

Introduction to SPM Outline

- SPM Components
- Spatial Transformations
- Comments

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SPM: Overview

- Library of Matlab and C functions
- “Point-&-click” graphical user interface
- Consists of 4 general components
 - Preprocessing
 - Model Specification & Fitting
 - Inference & Results Interrogation
 - Supplemental Tools

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SPM: Preprocessing

- Elimination of systematic variation before statistical modeling
- “Realign”ment
 - Intrasubject registration
 - Motion correction
 - “Realign & Unwarp”
 - Correct EPI effects of movement-dependent changes in susceptibility
- “Coregister”ation
 - Intrasubject, *inter*modality registration
 - Registration of MR images with different TR/TE
 - PET-MR registration

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SPM: Preprocessing

- Slice timing
 - Adjust for variable acquisition time over slices
 - SPM’s slice timing can induce artifacts; use UM’s
- Spatial “Normalize”ation
 - *Inter*subject registration
 - Register subject anatomy to atlas space
- Spatial “Smooth”ing
 - Blur data into submission...
 - To satisfy random field theory assumptions
 - For intersubject analyses
- “Segment”ation into GM/WM/CSF
 - Usually not directly used
 - Useful for structural studies

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SPM: Model Specification & Fitting

- “Basic models”
 - t-tests (Two sample, One sample, Paired)
 - Regression
- “fMRI”
 - “design” Specify the design
 - “data” Specify the data for an existing design
- “Review design”
 - Examine correlation of predictors
 - Power spectrum of experimental effects
- “Estimate”
 - Fit a specified model

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SPM: Inference & Results Interrogation

- “Results” button
- First brings up “Contrast Manager”
 - Can define single (t) or sets (F) of contrasts
- Then shows MIP in Graphics window
 - MIP = Maximum Intensity Projection
 - Glass Brain
 - Can “surf” by dragging cursor

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SPM: Inference & Results Interrogation

- Interactive window
 - p-values
 - Corrected for whole brain or subregion
 - Plotting of time courses
 - “Overlays”
 - Superimpose results on other images
 - Current location and value

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SPM: Miscellaneous Tools

- “Display”
 - Display an image with orthogonal sections.
 - Check intensity values
 - Change origin
 - Change world space
 - I.e. apply rotations/translations to mat file
- “Check Reg”
 - Display multiple images
 - *Essential* tool for assessing estimated or assumed alignment of images.
 - All images are displayed in the space of the first image.

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SPM: Miscellaneous Tools

- “ImCalc”
 - Image calculator
 - Give one or more images, perform Matlab arithmetic and write out result
- “Utils”
 - Change directory
 - Results are written to current directory!
 - delete files, etc.

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SPM: Miscellaneous Tools

- “Rendering”
 - Sexy brains
- “Defaults”
 - Change defaults for one session.
 - To make permanent changes, edit `spm_defaults.m`
- “Help”
 - Some help
 - Also not “Tool tip” help balloons

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SPM: Pipeline

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Spatial Transformations: Image File

- Data must be in analyze format
- `.img` Raw, binary data; single 3D volume
- `.hdr` Short binary header
 - Image dimension
 - Voxel size
 - Origin, in voxels
 - First element 1, not 0
- `.mat` Optional, SPM extension
 - Defines transformation from voxel to world space
 - If exists, `.hdr` voxel size & origin are ignored
 - Origin can be represented as mm location
 - e.g. between voxels

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Spatial Transformations: Voxel vs. World Space

- Voxel Space
 - Just the original image
 - No reorientations or flips
- World Space
 - Space defined by `.mat` file
 - `.mat` - 4×4 homogeneous transformation matrix M
 - Let v be a voxel location indexed from (1,1,1)
 - Then $w=M*[v;1]$ is that location in world space
 - Has units of *mm*
 - Can represent rotations, translations and flips

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Spatial Transformations: Coregistration & Realignment

- Coregistration & Realignment are rigid body transformations
 - Subject's doesn't change size or warp between scans
 - Well, actually...
- Each requires a "Target" and an "Object"
 - Target — Fixed image
 - Object — Image that is transformed
- SPM modifies the `.mat` file of the *object* image
 - Unless you explicitly ask it to, it doesn't write out an image

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Spatial Transformations: Coregistration & Realignment

- This is very cool!
 - You have 1000 images
 - You realign 2nd through the 1000th to the 1st
 - Target=1st, Object=2nd-1000th
 - Instead of doubling the disk space required by writing out 1000 images, you only need to modify the `.mat`'s!

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Spatial Transformations: Coregistration

- `.mat`'s handy for coregistration
- e.g. Coregister
 - Target: Functional space, 7 slices
 - e.g. 7 slice, low resolution anatomical in space of func's, "t1_gre"
 - Object: Structural space
 - e.g. high resolution anatomical, 120 slices difference space, "t1_spgr"
- Reslicing an image, creating "t1_spgr-gre"
 - You get a 7 slice, low resolution SPGR

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Spatial Transformations: Coregistration

- But don't have to reslice
 - `t1_spgr`'s world space now corresponds to `t1_gre`
 - The `.mat` file has captured the transformation *without* throwing away any information

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Spatial Transformations: Easy to forget about `.mat`'s

- Easy to forget about `.mat`'s
 - If you want to start over and re-do registration *must delete the .mat's!*

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Spatial Transformations: Left is Right is Left is Right is ...

- Two conventions for images
- Neurological
 - On the screen, Left is Left side of subject
 - As if standing behind the patient
- Radiological
 - On the screen, Left is Right side of subject
 - As if standing at the foot of the patient
- Standard in clinical radiology is, um, radiological
- SPM2 and SPM99 differ on their conventions
 - Be very careful!

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Spatial Transformations: Rad. vs. Neuro., SPM2 vs. SPM99

- SPM99
 - Analyze images read and written in *Neurological* format
 - nb: Official Analyze standard specifies Radiological format
 - **Exception:** Spatial Normalization reads in Radiological (by default; switchable to Neurological)
 - Default set by `spt1.Ornt` in `spm_defaults.m`
- SPM2
 - Analyze images *consistently*, always assumed to have the same format
 - Default set by `defaults.analyze.flip` in `spm_defaults.m`
 - `flip = 0` ⇔ Neuro.
 - `flip = 1` ⇔ Rad. (SPM2 default; *diff. from SPM99!*)

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Spatial Transformations: Left is Right is Left is Right is ...

- Best to make a lab convention
 - fMRI Lab produces everything in neurological!!!
 - SPM99
 - Set `spt1.Ornt` to Neurological option
 - SPM2
 - Set `defaults.analyze.flip` to 0, Neurological
- If paranoid
 - Tape a vitamin E capsule to head and call me in the morning
 - (Note location of capsule in acquired images)

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SPM: SPMese Decoder Ring

- “Spatial Normalization”
 - Intersubject registration
- “Coregistration”
 - Intermodality registration (intrasubject)
- “Registration”
 - Intrasubject registration (movement corr)
- “Results”
 - Inference
- “Interscan Interval”
 - TR

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SPM: Perspective

- SPM tries to be a “sole source”, turn key solution for fMRI
- At this point, *there can be no such thing!*
 - This is impossible in a cutting edge, rapidly evolving field where each dataset has 10's of millions of observations!!!
- Don't let SPM be a black box!
- Understand what each component does
- Understand how to get at the data
 - e.g. using 'Display' and 'Check Reg' alot.

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SPM: Alternatives

- VoxBo
 - Started as independent coding (and validation!) of SPM methods in IDL
 - Uses random field theory, etc
 - Easy to do to parallel computing; easy to automate
- FSL
 - Started as extensions to MEDx
 - Best temporal autocorrelation modeling available
 - Regularized ACF fit at every voxel
 - Most sophisticated group modeling available
 - Between and within subj. variance estimated
 - Better design specification UI, easy to automate

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