Equitable Thresholding And Clustering (ETAC) in AFNI

HBM 2017 #4117

Robert W Cox robertcox@mail.nih.gov https://afni.nimh.nih.gov
Scientific and Statistical Computing Core – NIMH & NINDS / NIH / DHHS / Bethesda MD USA

TL;DR: Equity and Balance reduce arbitrariness in FMRI thresholding while maintaining FPR control (globally and locally) *and* improving detection power

Equity and Balance:

- Use ***multiple plausible methods*** to form and threshold clusters of "significant" voxels
- Choose thresholding parameter(s) in each method to give all individual methods the same global **F**alse **P**ositive **R**ate (**FPR**) α_0 – methods are ***balanced*** (***equitable***)
- Accept as "active" (or "globally significant") the *union* over all methods of their resulting supra-threshold maps
- Union FPR α_U will be > α_0 ; adjust α_0 to get desired α_U = 5% global FPR

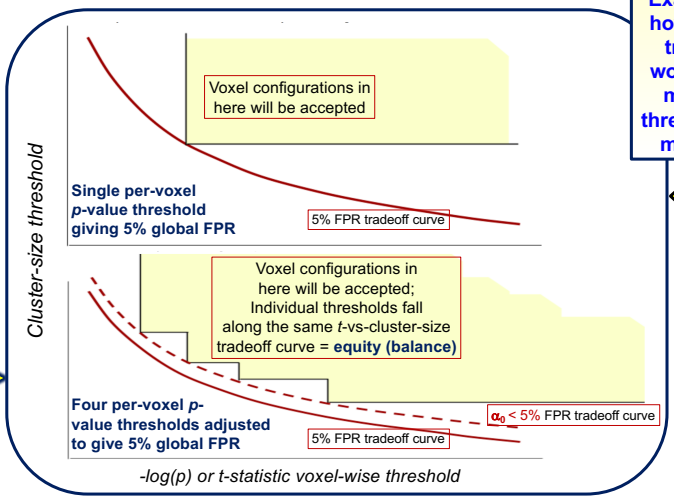
Multiple Plausible Methods:

1. Voxel-wise thresholding at several *p*-values, followed by cluster-FOM thresholding
   - Potential to detect small intense clusters *and* large weak clusters ***equitably***
2. Multiple cases of spatial blurring in one analysis
3. Cluster-FOM = cluster-size and/or sum of cluster z-scores squared
4. Use different cluster-FOM thresholds in different brain regions – ***to balance FPR across space***
   - treating different regions ***equitably*** in FPR

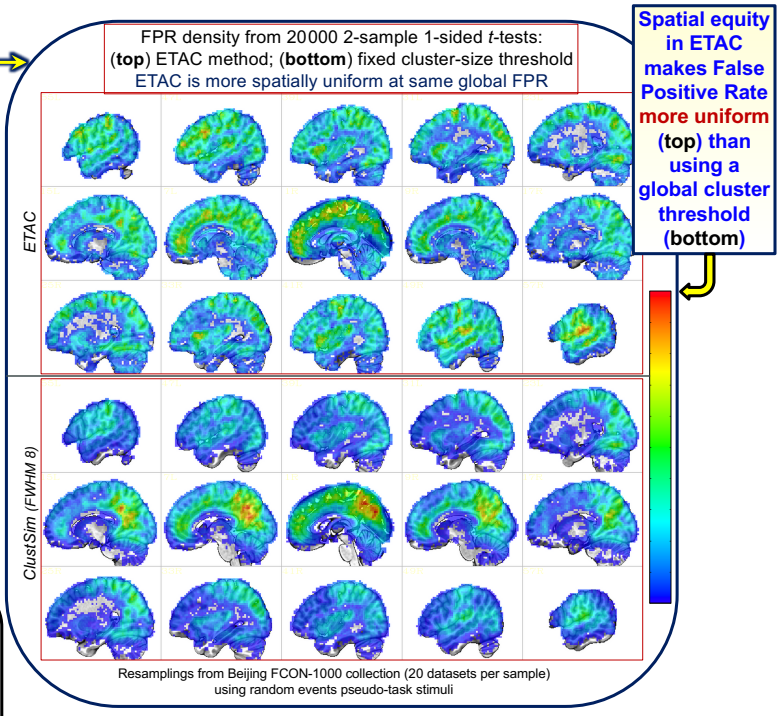
Software:

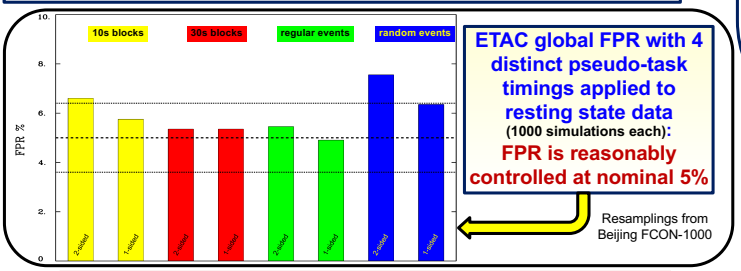
- Implemented in AFNI program `3dttest++`, with help from new codes `3dXClustSim` and `3dMultiThresh`
- Resampled *t*-tests to assess α_0 for each sub-method
  - *No parametric model for spatial smoothness*
- Build cluster collections using each sub-method
- Iteratively adjust α_0 for each sub-method to get to global union FPR=5% (or chosen FPR goal)
- **Inputs**: user chooses *p* thresholds, FOM parameters, blurring cases
  - Plus 1- or 2-sided-ness of *t*-test
  - Plus NN clustering level (1 or 2 or 3)
  - Multiple ETAC input sets can be run at once, saving time by re-using resampling simulations
- **Output** = mask of voxels that survive at least one sub-method's thresholding

Example of how equity tradeoff works with multiple thresholding methods



Spatial equity in ETAC makes False Positive Rate more uniform (top) than using a global cluster threshold (bottom)

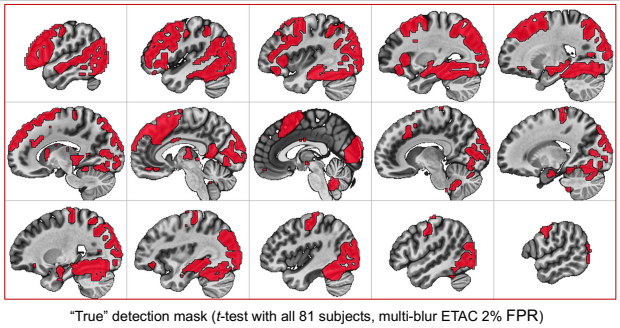




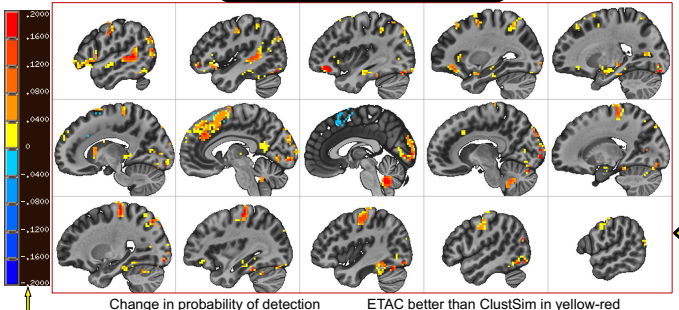
ETAC global FPR with 4 distinct pseudo-task timings applied to resting state data (1000 simulations each): FPR is reasonably controlled at nominal 5%

Resamplings from Beijing FCON-1000

UCLA Phenomics study:
pamenc vs control **task activation**
(from OpenFMRI)



"True" detection mask (*t*-test with all 81 subjects, multi-blur ETAC 2% FPR)



Change in probability of detection with 20 out of 81 subjects (500 sims)

ETAC better than ClustSim in yellow-red
ClustSim better than ETAC in cyan-blue

ETAC power of detection in a *real task* is equal to or better than using a global cluster threshold (right frame)