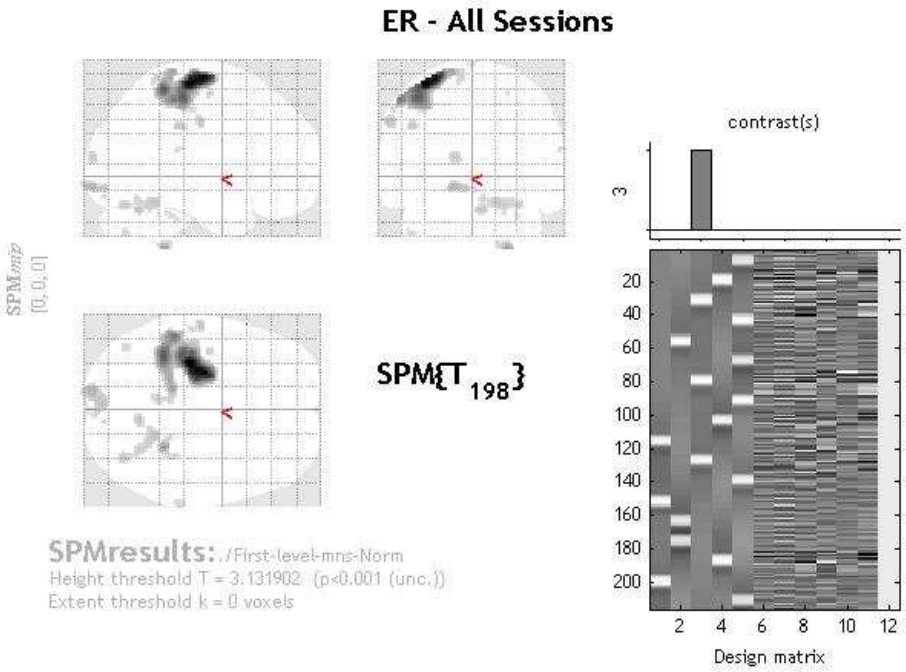
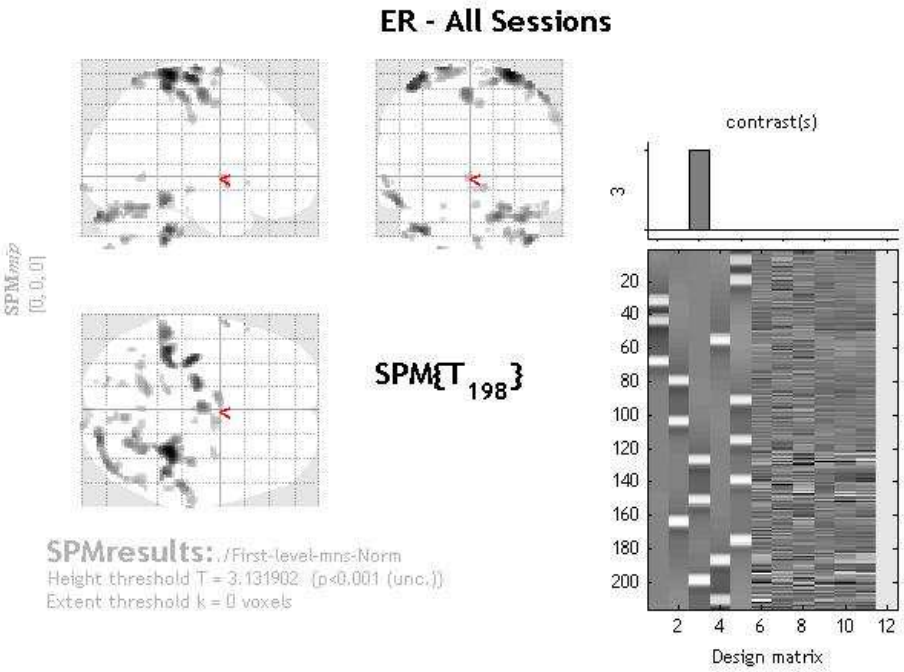
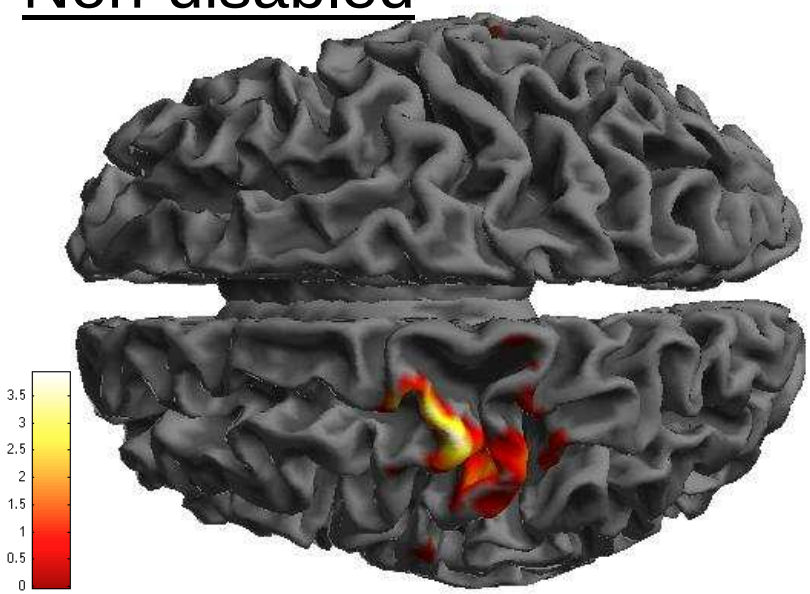
Laterality index in brain imaging research

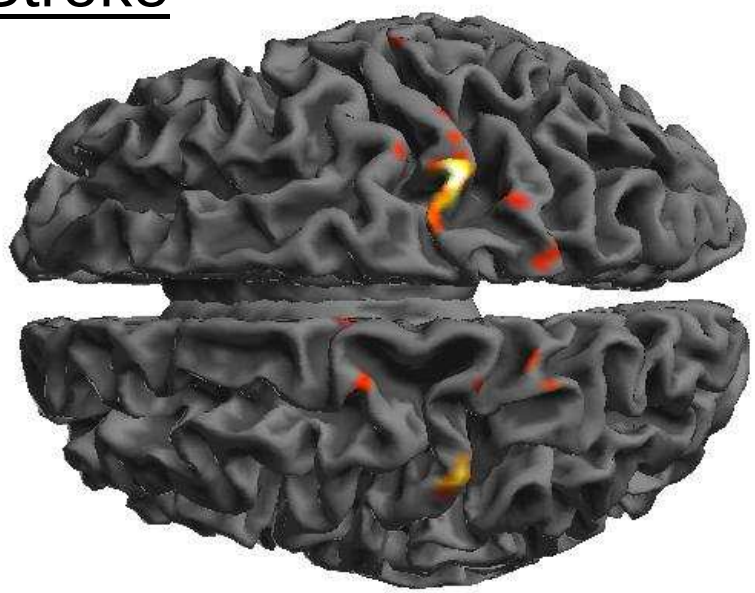




Non-disabled



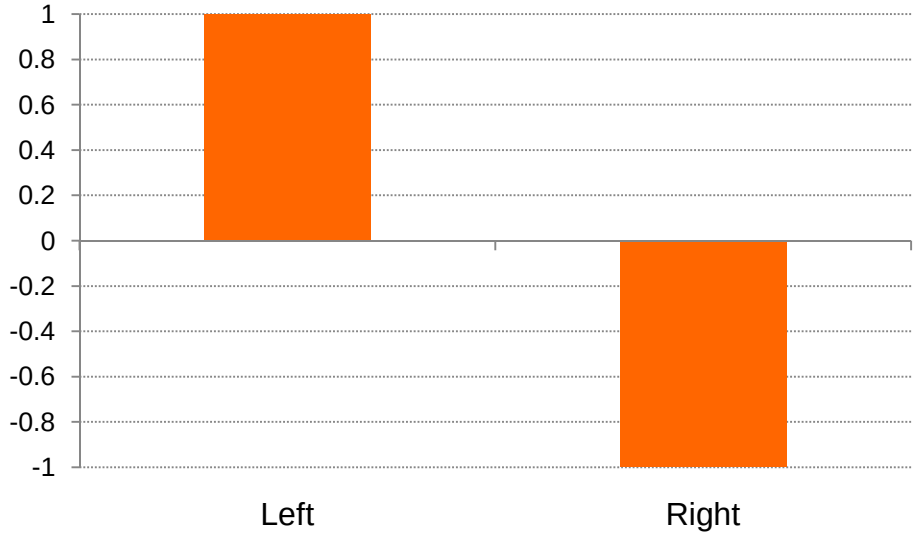
Stroke



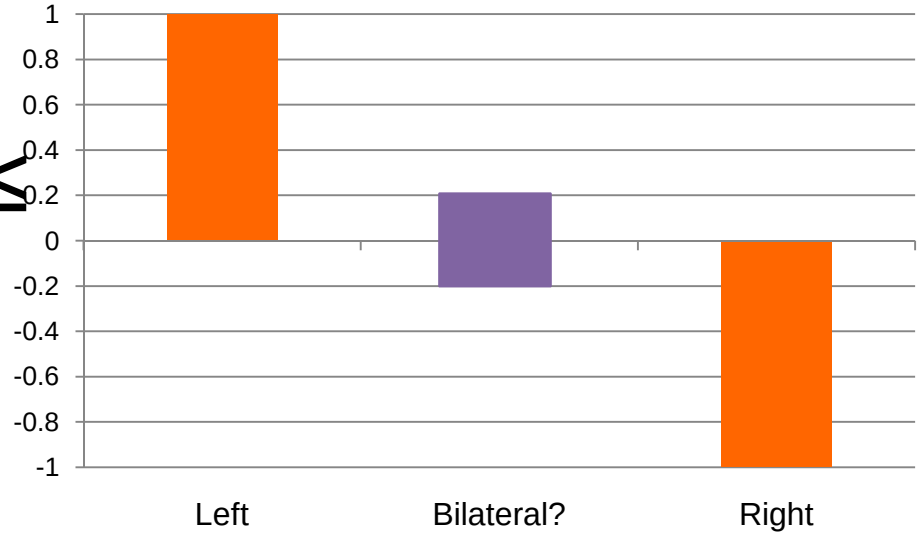
$$LI = \frac{\text{Left - Right}}{\text{Left + Right}}$$

LI > 0 = Left

LI < 0 = Right



$|LI| \leq 0.2 = \text{Bias} \leq$



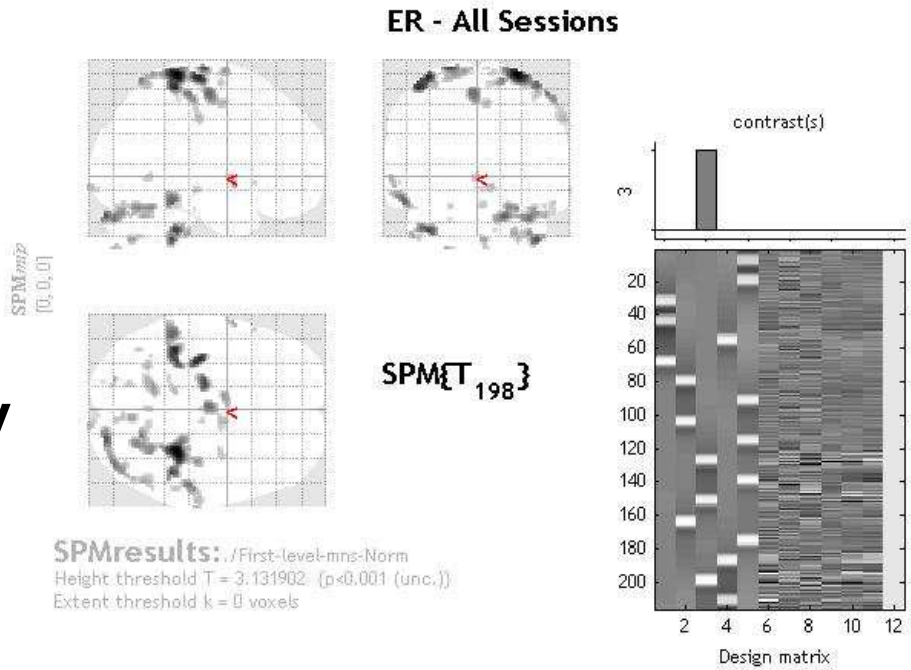
LI affected by:

1. Measure of activity

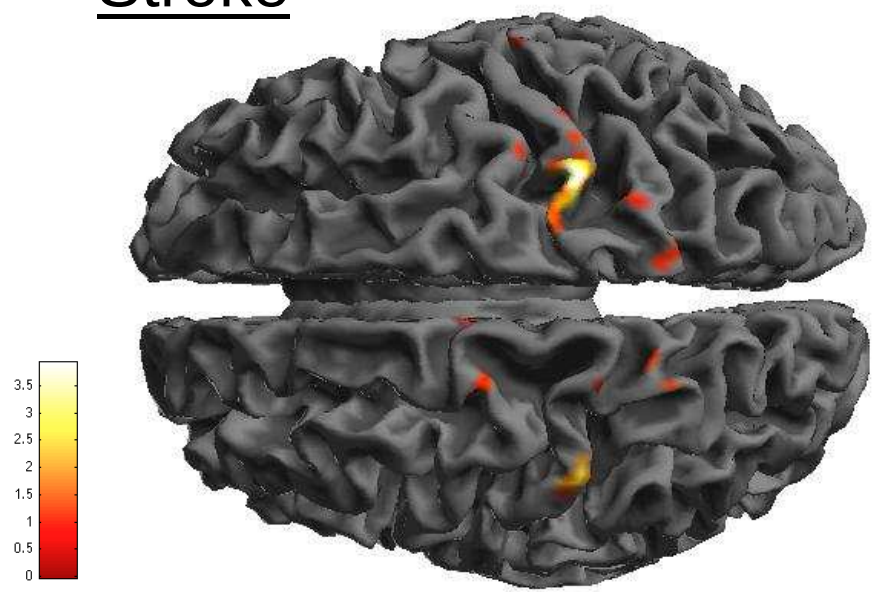
A. Extent

B. Magnitude

2. Choice of ROI



Stroke



LI affected by:

1. Measure of activity

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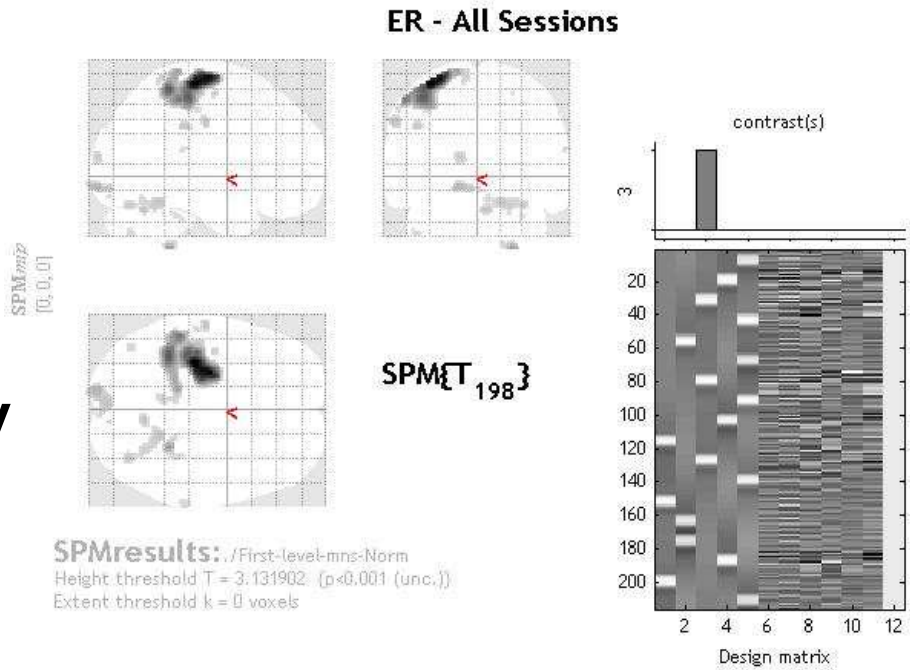
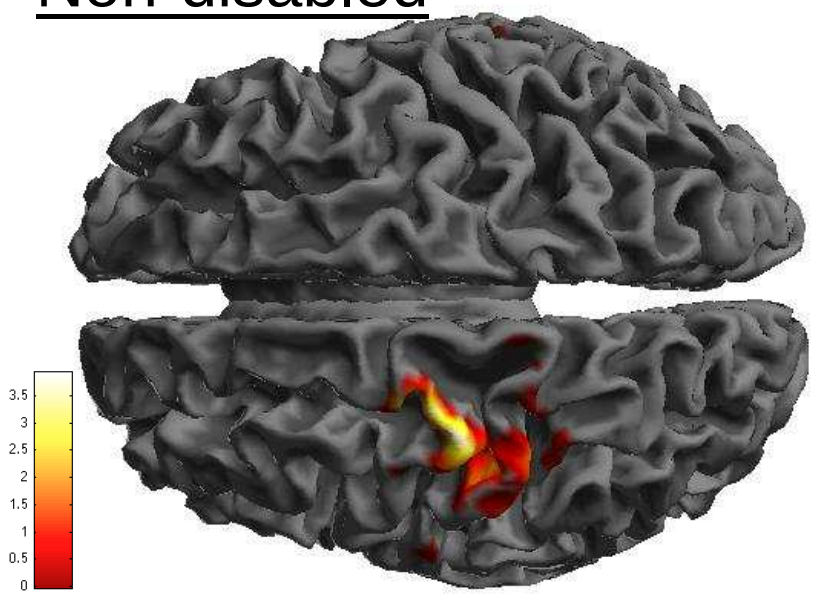


Non-disabled



A. Extent - # voxels

B. Magnitude - % signal change

A. Extent - # voxels *at variable thresholds*

B. Magnitude - % signal change *of most active*

A. LI based on extent of activity:

Wilke, 2006, 2007

LI-toolbox ***SPM2 SPM5 SPM8***

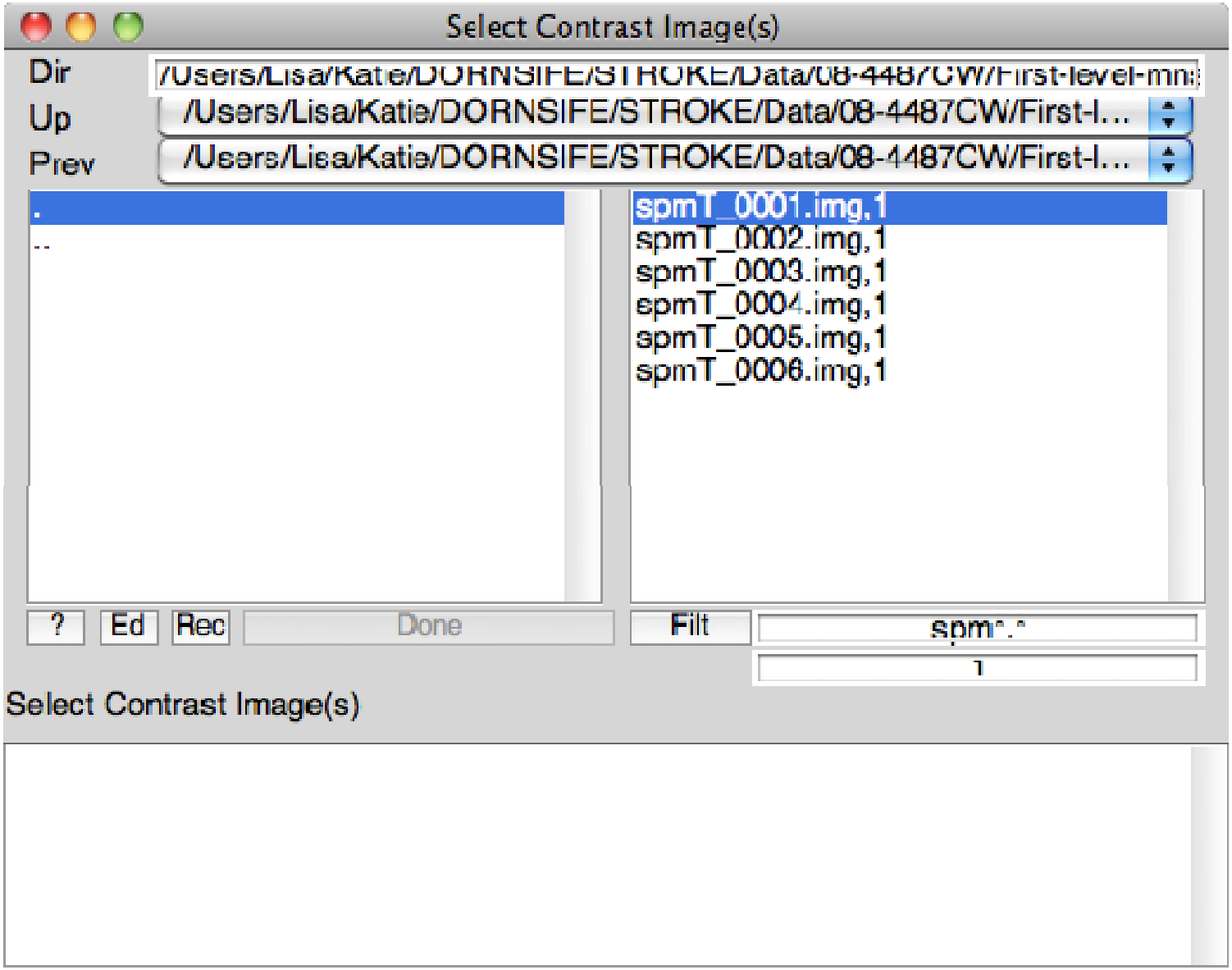
Summary: Allows assessment of laterality effects in imaging data using various thresholding options. Amog other features, regionally-restricted analyses are possible and a bootstrapping approach allows to assess data homogeneity to reduce the effect of outliers. The toolbox can now be scripted, allowing for unattended analyses. Matlab from version 6.5.1 on is required.

Author: Marko Wilke

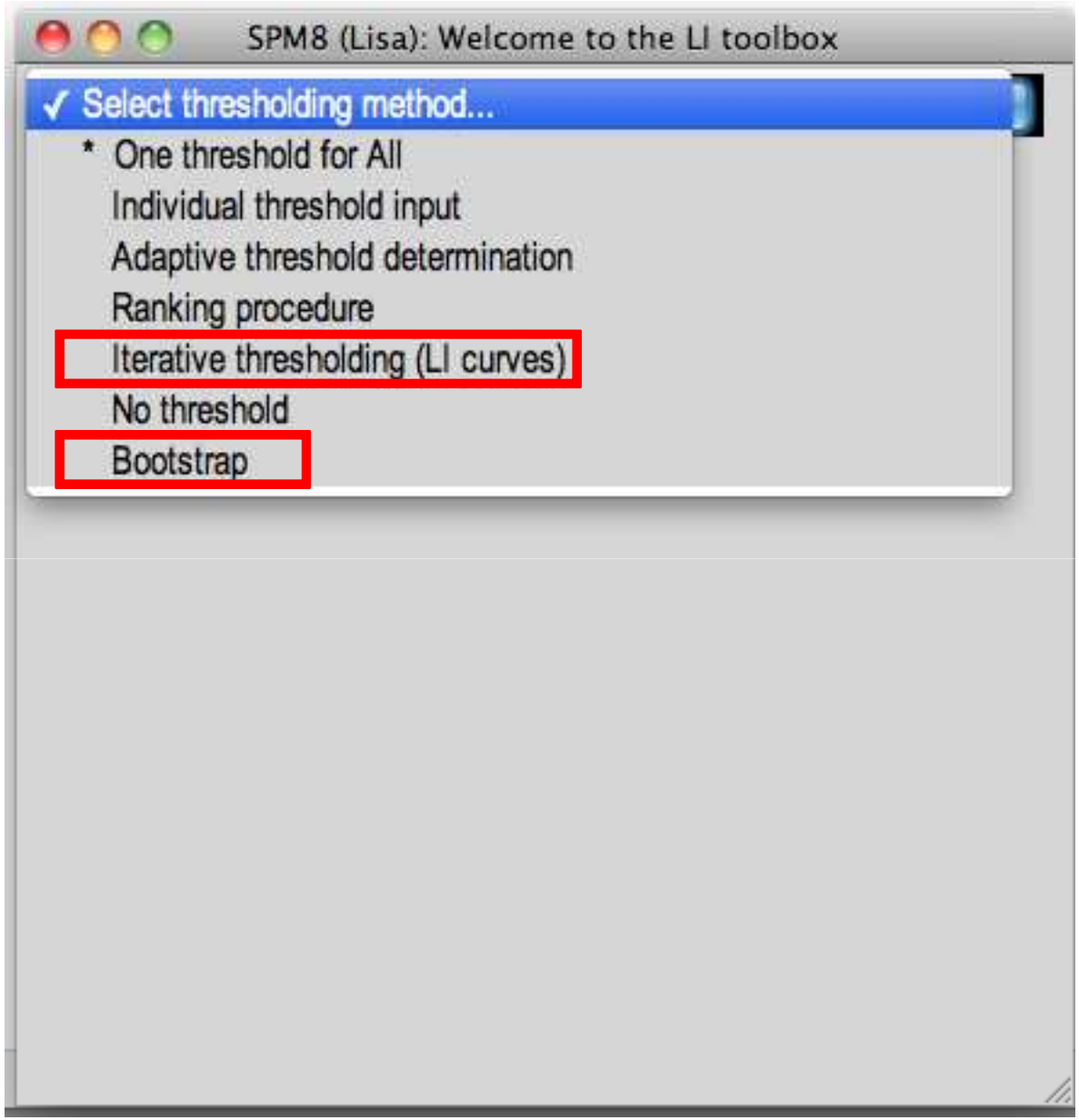
URL: Contact Marko by email.

file:///Applications/MATLAB_R2010a/spm8/toolbox/LI/man/index.html

1. Select contrast image

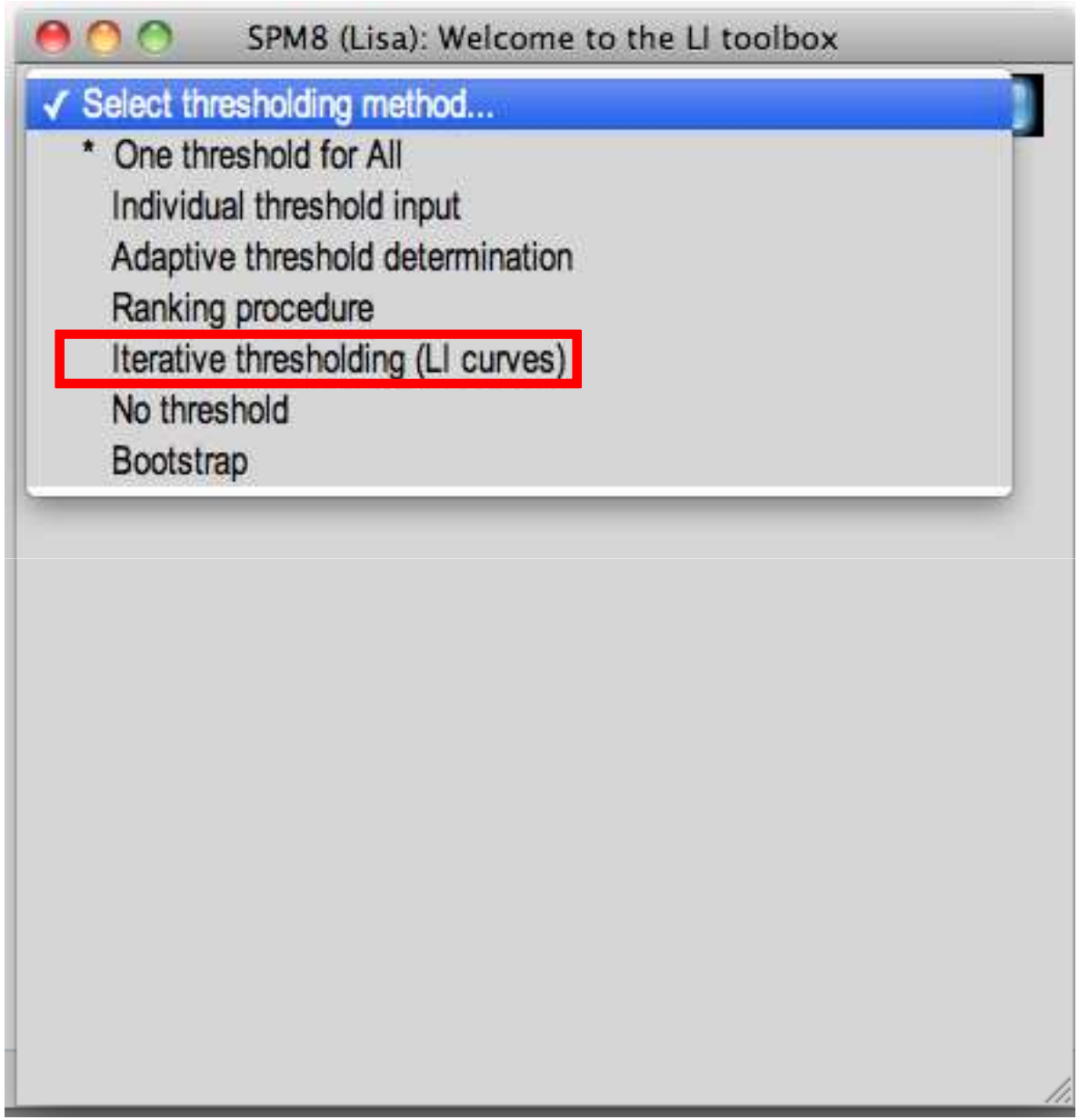


2. Select threshold method

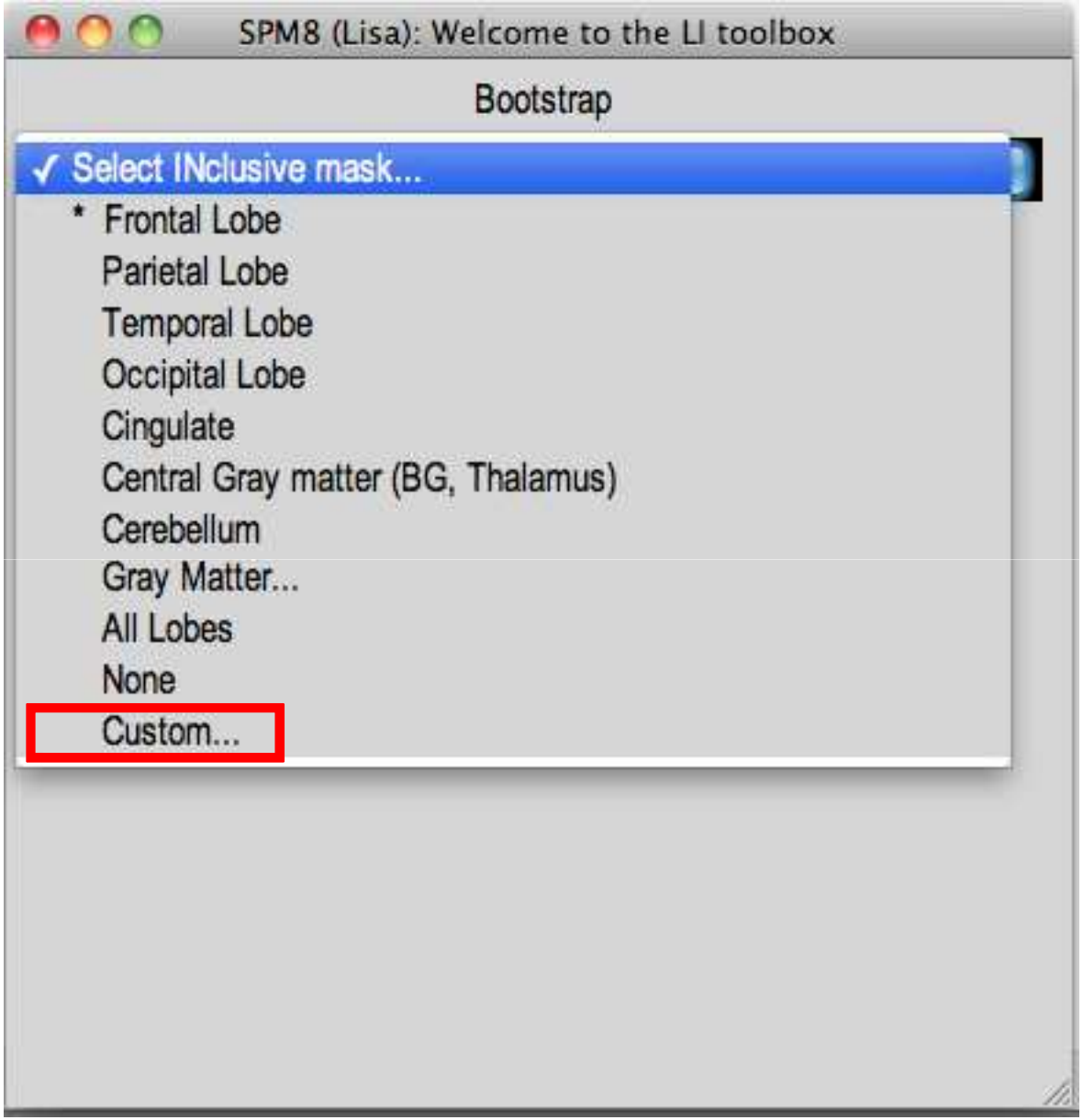


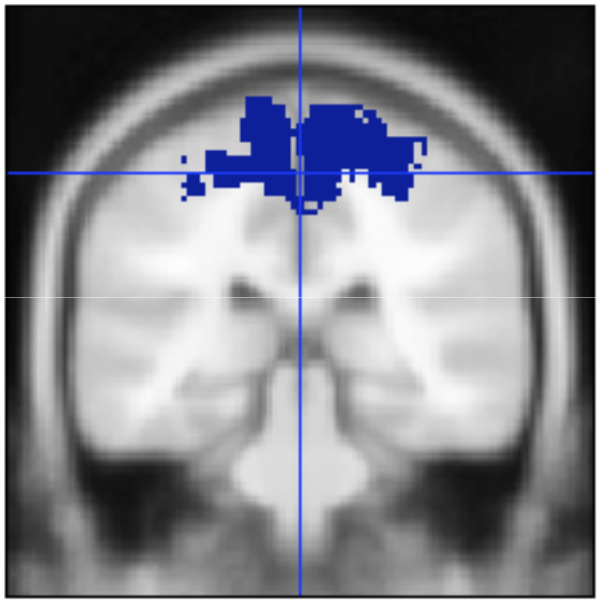
LI based on extent = dependen

2. Select iterative threshold method



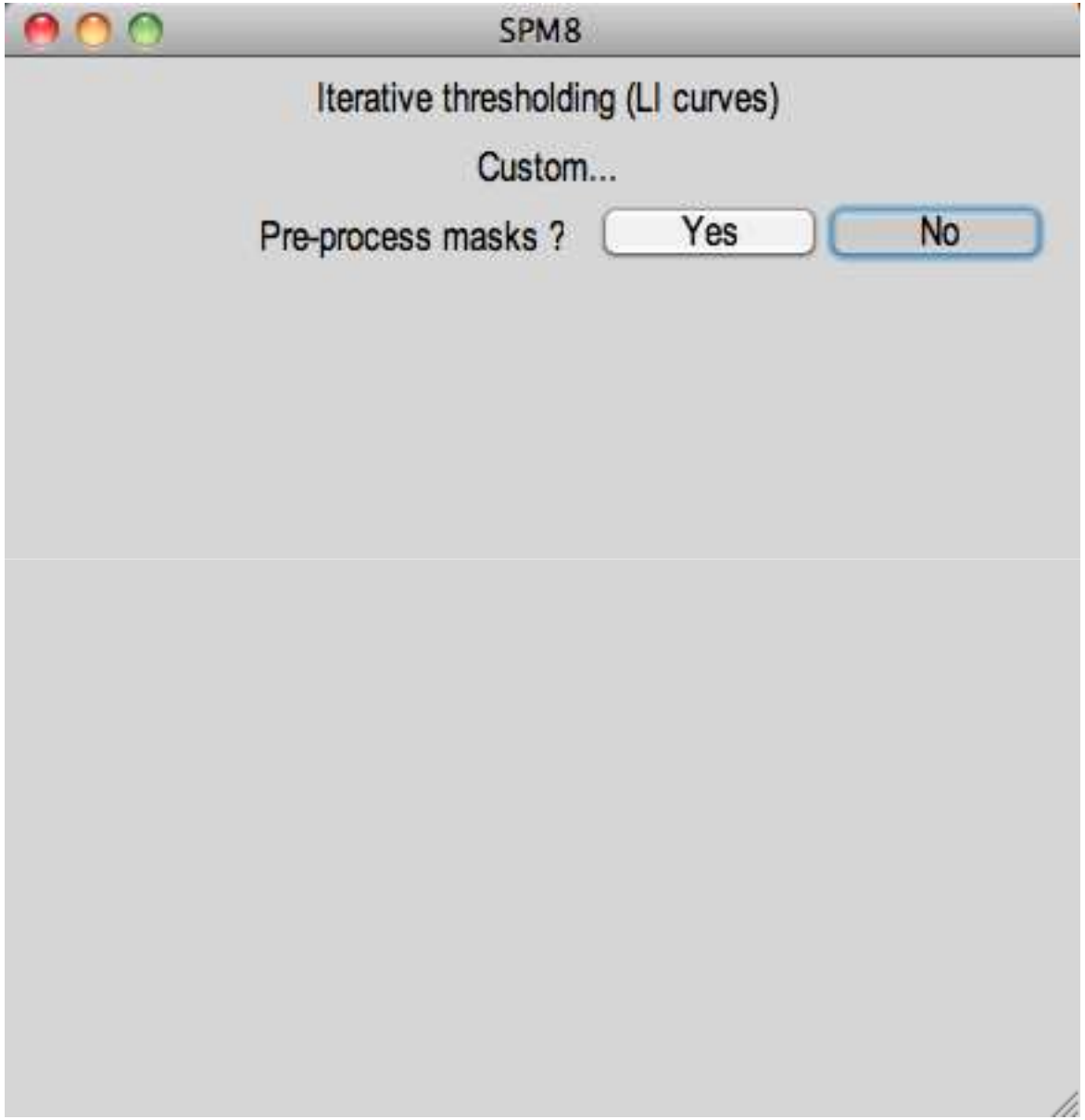
3. Select inclusive mask



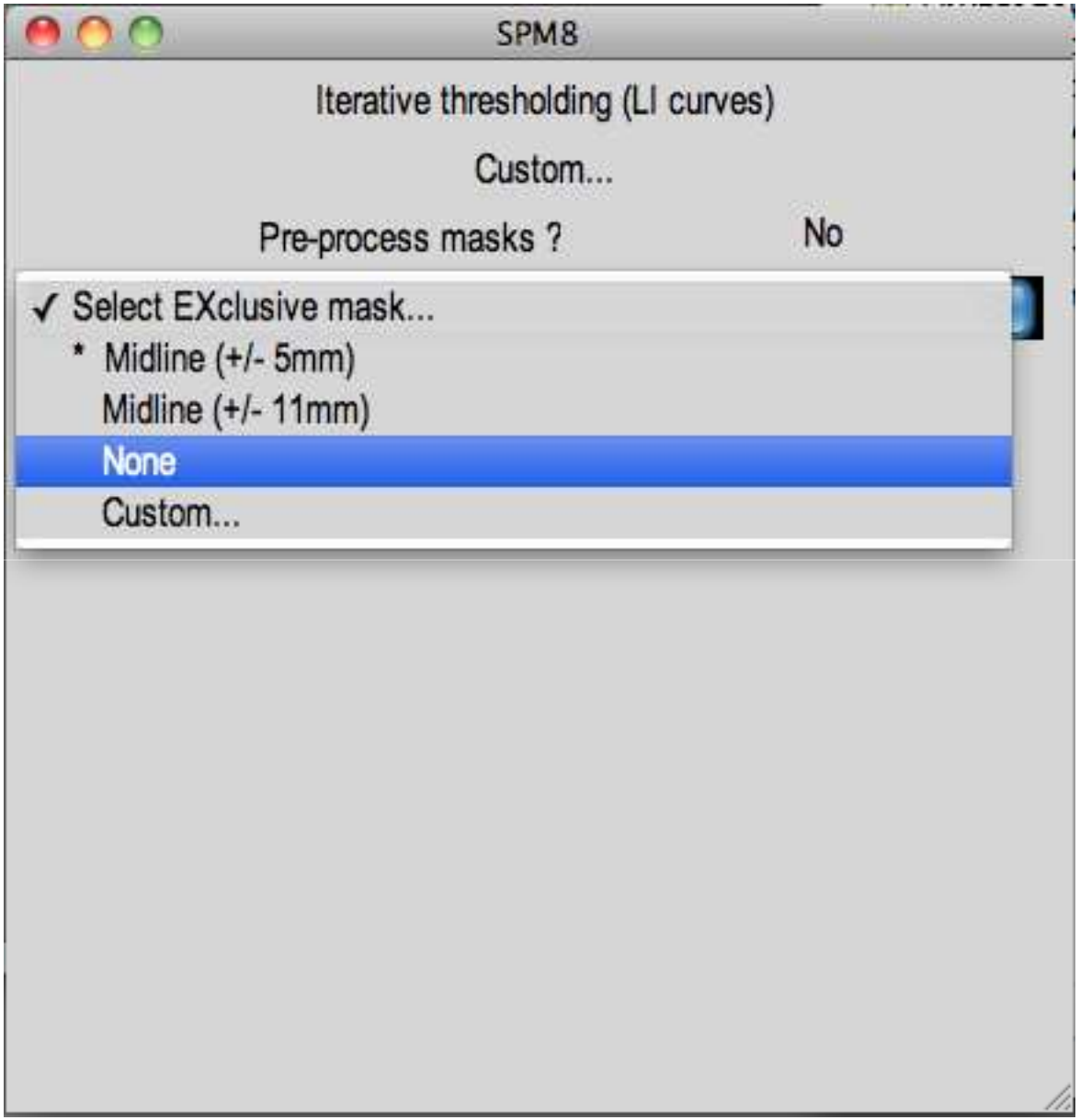


Primary motor corte
BA 4a + 4p

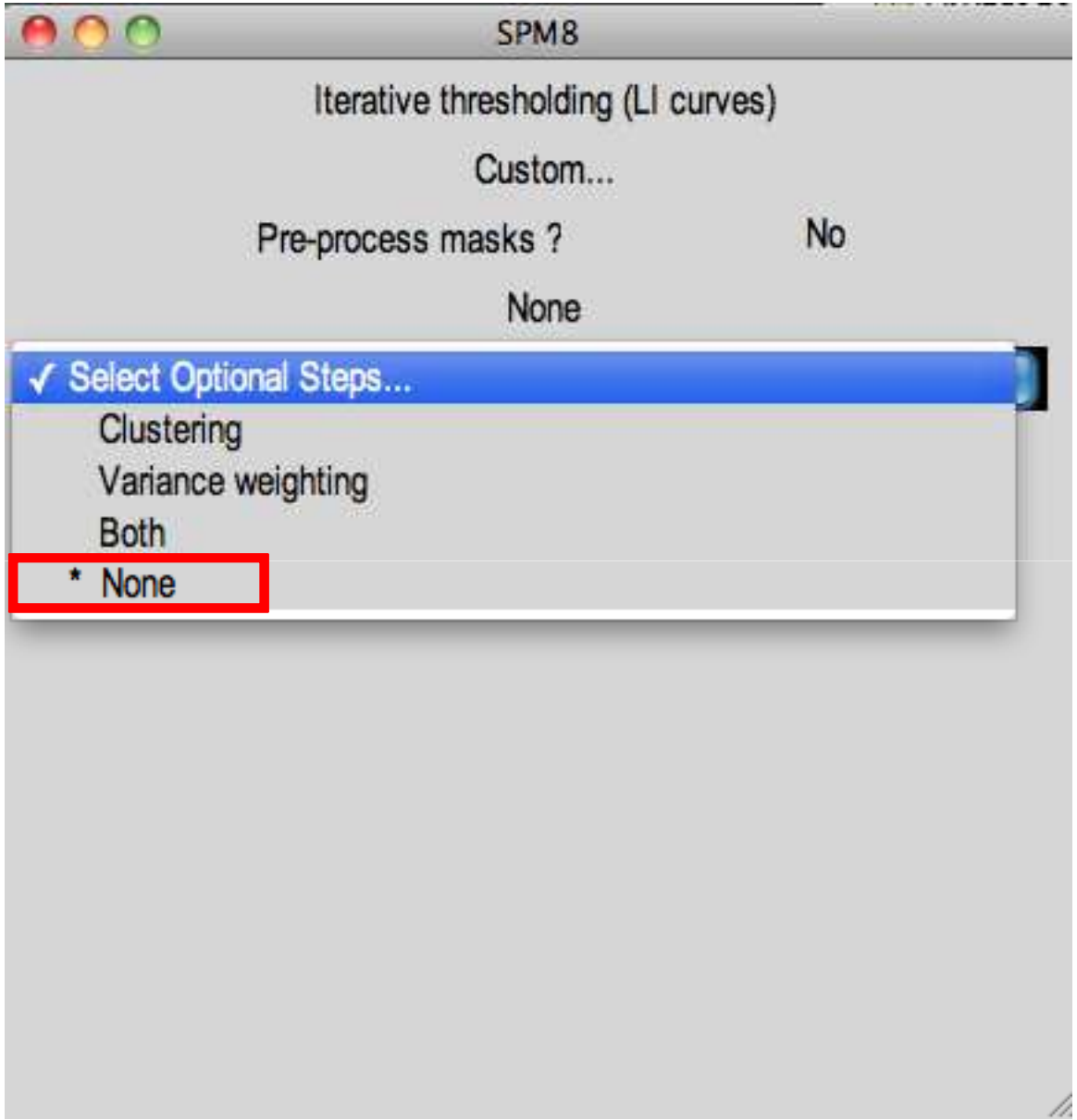
4. Pre-process masks?



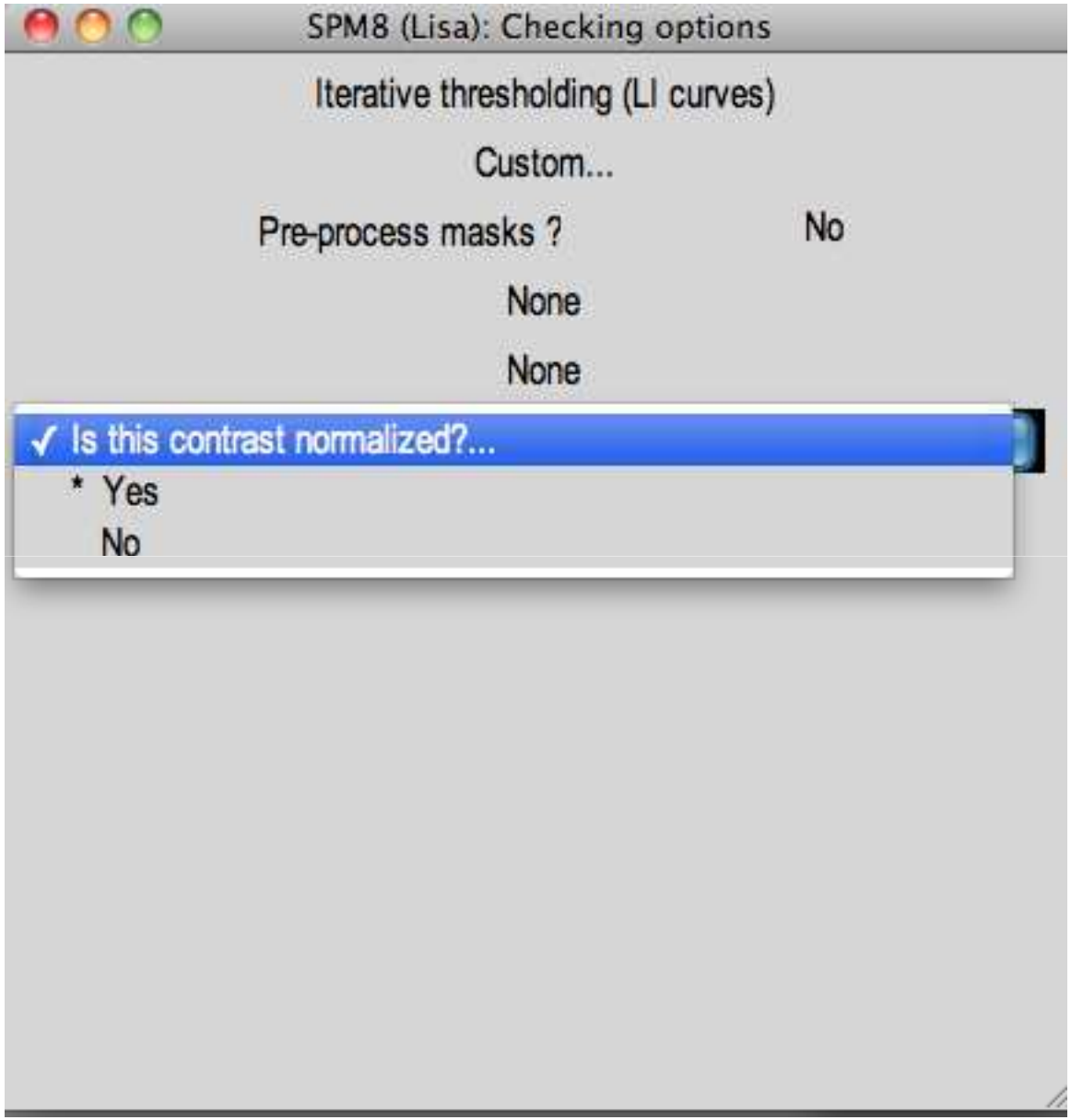
5. Select exclusive mask



6. Optional steps



7. Is the contrast normalized?



Iterative thresholding output:

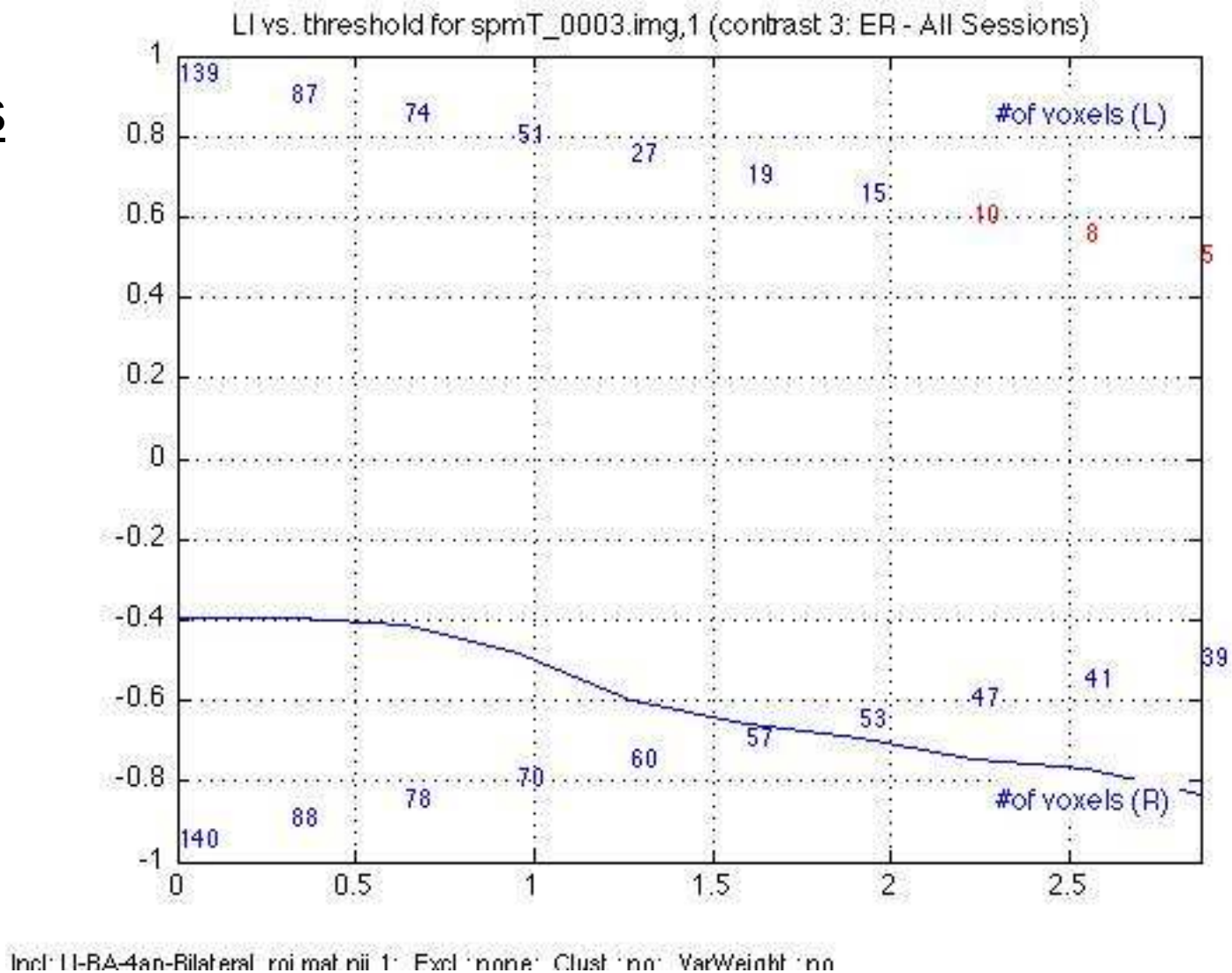
- LI report
- LI curves

LI = [-39 to -.83]

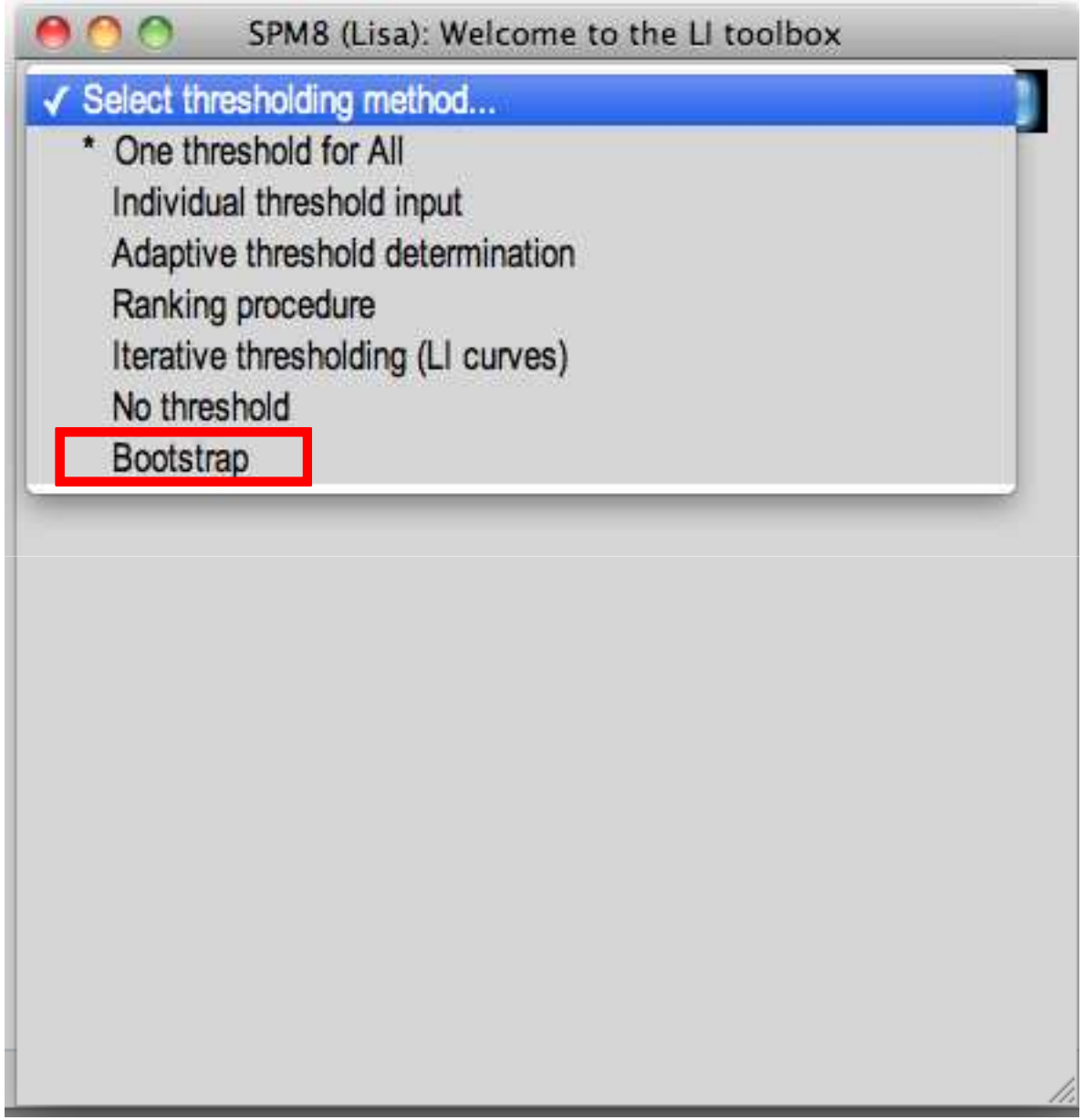
*weighted by voxel value
*you can specify voxel count instead
*overall LI results are similar
*take the mean to report

Iterative thresholding output:

- LI report
- LI curves



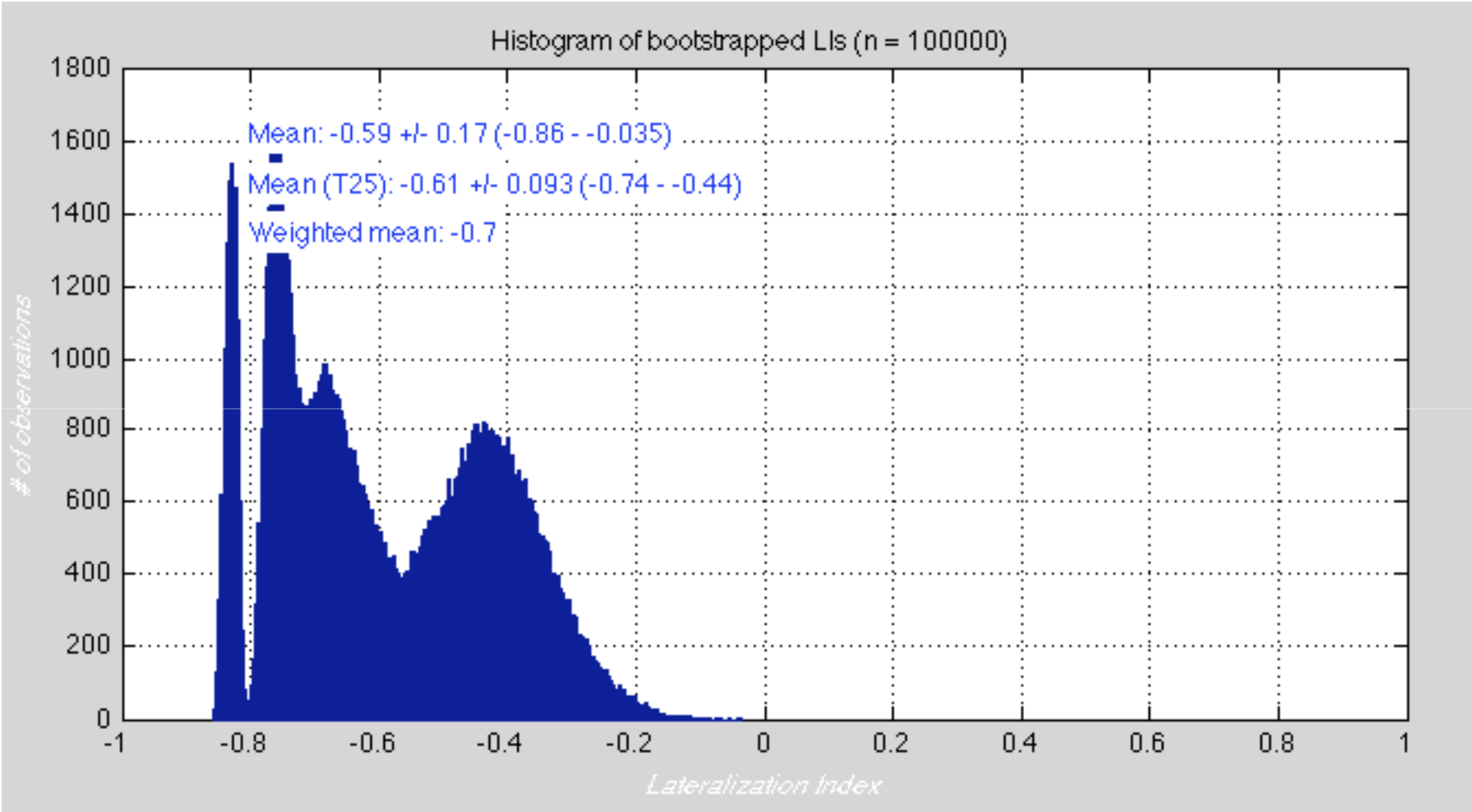
Back to 2. Select bootstrap threshold method:



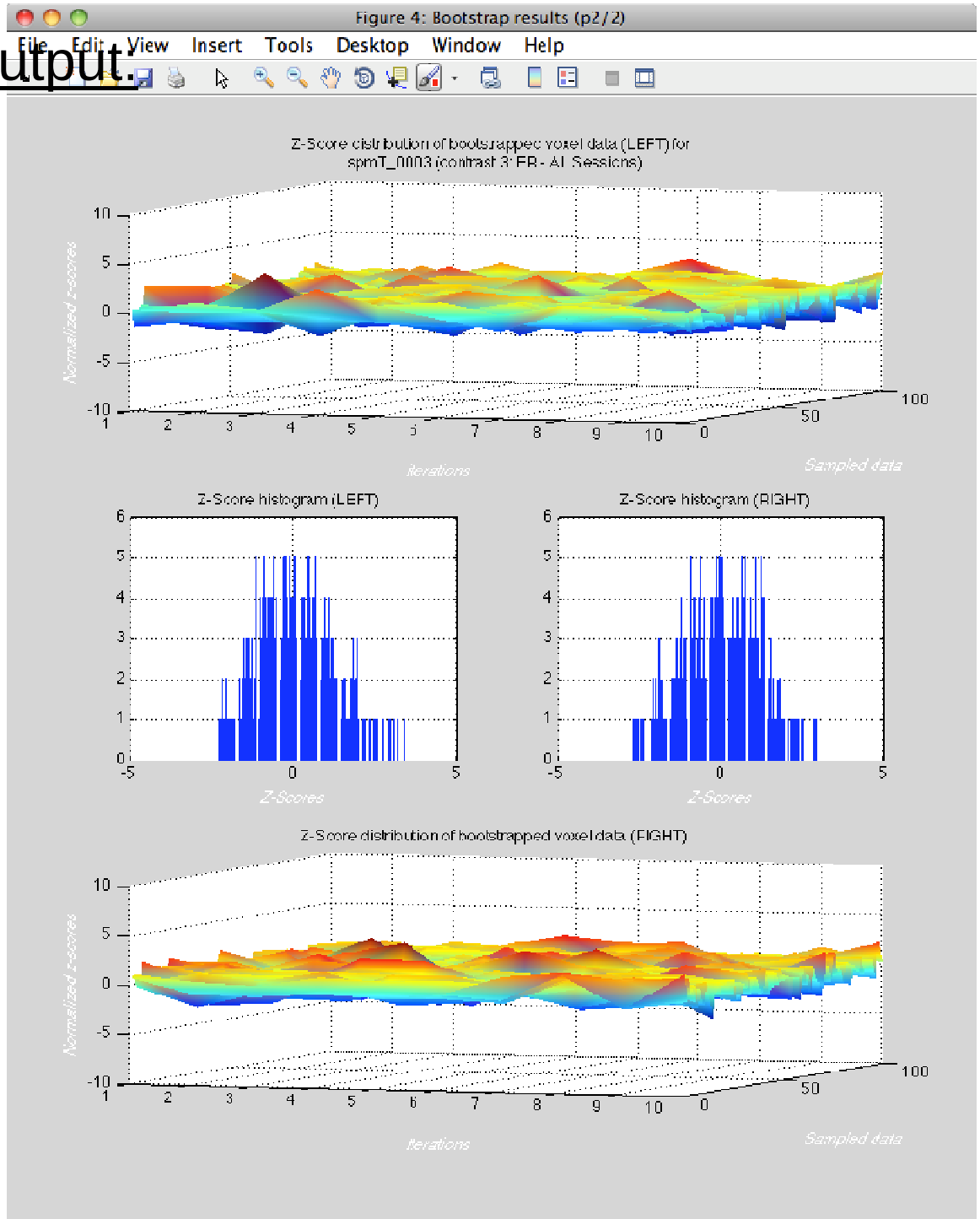
Wilke, 2006

Bootstrap output:

Bootstrap output:



Bootstrap output.



<u>Bootstrap output:</u>

- Overall bootstrap mean LI = -.59

- results from all thresholds, along x-axis
- trimmed and weighted

- Weighted mean LI = -.70

- based on results from all thresholds along LI curve x-axis, v
- e.g. voxels that survive higher thresholds likely correlate m

- Trimmed mean LI = -.61

- based on the trimmed means at each threshold, punishes c

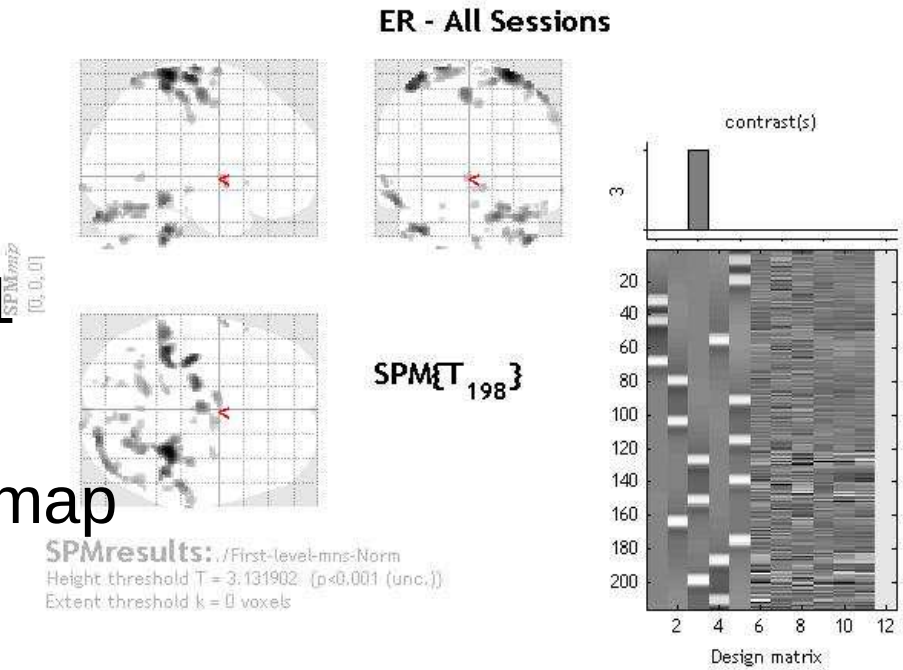
- Which to use depends on your question, region, t

B. LI based on mag

Fernandez, 2001

First, get single subject T-map

at p<.001 uncorrected



Statistics: *p-values adjusted for search volume*

set-level		cluster-level				peak-level					mm mm mm
p	c	$p_{FWE-corr}$	$q_{FDR-corr}$	k_E	p_{uncorr}	$p_{FWE-corr}$	$q_{FDR-corr}$	T	$(Z_=)$	p_{uncorr}	
0.000	39	0.003	0.007	272	0.000	0.000	0.000	8.14	7.55	0.000	30 -36 72
						0.002	0.001	5.72	5.50	0.000	44 -38 64
						0.143	0.027	4.66	4.53	0.000	36 -22 68
		0.592	0.209	54	0.054	0.000	0.000	7.05	6.65	0.000	-36 -20 70
		0.199	0.110	97	0.013	0.000	0.000	7.04	6.64	0.000	-42 -38 62
		0.768	0.311	41	0.088	0.000	0.000	6.41	6.10	0.000	-34 -36 -38
		0.540	0.209	58	0.047	0.000	0.000	6.37	6.07	0.000	-20 -16 76
		0.553	0.209	57	0.048	0.000	0.000	6.24	5.95	0.000	44 -40 -44
						0.073	0.015	4.84	4.70	0.000	38 -36 -40
						0.431	0.075	4.30	4.20	0.000	28 -30 -40
		0.086	0.097	129	0.005	0.000	0.000	6.01	5.75	0.000	20 -88 -28
						0.005	0.002	5.48	5.28	0.000	38 -82 -30
						0.700	0.134	4.07	3.98	0.000	46 -72 -26
		0.424	0.184	68	0.033	0.002	0.001	5.75	5.52	0.000	-52 -40 -18
						1.000	0.647	3.34	3.29	0.000	-44 -38 -22
		0.117	0.097	117	0.007	0.005	0.001	5.51	5.31	0.000	-2 -12 58
						0.709	0.134	4.06	3.98	0.000	8 -4 52
		0.393	0.184	71	0.030	0.010	0.003	5.33	5.15	0.000	52 -28 58
						0.846	0.175	3.93	3.85	0.000	64 -20 42
		0.857	0.339	34	0.117	0.017	0.004	5.21	5.03	0.000	18 -62 68
						0.998	0.441	3.53	3.47	0.000	10 -58 66
		0.210	0.110	95	0.014	0.042	0.010	4.99	4.83	0.000	24 -64 -22
						0.058	0.013	4.90	4.76	0.000	28 -56 -22

table shows 3 local maxima more than 8.0mm apart

Height threshold: T = 3.13, p = 0.001 (1.000)
Extent threshold: k = 0 voxels, p = 1.000 (1.000)
Expected voxels per cluster, <k> = 14.35
Expected number of clusters, <c> = 16.6
FWEp: 4.940, FDRp: 4.534, FWEc: 272, FDRc: 272

Degrees of freedom = [1.0, 198.0]
FWHM = 10.1 10.4 9.6 mm mm mm; 5.0 5.2 4.8 {voxels}
Volume: 1702808 = 212851 voxels = 1574.8 resels
Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 125.63 voxels)
Page 1

< >

1

LI based on magnitude

Statistics: *p-values adjusted for search volume*

set-level		cluster-level				peak-level					mm mm mm		
p	c	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	k_E	p_{uncorr}	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	T	$(Z_=)$	p_{uncorr}			
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						0.143	0.027	4.66	4.53	0.000	36	-22	68
		0.592	0.209	54	0.054	0.000	0.000	7.05	6.65	0.000	-36	-20	70
		0.199	0.110	97	0.013	0.000	0.000	7.04	6.64	0.000	-42	-38	62
		0.768	0.311	41	0.088	0.000	0.000	6.41	6.10	0.000	-34	-36	-38
		0.540	0.209	58	0.047	0.000	0.000	6.37	6.07	0.000	-20	-16	76
		0.553	0.209	57	0.048	0.000	0.000	6.24	5.95	0.000	44	-40	-44
						0.073	0.015	4.84	4.70	0.000	38	-36	-40
						0.431	0.075	4.30	4.20	0.000	28	-30	-40

1. Mean maximum T value –= mean of top 5% T values

LI based on magnitude

For each individual participant:

1. Mean maximum T value (T) –

   T = mean of top 5% T values 8.14 - (8.14 * .05) = 7.73

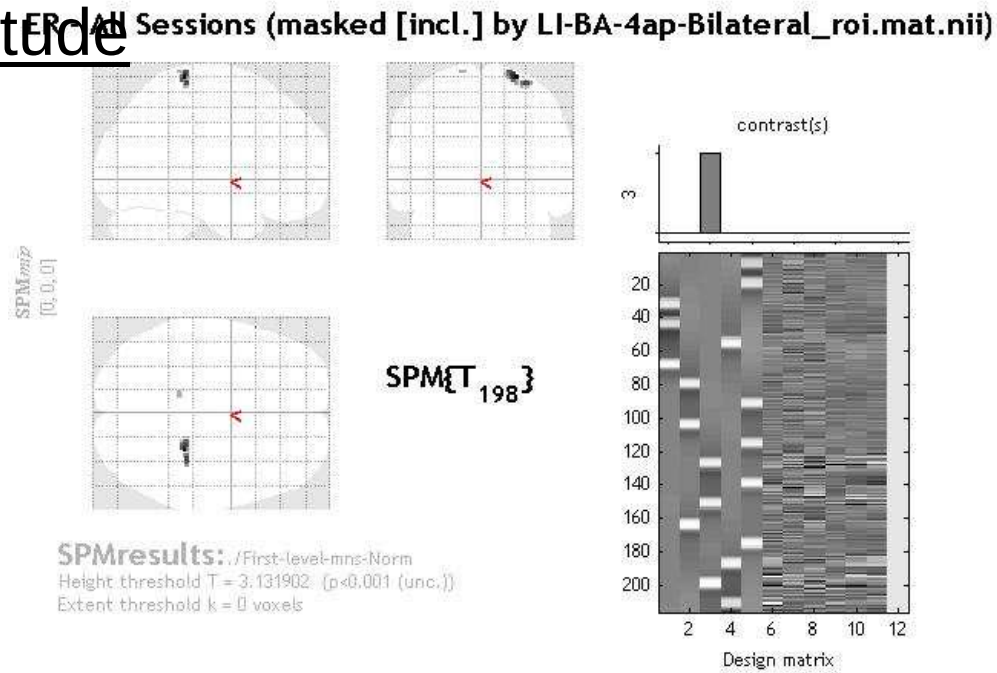
2. Take half the mean maximum T value (T/2)

   T/2 = 7.73/2 = 3.87

3. In your ROI, sum T values of voxels above T/2 = (t), and calculate LI

   $LI = (t_L –- t_R) / (t_L –+ t_R)$
   see next slide..

LI based on magnitude



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1.000	2	0.845	0.339	35	0.112	0.000	0.000	6.37	6.07	0.000	26	-34	72
		1.000	0.772	3	0.653	0.889	0.201	3.88	3.80	0.000	-14	-38	76

3. Inclusive mask of your ROI
   OR small volume correct for your ROI–

Here, again using bilateral M1

table shows 3 local maxima more than 8.0mm apart

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FWEp: 4.940, FDRp: 4.534, FWEc: 272, FDRc: 272

Degrees of freedom = [1.0, 198.0]
FWHM = 10.1 10.4 9.6 mm mm mm; 5.0 5.2 4.8 {voxels}
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Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 125.63 voxels)

LI based on magnitude

Statistics: *p-values adjusted for search volume*

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p	c	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	k_E	p_{uncorr}	$p_{FWE\text{-}corr}$	$q_{FDR\text{-}corr}$	T	$(Z_=)$	p_{uncorr}	mm	mm	mm
1.000	2	0.845	0.339	35	0.112	0.000	0.000	6.37	6.07	0.000	26	-34	72
		1.000	0.772	3	0.653	0.889	0.201	3.88	3.80	0.000	-14	-38	76

t = sum of t-values that pass T/2 in each hemisphere

$LI = (t_L -- t_R) / (t_L -+ t_R)$

LI = (3.88 –- 6.37) / (3.88 + 6.37) = -.24

Pretty different from LI calculated based on extent LI = [-39 to -.8

Last, take mean across par

A. Extent

- Straightforward
- As reproducible

B. Magnitude

- More robust
- Robustness depends on choice of ROI
- Must choose ROI that includes task-related signal,
- E.g. may not be as useful in people with structural l

*slightly different meaning, depending on your question, re

References

1. Cramer, S., Nelles G, Benson RR, Kaplan JD, Parker RA, Kwong KK, Kennedy
   A functional MRI study of subjects recoered from hemiparetic stroke. Stroke, 1
2. Wilke, M. and V.J. Schmithorst, *A combined bootstrap/histogram analysis appr*
   *a lateralization index from neuroimaging data.*Neuroimage, 2006. **33**(2): p. 52
3. Wilke, M. and K. Lidzba, *LI-tool: a new toolbox to assess lateralization in functi*
   J Neurosci Methods, 2007. **163**(1): p. 128-36.
4. Fernandez, G., et al., *Language mapping in less than 15 minutes: real-time fur*
   *investigation.*Neuroimage, 2001. **14**(3): p. 585-94.
5. Jansen, A., et al., *The assessment of hemispheric lateralization in functional M*

Neuroimage, 2006. **33**(1): p. 204-17.