Instant Analyses in **AFNI** and **SUMA**: Clusters and Correlations

Data for this presentation: **AFNI_data5/ directory**

All data herein from Alex Martin, *et al.* [NIMH IRP]
“Insta” Functions

• 3 new capabilities added to the interactive AFNI
• Each one: compute new dataset volumes instantly to replace the Overlay volume for image viewing

• **Clusters** = interactive clustering
  • remove clusters below a user-chosen size
  • display a table of clusters

• **InstaCorr** = interactive exploration of inter-voxel time series correlation
  • choose a seed voxel and see correlation map
  • SUMA version also exists

• **InstaCalc** = interactive version of 3dcalc
  • e.g., display ratio of 2 datasets
**Clusters: Setup**

- Open **Define Overlay**, choose **Clusters** from menu in top right corner.

- Then press **Clusterize** to get the clusters control menu.
Clusters Control Menu

Operates on user’s chosen Overlay dataset at the user’s threshold; Next slide example: AFNI_ICOR_sample

Default: NN clustering

Default: 20 voxel minimum cluster size

Clustering is done in 3D

Press one of these buttons to create clusterized volume for display as new Overlay
Clusters Results

No clustering

Cluster report window

Jump: crosshairs move
Flash: colors on & off

With clustering
InstaCorr

- On-the-fly instantaneous correlation map of resting state data with interactively selected seed voxel
- **Setup phase:** prepares data for correlations (several-to-10+ seconds)
- **Correlation phase:** you select seed voxel, correlation map appears by *magic*
InstaCorr: Outline of 2 Phases

• **Setup phase**:  
  - Masking: user-selected *or* Automask  
  - Bandpass and other filtering of voxel time series  
  - Blurring inside mask = the slowest part

• **Correlation phase**:  
  - Correlate selected seed voxel time series with all other prepared voxel time series  
  - Make new dataset, if needed, to store results  
  - Save seed time series for graphing  
  - Redisplay color overlay  
  - Optional: compute FDR curve for correlations  
    - Calculation is slow, so FDR is not turned on by default
**InstaCorr: Setup**

- Open **Define Overlay**, choose **InstaCorr** from menu in top right corner
**InstaCorr: Setup**

- Open **Define Overlay**, choose **InstaCorr** from menu in top right corner.

- Then press **Setup ICorr** button to get control panel.
InstaCorr: Setup

- Mostly self-explanatory (I hope) — cf. Help
- **Global Orts** = extra time series to be projected out of dataset before correlation
  - All columns in selected 1D file
  - *e.g.*, movement parameters
  - The first **Ignore** rows (time points) will be skipped
- When ready, press one of the **Setup** buttons

**Doesn’t have to be current underlay**
InstaCorr: Setup

- Text output to shell window details the setup procedures:
  ++ InstaCorr preparations:
    + Automask from '/Users/rwcox/data/Resting/ZSS/s620/s620_rest_r1+orig.BRIK' has 197234 voxels
    + Extracting dataset time series
    + Filtering 197234 dataset time series
    + bandpass: ntime=139 nFFT=160 dt=3.5 dFreq=0.00178571
      Nyquist=0.142857 passband indexes=6..56
    + Spatially blurring 139 dataset volumes
    + Normalizing dataset time series
  ++ InstaCorr setup: 197234 voxels ready for work: 15.43 sec

Most of the CPU time: Uses BlurInMask
or Preprocess via afni_proc.py

## Adapted from Example 9b in afni_proc.py -help
## Eliminated tlrc block; add blur_size of 5mm

```
afni_proc.py -subj_id s620
  -dsets s620_rest_r1+orig.HEAD
  -copy_anat s620_t1_al2epi+orig.HEAD
  -blocks despike tshift align volreg blur mask regress
  -tcat_remove_first_trs 2
  -volreg_align_e2a
  -blur_size 5
  -regress_anaticor_fast
  -regress_censor_motion 0.2
  -regress_censor_outliers 0.1
  -regress_bandpass 0.01 0.2
  -regress_apply_mot_types demean deriv
  -regress_run_clustsim no  -regress_est_blur_errts
```
**InstaCorr: The Fun Part**

- In image viewer, set crosshairs to desired seed voxel
  - **Right-click** popup menu → **InstaCorr Set**
    - Creates new dataset **A_ICOR** for Overlay
    - **Shortcut**: `Shift+Ctrl+Left-click` sets new crosshair location, then does **InstaCorr Set**
      - Can also hold down `Shift+Ctrl+Left-click` and drag seed around
  - **InstaCorr SeedJump** jumps focus to current seed
InstaCorr: The Fun Part

- In graph window:
  - Set Ignore with **FIM→Ignore** menu (or I key)
  - Set seed overlay with **FIM→Pick Ideal** menu

- When you change seed voxel, saved overlay time series will change (but you have to refresh graph to see it)
InstaCorr: Effects of Blurring

- Is this a pure vascular/cardiac effect being progressively smeared? Or real neural correlations seen via BOLD? Or some of both? *Venograms?*
- Dataset was RETROICOR-ized; mask is whole brain
InstaCorr: Effects of Blurring

- Similar calculations, but with FreeSurfer-generated gray matter mask instead of Automask from EPI data
  - Blurring is done only inside the mask (**3dBlurInMask**)
    - Using a discrete PDE-based iterative approach
InstaCorr: SVD-based “Blurring”

- Similar calculations, with Automask from EPI data, using \texttt{3dLocalPV} over 5 mm radius sphere (67 voxels)
  - Project each vector onto 2-dim principal subspace
  - Far too slow to calculate interactively (at this time)
InstaCorr: SVD-based “Blurring”

- Volume rendering of InstaCorr maps (threshold at $r=0.5$)
  - Renderer updates automatically if DynaDraw is on
- SVD smoothing has cleaner spatial structure?
  - Or has it lost some information?  *I don’t know.*
**InstaCorr: Options and Plans**

- Underlay doesn’t have to be EPI data; could be anat
  - Can use InstaCorr in multiple AFNI controllers
- FDR: `setenv AFNI_INSTACORR_FDR YES`
  - Will slow things down by a significant factor
- Saving `A_ICOR` dataset: overwrites previous copies

**Future Possibilities:**
- Select ROI-based Orts to be detrended?
  - Based on ROIs from FreeSurfer or atlases?
- Or multiple seeds (partial + multiple correlations)?
- Interactive local SVD “smoothing”? (needs speedup)
- Group analysis **InstaCorr** (in standardized space)
  - Not quite “Insta” any more; \( \approx 0.1 \times \#\text{Subjects} \) sec per seed
  - External script to do subject setups
- Use time series subsets? (e.g., for block design data)
Group InstaCorr

• If you have a robust enough system (multiple CPUs, several gigabytes of RAM), you can explore the group analysis of resting state seed-based correlations

• Setup Phase:
  ▪ Unlike individual InstaCorr, the setup is done outside the AFNI GUI with command line programs
  ▪ Step 1: pre-process all datasets (including into template space) by using afni_proc.py
    o We recommend something like Example 9b in the afni_proc.py help output
  ▪ Step 2: collect groups of time series datasets into one big file = 3dSetupGroupInCorr

• Interactive Phase: point-and-click to set seed voxel
3dGroupInCorr: Setup #2

- **3dSetupGroupInCorr** reads all filtered & blurred resting state EPI datasets, masks & normalizes them, and writes them to one *big* file for **3dGroupInCorr**
  - Sample tcsh script fragment below: 2 groups of subjects

```bash
set AAA = ( s601 s604 ... s644 s646 )
set BBB = ( s611 s612 ... s652 s654 )
set ggg = ( )
foreach fred ( $AAA )
    set ggg = ( $ggg errts.${fred}.fanaticor+tlrc.HEAD )
end
3dSetupGroupInCorr -mask ALL_am50+tlrc -prefix AAA $ggg
set ggg = ( )
foreach fred ( $BBB )
    set ggg = ( $ggg errts.${fred}.fanaticor+tlrc.HEAD )
end
3dSetupGroupInCorr -mask ALL_am50+tlrc -prefix BBB $ggg
```
3dGroupInCorr: Interactive Phase

- Start server program (2-sample t-test here):
  ```
  3dGroupInCorr -setA AAA.grpincorr.niml
   -setB BBB.grpincorr.niml
  ```
  - Startup takes a little while, as all data must be read into RAM (in this example, 3.2 Gbytes)
  - After data is read, connects to AFNI using a NIML socket
  - Server will use multiple CPUs if compiled with OpenMP (currently on Mac OS X 10.5 and 10.6)

- In a separate terminal window, start AFNI:
  ```
  afni -niml ~/abin/MNI_avg152T1+tlrc.HEAD
  ```
  - Then open the Define Overlay control panel
  - Select GrpInCorr from the Clusters menu
3dGrpInCorr: Interactive Results

- Use same buttons as individual subject InstaCcorr to set seed
- Use Setup GICor panel to set the few options available interactively
  - **SeedRad** = extra smoothing radius for seed voxel time series (flat average)
  - **Cluster** = min number of voxels to keep above thresh
3dGrpInCorr: What It Computes

• Step 1: Extract seed time series from each dataset; correlate with all voxel time series in that dataset
• Step 2: Group analysis: $t$-test among correlation bricks

1-sample $t$-test ( –setA only) gives 2 sub-bricks:
  ▪ mean of $\tanh^{-1}$ (correlation with seed)
  ▪ $Z$-score of $t$-statistic of this mean

2-sample test ( –setA and –setB) gives 6 sub-bricks:
  ▪ difference of means (A-B) of $\tanh^{-1}$ (correlation)
  ▪ $Z$-score of $t$-statistic of this difference
    ○ Pooled or unpooled variance, or paired $t$-test (your option)
  ▪ Plus 1-sample results for –setA and –setB separately
    ○ View these in AFNI [B] and [C] controllers, to see it all!
3dGrpInCort: To Do It By Hand?

- After preprocessing all datasets, you would have to do the following steps on each resting state dataset:
  - Extract seed time series from each dataset [3dmaskave]
  - Correlate seed time series with all voxels from its dataset [3dDeconvolve or 3dfim]
  - Convert to $\tanh^{-1}(\text{correlation})$ [3dcalc]

- Then do the following on the results from the above:
  - Compute the $t$-test [3dttest]
  - Convert to $Z$-score [3dcalc]
  - Read into AFNI for display

- Even with a script, this would be annoying to do a lot
  - Just ask Daniel Handwerker!
**Group InstaCorr: Final Notes**

- Time series datasets can have different lengths
  - But all must have the same spatial grid and use the same mask!

- **Fun Stuff:** volume render results with *DynaDraw*

- Sometimes AFNI drops the shared memory connection to *3dGroupInCorr*
  - Due to unknown bugs somewhere in AFNI
  - Program tries to reconnect when this happens
  - If this gets bad, use the `--NOshm` option to *3dGroupInCorr* to force it to use TCP/IP only
    - Slower data transfer, but more reliable
Group InstaCorr: Finalest Notes

• Shift+Ctrl+Click+Drag method for dynamically setting the seed voxel also works with Group InstaCorr
  ▪ But speed of interaction can be slow
• Can also include subject-level covariates (e.g., IQ, age) in the analysis at the group step
  ▪ To regress them out (nuisance variables), and/or to test the slope of $\tanh^{-1}(\text{correlation})$ vs. covariate
• Can also run in batch mode (no talking to AFNI)
• Further ideas (i.e., to dream the impossible dream):
  ▪ Granger-ize: correlate with lag-0 and lag-1 of seed and test Granger causality
  ▪ Allow user to set other seeds to be "partialed out" of the analysis
**InstaCalc: Dataset Calculator**

- Open **Define Overlay**, choose **InstaCalc** from menu in top right corner

- Then press **Setup ICalc** button to get control panel
InstaCalc: Setup

- Select datasets with **Choose Dataset** buttons
  - and sub-bricks with the `[−]` controls
- Enter symbolic expression
- Press **Compute InstaCalc**
- Creates new 1-brick dataset A_ICALC for Overlay
  - voxel-by-voxel calculations
• Similar in concept to AFNI \texttt{InstaCorr} but requires external pre-processing of time series datasets
  - Removal of baseline, projection to surface, blurring
• In the \texttt{AFNI\_data5/} directory, run the script \texttt{tcsh ./@run\_REST\_demo}
  - starts SUMA with 2 hemispheres
  - loads pre-processed datasets into SUMA
  - sets up SUMA’s \texttt{InstaCorr}
• After all the setup is ready, right-clicking on the surface will do the \texttt{InstaCorr} calculations
• \texttt{3dGroupInCorr} also works with SUMA
InstaCorr: Sample

Seed voxel and Seed voxel time series graph