**-longitudinal**

Convert all subjects/sessions into individual pseudo-subjects. Use if you do not want T1w averaged across sessions during FMRIPrep

**-submit, -s**

Flag to submit commands to the HPC.

**-debug, -d**

Flag to enable detailed error messages and traceback.

**-dcm2bids, -heudiconv**

Specify which converter to use.

## Arguments

### SUBJECTS

Optional argument(s)





## BIDS VALIDATION

clpipe contains a convenience function to validate your datasets directly on the HPC. This function uses a Singularity image of the [BIDs Validator](#).

The output of this command will appear in your *logs/bids\_validation\_logs* folder by default.

### 5.1 bids\_validate

Validate if a directory BIDS standard.

Validates the directory at BIDS\_DIR, or at the BIDS directory in your config file's DICOMToBIDSOPTIONS if -config\_file is given.

Results are viewable in logs/bids\_validation\_logs unless -interactive is used.

```
bids_validate [OPTIONS] [BIDS_DIR]
```

#### Options

**-config\_file** <config\_file>

The path to your clpipe configuration file.

**-log\_dir** <log\_dir>

Where to put your HPC output files (such as SLURM output files).

**-verbose**

Creates verbose validator output. Use if you want to see ALL files with errors/warnings.

**-submit**

Flag to submit commands to the HPC.

**-interactive**

Run in interactive mode. Only use in an interactive compute session.

**-debug**

Flag to enable detailed error messages and traceback.

## Arguments

**BIDS\_DIR**

Optional argument

## PREPROCESSING WITH FMRIPREP

clpipe uses **fMRIPrep** to perform minimal preprocessing on functional MRI data.

**fmriprep\_process** creates one batch job per subject. If you find that you are running out of memory, increase the *[FMRIprepOptions][FMRIprepMemoryUsage]* option in the configuration file.

To submit your dataset for preprocessing, use the following command:

### 6.1 fmriprep\_process

Submit BIDS-formatted images to fMRIPrep.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

```
> clpipe preprocess 123 124 125 ...
```

```
fmriprep_process [OPTIONS] [SUBJECTS]...
```

#### Options

**-config\_file** <config\_file>

The path to your clpipe configuration file.

**-bids\_dir** <bids\_dir>

The dicom info output file name.

**-working\_dir** <working\_dir>

Where to generate the working directory.

**-output\_dir** <output\_dir>

Where to put the preprocessed data. If a configuration file is provided with a output directory, this argument is not necessary.

**-log\_dir** <log\_dir>

Where to put your HPC output files (such as SLURM output files).

**-submit**

Flag to submit commands to the HPC.

**-debug**

Flag to enable detailed error messages and traceback.

## Arguments

### SUBJECTS

Optional argument(s)

## 6.2 Getting Quality Control Reports

fMRIPrep produces detailed html reports for each subject, allowing users to visually inspect registration, normalization and confound plots. However, these reports do not have the images directly embedded in them, which means that directly downloading them from the HPC will not result in a usable report. There are two options:

1. Open the html reports directly on the HPC, using some sort of interactive web browser.
2. Download the reports and the images in the correct directory structure.

clpipe has a convenience function to organize and prepare a zip archive containing the reports and images, for quick download onto a personal computer.

This command uses the working directory previously specified to copy the reports and images to, then creates a zip archive containing them. This command is not a batch

command, and can take a little time creating the archive, so be aware.

Once the archive is created, it can be downloaded and unzipped to a personal computer. The reports should correctly load images once opened.

### 6.2.1 get\_reports

This command creates a zip archive of fmriprep QC reports for download.

```
get_reports [OPTIONS]
```

#### Options

**-config\_file** <config\_file>

**Required** The configuration file for the current data processing setup.

**-output\_name** <output\_name>

Path and name of the output archive. Defaults to current working directory and “Report\_Archive.zip”

**-debug**

Print traceback on errors.

## POSTPROCESSING

When performing functional connectivity analysis, there are several additional processing steps that need to be taken after the minimal preprocessing of fMRIPrep. `clpipe` implements these steps in Python, and a fMRIPrep preprocessed dataset can be postprocessed using the following command:

### 7.1 fmri\_postprocess

Additional processing for connectivity analysis.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

```
> clpipe postprocess 123 124 125 ...
```

```
fmri_postprocess [OPTIONS] [SUBJECTS] ...
```

#### Options

**-config\_file** <config\_file>

Use a given configuration file. If left blank, uses the default config file, requiring definition of BIDS, working and output directories.

**-target\_dir** <target\_dir>

Which fmriprep directory to process. If a configuration file is provided with a BIDS directory, this argument is not necessary. Note, must point to the `fmriprep` directory, not its parent directory.

**-target\_suffix** <target\_suffix>

Which file suffix to use. If a configuration file is provided with a target suffix, this argument is not necessary. Defaults to “`preproc_bold.nii.gz`”

**-output\_dir** <output\_dir>

Where to put the postprocessed data. If a configuration file is provided with a output directory, this argument is not necessary.

**-output\_suffix** <output\_suffix>

What suffix to append to the postprocessed files. If a configuration file is provided with a output suffix, this argument is not necessary.

**-task** <task>

Which task to postprocess. If left blank, defaults to all tasks.

**-TR <tr>**

The TR of the scans. If a config file is not provided, this option is required. If a config file is provided, this information is found from the sidcar jsons.

**-processing\_stream <processing\_stream>**

Optional processing stream selector.

**-log\_dir <log\_dir>**

Where to put HPC output files. If not specified, defaults to <outputDir>/batchOutput.

**-beta\_series**

Flag to activate beta-series correlation correlation. ADVANCED METHOD, refer to the documentation.

**-submit**

Flag to submit commands to the HPC.

**-batch, -single**

Submit to batch, or run in current session. Mainly used internally.

**-debug**

Print detailed processing information and traceback for errors.

## Arguments

### SUBJECTS

Optional argument(s)

## 7.2 Processing Checker

clpipe has a convenient function for determining which scans successfully made it through both preprocessing using fMRIPrep and postprocessing.

This command will create a csv file listing all scans found in the BIDS dataset, and corresponding scans in the fMRIPrep dataset and the postprocessed dataset.

For a description of the various postprocessing steps, along with references, please see the following documentation:

1. Nuisance Regression
2. Frequency Filtering
3. Scrubbing
4. Spectral Interpolation

### 7.2.1 fmri\_process\_check

This command checks a BIDS dataset, an fMRIPrep'ed dataset and a postprocessed dataset, and creates a CSV file that lists all scans across all three datasets. Use to find which subjects/scans failed processing.

<code>fmri_process_check [OPTIONS]</code>
---

## Options

**-config\_file** <config\_file>

**Required** The configuration file for the current data processing setup.

**-output\_file** <output\_file>

Path and name of the output archive. Defaults to current working directory and “Report\_Archive.zip”

**-debug**

Print traceback and detailed processing messages.

## 7.3 SUSAN Spatial Smoothing

clpipe uses FSL’s [SUSAN smoothing](#) to perform spatial smoothing. This step is usually done after postprocessing. Options for this are configurable on a processing stream basis, see config file for more details.

### 7.3.1 susan\_smoothing

```
susan_smoothing [OPTIONS] [SUBJECTS]...
```

## Options

**-config\_file** <config\_file>

Use a given configuration file. If left blank, uses the default config file, requiring definition of BIDS, working and output directories.

**-target\_dir** <target\_dir>

Which directory to process. If a configuration file is provided.

**-target\_suffix** <target\_suffix>

Which file suffix to use. If a configuration file is provided with a target suffix, this argument is not necessary. Defaults to “preproc\_bold.nii.gz”

**-output\_dir** <output\_dir>

Where to put the postprocessed data. If a configuration file is provided with a output directory, this argument is not necessary.

**-output\_suffix** <output\_suffix>

What suffix to append to the smoothed files. If a configuration file is provided with a output suffix, this argument is not necessary.

**-task** <task>

Which task to smooth. If left blank, defaults to all tasks.

**-processing\_stream** <processing\_stream>

Optional processing stream selector.

**-log\_dir** <log\_dir>

Where to put HPC output files. If not specified, defaults to <outputDir>/batchOutput.

**-submit**

Flag to submit commands to the HPC.

**-batch, -single**

Submit to batch, or run in current session. Mainly used internally.

**-debug**

Print detailed processing information and traceback for errors.

## Arguments

### SUBJECTS

Optional argument(s)

## 7.4 fmri\_postprocess2

New to clpipe v1.5, the command `fmri_postprocess2` combines the functionality of `fmri_postprocess` and `glm_setup` into a unified postprocessing stream.

This command allows for flexible creation of processing streams. The order of processing steps and their specific implementations can be modified in the configuration file. Any temporally-relevant processing steps can also be applied to each image's corresponding confounds file. `fmri_postprocess2` caches its processing intermediaries in a working directory, which allows quick re-runs of pipelines with new parameters.

This command will also output a detailed processing graph for each processing stream.

Available processing steps:

- Temporal Filtering
- Intensity Normalization
- Spatial Smoothing
- AROMA Regression
- Confound Regression
- Apply Mask
- Resample
- Trim Timepoints





### 7.4.1 Configuration Setup

This command requires a new configuration block - if you using an existing clpipe project, you will have to insert this json into your configuration file. Otherwise, this block will be included when running “project setup.”

```
"PostProcessingOptions2": {
  "WorkingDirectory": "",
  "WriteProcessGraph": true,
  "TargetImageSpace": "MNI152Nlin2009cAsym",
  "TargetTasks": [],
  "TargetAcquisitions": [],
  "ProcessingSteps": [
    "SpatialSmoothing",
    "TemporalFiltering",
    "IntensityNormalization",
    "ApplyMask"
  ],
  "ProcessingStepOptions": {
    "TemporalFiltering": {
      "Implementation": "fslmaths",
      "FilteringHighPass": 0.008,
      "FilteringLowPass": -1,
      "FilteringOrder": 2
    },
    "IntensityNormalization": {
      "Implementation": "10000_GlobalMedian"
    },
    "SpatialSmoothing": {
      "Implementation": "SUSAN",
      "FWHM": 6
    },
    "AROMAREgression": {
      "Implementation": "fsl_regfilt_R"
    },
    "Resample": {
      "ReferenceImage": "SET REFERENCE IMAGE"
    },
    "TrimTimepoints": {
      "FromEnd": 0,
      "FromBeginning": 0
    },
    "ConfoundRegression": {
      "Implementation": "afni_3dTproject"
    }
  },
  "ConfoundOptions": {
    "Columns": [
      "csf", "csf_derivative1", "white_matter", "white_matter_
↪derivative1"
    ],
    "MotionOutliers": {
      "Include": true,
      "ScrubVar": "framewise_displacement",
```

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```

        "Threshold": 0.9,
        "ScrubAhead": 0,
        "ScrubBehind": 0,
        "ScrubContiguous": 0
    },
    "BatchOptions": {
        "MemoryUsage": "20000",
        "TimeUsage": "2:0:0",
        "NThreads": "1"
    }
}

```

- **PostProcessingOptions:** Options for configuring post-fmriprep processing steps.
  - **WorkingDirectory:** Directory for caching intermediary processing files.
  - **WriteProcessGraph:** Set ‘true’ to write a processing graph alongside your output.
  - **TargetImageSpace:** Which space to use from your fmriprep output. This is the value that follows “space-” in the image file names.
  - **TargetTasks:** Which tasks to use from your fmriprep output. This is the value that follows “task-” in the image file names. Leave blank to target all tasks.
  - **TargetAcquisitions:** Which acquisitions to use from your fmriprep output. This is the value that follows “acq-” in the image file names. Leave blank to target all acquisitions.
  - **ProcessingSteps:** The default list of processing steps to use. Processing will follow the order of this list.
  - **ProcessingStepOptions:** The default processing options for each step.
    - \* **TemporalFiltering:** Apply temporal filtering to the image data. Also be applied to confounds.
      - **Implementation:** Currently limited to “fslmaths”
      - **FilteringHighPass:** High pass frequency for filtering. Defaults to .08 Hz. Set to -1 to remove high pass filtering.
      - **FilteringLowPass:** Low pass frequency for filtering. Defaults to no filter (-1). Set to -1 to remove low pass filtering.
      - **FilteringOrder:** Order of filter. Defaults to 2.
    - \* **IntensityNormalization:** Apply intensity normalization to the image data.
      - **Implementation:** Currently limited to “10000\_GlobalMedian”
    - \* **SpatialSmoothing:** Apply spatial smoothing to the image data.
      - **Implementation:** Currently limited to “SUSAN”
      - **FWHM:** The size of the smoothing kernel. Specifically the full width half max of the Gaussian kernel. Scaled in millimeters.
    - \* **AROMAREgression:** Regress out AROMA artifacts from the image data. Also be applied to confounds.
      - **Implementation:** Currently limited to “fsl\_regfilt\_R”
    - \* **Resample:** Resample the image into a new space.

- \* **TrimTimepoints**: Trim timepoints from the beginning or end of an image. Also be applied to confounds.
  - **FromEnd**: Number of timepoints to trim from the end of each image.
  - **FromBeginning**: Number of timepoints to trim from the beginning of each image.
- \* **ConfoundRegression**: Regress out the confound file values from your image. If any other processing steps are relevant to the confounds, they will be applied first.
  - **Implementation**: Currently limited to “afni\_3dTproject”
- **ConfoundOptions**: The default options to apply to the confounds files.
  - \* **Columns**: A list containing a subset of confound file columns to use from each image’s confound file.
  - \* **MotionOutliers**: Options specific to motion outliers.
    - **Include**: Set ‘true’ to add motion outlier spike regressors to each confound file.
    - **ScrubVar**: Which variable in the confounds file should be used to calculate motion outliers, defaults to framewise displacement.
    - **Threshold**: Threshold at which to flag a timepoint as a motion outlier, defaults to .9
    - **ScrubAhead**: How many time points ahead of a flagged time point should be flagged also, defaults to 0.
    - **ScrubBehind**: If a timepoint is scrubbed, how many points before to remove. Defaults to 0.
    - **ScrubContiguous**: How many good contiguous timepoints need to exist. Defaults to 0.
- **BatchOptions**: The batch settings for postprocessing.
  - \* **MemoryUsage**: How much memory to allocate per job.
  - \* **TimeUsage**: How much time to allocate per job.
  - \* **NThreads**: How many threads to allocate per job.

## 7.4.2 Processing Streams Setup

By default, the output from running `fmri_postprocess2` will appear in your `clpipe` folder at `data_postproc2/smooth_filter_normalize`, reflecting the defaults from `PostProcessingOptions2`.

However, you can utilize the power of processing streams to deploy multiple postprocessing streams. Each processing stream you define your config file’s `ProcessingStreams` block will create a new output folder named after the `ProcessingStream` setting.

Within each processing stream, you can override any of the settings in the main `PostProcessingOptions2` section. For example, in the follow json snippet, the first processing stream will only pick “rest” tasks and defines its own set of processing steps. The second stream does the same thing, but specifies a filtering high pass by overriding the default value of -1 with .009.

```
...
"ProcessingStreams": [
  ...
  {
    "ProcessingStream": "smooth_aroma-regress_filter-butterworth_normalize",
    "PostProcessingOptions": {
      "TargetTasks": [
        "rest"
```

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```

    ],
    "ProcessingSteps": [
        "SpatialSmoothing",
        "AROMAREgression",
        "TemporalFiltering",
        "IntensityNormalization",
        "ApplyMask"
    ]
  },
  {
    "ProcessingStream": "smooth_aroma-regress_filter-high-only_normalize",
    "PostProcessingOptions": {
      "TargetTasks": [
        "rest"
      ],
      "ProcessingSteps": [
        "SpatialSmoothing",
        "AROMAREgression",
        "TemporalFiltering",
        "IntensityNormalization",
        "ApplyMask"
      ],
      "ProcessingStepOptions": {
        "TemporalFiltering": {
          "FilteringHighPass": .009
        }
      }
    }
  },
  ...

```

To run a specific stream, give the `-processing_stream` stream option of `fmri_postprocess2` the name of the stream:

```
fmri_postprocess2 -config_file clpipe_config.json -processing_stream smooth_aroma-
↪regress_filter-butterworth_normalize -submit
```



## 8.1 Overview

clpipe includes functions to help you set up and run general linear models (GLM) on your neuroimaging data. It uses FSL's implementation of GLM (FEAT), and the functions provided in clpipe serve to help setup and manage the necessary files and folders.

Currently, clpipe includes the following commands:

1. **glm\_setup** This function serves to resample your fmripipped data into a standard resolution and image size, apply a brain mask (calculated by FMRIprep), optionally perform SUSAN smoothing, and drop timepoints from the beginning and ending of the images. Note: The resampling is not registration and this **glm\_setup** function requires that you have already preprocessed your data using FMRIprep.
2. **fsl\_onset\_extract** This function will extract task trial onset, duration and an optional parametric variable from the BIDS formatted events files, and constructs a set of FSL 3-column EV files.
3. **glm\_l1\_preparefsfs** This function takes an fsf file that you have generated as a prototype, and copies/modifies it for use with the images in your dataset. Multiple different L1 fsfs can be used, and images can be excluded or explicitly included in a given L1. See below for details on the glm configuration file.
4. **glm\_l1\_launch** Use this command to launch the fsf files generated by the **glm\_l1\_preparefsfs** command.
5. **glm\_l2\_preparefsfs** This function takes an fsf file, and a csv sheet that contains information about which image goes with which subject, and copies/modifies the fsf file for use with your dataset. Similarly to L1, multiple L2 fsf files can be specified. See below for details on how to do this.
6. **glm\_l2\_launch** Use this command to launch the fsf files generated by the **glm\_l2\_preparefsfs** command.

## 8.2 Configuration Files

In clpipe, a GLM configuration file describes the L1 and L2 setup for a single task. It is structured as follows:

## 8.2.1 Preamble

- GLMName: Descriptive Name
- Authors: Author List
- DateCreated: Date
- GLMSetupOptions: Options for the initial resampling of data
  - ParentClpipeConfig: File path to project's clpipe config json,
  - TargetDirectory: Directory containing the image files, defaults to fmriprep directory,
  - TargetSuffix: Suffix that designates the files to be resampled, defaults to space-MNI152NLin2009cAsym\_desc-preproc\_bold.nii.gz,
  - WorkingDirectory: Working directory, must be user specified,
  - TaskName: Name of the task that the GLM is run on, must be the same as in the task-\*, descriptors
  - ReferenceImage: Reference image, used to determine dimensions and resolution. Should be the reference image for the space the data is normalized to, e.g. MNI152NLin2009cAsym ,
  - DummyScans: Number of timepoints at the beginning of the scan to drop. Specify as an integer
  - ApplyFMRIPREPMask: Apply brain mask, defaults to true
  - MaskFolderRoot: Root of the directory tree that contains the masks, defaults to fmriprep directory,
  - MaskSuffix: Suffix of the mask file, defaults to space-MNI152NLin2009cAsym\_desc-brain\_mask.nii.gz,
  - SUSANSmoothing: Perform Susan Smoothing? Defaults to false
  - **SUSANOptions: Options for SUSAN spatial smoothing**
    - \* BrightnessThreshold: Brightness threshold for SUSAN
    - \* FWHM: Full Width Half Max (Same as in FEAT GUI, not the same as in SUSAN GUI)
  - PreppedDataDirectory: Output directory for resampled images, project setup defaults this to main project directory/data\_glm,
  - PreppedSuffix: Suffix for resampled data, defaults to resampled.nii.gz,
  - PrepareConfounds: Boolean flag to prepare confound tables, defaults to true,
  - ConfoundSuffix: Suffix for files containing confound information, defaults to desc-confounds\_regressors.tsv,
  - Confounds: A list of confound names. Note, the use of .\* specifies a wildcard (i.e. a\_comp\_cor.\* will extract all confounds that begin with a\_comp\_cor). Defaults to 6 motion parameters, CSF, WM and Global Signal.
  - ConfoundsQuad: Which confounds to calculate quadratic expansions. Defaults to previous confounds list.
  - ConfoundsDerive: Which confounds to calculate first derivatives? Defaults to previous confounds list.
  - ConfoundsQuadDerive: Which confounds to calculate quadratic expansions of first derivatives.
  - MotionOutliers: Calculate motion outliers. If true then dummy codes for motion outliers will be included in the confounds file. Defaults to true
  - ScrubVar: Which variable in the confounds file should be used to calculate motion outliers, defaults to framewise displacement
  - Threshold: Threshold at which to flag a timepoint as a motion outlier, defaults to .2



- ScrubAhead: How many time points ahead of a flagged time point should be flagged also, defaults to 0
- ScrubBehind: How many time points behind of a flagged time point should be flagged also, defaults to 0
- ScrubContiguous: How many “good” contiguous timepoints are needed, defaults to 5
- MemoryUsage: Memory usage, defaults to 5 GB
- TimeUsage: Time usage, defaults to 1 hour
- NThreads: Number of processing threads, defaults to 1
- LogDirectory: Log directory, defaults to `glm_setup_logs` in the project logs directory.

## 8.2.2 Level 1 Onsets

The entry `Level1Onsets` contains the specification for extracting the onset timing files and transforming them into FSL three column format EV files.

- **EventFileSuffix:** Suffix for the BIDS format event file. Unless your data is not in BIDS format, this likely shouldn't be changed.
- **TrialTypeVariable:** The name of the variable that contains information as to the trial type. Defaults to `trial_type`, which is a BIDS standard header for the events files, but can be changed to use any variable.
- **TrialTypeToExtract:** The values of the trial type variable to extract. A warning will be thrown if there are no trials with a given trial type (which might indicate a misspelling or a mistake in this field)
- **TimeConversionFactor:** The factor the onset/duration values need to be divided by to put them into units of seconds. For example, if your onsets are in milliseconds, this factor would be 1000. If in seconds, the factor is 1.
- **ParametricResponseVariable:** The name of the variable in the events file that corresponds to the third column of the FSL 3 column format EV file. If left empty (“”), this defaults to 1
- **EVDirectory:** What directory to output the EV files to.

## 8.2.3 Level 1 Setups

The entry `Level1Setups` contains a list of Level 1 specifications of the following form:

- **ModelName:** Name of this L1 setup. Will be used when you use the `glm_l1_preparefsfs` function
- **TargetDirectory:** Target directory containing the files to be analyzed, defaults to resampled data directory from GLM setup
- **TargetSuffix:** File suffix that specifies which files are to be used, defaults to `resampled.nii.gz`,
- **FSFPrototype:** A .fsf file that acts as the prototype for this setup,
- **ImageIncludeList:** A list of which images should be included in this setup (MUTUALLY EXCLUSIVE WITH `ImageExcludeList`)
- **ImageExcludeList:** A list of which images should NOT be included in this setup (MUTUALLY EXCLUSIVE WITH `ImageIncludeList`)
- **FSFDir:** The directory that the generated .fsf files are created in, defaults to `l1_fsfs`,
- **EVDirectory:** The directory that contains the onset files for each image. These files must be in FSL 3 column format. The filenames have specific structuring as well (see below),
- **ConfoundDirectory:** Directory that contains the confound files, defaults to the directory containing the resampled data,

- **EVFileSuffices:** A list of file suffices that specify which event file to use. NOTE: This list is ordered, so the first suffix corresponds with EV 1, the second with EV 2, etc.
- **ConfoundSuffix:** Suffix that specifies which files are the confound files.
- **OutputDir:** Where the resulting FEAT directories will be created.

## 8.2.4 Filenames for EV Onset Files

Event Onset files must be in the FSL 3 column format. Additionally, the file names for the onset files must be of the following form: filename of image - target suffix + EV file suffix. For example. If the image filename was “sub-1001\_ses-01\_task-gng\_run-01\_bold.nii.gz”, the target suffix was “\_bold.nii.gz” and a EV suffix was “\_hit.txt”, then the EV file should be named: “sub-1001\_ses-01\_task-gng\_run-01\_hit.txt”.

## 8.2.5 Level 2 Setups

The entry `Level2Setups` contains a list of Level 2 specifications of the following form:

- **ModelName:** The model name, used in the `glm_l2_preparefsfs` function.
- **FSFPrototype:** A .fsf prototype used in this setup.
- **SubjectFile:** A .csv file containing information as to which images go into which L2 model. See below for details.
- **FSFDir:** The directory in which the fsfs will be generated.
- **OutputDir:** Which folder will the L2 gfeat folders be generated

## 8.2.6 Subject File Formatting

The L2 subject file maps each image onto a specific L2 model setup entry and onto a specific L2 model (i.e. assigns a subject’s images to that subject.) This is a three column csv file, with the headers: `fsf_name`, `feat_folders`, `L2_name`. The `fsf_name` column contains the desired name of a L2 fsf file, the `feat_folders` column contains the paths to the feat folders that are used in the L2 FSF files (in order), and the `L2_name` column contains which `ModelName` corresponds to a given image. For an example, see the `l2_sublist.csv` file generated when you run the `project_setup` function.

# 8.3 Commands

## 8.3.1 glm\_setup

Additional preprocessing for GLM analysis.

Providing no `SUBJECTS` will default to all subjects. List subject IDs in `SUBJECTS` to process specific subjects:

```
> clpipe glm setup 123 124 125 ...
```

```
glm_setup [OPTIONS] [SUBJECTS] ...
```

## Options

- config\_file** <config\_file>  
**Required** Use a given configuration file.
- glm\_config\_file** <glm\_config\_file>  
**Required** Use a given GLM configuration file.
- drop\_tps** <drop\_tps>  
Drop timepoints csv sheet
- submit**  
Flag to submit commands to the HPC.
- batch, -single**  
Submit to batch, or run in current session. Mainly used internally.
- debug**  
Print detailed processing information and traceback for errors.

## Arguments

### SUBJECTS

Optional argument(s)

## 8.3.2 fsl\_onset\_extract

Convert onset files to FSL's 3 column format.

```
fsl_onset_extract [OPTIONS]
```

## Options

- config\_file** <config\_file>  
**Required** Use a given configuration file.
- glm\_config\_file** <glm\_config\_file>  
**Required** Use a given GLM configuration file.
- debug**  
Print detailed processing information and traceback for errors.

## 8.3.3 glm\_l1\_preparefsf

Propagate an .fsf file template for L1 GLM analysis.

You must create a template .fsf file in FSL's FEAT GUI first.

```
glm_l1_preparefsf [OPTIONS]
```

## Options

**-glm\_config\_file** <glm\_config\_file>

**Required** Your GLM configuration file.

**-l1\_name** <l1\_name>

**Required** Name for a given L1 model as defined in your GLM configuration file.

**-debug**

Flag to enable detailed error messages and traceback

### 8.3.4 glm\_l1\_launch

Launch all prepared .fsf files for L1 GLM analysis.

```
glm_l1_launch [OPTIONS]
```

## Options

**-glm\_config\_file** <glm\_config\_file>

**Required** The path to your clpipe configuration file.

**-l1\_name** <l1\_name>

**Required** Name of your L1 model

**-test\_one**

Only submit one job for testing purposes.

**-submit**

Flag to submit commands to the HPC.

**-debug**

Flag to enable detailed error messages and traceback.

### 8.3.5 glm\_l2\_preparefsf

Propagate an .fsf file template for L2 GLM analysis.

You must create a group-level template .fsf file in FSL's FEAT GUI first.

```
glm_l2_preparefsf [OPTIONS]
```

## Options

**-glm\_config\_file** <glm\_config\_file>

**Required** Your GLM configuration file.

**-l2\_name** <l2\_name>

**Required** Name for a given L2 model

**-debug**

Flag to enable detailed error messages and traceback

### 8.3.6 glm\_l2\_launch

Launch all prepared .fsf files for L2 GLM analysis.

```
glm_l2_launch [OPTIONS]
```

#### Options

**-glm\_config\_file** <glm\_config\_file>

**Required** The path to your clpipe configuration file.

**-l2\_name** <l2\_name>

**Required** Name of your L2 model

**-test\_one**

Only submit one job for testing purposes.

**-submit**

Flag to submit commands to the HPC.

**-debug**

Flag to enable detailed error messages and traceback.



## ROI EXTRACTION

clpipe comes with a variety of functional and anatomical atlases, which can be used to extract ROI time series data from functional scans.

By default, ROIs are calculated with respect to the brain mask, and ROIs with fewer than the “PropVoxels” option voxels will be set to NAN. If any ROI has no voxels in the brain mask, then all ROIs will be extracted without respect to the brain mask, and then ROIs with fewer than “PropVoxels” voxels will be set to NAN. This is a workaround for the limitations on Nilearn’s ROI extractor functions.

### 9.1 fmri\_roi\_extraction

Extract ROIs with a given atlas.

```
fmri_roi_extraction [OPTIONS] [SUBJECTS]...
```

#### Options

**-config\_file** <config\_file>

Use a given configuration file. If left blank, uses the default config file, requiring definition of BIDS, working and output directories. This will extract all ROI sets specified in the configuration file.

**-target\_dir** <target\_dir>

Which postprocessed directory to process. If a configuration file is provided with a target directory, this argument is not necessary.

**-target\_suffix** <target\_suffix>

Which target suffix to process. If a configuration file is provided with a target suffix, this argument is not necessary.

**-output\_dir** <output\_dir>

Where to put the ROI extracted data. If a configuration file is provided with a output directory, this argument is not necessary.

**-task** <task>

Which task to process. If none, then all tasks are processed.

**-atlas\_name** <atlas\_name>

What atlas to use. Please refer to documentation, or use the command `get_available_atlases` to see which are available. When specified for a custom atlas, this is what the output files will be named.

**-custom\_atlas** <custom\_atlas>

A custom atlas image, in .nii or .nii.gz for label or maps, or a .txt tab delimited set of ROI coordinates if for a sphere atlas. Not needed if specified in config.

**-custom\_label** <custom\_label>

A custom atlas label file. Not needed if specified in config.

**-custom\_type** <custom\_type>

What type of atlas? (label, maps, or spheres). Not needed if specified in config.

**-radius** <radius>

If a sphere atlas, what radius sphere, in mm. Not needed if specified in config.

**-overlap\_ok**

Are overlapping ROIs allowed?

**-overwrite**

Overwrite existing ROI timeseries?

**-log\_output\_dir** <log\_output\_dir>

Where to put HPC output files (such as SLURM output files). If not specified, defaults to <output-Dir>/batchOutput.

**-submit**

Flag to submit commands to the HPC

**-single**

Flag to directly run command. Used internally.

**-debug**

Flag to enable detailed error messages and traceback

## Arguments

### SUBJECTS

Optional argument(s)

To view the available built-in atlases, you can use the `get_available_atlases` command.

## 9.2 get\_available\_atlases

Display all available atlases.

<code>get_available_atlases [OPTIONS]</code>
--



## UNIFIED CLI - NEW

clpipe now provides a unified command line interface under the “clpipe” command. This interface uses the same processing functions as clpipe’s traditional commands, except they are grouped together and given slightly different names. Unifying the commands makes them easier to find and conceptualize in relation to one another without having to rely too much on documentation.

Running this command on its own will show you a subset of clpipe’s processing commands, in the order that they are intended to be used:

```
> clpipe

Usage: clpipe [OPTIONS] COMMAND [ARGS]...

Welcome to clpipe. Please choose a processing command.

Options:
-v, --version  Display clpipe's version.
--help        Show this message and exit.

Commands:
setup          Set up a clpipe project
bids           BIDS Commands
preprocess     Submit BIDS-formatted images to fMRIPrep
postprocess    Additional preprocessing for connectivity analysis
postprocess2   Additional preprocessing for GLM or connectivity analysis
glm           GLM Commands
status        Check the status of your project
```

NOTE - ROI extraction has yet to be added because one of its dependencies causes the CLI to output an un-hidable warning

To see the options for a particular sub-command, call this command after “clpipe” and ask for –help:

```
> clpipe setup --help

Usage: clpipe setup [OPTIONS]

Set up a clpipe project

Options:
-project_title TEXT      [required]
-project_dir DIRECTORY  Where the project will be located. [required]
-source_data DIRECTORY  Where the raw data (usually DICOMs) are located.
```

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```
-move_source_data    Move source data into project/data_DICOMs folder.
                     USE WITH CAUTION.
-symlink_source_data  Symlink the source data into project/data_dicoms.
                     Usually safe to do.
-debug              Flag to enable detailed error messages and traceback
--help              Show this message and exit.
```

This command can be used just like the original `project_setup` command in `clpipe`:

```
> clpipe setup -project_title "My Project" -project_dir . -debug
```

Some of the `clpipe` commands, like `bids` and `glm`, contain their own nested sub commands, which can be viewed by calling the top command:

```
> clpipe bids

Usage: clpipe bids [OPTIONS] COMMAND [ARGS]...

BIDS Commands

Options:
--help Show this message and exit.

Commands:
convert  Convert DICOM files to BIDS format
validate Check that the given directory conforms to the BIDS standard
```

These commands contain their own help dialouge as well:

```
> clpipe bids validate --help

Usage: clpipe bids validate [OPTIONS] [BIDS_DIR]

Check that the given directory conforms to the BIDS standard

Options:
-config_file FILE  Uses a given configuration file
-log_dir FILE      Where to put HPC output files (such as SLURM output
                  files)
-verbose          Creates verbose validator output. Use if you want to see
                  ALL files with errors/warnings.
-submit           Flag to submit commands to the HPC
-interactive       Run in an interactive session. Only use in an interactive
                  compute session.
-debug            Flag to enable detailed error messages and traceback
--help            Show this message and exit.
```

Here we perform the command equivalent to “`bids_validate`”:

```
> clpipe bids validate -config_file path/to/my/config -submit
```

Finally, here is an equivalent command taking advantage of short option names:

```
> clpipe bids validate -c path/to/my/config -s
```

Here is a description of all available commands:

## 10.1 clpipe

Welcome to clpipe.

Please choose one of the commands below for more information.

If you're not sure where to begin, please see the documentation at: <https://clpipe.readthedocs.io/en/latest/index.html>

```
clpipe [OPTIONS] COMMAND [ARGS]...
```

### Options

**-v, --version**

Display clpipe's version.

#### 10.1.1 bids

BIDS Commands.

Please choose one of the commands below for more information.

```
clpipe bids [OPTIONS] COMMAND [ARGS]...
```

#### convert

Convert DICOM files to BIDS format.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

```
> clpipe bids convert 123 124 125 ...
```

Available subject IDs are determined by the dicom\_dir\_format string.

```
clpipe bids convert [OPTIONS] [SUBJECTS]...
```

### Options

**-config\_file, -c <config\_file>**

The path to your clpipe configuration file.

**-conv\_config\_file <conv\_config\_file>**

A conversion definition file, either a dcm2bids conversion config .json file or a heudiconv heuristic .py file.

**-dicom\_dir, -i <dicom\_dir>**

The folder where subject dicoms are located.

**-dicom\_dir\_format** <dicom\_dir\_format>

Format string which specifies how subjects/sessions are organized within the dicom\_dir. Example: {subject}\_{session}. See [https://clpipe.readthedocs.io/en/latest/bids\\_convert.html](https://clpipe.readthedocs.io/en/latest/bids_convert.html) for more details.

**-BIDS\_dir, -o** <bids\_dir>

The dicom info output file name.

**-overwrite**

Overwrite existing BIDS data?

**-log\_dir** <log\_dir>

Where to put your HPC output files (such as SLURM output files).

**-subject** <subject>

DEPRECATED: specify one subject to process - can give an arbitrary number of subjects as arguments now.

**-session** <session>

Specify the session to convert. Available sessions determined by the {session} placeholder given by dicom\_dir\_format.

**-longitudinal**

Convert all subjects/sessions into individual pseudo-subjects. Use if you do not want T1w averaged across sessions during FMRIprep

**-submit, -s**

Flag to submit commands to the HPC.

**-debug, -d**

Flag to enable detailed error messages and traceback.

**-dcm2bids, -heudiconv**

Specify which converter to use.

## Arguments

### SUBJECTS

Optional argument(s)

### validate

Validate if a directory BIDS standard.

Validates the directory at BIDS\_DIR, or at the BIDS directory in your config file's DICOMToBIDSOPTIONS if -config\_file is given.

Results are viewable in logs/bids\_validation\_logs unless -interactive is used.

```
clpipe bids validate [OPTIONS] [BIDS_DIR]
```

## Options

**-config\_file** <config\_file>

The path to your clpipe configuration file.

**-log\_dir** <log\_dir>

Where to put your HPC output files (such as SLURM output files).

**-verbose**

Creates verbose validator output. Use if you want to see ALL files with errors/warnings.

**-submit**

Flag to submit commands to the HPC.

**-interactive**

Run in interactive mode. Only use in an interactive compute session.

**-debug**

Flag to enable detailed error messages and traceback.

## Arguments

**BIDS\_DIR**

Optional argument

### 10.1.2 glm

General Linear Model (GLM) Commands.

Please choose one of the commands below for more information.

```
clpipe glm [OPTIONS] COMMAND [ARGS]...
```

#### apply\_mumford

Apply the Mumford registration workaround to L1 FEAT folders.

Applied by default in glm-l2-preparefsf. This command is useful for applying the Mumford workaround to single-run subjects who skip L2, allowing you to still combine them with multiple-run subjects at L3.

Must provide GLM config file OR a path to your L1 FEAT folders.

```
clpipe glm apply_mumford [OPTIONS]
```

## Options

**-glm\_config\_file** <glm\_config\_file>

Your GLM configuration file.

**-l1\_feat\_folders\_path** <l1\_feat\_folders\_path>

Directory containing your L1 FEAT folders.

**-remove\_reg\_standard**

Remove reg\_standard folders (generated by L2) in addition to reg.

**-debug**

Flag to enable detailed error messages and traceback

## fsl\_onset\_extract

Convert onset files to FSL's 3 column format.

```
clpipe glm fsl_onset_extract [OPTIONS]
```

## Options

**-config\_file** <config\_file>

**Required** Use a given configuration file.

**-glm\_config\_file** <glm\_config\_file>

**Required** Use a given GLM configuration file.

**-debug**

Print detailed processing information and traceback for errors.

## l1\_prepare\_fsf

Propagate an .fsf file template for L1 GLM analysis.

You must create a template .fsf file in FSL's FEAT GUI first.

```
clpipe glm l1_prepare_fsf [OPTIONS]
```

## Options

**-glm\_config\_file** <glm\_config\_file>

**Required** Your GLM configuration file.

**-l1\_name** <l1\_name>

**Required** Name for a given L1 model as defined in your GLM configuration file.

**-debug**

Flag to enable detailed error messages and traceback

## l2\_prepare\_fsf

Propagate an .fsf file template for L2 GLM analysis.

You must create a group-level template .fsf file in FSL's FEAT GUI first.

```
clpipe glm l2_prepare_fsf [OPTIONS]
```

### Options

**-glm\_config\_file** <glm\_config\_file>

**Required** Your GLM configuration file.

**-l2\_name** <l2\_name>

**Required** Name for a given L2 model

**-debug**

Flag to enable detailed error messages and traceback

### launch

Launch all prepared .fsf files for L1 or L2 GLM analysis.

LEVEL is the level of anlysis, L1 or L2

MODEL must be a a corresponding L1 or L2 model from your GLM configuration file.

```
clpipe glm launch [OPTIONS] LEVEL MODEL
```

### Options

**-glm\_config\_file** <glm\_config\_file>

**Required** The path to your clpipe configuration file.

**-test\_one**

Only submit one job for testing purposes.

**-submit**

Flag to submit commands to the HPC.

**-debug**

Flag to enable detailed error messages and traceback.

### Arguments

**LEVEL**

Required argument

**MODEL**

Required argument

## report\_outliers

Generate a confound outliers report.

Must provide one of either `--confounds_dir` or `--confounds_file`.

```
clpipe glm report_outliers [OPTIONS]
```

### Options

**--confounds\_dir** <confounds\_dir>

Path to a directory containing subjects and confounds files.

**--confounds\_file** <confounds\_file>

Path to confounds file

**--output\_file** <output\_file>

Path to save outlier count results.

**--confound\_suffix** <confound\_suffix>

Confound file to search for, like 'confounds.tsv'

## setup

Additional preprocessing for GLM analysis.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

> clpipe glm setup 123 124 125 ...

```
clpipe glm setup [OPTIONS] [SUBJECTS]...
```

### Options

**-config\_file** <config\_file>

**Required** Use a given configuration file.

**-glm\_config\_file** <glm\_config\_file>

**Required** Use a given GLM configuration file.

**-drop\_tps** <drop\_tps>

Drop timepoints csv sheet

**-submit**

Flag to submit commands to the HPC.

**-batch, -single**

Submit to batch, or run in current session. Mainly used internally.

**-debug**

Print detailed processing information and traceback for errors.



## Arguments

### SUBJECTS

Optional argument(s)

### 10.1.3 postprocess

Additional processing for connectivity analysis.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

```
> clpipe postprocess 123 124 125 ...
```

```
clpipe postprocess [OPTIONS] [SUBJECTS]...
```

## Options

### **-config\_file** <config\_file>

Use a given configuration file. If left blank, uses the default config file, requiring definition of BIDS, working and output directories.

### **-target\_dir** <target\_dir>

Which fmriprep directory to process. If a configuration file is provided with a BIDS directory, this argument is not necessary. Note, must point to the `fmriprep` directory, not its parent directory.

### **-target\_suffix** <target\_suffix>

Which file suffix to use. If a configuration file is provided with a target suffix, this argument is not necessary. Defaults to “`preproc_bold.nii.gz`”

### **-output\_dir** <output\_dir>

Where to put the postprocessed data. If a configuration file is provided with a output directory, this argument is not necessary.

### **-output\_suffix** <output\_suffix>

What suffix to append to the postprocessed files. If a configuration file is provided with a output suffix, this argument is not necessary.

### **-task** <task>

Which task to postprocess. If left blank, defaults to all tasks.

### **-TR** <tr>

The TR of the scans. If a config file is not provided, this option is required. If a config file is provided, this information is found from the sidecar jsons.

### **-processing\_stream** <processing\_stream>

Optional processing stream selector.

### **-log\_dir** <log\_dir>

Where to put HPC output files. If not specified, defaults to `<outputDir>/batchOutput`.

### **-beta\_series**

Flag to activate beta-series correlation correlation. ADVANCED METHOD, refer to the documentation.

### **-submit**

Flag to submit commands to the HPC.

**-batch, -single**

Submit to batch, or run in current session. Mainly used internally.

**-debug**

Print detailed processing information and traceback for errors.

## Arguments

**SUBJECTS**

Optional argument(s)

### 10.1.4 postprocess2

Additional processing for GLM or connectivity analysis.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

> clpipe postprocess2 123 124 125 ...

clpipe postprocess2 [OPTIONS] [SUBJECTS]...

## Options

**-config\_file, -c <config\_file>**

**Required** The path to your clpipe configuration file.

**-fmrip\_dir, -i <fmrip\_dir>**

Which fmrip\_dir directory to process. If a configuration file is provided with a BIDS directory, this argument is not necessary. Note, must point to the `fmrip_dir` directory, not its parent directory.

**-output\_dir, -o <output\_dir>**

Where to put the postprocessed data. If a configuration file is provided with a output directory, this argument is not necessary.

**-processing\_stream, -p <processing\_stream>**

Specify a processing stream to use defined in your configuration file.

**-log\_dir, -l <log\_dir>**

Where to put your HPC output files (such as SLURM output files).

**-index\_dir <index\_dir>**

Give the path to an existing pybids index database.

**-refresh\_index, -r**

Refresh the pybids index database to reflect new fmrip\_dir artifacts.

**-batch, -no\_batch**

Flag to create batch jobs without prompting.

**-cache, -no\_cache**

**-submit, -s**

Flag to submit commands to the HPC.

**-debug, -d**

Flag to enable detailed error messages and traceback.

## Arguments

### SUBJECTS

Optional argument(s)

## 10.1.5 preprocess

Submit BIDS-formatted images to fMRIPrep.

Providing no SUBJECTS will default to all subjects. List subject IDs in SUBJECTS to process specific subjects:

```
> clpipe preprocess 123 124 125 ...
```

```
clpipe preprocess [OPTIONS] [SUBJECTS] ...
```

## Options

**-config\_file** <config\_file>

The path to your clpipe configuration file.

**-bids\_dir** <bids\_dir>

The dicom info output file name.

**-working\_dir** <working\_dir>

Where to generate the working directory.

**-output\_dir** <output\_dir>

Where to put the preprocessed data. If a configuration file is provided with a output directory, this argument is not necessary.

**-log\_dir** <log\_dir>

Where to put your HPC output files (such as SLURM output files).

**-submit**

Flag to submit commands to the HPC.

**-debug**

Flag to enable detailed error messages and traceback.

## Arguments

### SUBJECTS

Optional argument(s)

### 10.1.6 roi

Region of Interest (ROI) Commands.

Please choose one of the commands below for more information.

```
clpipe roi [OPTIONS] COMMAND [ARGS]...
```

#### atlases

Display all available atlases.

```
clpipe roi atlases [OPTIONS]
```

#### extract

Extract ROIs with a given atlas.

```
clpipe roi extract [OPTIONS] [SUBJECTS]...
```

### Options

**-config\_file** <config\_file>

Use a given configuration file. If left blank, uses the default config file, requiring definition of BIDS, working and output directories. This will extract all ROI sets specified in the configuration file.

**-target\_dir** <target\_dir>

Which postprocessed directory to process. If a configuration file is provided with a target directory, this argument is not necessary.

**-target\_suffix** <target\_suffix>

Which target suffix to process. If a configuration file is provided with a target suffix, this argument is not necessary.

**-output\_dir** <output\_dir>

Where to put the ROI extracted data. If a configuration file is provided with a output directory, this argument is not necessary.

**-task** <task>

Which task to process. If none, then all tasks are processed.

**-atlas\_name** <atlas\_name>

What atlas to use. Please refer to documentation, or use the command `get_available_atlases` to see which are available. When specified for a custom atlas, this is what the output files will be named.

**-custom\_atlas** <custom\_atlas>

A custom atlas image, in .nii or .nii.gz for label or maps, or a .txt tab delimited set of ROI coordinates if for a sphere atlas. Not needed if specified in config.

**-custom\_label** <custom\_label>

A custom atlas label file. Not needed if specified in config.

**-custom\_type** <custom\_type>

What type of atlas? (label, maps, or spheres). Not needed if specified in config.

**-radius** <radius>

If a sphere atlas, what radius sphere, in mm. Not needed if specified in config.

**-overlap\_ok**

Are overlapping ROIs allowed?

**-overwrite**

Overwrite existing ROI timeseries?

**-log\_output\_dir** <log\_output\_dir>

Where to put HPC output files (such as SLURM output files). If not specified, defaults to <output-Dir>/batchOutput.

**-submit**

Flag to submit commands to the HPC

**-single**

Flag to directly run command. Used internally.

**-debug**

Flag to enable detailed error messages and traceback

## Arguments

**SUBJECTS**

Optional argument(s)

### 10.1.7 setup

Set up a clpipe project.

```
clpipe setup [OPTIONS]
```

## Options

**-project\_title** <project\_title>

**Required**

**-project\_dir** <project\_dir>

**Required** Where the project will be located.

**-source\_data** <source\_data>

Where the raw data (usually DICOMs) are located.

**-move\_source\_data**

Move source data into project/data\_DICOMs folder. USE WITH CAUTION.

**-symlink\_source\_data**

Symlink the source data into project/data\_dicoms. Usually safe to do.

**-debug**

Flag to enable detailed error messages and traceback.

### 10.1.8 status

Check the status of your project.

```
clpipe status [OPTIONS]
```

#### Options

**-config\_file** <config\_file>

The path to your clpipe configuration file.

**-cache\_file** <cache\_file>

Path to your status cache file.

## PROJECT SETUP

### 11.1 Installation and Folder Setup

First, install `clpipe` using pip and Github

```
pip3 install --upgrade git+https://github.com/cohenlabUNC/clpipe.git
```

Create a new folder for your project

```
mkdir clpipe_tutorial_project
cd clpipe_tutorial_project
```

Running project setup requires us to have a source data directory ready. Create an empty one for now

```
mkdir data_DICOMs
```

Now you are ready to run the `project_setup` command

### 11.2 Running `project_setup`

```
project_setup -project_title clpipe_tutorial_project -project_dir . -source_data data_
↪DICOMs
```

If successful, your folder will now contain the following structure:

```
.
├── analyses
├── clpipe_config.json
├── conversion_config.json
├── data_BIDS
├── data_DICOMs
├── data_fmriprep
├── data_GLMPrep
├── data_onsets
├── data_postproc
├── data_ROI_ts
├── glm_config.json
├── l1_feat_folders
├── l1_fsfs
```

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```

— 12_fsfs
— 12_gfeat_folders
— 12_sublist.csv
— logs
— scripts

```

clpipe automatically creates many of the directories we will need in the future. For now, let's just familiarize ourselves with the most important file, `clpipe_config.json`, which allows you to configure clpipe's core functionalities. Open `clpipe_config.json` with the editor of your choice.

## 11.3 Understanding the `clpipe_config.json` File

There is quite a bit going on in this file, because it controls most of clpipe's processing options. As a `.json` file, this configuration is organized as a collection of key/value pairs, such as:

```
"ProjectTitle": "A Neuroimaging Project"
```

The key here is "ProjectTitle", an attribute corresponding to the project's name, and the value is "A Neuroimaging Project", the name of the project.

Examine the first few lines of the file, which contain metadata about your project:

```

"ProjectTitle": "clpipe_tutorial_project",
"Authors/Contributors": "",
"ProjectDirectory": "<your system's path>/clpipe_tutorial_project",
"EmailAddress": "",
"TempDirectory": "",

```

Notice that the project directory and title have already been filled in by clpipe.

Let's make our first configuration change by setting your name as the author, and providing your email address -

```

"ProjectTitle": "clpipe_tutorial_project",
"Authors/Contributors": "Your Name Here",
"ProjectDirectory": "/nas/longleaf/home/willasc/data/clpipe/clpipe_tutorial_project",
"EmailAddress": "myemail@domain.com",
"TempDirectory": "",

```

Values in a key/value pair are not just limited to text - we can also have a list of more key/value pairs, which allows for hierarchical structures:

```

"top-level-key": {
    "key1": "value",
    "key2": "value",
    "key3": "value"
}

```

The options for clpipe's various processing steps, such as "DICOMToBIDSOptions", follow this structure:

```
"DICOMToBIDSOptions": {
```

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```
"DICOMToBIDSOptions": {  
  "DICOMDirectory": "<your system's path>/clpipe_tutorial_project/data_DICOMs",  
  "BIDSDirectory": "<your system's path>/clpipe_tutorial_project/data_BIDS",  
  "ConversionConfig": "<your system's path>/clpipe_tutorial_project/conversion_config.json  
↩",  
  "DICOMFormatString": "",  
  "TimeUsage": "1:0:0",  
  "MemUsage": "5000",  
  "CoreUsage": "2",  
  "LogDirectory": "<your system's path>/clpipe_tutorial_project/logs/DCM2BIDS_logs"  
}  
}
```

We will go over these processing step options in the following tutorial



## BIDS CONVERSION

The goal of this processing step is to convert “raw” DICOM format images into BIDS format. If your data is already in BIDS format, move on to the BIDS Validation step.

Due to the manual labeling necessary for DICOM to BIDS conversion, this is one of the most difficult parts of clpipe to setup - do not be discouraged by this early step!

Note: This tutorial is a clpipe implementation of the [dcm2bids](#) tutorial, which clpipe uses for dcm to BIDS conversion.

### 12.1 Obtaining Sample Raw Data

To obtain the raw DICOM data necessary for this tutorial, run the following commands:

```
cd data_DICOMs
git clone git@github.com:neurolabusc/dcm_qa_nih.git
cd ..
```

Let's examine this data:

```
dcm_qa_nih/In/
├── 20180918GE
│   ├── mr_0004
│   ├── mr_0005
│   ├── mr_0006
│   ├── mr_0007
│   └── README-Study.txt
├── 20180918Si
│   ├── mr_0003
│   ├── mr_0004
│   ├── mr_0005
│   ├── mr_0006
│   └── README-Study.txt
```

This dataset contains two sets of data, one from a GE scanner, containing functional images, and another from a Siemens, containing field map images. The labels in the form `mr_000x` are subject ids, which will be important for setting up our bids conversion.

Note: The BIDS data generated in this step will also be used in the BIDS Validation tutorial, but tutorials starting from fMRIprep and on we will use a different BIDS dataset

## 12.2 clpipe\_config.json Setup

Open `clpipe_config.json` and navigate to the “DICOMToBIDSOptions”:

```
"DICOMToBIDSOptions": {
  "DICOMDirectory": "<your system's path>/clpipe_tutorial_project/data_DICOMs",
  "BIDSDirectory": "<your system's path>/clpipe_tutorial_project/data_BIDS",
  "ConversionConfig": "<your system's path>/clpipe_tutorial_project/conversion_
↪config.json",
  "DICOMFormatString": "",
  "TimeUsage": "1:0:0",
  "MemUsage": "5000",
  "CoreUsage": "2",
  "LogDirectory": "<your system's path>/clpipe_tutorial_project/logs/DCM2BIDS_logs"
}
```

This section tells `clpipe` how to run your BIDS conversion. Note that `clpipe` has been automatically configured to point to your DICOM directory, “DICOMDirectory”, which will serve as the input to the `dcm2bids` command. The output folder, “BIDSDirectory”, is also already set. These can be modified to point to new locations if necessary - for example, you may want to create more than one BIDS directory for testing purposes.

The option “DICOMFormatString” must be set to run your bids conversion. This configuration tells `clpipe` how to identify subjects and (if relevant) sessions within `data_DICOMs`. To pick up on the subject ids in our example dataset, the placeholder `{subject}` should be given in place of a specific subject’s directory. The subject ID cannot contain underscores, so we will include the `mr_` portion of the subject folder name before the `{subject}` placeholder to exclude it from the subject’s generated id:

```
"DICOMFormatString": "dcm_qa_nih/In/20180918GE/mr_{subject}"
```

If your data contained an additional folder layer corresponding to session ids, you would similarly mark this with a `{session}` placeholder

The “ConversionConfig” command gives a path to your automatically generated `conversion_config.json` file. Let’s open that file now:

```
{
  "descriptions": [
    {
      "dataType": "func",
      "modalityLabel": "bold",
      "customLabels": "task-srt",
      "criteria": {
        "SeriesDescription": "*_srt",
        "ImageType": [
          "ORIG*",
          "PRIMARY",
          "M",
          "ND",
          "MOSAIC"
        ]
      }
    }
  ]
}
```

The conversion file contains a list of descriptions, each of which attempts to map raw DICOM images to a given criteria. clpipe has prepopulated the conversion config file with an example description.

The “criteria” item gives a list of criteria by which to match DICOM images. The other tags specify the format of the output NIfTI image that match this criteria. “dataType” and “modalityLabel” configure the name of your output

More information on setting up clpipe for BIDS conversion can be found in the [clpipe documentation](#).

## 12.3 Setting up the Conversion File

From here, follow the [Dcm2Bids tutorial](#) and stop before the “Running dcm2bids” section - clpipe will handling running dcm2bids for you. The helper command dcm2bids\_helper will be available to you via the clpipe installation, and should be used as indicated in the tutorial to help you get started. You should also skip the “Building the configuration file” step because, as shown above, clpipe has already created this file.

You can find a supplementary explanation and another example of a conversion\_config.json file in the [clpipe documentation](#)

## 12.4 Running the Conversion

Now you are ready to launch the conversion with clpipe, which will convert your raw DICOMs into NIfTI format, then rename and sort them into the BIDS standard.

If everything has been set up correctly, running the conversion only takes a simple call to the [CLI application](#) with the configuration file as an argument:

```
convert2bids -config_file clpipe_config.json
```

clpipe will then print out a “plan” for executing your jobs:

```
dcm_qa_nih/In/20180918GE/*
<your system's path>/clpipe_tutorial_project/data_DICOMs/dcm_qa_nih/In/20180918GE/
↪{subject}/
sbatch --no-requeue -n 1 --mem=5000 --time=1:0:0 --cpus-per-task=2 --job-name="convert_
↪sub-0004" --output=<your system's path>/clpipe_tutorial_project/logs/DCM2BIDS_logs/
↪Output-convert_sub-0004-jobid-%j.out --wrap="dcm2bids -d <your system's path>/clpipe_
↪tutorial_project/data_DICOMs/dcm_qa_nih/In/20180918GE/0004/ -o <your system's path>/
↪clpipe/clpipe_tutorial_project/data_BIDS -p 0004 -c <your system's path>/clpipe_
↪tutorial_project/conversion_config.json"
sbatch --no-requeue -n 1 --mem=5000 --time=1:0:0 --cpus-per-task=2 --job-name="convert_
↪sub-0005" --output=<your system's path>/clpipe_tutorial_project/logs/DCM2BIDS_logs/
↪Output-convert_sub-0005-jobid-%j.out --wrap="dcm2bids -d <your system's path>/clpipe_
↪tutorial_project/data_DICOMs/dcm_qa_nih/In/20180918GE/0005/ -o <your system's path>/
↪clpipe_tutorial_project/data_BIDS -p 0005 -c <your system's path>/clpipe_tutorial_
↪project/conversion_config.json"
...
```

Each sbatch command here will submit a separate job to the cluster.

Check that your output looks correct, especially the subject ids, then run again with the -submit flag to run your conversions in parallel:

```
convert2bids -config_file clpipe_config.json -submit
```

clpipe should then report that you have submitted 4 jobs to the cluster:

```
dcm_qa_nih/In/20180918GE/*
<your system's path>/clpipe_tutorial_project/data_DICOMs/dcm_qa_nih/In/20180918GE/mr_
↪{subject}/
Submitted batch job 38210854
Submitted batch job 38210855
Submitted batch job 38210856
Submitted batch job 38210857
```

Now, your BIDS directory should look something like this:

```
├── CHANGES
├── code
├── dataset_description.json
├── derivatives
├── participants.json
├── participants.tsv
├── README
├── sourcedata
├── sub-0004
│   └── func
│       ├── sub-0004_task-rest_bold.json
│       └── sub-0004_task-rest_bold.nii.gz
└── tmp_dcm2bids
```

But wait a second! You were expecting four subjects to be in your BIDS directory, but only sub-0004 is present. The next section will guide you through how to tune your `conversion_config.json` file to pick up all of the images you need.

## 12.5 Iterating on Your Conversion

Inevitably, you will probably not get the conversion completely correct on the first try, and some files may have been missed.

The folder `tmp_dcm2bids` contains all of the images that were not matched to any of the patterns described in your `conversion_config.json` file, as well as helpful log files:

```
├── tmp_dcm2bids
│   ├── log
│   │   ├── sub-0004_2022-02-17T103129.039268.log
│   │   ├── sub-0005_2022-02-17T103129.116426.log
│   │   ├── sub-0006_2022-02-17T103129.082788.log
│   │   └── sub-0007_2022-02-17T103129.191004.log
│   ├── sub-0004
│   ├── sub-0005
│   │   ├── 005_0005_Axial_EPI-FMRI_(Sequential_I_to_S)_20180918114023.json
│   │   └── 005_0005_Axial_EPI-FMRI_(Sequential_I_to_S)_20180918114023.nii.gz
│   ├── sub-0006
│   │   ├── 006_0006_Axial_EPI-FMRI_(Interleaved_S_to_I)_20180918114023.json
│   │   └── 006_0006_Axial_EPI-FMRI_(Interleaved_S_to_I)_20180918114023.nii.gz
│   └── sub-0007
│       ├── 007_0007_Axial_EPI-FMRI_(Sequential_S_to_I)_20180918114023.json
│       └── 007_0007_Axial_EPI-FMRI_(Sequential_S_to_I)_20180918114023.nii.gz
```

As the raw data folder we have pointed clpipe toward, 20180918GE, contains functional data, we will look at the "func" list item in our `conversion_config.json` to adjust:

```
{
  "dataType": "func",
  "modalityLabel": "bold",
  "customLabels": "task-rest",
  "criteria": {
    "SeriesDescription": "Axial_EPI-FMRI*",
    "SidecarFilename": "*Interleaved_I_to_S*"
  }
}
```

Sidecars are .json files that have the same name as the .nii.gz main image file, and contain additional metadata for the image; they are part of the BIDS standard.

This configuration is trying to match on a side car with the pattern `"*Interleaved_I_to_S"`, but we can see in the `tmp_dcm2bids` folder that none of the subjects here match this pattern. If we want to pick up the remaining subjects, we can relax this criteria by removing it from `conversion_config.json`:

```
{
  "dataType": "func",
  "modalityLabel": "bold",
  "customLabels": "task-rest",
  "criteria": {
    "SeriesDescription": "Axial_EPI-FMRI*"
  }
}
```

Note: Take special care to remove the comma following the "SeriesDescription" list item - using commas in a single-item list will result in invalid JSON that will cause an error

And rerunning the conversion:

```
convert2bids -config_file clpipe_config.json -submit
```

Now, all subjects should be present in your BIDS directory along with their resting state images:

```
...
├── sub-0004
│   └── func
│       ├── sub-0004_task-rest_bold.json
│       └── sub-0004_task-rest_bold.nii.gz
├── sub-0005
│   └── func
│       ├── sub-0005_task-rest_bold.json
│       └── sub-0005_task-rest_bold.nii.gz
├── sub-0006
│   └── func
│       ├── sub-0006_task-rest_bold.json
│       └── sub-0006_task-rest_bold.nii.gz
├── sub-0007
│   └── func
│       └── sub-0007_task-rest_bold.json
```

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```
└─ sub-0007_task-rest_bold.nii.gz
└─ tmp_dcm2bids
```

## 12.6 Adding an Additional Data Source

Our raw data folder at `data_DICOMs/dcm_qa_nih/In/20180918Si` contains additional images for our sample study. These are field maps that correspond to our functional resting state images.

Due to the location of these field maps being in a separate folder from the functional data, they are a distinct source of data from the point of view of clpipe. Although we could combine the functional images and field maps into one folder, under their respective subjects, often we only want to read from source data.

We can point clpipe to this additional data by modifying the `clpipe_config.json` to point to its path in `DICOMToBIDSOptions`, under `DICOMFormatString`:

```
"DICOMToBIDSOptions": {
  "DICOMDirectory": "<your system's path>/clpipe_tutorial_project/data_DICOMs",
  "BIDSDirectory": "<your system's path>/clpipe_tutorial_project/data_BIDS",
  "ConversionConfig": "<your system's path>/clpipe_tutorial_project/conversion_
↪ config.json",
  "DICOMFormatString": "dcm_qa_nih/In/20180918Si/mr_{subject}",
  "TimeUsage": "1:0:0",
  "MemUsage": "5000",
  "CoreUsage": "2",
  "LogDirectory": "<your system's path>/clpipe_tutorial_project/logs/DCM2BIDS_logs"
}
```

We pick up a new subject this way:

```
└─ sub-0003
  └─ fmap
    └─ sub-0003_dir-AP_epi.json
    └─ sub-0003_dir-AP_epi.nii.gz
```

However, our `tmp_dcm2bids` now contains more images that were not picked up. The images with “EPI” in the title are the field maps that our criteria did not match:

```
└─ tmp_dcm2bids
  └─ sub-0004
    └─ 004_0004_Axial_EPI-FMRI_(Interleaved_I_to_S)_20180918114023.json
    └─ 004_0004_Axial_EPI-FMRI_(Interleaved_I_to_S)_20180918114023.nii.gz
  └─ sub-0005
    └─ 005_0005_EPI_PE=RL_20180918121230.json
    └─ 005_0005_EPI_PE=RL_20180918121230.nii.gz
  └─ sub-0006
    └─ 006_0006_EPI_PE=LR_20180918121230.json
    └─ 006_0006_EPI_PE=LR_20180918121230.nii.gz
```

Like our last iteration, we can adjust the `conversion_config.json` file to pick up these images. However, the two `fmap` criteria we have already are properly picking up on the AP/PA field maps. Create two new criteria to match the field maps found in `sub-0005` and `sub-0006`, one from LR and another for RL:



```
{
  "dataType": "fmap",
  "modalityLabel": "epi",
  "customLabels": "dir-RL",
  "criteria": {
    "SidecarFilename": "*EPI_PE=RL*"
  },
  "intendedFor": 0
},
{
  "dataType": "fmap",
  "modalityLabel": "epi",
  "customLabels": "dir-LR",
  "criteria": {
    "SidecarFilename": "*EPI_PE=LR*"
  },
  "intendedFor": 0
}
```

Note: The “intendedFor” field points the fieldmap criteria to the index of its corresponding functional image criteria. In this case, we only have one functional image criteria, for the resting state image, which is listed first (index 0). Therefore, it is important that the resting image criteria stays first in the list; otherwise, these indexes would need to be updated.

After running the conversion again, you should now see that sub-0005 and sub-0006 have fieldmap images in addition to their functional scans:

```
— sub-0005
  — fmap
    — sub-0005_dir-RL_epi.json
    — sub-0005_dir-RL_epi.nii.gz
  — func
    — sub-0005_task-rest_bold.json
    — sub-0005_task-rest_bold.nii.gz
— sub-0006
  — fmap
    — sub-0006_dir-LR_epi.json
    — sub-0006_dir-LR_epi.nii.gz
  — func
    — sub-0006_task-rest_bold.json
    — sub-0006_task-rest_bold.nii.gz
```

Great! However, this BIDS directory is not finished quite yet - next we will use the BIDS validator tool to detect the problems with our BIDS directory.



## BIDS VALIDATION

### 13.1 Running the bids\_validate command

Use the `bids_validate` command without the `-submit` flag to check your execution plan:

```
bids_validate -config_file clpipe_config.json
```

```
sbatch --no-requeue -n 1 --mem=3000 --time=1:0:0 --cpus-per-task=1 --job-name=
↪ "BIDSValidator" --output=<your system's path>/clpipe_tutorial_project/Output-
↪ BIDSValidator-jobid-%j.out --wrap="singularity run --cleanenv -B /proj,/pine,/nas02,/
↪ nas <your validation image path>/validator.simg <your system's path>/clpipe_tutorial_
↪ project/data_BIDS"
```

If you are happy with the submission plan, add the submit flag:

```
bids_validate -config_file clpipe_config.json -submit
```

### 13.2 Interpreting & Fixing the Validation Results

You should see the output of your validation at the root of your project directory, like this (it really should end up in the logs folder - we're working on it!):

```
— analyses
— clpipe_config.json
— conversion_config.json
— data_BIDS
— data_DICOMs
— data_fmriprep
— data_GLMPrep
— data_onsets
— data_postproc
— data_ROI_ts
— glm_config.json
— l1_feat_folders
— l1_fsfs
— l2_fsfs
— l2_gfeat_folders
— l2_sublist.csv
```

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```
├─ logs
├─ Output-BIDSValidator-jobid-41362508.out
```

Now open this file - there will be two types of issues, [ERR] for errors and [WARN] for warnings. The errors must be resolved for the dataset to be considered a valid BIDS dataset. Warnings are important to review for insight into further potential problems in the data, but do not invalidate your dataset.

Note: fMRIPrep runs BIDS validation again before it starts processing, and will not start if the dataset contains any errors!

### 13.2.1 Error #1

Let's start with the first error:

```
[31m1: [ERR] Files with such naming scheme are not part of BIDS specification...
      ./tmp_dcm2bids/log/sub-0003_2022-03-23T155433.420971.log
      Evidence: sub-0003_2022-03-23T155433.420971.log
      ./tmp_dcm2bids/log/sub-0004_2022-03-23T153854.035740.log
```

If you look closely, the BIDS validator is complaining about the tmp\_dcm2bids files, which are not intended to be part of the dataset! In order to ask for this folder to not be considered part of the BIDS dataset, we need to specify this in a .bidsignore file.

Create a .bidsignore file in your BIDS directory:

```
touch data_BIDS/.bidsignore
```

Now, open this file and add the folder you'd like to ignore:

```
tmp_dcm2bids
```

Next, rerun the validation command and open your new validation results (make sure you aren't looking at the old results file again!). You should see that the error message about the tmp\_dcm2bids folder is gone.

Note: We plan to have clpipe automatically create this file soon

### 13.2.2 Error #2

The next error should look like this:

```
[31m1: [ERR] 'IntendedFor' field needs to point to an existing file. (code: 37 -_
↳ INTENDED_FOR) [39m
      ./sub-0003/fmap/sub-0003_dir-AP_epi.nii.gz
      Evidence: func/sub-0003_task-rest_bold.nii.gz
```

It looks like sub-0003's 'IntendedFor' field points to a non-existent file. Let's verify this by opening the subject's .json sidecar, located at data\_BIDS/sub-0003/fmap/sub-0003\_dir-AP\_epi.json

At the bottom of the file, we can see that sub-0003's IntendedFor field is pointing to a function image, but this subject has no functional images!

```
...
    "InPlanePhaseEncodingDirectionDICOM": "COL",
    "ConversionSoftware": "dcm2niix",
    "ConversionSoftwareVersion": "v1.0.20190902",
    "Dcm2bidsVersion": "2.1.6",
    "IntendedFor": "func/sub-0003_task-rest_bold.nii.gz"
}
```

Let's erase this field (don't forget to remove the comma on the line before it, too):

```
...
    "InPlanePhaseEncodingDirectionDICOM": "COL",
    "ConversionSoftware": "dcm2niix",
    "ConversionSoftwareVersion": "v1.0.20190902",
    "Dcm2bidsVersion": "2.1.6"
}
```

And try again. Now, the error message for this subject should be gone.

### 13.2.3 Error #3

The final error is asking for the 'TaskName' on our rest data:

```
[31m1: [ERR] You have to define 'TaskName' for this file. (code: 50 - TASK_NAME_MUST_
↪DEFINE) [39m
./sub-0004/func/sub-0004_task-rest_bold.nii.gz
./sub-0005/func/sub-0005_task-rest_bold.nii.gz
./sub-0006/func/sub-0006_task-rest_bold.nii.gz
./sub-0007/func/sub-0007_task-rest_bold.nii.gz
```

This error is asking us to include a "TaskName" field in our .json sidecar files. Luckily, we can ask dcm2bids to specify this in the `conversion_config.json` file. Open up `conversion_config.json` and add the `sidecarChanges` field to specify a task name to automatically add to our generated sidecar files:

```
{
  "descriptions": [
    {
      "dataType": "func",
      "modalityLabel": "bold",
      "customLabels": "task-rest",
      "sidecarChanges": {
        "TaskName": "rest"
      },
      "criteria": {
        "SeriesDescription": "Axial_EPI-FMRI*"
      }
    },
    ...
  ]
}
```

For this change, we will need to rerun the BIDS conversion. However, because these rest images were already successfully sorted into BIDS format, we will need to add the `-overwrite` flag to our `convert2bids` command (which calls `dcm2bid's --forceDcm2niix` and `--clobber` options under the hood)

Now we will have a clean slate when rerunning `convert2bids`, and we can see that the rest image sidecars now contain the `TaskName` field:

```
...
  "InPlanePhaseEncodingDirectionDICOM": "COL",
  "ConversionSoftware": "dcm2niix",
  "ConversionSoftwareVersion": "v1.0.20190902",
  "Dcm2bidsVersion": "2.1.6",
  "TaskName": "rest"
}
```

Finally, because we used the `-overwrite` flag, sub-0003's `IntendedFor` field will be re-inserted (Error #2). Repeat the fix for this problem by removing the `IntendedFor` field from sub-0003's sidecar `.json`.

Now, rerun `bids_validate` - you should be completely free of errors!

## Symbols

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