hcp-users FAQ #9: How do I map data between FreeSurfer and HCP?

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Overview. Comparisons between HCP-derived data (including the new HCP_MMP1.0 cortical parcellation – Glasser et al., Nature, 2016) and data analyzed in FreeSurfer entail mapping between different surface 'spaces': HCP data are generally on a standard fs_LR mesh (left and right hemispheres aligned), whereas FreeSurfer data are on a native mesh or on the fsaverage mesh (in both cases, no correspondence between hemispheres). Mapping data from one surface mesh to another involves one-step "resample" options within "wb_command", plus preparatory steps that may also be needed. These instructions cover mappings from:

A) fsaverage group data to fs_LR
B) FreeSurfer native individual data to fs_LR
C) fs_LR group data to fsaverage
D) fs_LR individual data to fsaverage

We recommend options (A) or (B) so as to benefit from the correspondences between left and right hemispheres provided by the fs_LR atlas. Option (B) presumes that FreeSurfer was run using mris_register, yielding a "?h.sphere.reg" native mesh sphere registered to fsaverage.

For these operations, you need to use the command line, and Connectome Workbench software, available at http://www.humanconnectome.org/software/get-connectome-workbench.html and from NeuroDebian. For resampling Freesurfer native individual data to fs_LR, you will also need to have FreeSurfer installed, and have the "wb_shortcuts" bash script, available in Connectome Workbench v1.2.3 and above (also available at https://github.com/Washington-University/wb_shortcuts). To get usage information for something in either wb_command or wb_shortcuts, run the command with the operation switch and no additional arguments (i.e., "wb_command -metric-resample").

Any FreeSurfer data to be mapped to the fs_LR mesh must be in gifti format, use mris_convert if needed (https://surfer.nmr.mgh.harvard.edu/fswiki/mris_convert). For a brief introduction to the gifti format, see http://www.humanconnectome.org/software/workbench-command.php?function=-gifti-help (or wb_command -gifti-help if you are using v1.2.0 or above). To prevent problems when loading files into wb_view, use the same file extensions as specified in the instructions for output filename arguments (.surf.gii, .func.gii, .shape.gii, label.gii, etc). Output filenames can contain paths (like "../fsconvert/test.func.gii"), in order to put the result in a folder other than the current directory, though such folders must be created manually before running the command.

First, download http://brainvis.wustl.edu/workbench/standard_mesh_atlases.zip, then unzip this file somewhere. The most important files in it are in standard_mesh_atlases/resample_fsaverage. Inside this folder are two sets of spheres, one set for the FreeSurfer "fsaverage" mesh ("fsaverage?_std_sphere.?.???k_fsavg_?.surf.gii") and another set for the fs_LR mesh ("fs_LR-deformed_to-fsaverage.?.sphere.???k_fs_LR.surf.gii"). There are also "midthickness_va_avg" .shape.gii files, which are used for resampling group-average data. These files are also available in the HCP Pipelines repository (https://github.com/Washington-University/Pipelines), under global/templates/standard_mesh_atlases.

When using these data files with the following instructions, you will need to specify them with the path to where you unzipped them.

Appendix 1 lists theses files, to aid in selecting the names needed for some of the command line arguments.

Appendix 2 describes how these files relate to each other, and gives an overview of sphere-based resampling, for those that want to know what is going on behind the scenes.

A. FreeSurfer fsaverage group data to fs_LR
1) To map “metric” (scalar) data, use "wb_command -metric-resample”:

wb_command -metric-resample <metric-in> <current-sphere> <new-sphere> ADAP_BARY_AREA <metric-out> -area-metrics <current-area> <new-area>

- For **<metric-in>**, specify the metric file you want to resample
  - This must be in gifti format.
- For **<current-sphere>**, use fsaverage?_std_sphere.?.???k_fsavg_?.surf.gii
  - Use the appropriate hemisphere and resolution sphere from standard_mesh_atlases/resample_fsaverage. Typically, this will be ‘164k_fsavg’ resolution (see Appendix 1).
- For **<new-sphere>**, use fs_LR-deformed_to-fsaverage.?.sphere.???k_fs_LR.surf.gii
  - Use the appropriate hemisphere and desired resolution sphere from standard_mesh_atlases/resample_fsaverage.
- For **<metric-out>**, specify a name like <group>.<measure>.<hem>.???k_fs_LR.func.gii
- For **<current-area>**, use fsaverage*.midthickness_va_avg.???k_fsavg_?.shape.gii
  - These are also in standard_mesh_atlases/resample_fsaverage, choose the one matching <current-sphere>.
- For **<new-area>**, use fs_LR.?.midthickness_va_avg.???k_fs_LR.shape.gii
  - Choose the one matching <new-sphere>.

2) To map “label” (categorical) data, use "wb_command -label-resample", and otherwise follow step (1), but using “.label.gii” as the extension on **<label-out>**.

B. FreeSurfer native individual data to fs_LR.
1) Make sure you have wb_shortcuts (see prerequisites above). Run:

wb_shortcuts -freesurfer-resample-prep <fs-white> <fs-pial> <current-freesurfer-sphere> <new-sphere> <midthickness-current-out> <midthickness-new-out> <current-gifti-sphere-out>

- For **<fs-white>** and **<fs-pial>**, use the subject’s native mesh white and pial surfaces, respectively (usually $SUBJECTS_DIR/<subject>/surf/?h.white or ?h.pial)
- For **<current-freesurfer-sphere>**, use “$SUBJECTS_DIR/<subject>/surf/?h.sphere.reg”
- For **<new-sphere>**, use fs_LR-deformed_to-fsaverage.?.sphere.???k_fs_LR.surf.gii
  - Use the appropriate hemisphere and desired resolution from standard_mesh_atlases/resample_fsaverage
- For **<midthickness-current-out>**, specify a name like ?h.midthickness.surf.gii
- For **<midthickness-new-out>**, specify a name like <subject>.<hem>.midthickness.???k_fs_LR.surf.gii
- For **<current-gifti-sphere-out>**, specify a name like ?h.sphere.reg.surf.gii

2) To map “metric” (scalar) data, run "wb_command -metric-resample”:

wb_command -metric-resample <metric-in> <current-sphere> <new-sphere> ADAP_BARY_AREA <metric-out> -area-surfs <current-area> <new-area>

- For **<metric-in>**, specify the metric file you want to resample
  - This must be in gifti format.
- For **<current-sphere>**, use the <current-gifti-sphere-out> from step (1)
- For **<new-sphere>**, use the <new-sphere> from step (1)
- For **<metric-out>**, specify a name like <subject>.<measure>.<hem>.???k_fs_LR.func.gii
- For **<current-area>**, use <midthickness-current-out> from step (1)
- For **<new-area>**, use <midthickness-new-out> from step (1)

3) To map "label" (categorical) data, use "wb_command -label-resample", but otherwise follow step (2), using ".label.gii" as the extension on **<label-out>**.

4) To map surface (geometry) files, use "wb_command -surface-resample" with the same spheres as in step (2), but using the BARYCENTRIC method, and not using the -area-surfs option or its arguments (<current-area> and <new-area>). Use ".surf.gii" as the extension on **<surface-out>**.

C. fs_LR group data to fsaverage

1) If the fs_LR data is in CIFTI format (ends in something like .dscalar.nii or .dlabel.nii), use "wb_command -cifti-separate" with -metric or -label options (depending on the type of CIFTI file) to generate single-hemisphere GIFTI files, like this:

wb_command -cifti-separate <cifti-in> COLUMN -metric CORTEX_LEFT <metric-out-left> -metric CORTEX_RIGHT <metric-out-right>

- For **<cifti-in>**, specify the CIFTI file you want to use
- For **<metric-out-left>** and **<metric-out-right>**, specify a name for the left and right output files
- For .dlabel.nii files, use -label instead of -metric, and use the extension ".label.gii" on the output files

2) To map "metric" (scalar) data, use "wb_command -metric-resample":

wb_command -metric-resample <metric-in> <current-sphere> <new-sphere> ADAP_BARY_AREA <metric-out> -area-metrics <current-area> <new-area>

- For **<metric-in>**, specify the metric file you want to resample
- For **<current-sphere>**, use fs_LR-deformed_to-fsaverage.?.sphere.???k_fs_LR.surf.gii
  - Use the appropriate hemisphere and resolution from standard_mesh_atlases/resample_fsaverage.
- For **<new-sphere>**, use fsaverage?_std_sphere.?.???k_fsavg_?.surf.gii
  - Use the appropriate hemisphere and desired resolution.
- For **<metric-out>**, specify a name like <group>.<measure>.<hem>.???k_fsavg_?.func.gii
- For **<current-area>**, use fs_LR.?.midthickness_va_avg.???k_fs_LR.shape.gii
  - Use the one matching <current-sphere>.
- For **<new-areas>**, use fsaverage*.midthickness_va_avg.???k_fsavg_?.shape.gii
  - Use the one matching <new-sphere>.

3) To map “label” (categorical) data, use "wb_command -label-resample", and otherwise follow the steps in (2), but using “.label.gii” as the extension on **<label-out>**.

D. fs_LR individual data to fsaverage

1) Create the fsaverage-registered individual native sphere (needed for resampling native mesh files, and for step 2) by using “wb_command -surface-sphere-project-unproject”:

wb_command -surface-sphere-project-unproject <sphere-in> <sphere-project-to> <sphere-unproject-from> <sphere-out>

- For **<sphere-in>**, use MNINonLinear/Native/<subject>.?.sphere.MSMAll.native.surf.gii
- For **<sphere-project-to>**, use standard_mesh_atlases/fs_?/fs_?-to-fs_LR_fsaverage.*.surf.gii
- For **<sphere-unproject-from>**, use standard_mesh_atlases/fs_?/fsaverage.?.sphere.164k_fs_?.surf.gii
- For **<sphere-out>**, use a name like <subject>.?.sphere.fsaverage.native.surf.gii

2) Resample the individual’s native-space native-mesh midthickness surface to the desired fsaverage mesh with wb_command -surface-resample (needed for vertex area information for other resamplings):

wb_command -surface-resample <surface-in> <current-sphere> <new-sphere> BARYCENTRIC <surface-out>

- For **<surface-in>**, use T1w/Native/<subject>.?.midthickness.native.surf.gii
- For **<current-sphere>**, use the <sphere-out> made in step (1)
- For **<new-sphere>**, use fsaverage?_std_sphere.?.???k_fsavg_?.surf.gii
    - Use the appropriate hemisphere and desired resolution from standard_mesh_atlases/resample_fsaverage.
- For **<surface-out>**, use a name like <subject>.<hem>.midthickness.???k_fsavg_?.surf.gii

3) **For 164k data only:** resample the individual’s native-space native-mesh midthickness to 164k_fs_LR with “wb_command -surface-resample”:

wb_command -surface-resample <surface-in> <current-sphere> <new-sphere> BARYCENTRIC <surface-out>

- For **<surface-in>**, use T1w/Native/<subject>.?.midthickness.native.surf.gii
- For **<current-sphere>**, use MNINonLinear/Native/<subject>.?.sphere.MSMAll.native.surf.gii
- For **<new-sphere>**, use standard_mesh_atlases/fsaverage.?_LR.spherical_std.164k_fs_LR.surf.gii
- For **<surface-out>**, use a name like <subject>.<hem>.midthickness_MSMAll.164k_fs_LR.surf.gii
    - We suggest putting this in the subject’s T1w folder.
    - Note that there is a surface named this in the MNINonLinear folder, take care not to overwrite it.

4) If the fs_LR data is in CIFTI format (ends in something like .dscalar.nii or .dlabel.nii), use “wb_command -cifti-separate” with -metric or -label options (depending on the type of CIFTI file)

to generate single-hemisphere GIFTI files, like this:

wb_command -cifti-separate <cifti-in> COLUMN -metric CORTEX_LEFT <metric-out-left> -metric CORTEX_RIGHT <metric-out-right>

- For **<cifti-in>**, specify the CIFTI file you want to use
- For **<metric-out-left>** and **<metric-out-right>**, specify a name for the left and right output files
- For .dlabel.nii files, use -label instead of -metric, and use the extension ".label.gii" on the output files

5) To map "metric" (scalar) fs_LR data, use "wb_command -metric-resample":

wb_command -metric-resample <metric-in> <current-sphere> <new-sphere> ADAP_BARY_AREA <metric-out> -area-surfs <current-area> <new-area>

- For **<metric-in>**, specify the metric file you want to resample
- For **<current-sphere>**, use fs_LR-deformed_to-fsaverage.?.sphere.???k_fs_LR.surf.gii
    - Use the appropriate hemisphere and resolution from standard_mesh_atlases/resample_fsaverage.
- For **<new-sphere>**, use fsaverage?_std_sphere.?.???k_fsavg_?.surf.gii
    - Use the appropriate hemisphere and desired resolution.
- For **<metric-out>**, specify a name like <group>.<measure>.<hem>.???k_fsavg_?.func.gii
- For **<current-area>**, use T1w/fsaverage_LR??k/<subject>.?.midthickness_MSMAll.32k_fs_LR.surf.gii
    - **For 164k data only:** use the surface created in step (3)
- For **<new-area>**, use the surface made in step (2)

6) To map "label" (categorical) fs_LR data, use "wb_command -label-resample", but otherwise follow step (5)

7) To map native-mesh surface (geometry) files to fsaverage, follow step (2), substituting the **<surface-in>** and **<surface-out>** arguments according to the surface type you want to resample

- Note that while you can resample surfaces from an fs_LR mesh, the fs_LR surfaces are already resampled once starting from the native mesh, so resampling from the native mesh surface instead will result in better-preserved geometry.

8) To map native-mesh data, use "wb_command -metric-resample" or "wb_command -label-resample":

wb_command -metric-resample <metric-in> <current-sphere> <new-sphere> ADAP_BARY_AREA <metric-out> -area-surfs <current-area> <new-area>

- For **<metric-in>**, specify the metric file you want to resample
- For **<current-sphere>**, use the <sphere-out> made in step (1)
- For **<new-sphere>**, use fsaverage?_std_sphere.?.???k_fsavg_?.surf.gii
    - Use the appropriate hemisphere and desired resolution from standard_mesh_atlases/resample_fsaverage.
- For **<metric-out>**, specify a name like <group>.<measure>.<hem>.???k_fsavg_?.func.gii
- For **<current-area>**, use T1w/Native/<subject>.?.midthickness.native.surf.gii

- For **<new-area>**, use the surface made in step (2)

END of INSTRUCTIONS

Appendix 1. Filenames to choose from when running resampling-related commands in wb_command and wb_shortcuts:

standard_mesh_atlases/resample_fsaverage/
fsaverage4.L.midthickness_va_avg.3k_fsavg_L.shape.gii
fsaverage4.R.midthickness_va_avg.3k_fsavg_R.shape.gii
fsaverage4_std_sphere.L.3k_fsavg_L.surf.gii
fsaverage4_std_sphere.R.3k_fsavg_R.surf.gii
fsaverage5.L.midthickness_va_avg.10k_fsavg_L.shape.gii
fsaverage5.R.midthickness_va_avg.10k_fsavg_R.shape.gii
fsaverage5_std_sphere.L.10k_fsavg_L.surf.gii
fsaverage5_std_sphere.R.10k_fsavg_R.surf.gii
fsaverage6.L.midthickness_va_avg.41k_fsavg_L.shape.gii
fsaverage6.R.midthickness_va_avg.41k_fsavg_R.shape.gii
fsaverage6_std_sphere.L.41k_fsavg_L.surf.gii
fsaverage6_std_sphere.R.41k_fsavg_R.surf.gii
fsaverage.L.midthickness_va_avg.164k_fsavg_L.shape.gii
fsaverage.R.midthickness_va_avg.164k_fsavg_R.shape.gii
fsaverage_std_sphere.L.164k_fsavg_L.surf.gii
fsaverage_std_sphere.R.164k_fsavg_R.surf.gii
fs_LR-deformed_to-fsaverage.L.sphere.164k_fs_LR.surf.gii
fs_LR-deformed_to-fsaverage.L.sphere.32k_fs_LR.surf.gii
fs_LR-deformed_to-fsaverage.L.sphere.59k_fs_LR.surf.gii
fs_LR-deformed_to-fsaverage.R.sphere.164k_fs_LR.surf.gii
fs_LR-deformed_to-fsaverage.R.sphere.32k_fs_LR.surf.gii
fs_LR-deformed_to-fsaverage.R.sphere.59k_fs_LR.surf.gii
fs_LR.L.midthickness_va_avg.164k_fs_LR.shape.gii
fs_LR.L.midthickness_va_avg.32k_fs_LR.shape.gii
fs_LR.L.midthickness_va_avg.59k_fs_LR.shape.gii
fs_LR.R.midthickness_va_avg.164k_fs_LR.shape.gii
fs_LR.R.midthickness_va_avg.32k_fs_LR.shape.gii
fs_LR.R.midthickness_va_avg.59k_fs_LR.shape.gii

Appendix 2.

The files named “fsaverage*_std_sphere” are the standard spheres from FreeSurfer, converted to GIFTI format. The files named “fs_LR-deformed_to-fsaverage” are the fs_LR spheres registered to fsaverage, meaning that they “line up” with the fsaverage standard spheres in terms of what features of the registration templates end up at what spherical coodinates. This correspondence is used for the resampling weights, starting by projecting each vertex of one sphere onto the triangles of the other sphere.

The files named “midthickness_va_avg” were made by computing the per-vertex surface area of each HCP900 subject’s native-space midthickness surface, after resampling it to the specified

mesh. These files were then averaged across subjects. The reason for making these files is that a group-average surface loses a large amount of surface area, due to the variability of folding across subjects (and because MSMAll aims to align functional areas, and not folding patterns). When resampling group-average data, these are used in place of an anatomical surface, in order to correct the resampling weights for the variability in vertex areas - a vertex with less area is given less influence on the resampled result as it represents a smaller fraction of the total surface area.