

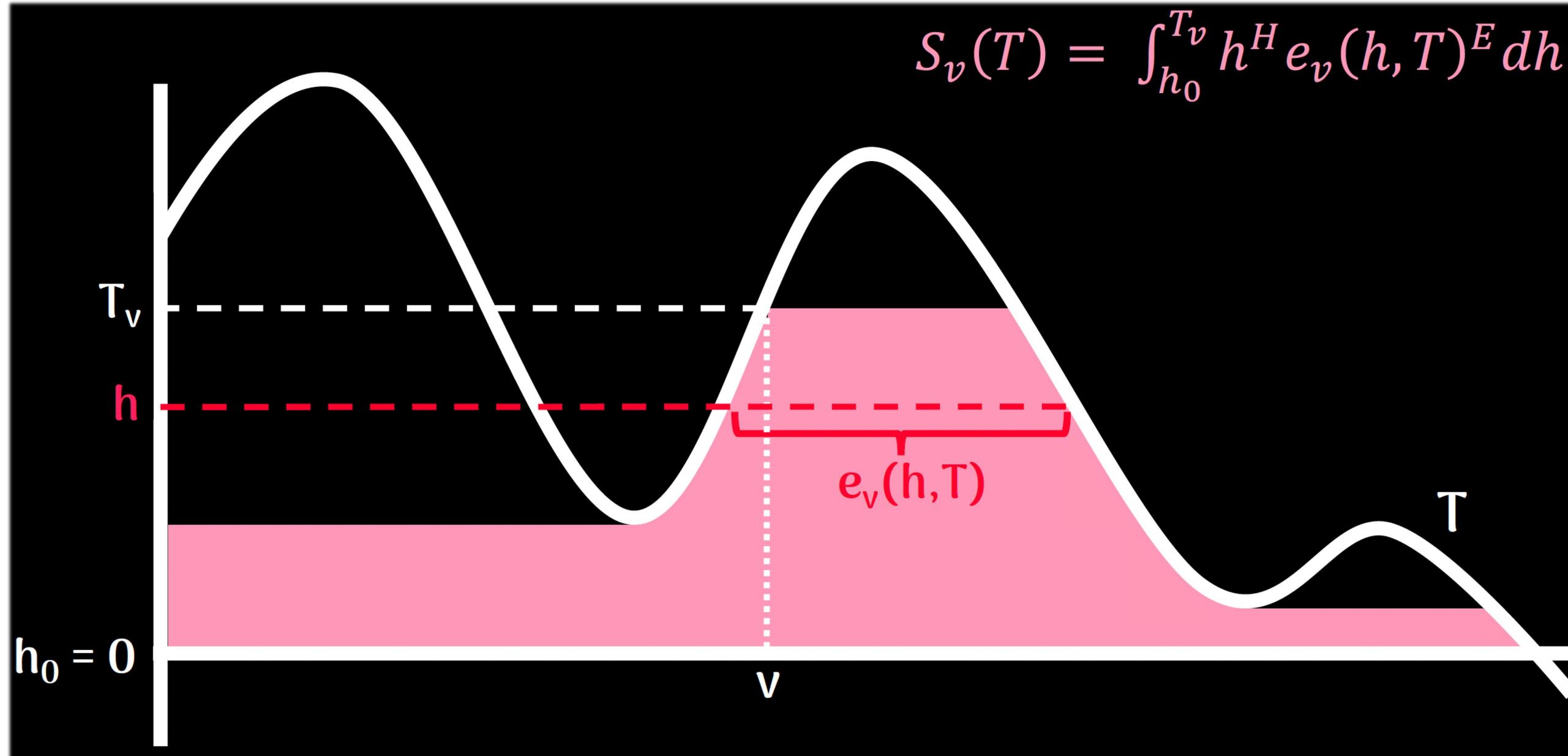
**BRISBANE**  
**OHBM 2025** JUNE  
24-28

Localized Cluster Enhancement (LCE):  
improving Threshold Free Cluster  
Enhancement (TFCE) for better localization  
of brain activity

Wouter Weeda

Thanks to Samuel Davenport

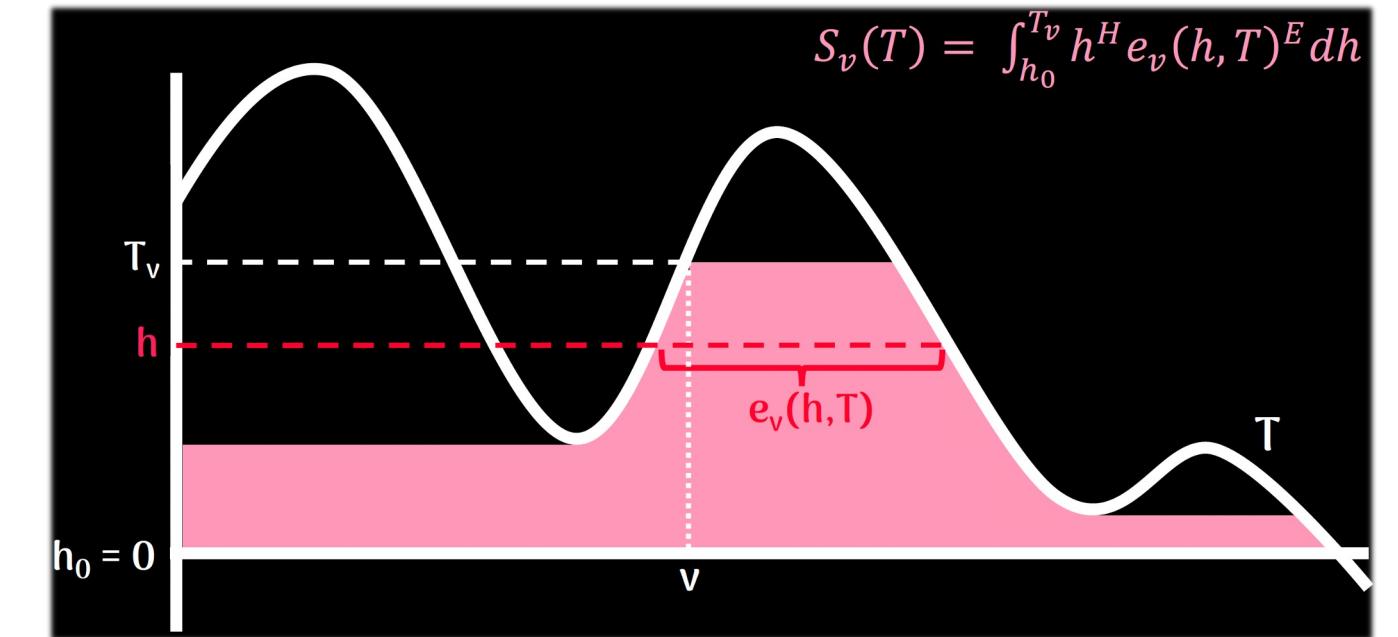
# Threshold Free Cluster Enhancement



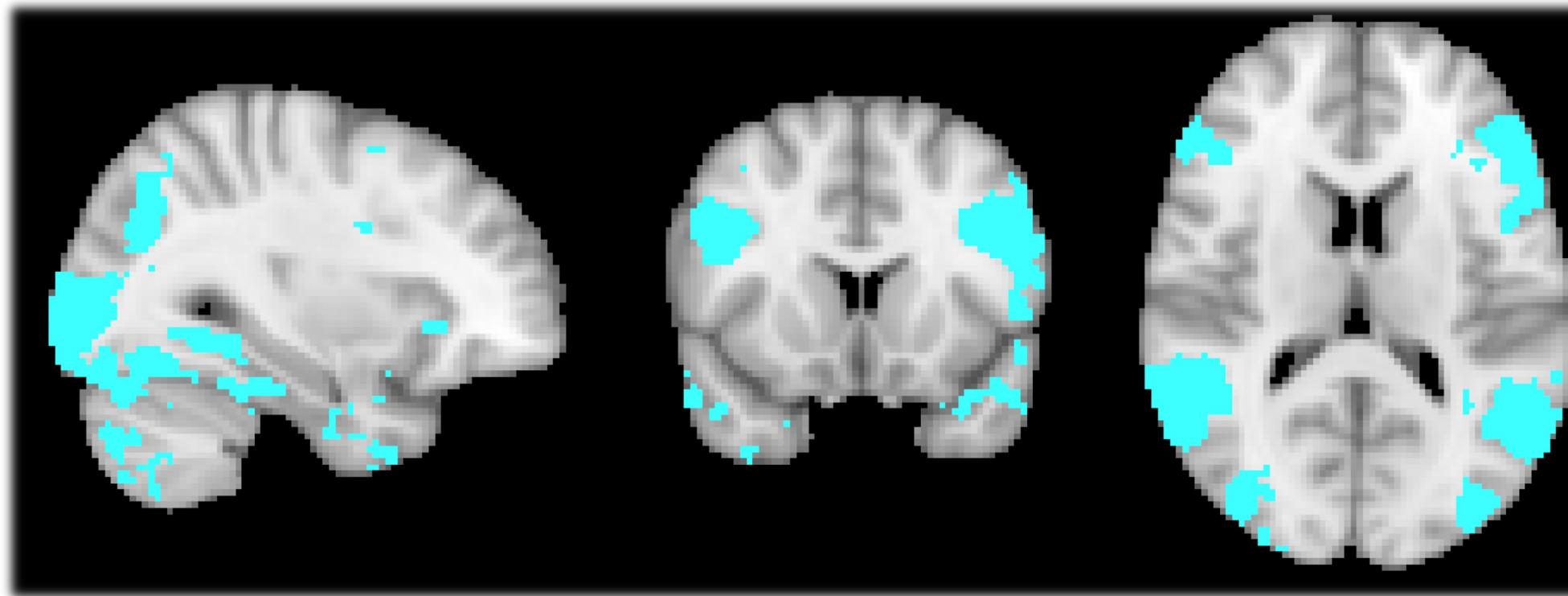
Threshold Free Cluster Enhancement (TFCE) uses neighboring voxels (support) to ‘enhance’ clusters found after thresholding.

# Threshold Free Cluster Enhancement

- For every voxel  $v$  the TFCE-value ( $S_v$ ) is the sum of all its ‘supporting’ voxels.
- The support is guided by a height (H) and extent (E) parameter and starts at  $H_0$ .
- In the example, the TFCE-value for voxel  $v$  is the size of the pink area.
- Calculations are done for every voxel
- Permutations are used to calculate TFCE significance (max  $S_v$  under the null).

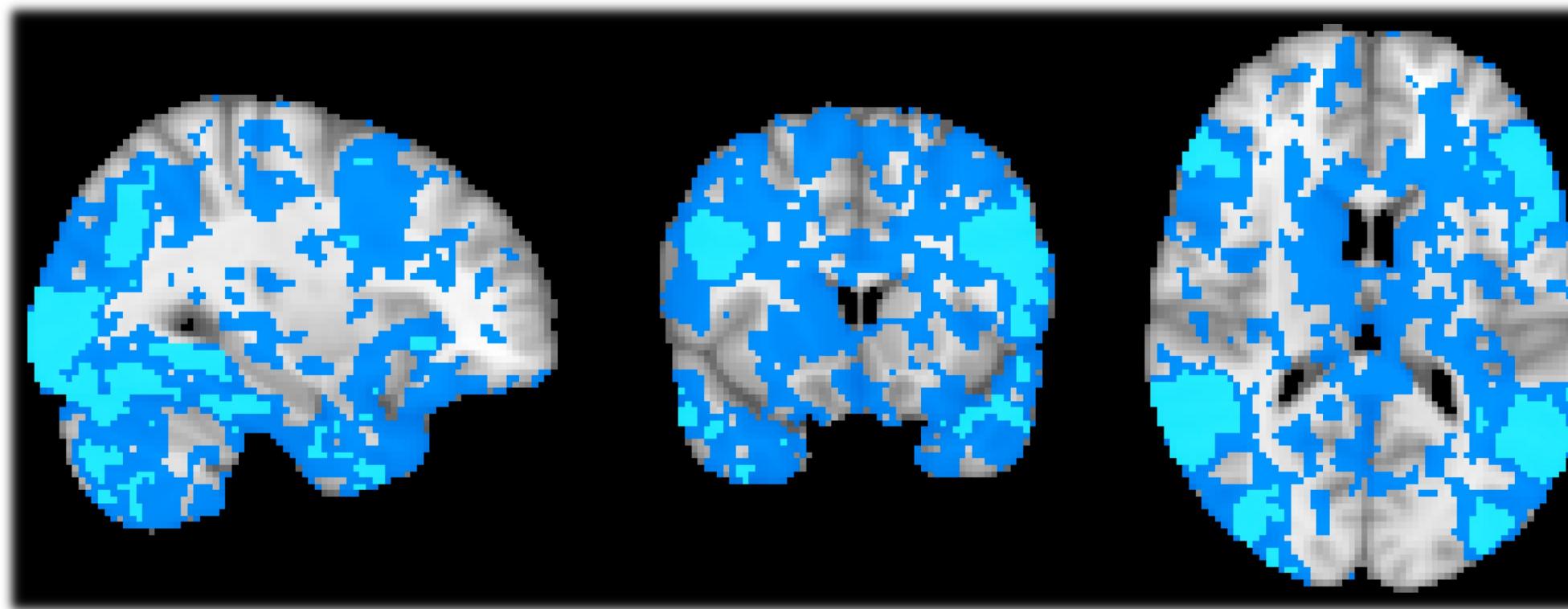


# Threshold Free Cluster Enhancement



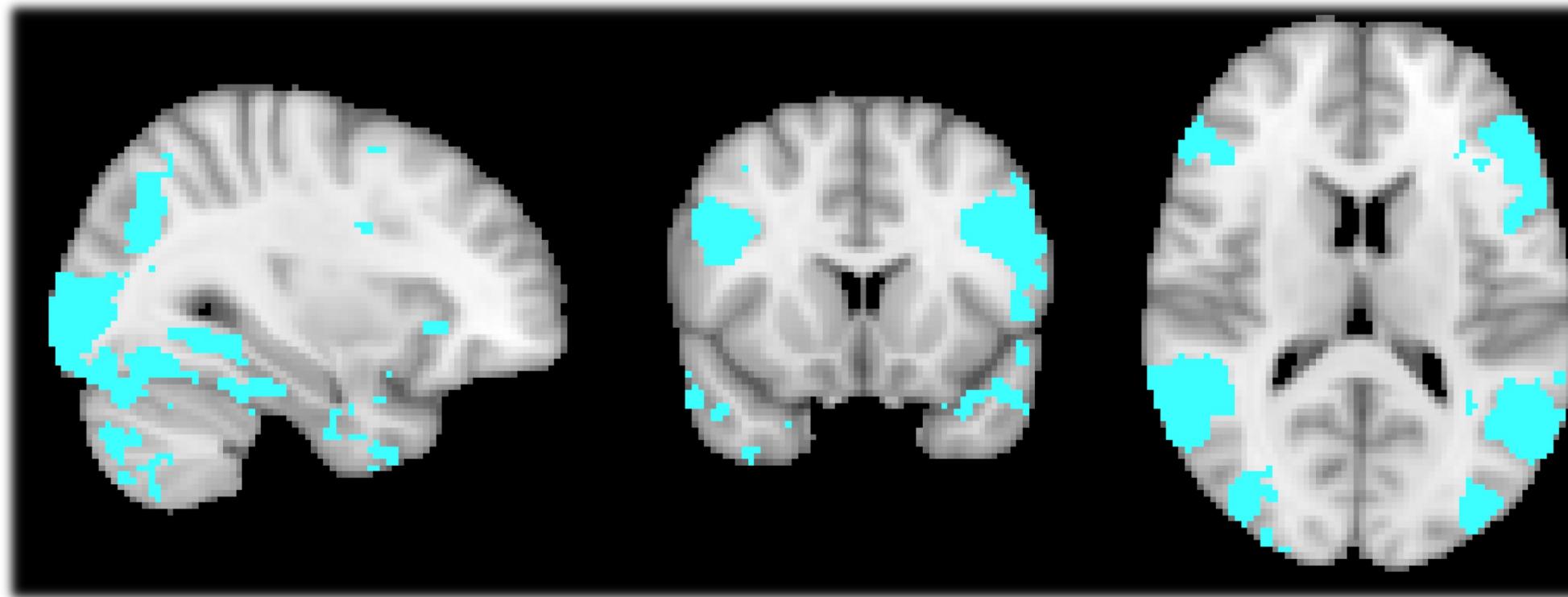
HCP ( $n=20$ ) *Social contrast*

< significant TFCE clusters



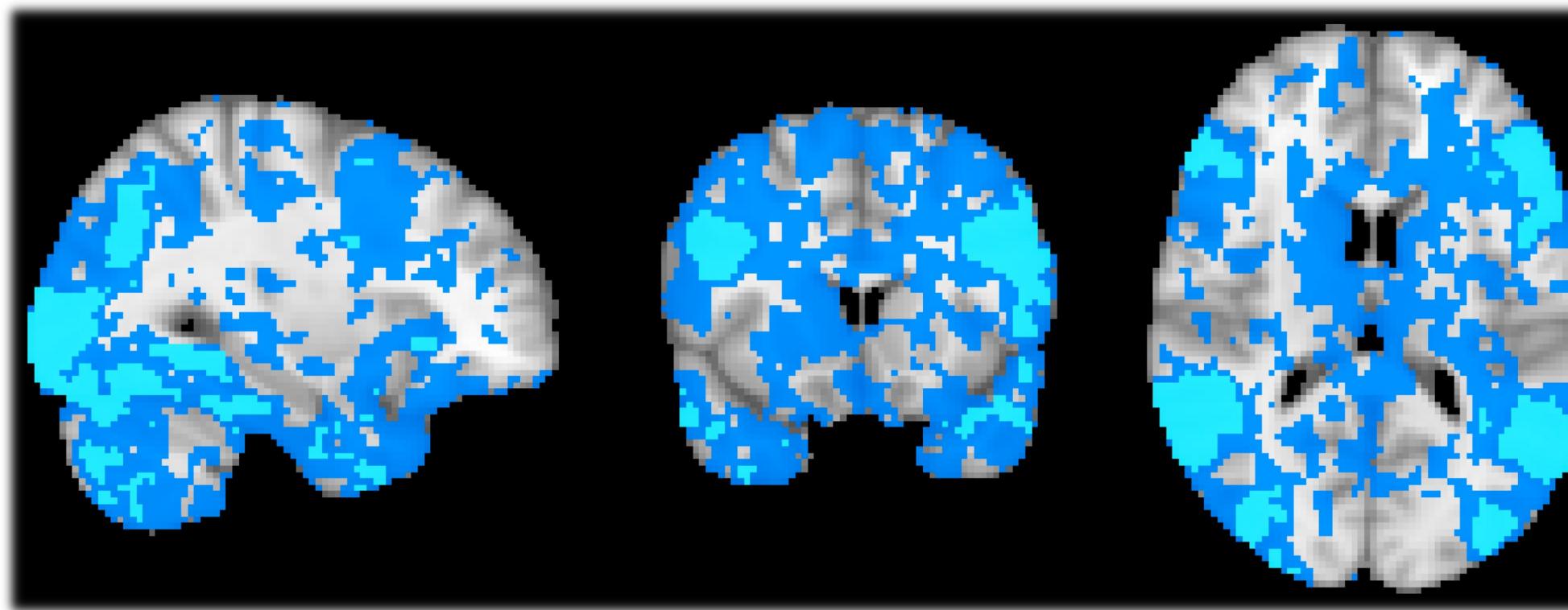
< support of significant TFCE clusters

# Threshold Free Cluster Enhancement



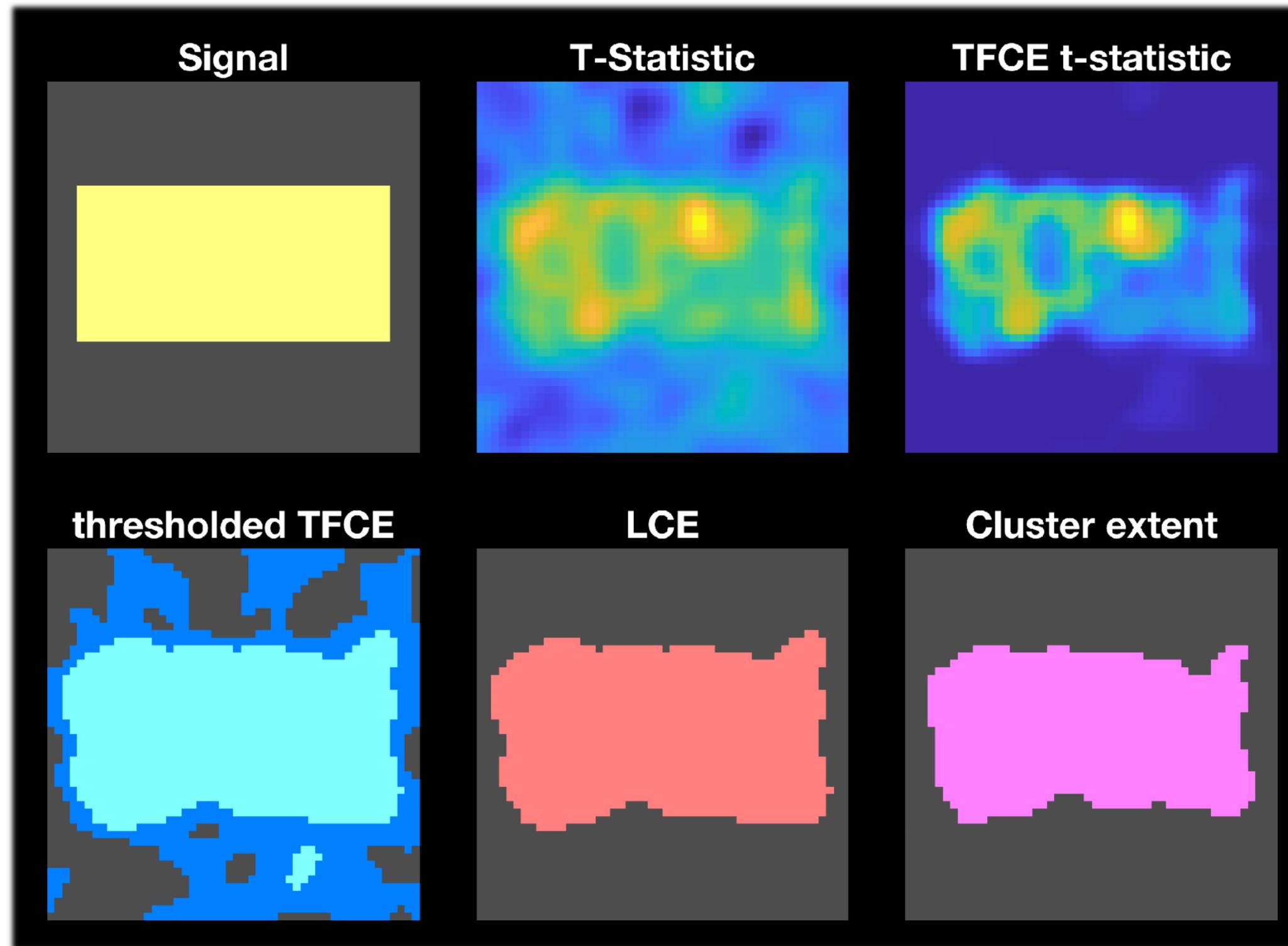
HCP ( $n=20$ ) *Social contrast*

< significant  
Localization not good



< SUPPORT  
Localization even worse  
clusters

# Threshold Free Cluster Enhancement

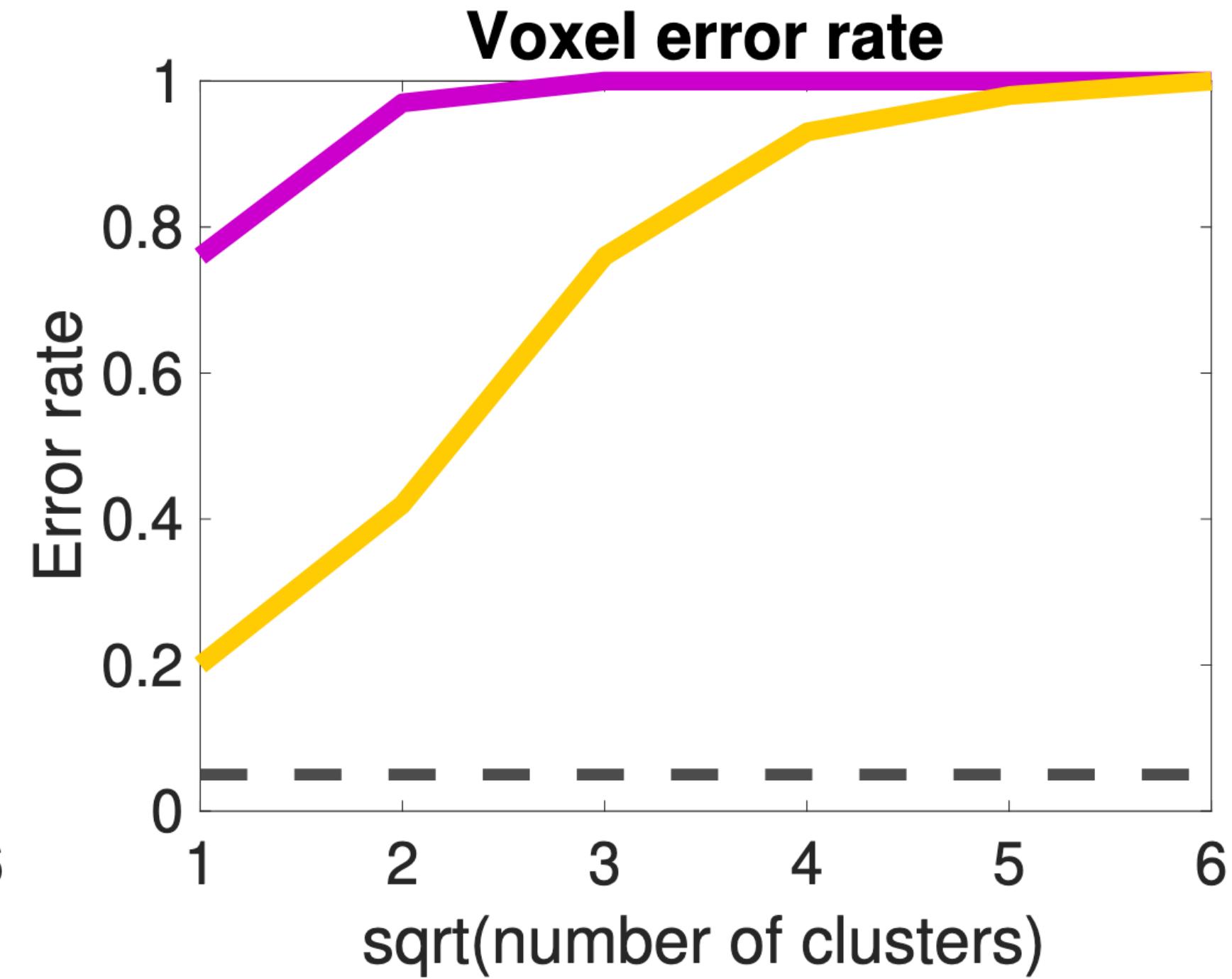
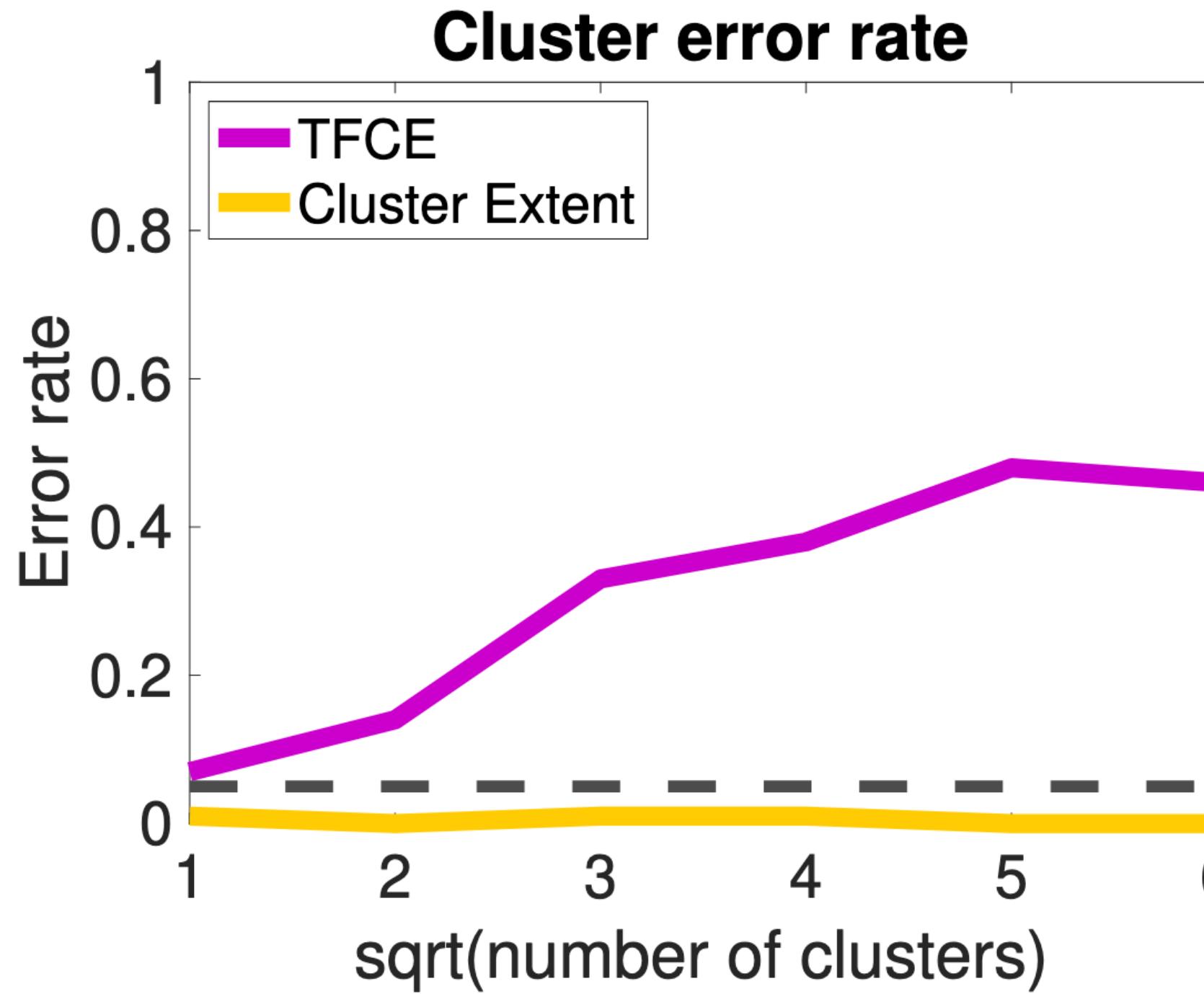


**Simulated data with a rectangular signal shape**

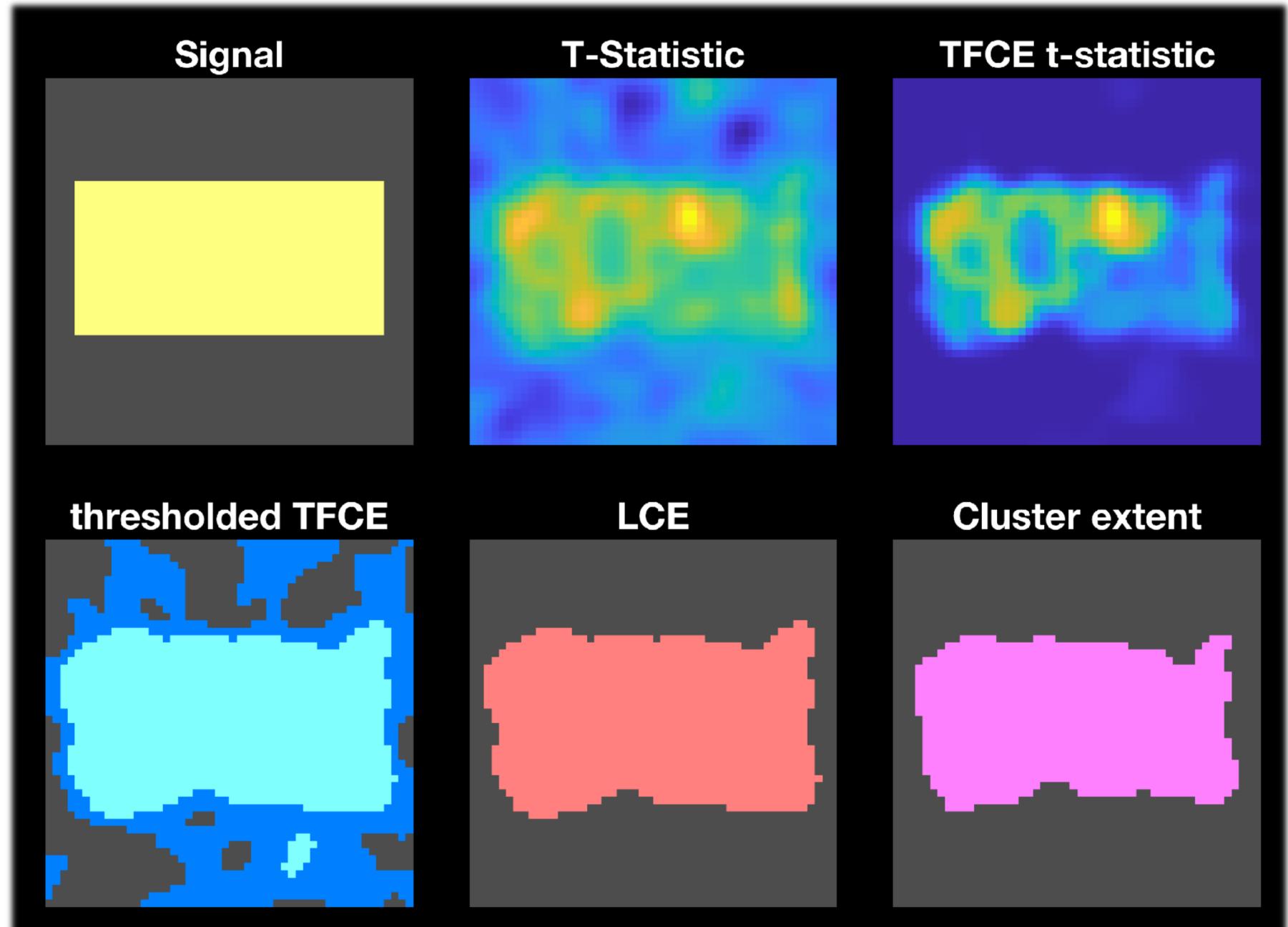
TFCE shows a false positive **cluster** and false-positive **voxels**

Cluster-extent and LCE show only false-positive **voxels**

# Cluster and voxel error rates



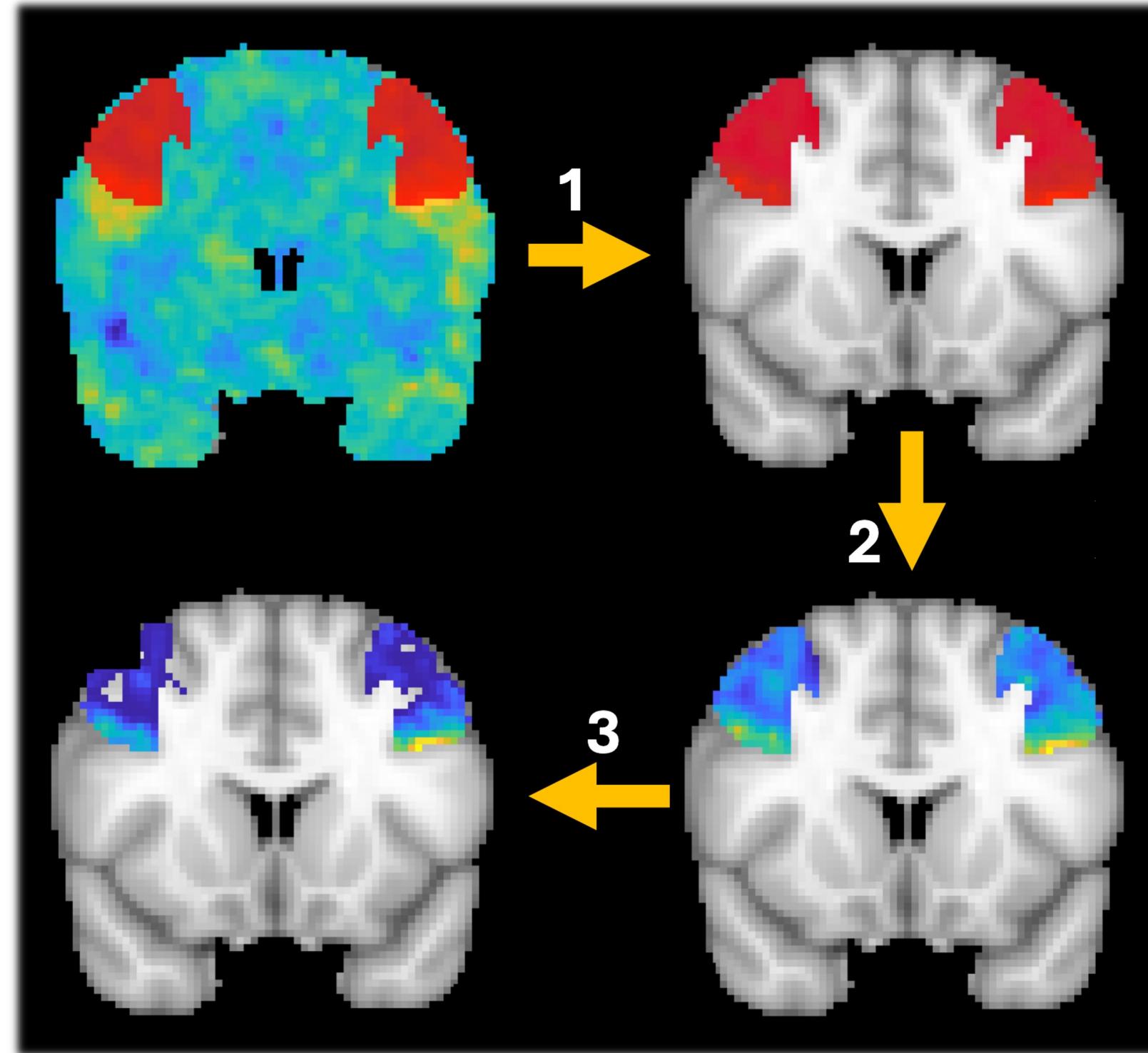
# Localized Cluster Enhancement



## Localized Cluster Enhancement

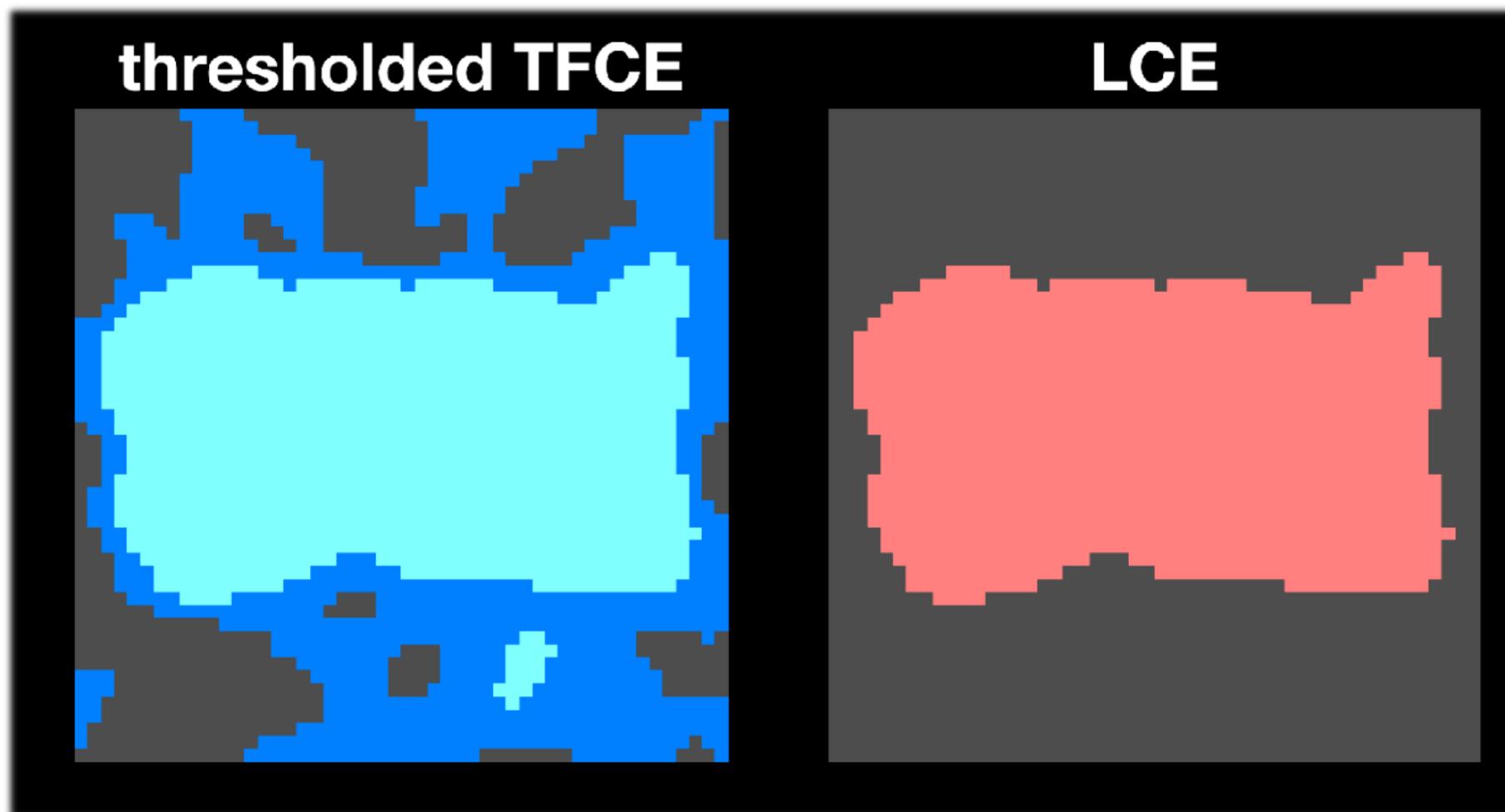
- LCE is the closed-testing version of TFCE.
- LCE provides a  $p$ -value for each region that is tested.
- In this case the thresholded TFCE map was used as a mask.
- LCE shows the red area to be significant but not the small blue region found by TFCE

# Localized Cluster Enhancement



- (0) Starting with the TFCE statistic for all voxels.
- (1) Mask out the region-of-interest (can be chosen post-hoc and for as many regions you want. e.g., from a cluster-extent analysis or using anatomical masks).
- (2) Use the TFCE procedure on only the masked data.
- (3) use the local TFCE statistics to calculate LCE significance.

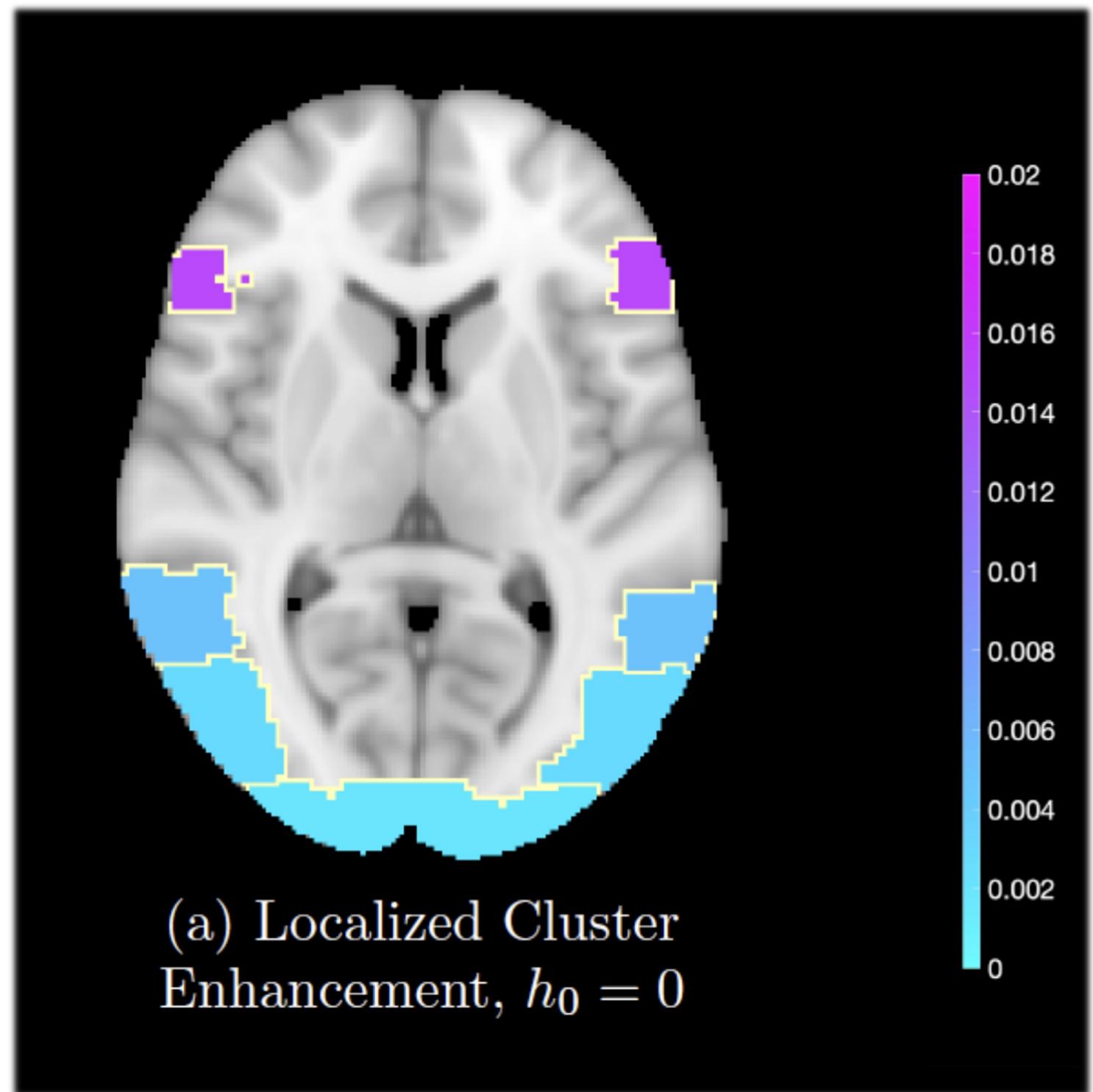
# Localized Cluster Enhancement



## Localized Cluster Enhancement

- LCE shows the red area to be significant but not the small blue region found by TFCE (light-blue region was the mask)
- LCE can be used to test any region for significance, even after seeing the data.

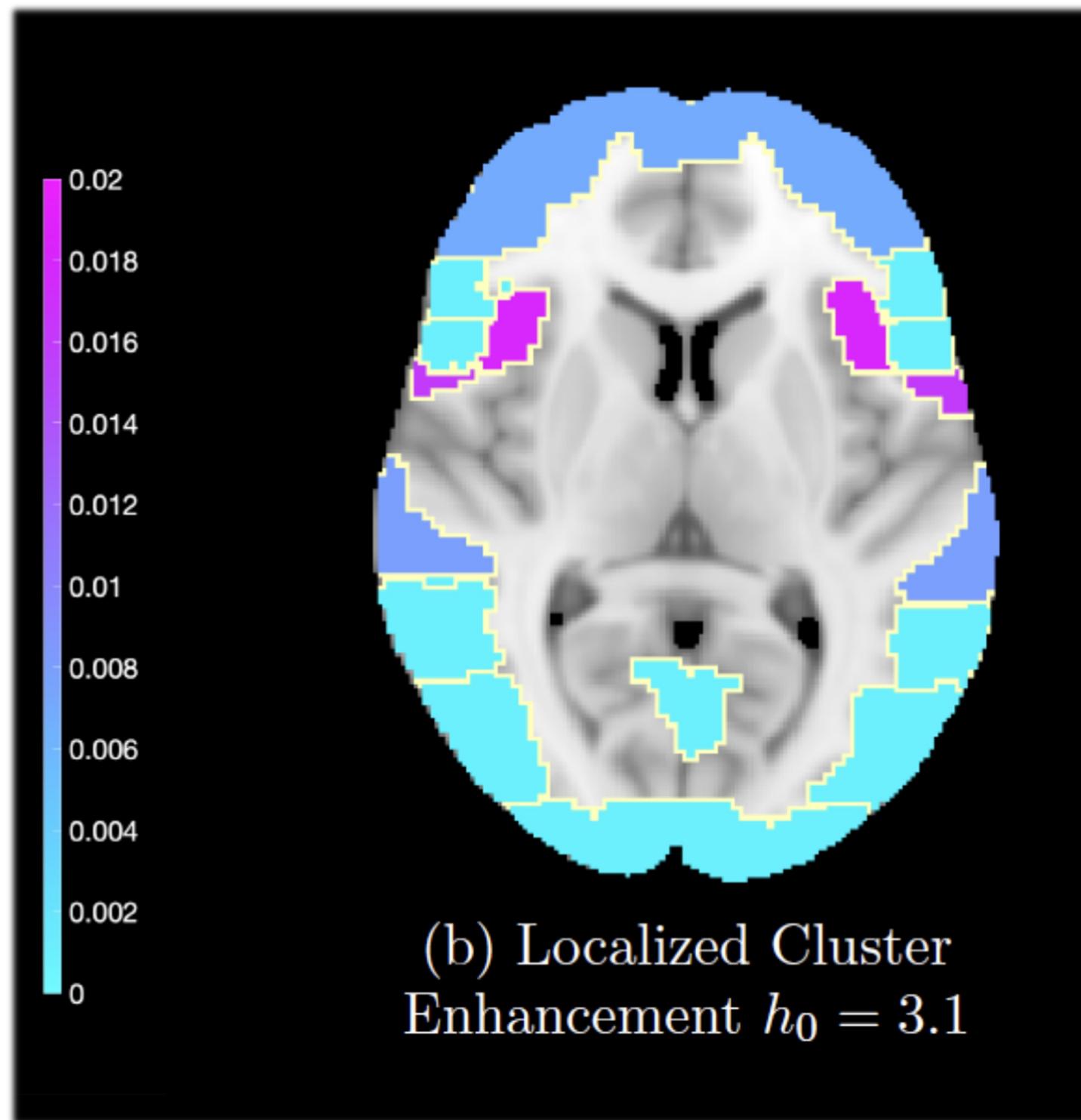
# Localized Cluster Enhancement



## Localized Cluster Enhancement

- For example, we can use the Harvard-Oxford atlas as a mask to test LCE significance.
- Shown here are the significant regions of the Social contrast.

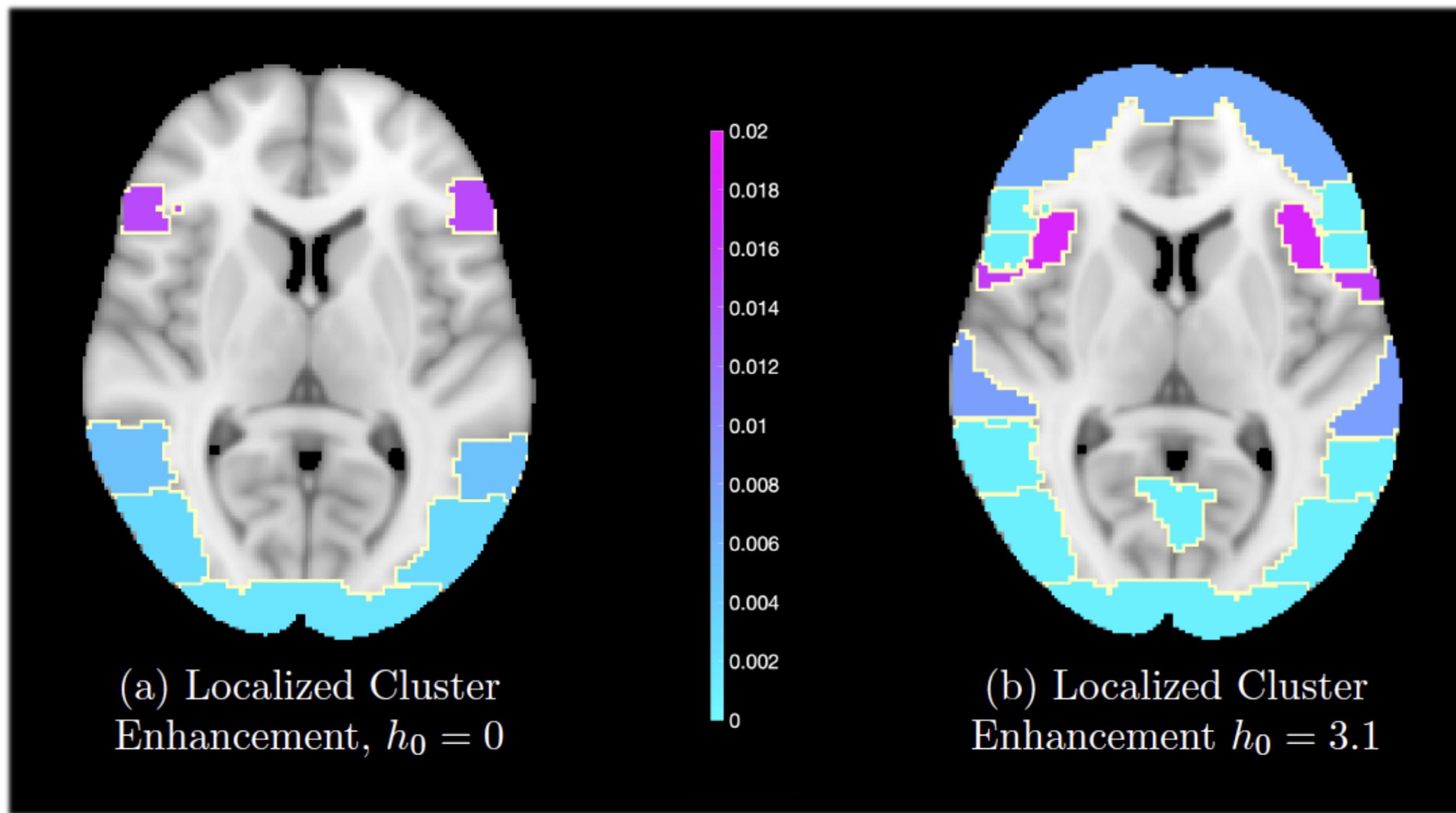
# Localized Cluster Enhancement



## Localized Cluster Enhancement

- One of the things that can be adjusted is the value of  $h_0$  (essentially a threshold on where the support of the TFCE statistic starts).
- This must be set **before** doing the analysis, it cannot be changed freely after seeing the data.
- But you can test any region using LCE afterwards.

# Localized Cluster Enhancement



# Localized Cluster Enhancement

```
_talk/LCE_tutorial_educourse_real.mlx

lues using LCE
n_region] = LCE(tstat_orig, surviving_tfce_
significance for each cluster.

done!
TFCE cluster maps
the maps of both the TFCE and LCE analyses.

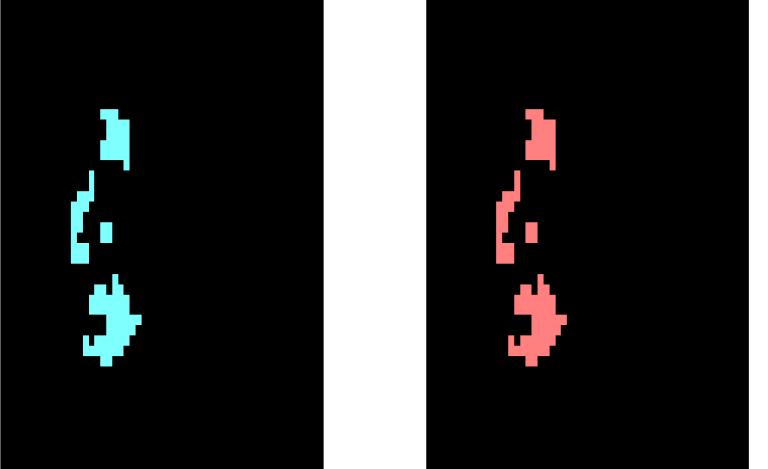
s
clusters
r_im, surviving_tfce_clusters, surviving_tf
clusters
rs_vec = surviving_tfce_clusters_vec(find(p
er_im( size(tfce_tstat), lce_significant_cl

Imask_small.nii'); % just for use as a temp
er_im.nii';
_cluster_im);

ter_im.nii' % use the same template, but ch
viving_tfce_cluster_im;

resh(squeeze(surviving_tfce_cluster_im(:,:,
```

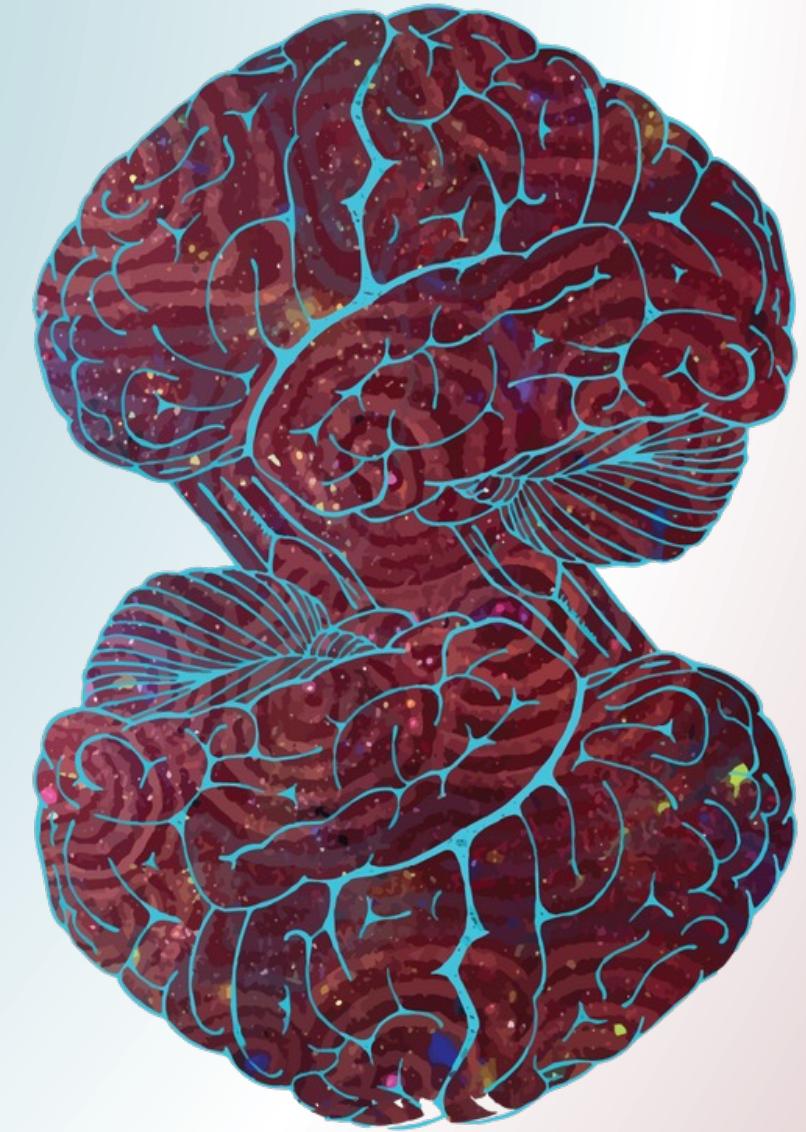
tfce perm progress: 100.0  
-----  
Progress: 100.0  
pvabs = 1x8  
0.0090 0.1760 0.0070 0.1890 0.0760 0.0120 0.0200 0.0050  
hdr = struct with fields:  
 fname: 'tfce\_cluster\_im.nii'  
 dim: [46 55 46]  
 dt: [16 0]  
 pinfo: [3x1 double]  
 mat: [4x4 double]  
 n: [1 1]  
 descrip: '2501.4 2025-04-22T09:56:22+01:00'  
 private: [1x1 nifti]



## Localized Cluster Enhancement

Matlab implementation using the Statbrainz package (written by Sam Davenport).

[github.com/sjdavenport/Statbrainz](https://github.com/sjdavenport/Statbrainz)



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