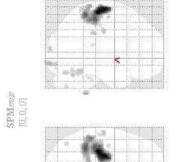
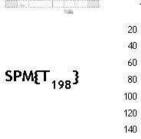
# Laterality index in brain imaging research

#### **ER - All Sessions**

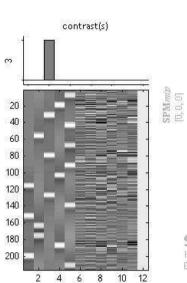






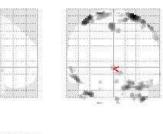
SPMresults: /First-level-mns-Norm Height threshold T = 3.131902 (p<0.001 (unc.)) Extent threshold k = 0 voxels





Design matrix

#### **ER - All Sessions**

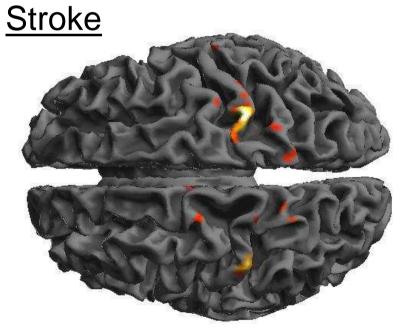


SPM{T<sub>198</sub>}

 $\begin{array}{l} \textbf{SPMresults:}, \textit{/First-level-mns-Norm} \\ \textbf{Height threshold T = 3.131902} (p<\!0.001 (unc.)) \\ \textbf{Extent threshold k = 0 voxels} \end{array}$ 

contrast(s)

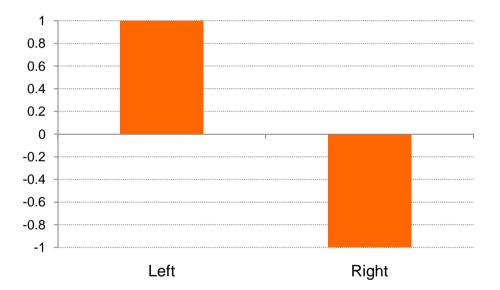
Design matrix

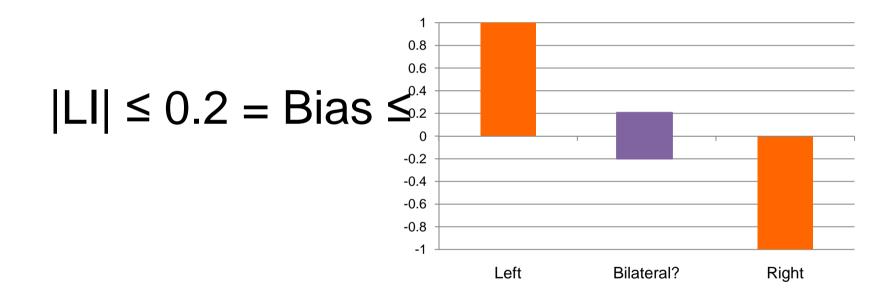


3.5 3 2.5 2 1.5 1 0.5 0

LI = Left - RightLeft + Right

# LI > 0 = LeftLI < 0 = Right

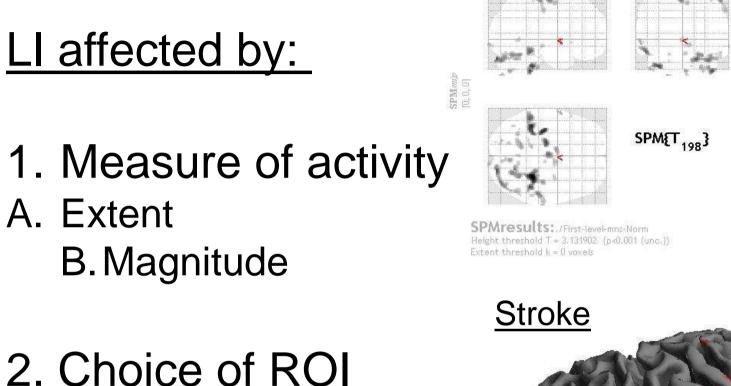




**ER - All Sessions** 

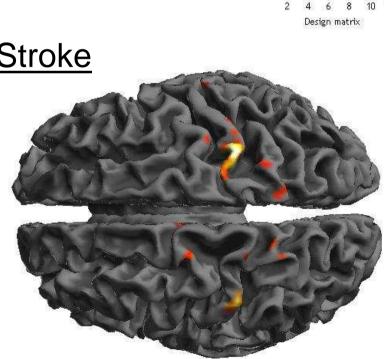
 $\mathbf{c}$ 

contrast(s)



3.5 2.5 1.5

0.5



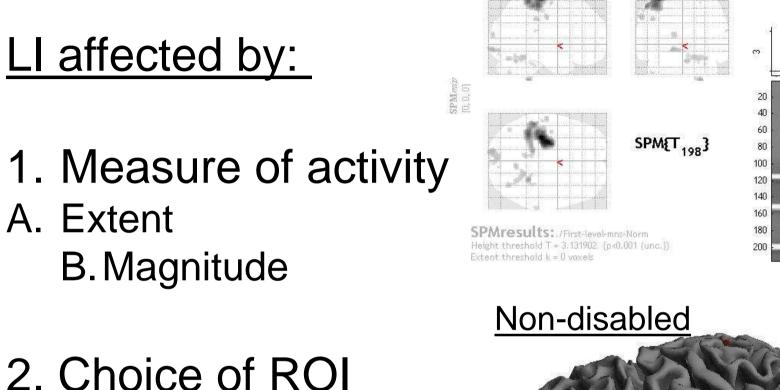
#### **ER - All Sessions**

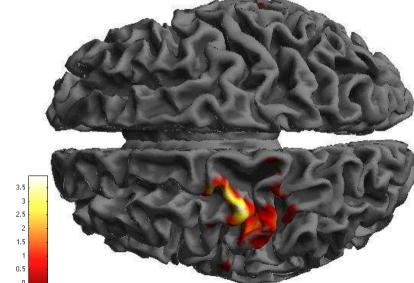
contrast(s)

10 12

2

4 6 8 Design matrix





# A. Extent - # voxelsB. 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

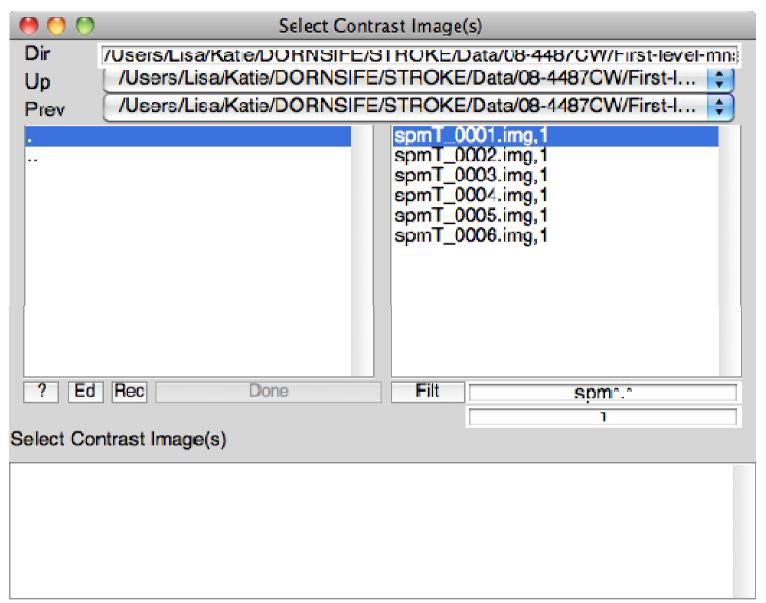
Summary: Allows assessment of laterality effects in imaging data using various thresholding options. Amog other features, regionally-restricted analyses are possible and a bootstrapping approach allows to assess data homogeneity to reduce the effect of outliers. The toolbox can now be scripted, allowing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

\varTheta 🔿 🔿 SPM8 (Lisa): Welcome to the LI toolbox
✓ Select thresholding method
* One threshold for All
Individual threshold input
Adaptive threshold determination
Ranking procedure
Iterative thresholding (LI curves)
No threshold
Bootstrap

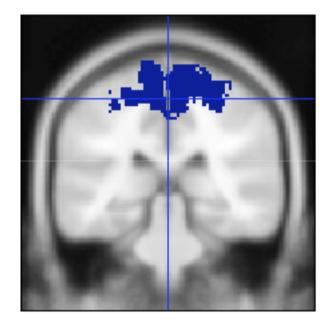
LI based on extent = dependen<sup>-</sup>

### 2. Select iterative threshold method

SPM8 (Lisa): Welcome to the LI toolbox
✓ Select thresholding method
* One threshold for All
Individual threshold input
Adaptive threshold determination
Ranking procedure
Iterative thresholding (LI curves)
No threshold
Bootstrap

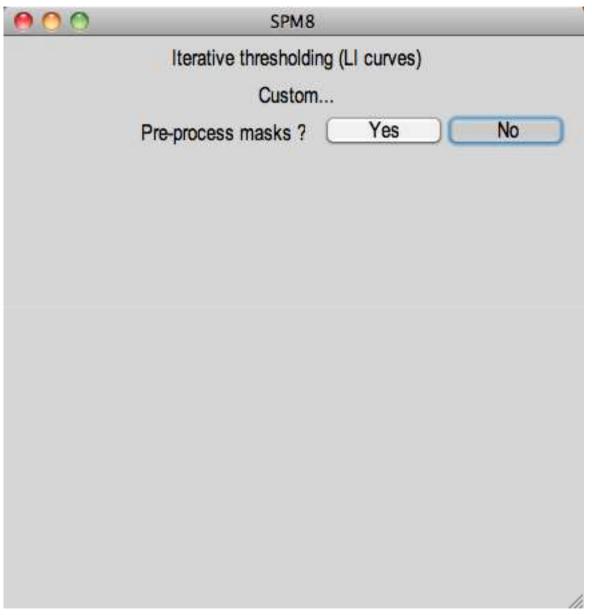
## 3. Select inclusive mask

Frontal Lobe Parietal Lobe Temporal Lobe Occipital Lobe Cingulate Central Gray matter (BG, Thalamus) Cerebellum Gray Matter All Lobes None	Bootstrap	
Parietal Lobe Temporal Lobe Occipital Lobe Cingulate Central Gray matter (BG, Thalamus) Cerebellum Gray Matter All Lobes None	Select INclusive mask	
Temporal Lobe Occipital Lobe Cingulate Central Gray matter (BG, Thalamus) Cerebellum Gray Matter All Lobes None	Frontal Lobe	
Occipital Lobe Cingulate Central Gray matter (BG, Thalamus) Cerebellum Gray Matter All Lobes None	Parietal Lobe	
Cingulate Central Gray matter (BG, Thalamus) Cerebellum Gray Matter All Lobes None	Temporal Lobe	
Central Gray matter (BG, Thalamus) Cerebellum Gray Matter All Lobes None	Occipital Lobe	
Cerebellum Gray Matter All Lobes None	Cingulate	
Cerebellum Gray Matter All Lobes None	Central Gray matter (BG, Thalamus)	
All Lobes None		
None	Gray Matter	
	All Lobes	
Custom	None	
	Custom	



Primary motor corte BA 4a + 4p

## 4. Pre-process masks?



## 5. Select exclusive mask

000	SPM8	a Madaa	0.572.6
	Iterative thresholding (LI of	curves)	
	Custom		
	Pre-process masks ?	No	
* Midline	(clusive mask (+/- 5mm) (+/- 11mm)		
None	•••••		
Custom			
Custom	***		

## 6. Optional steps

000	SPM8	
	Iterative thresholding (LI c	urves)
	Custom	
	Pre-process masks ?	No
	None	
✓ Select O	ptional Steps	
Cluster Variand Both * None	ce weighting	

## 7. Is the contrast normalized?

00	SPM8 (Lisa): Checking or	otions
	Iterative thresholding (LI c	urves)
	Custom	
	Pre-process masks ?	No
	None	
	None	
✓ Is this cor	ntrast normalized?	
* Yes No		
		1

### Iterative thresholding output:

- LI report
- LI curves

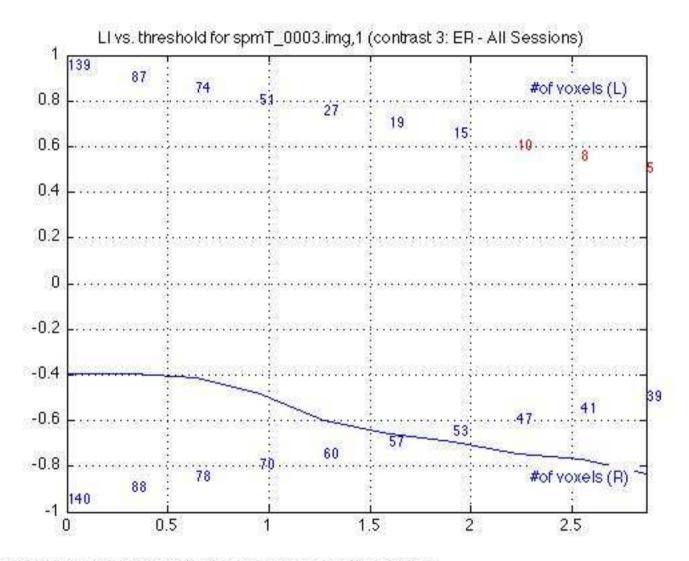
## LI = [-39 to -.83]

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

#### Iterative thresholding output:

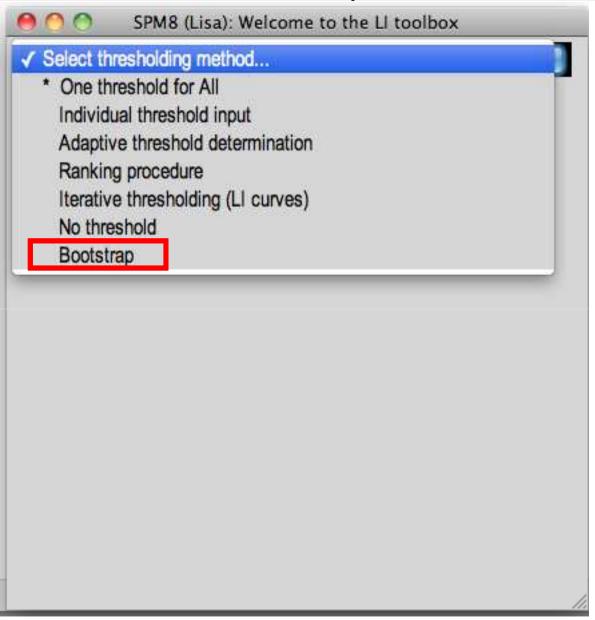
- LI report

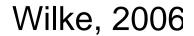




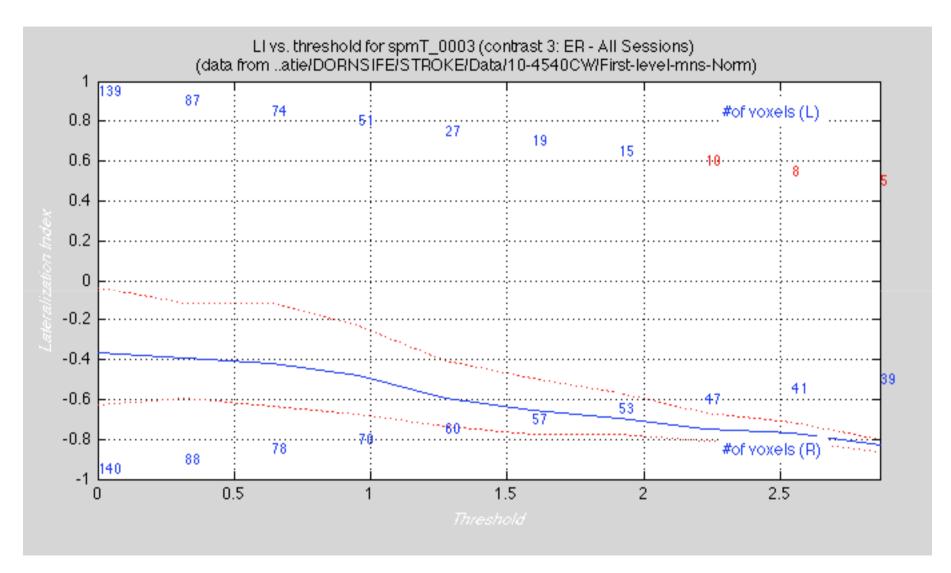
Incl: II-BA-4an-Bilateral ini matinii 1: Excl.:none: Clust.:no: VarWeight ing

#### Back to 2. Select bootstrap threshold method:

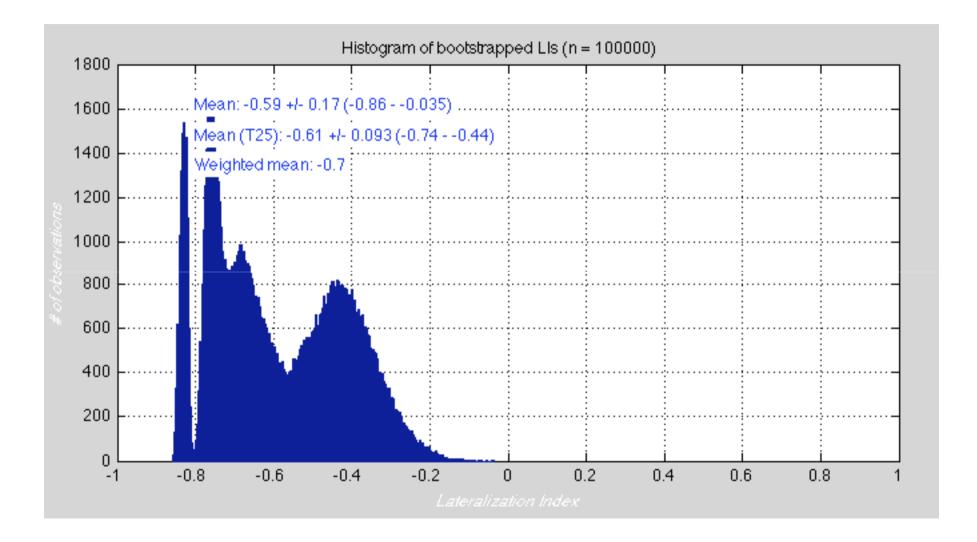


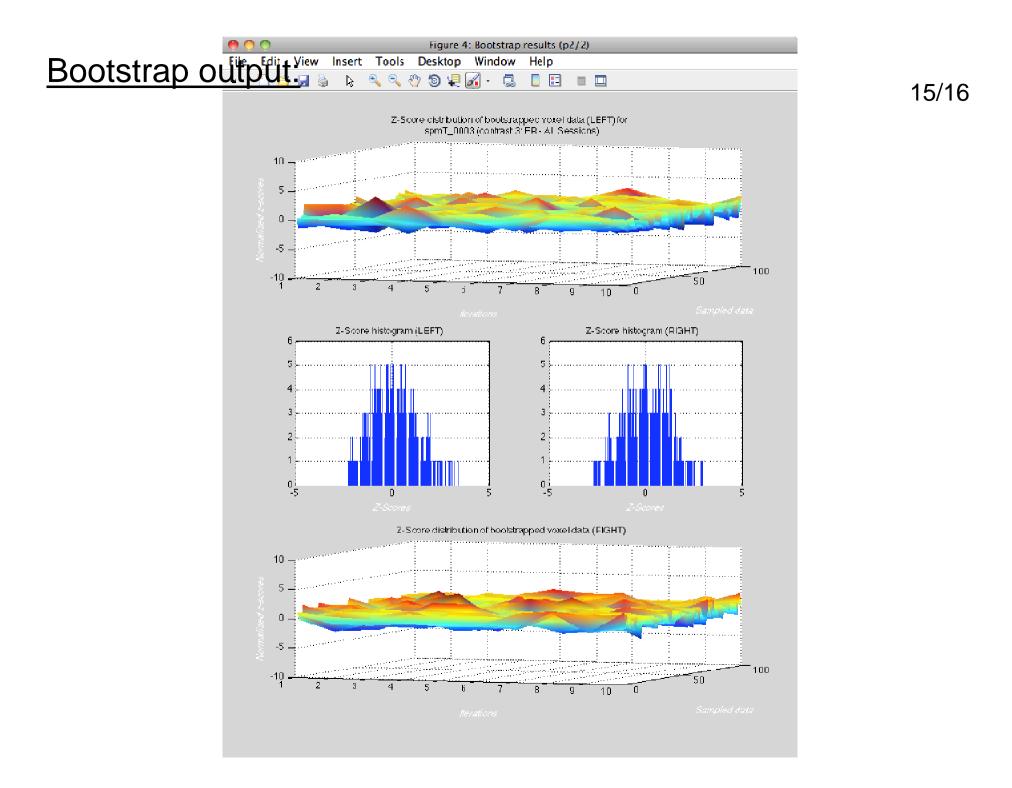


#### Bootstrap output:



#### Bootstrap output:

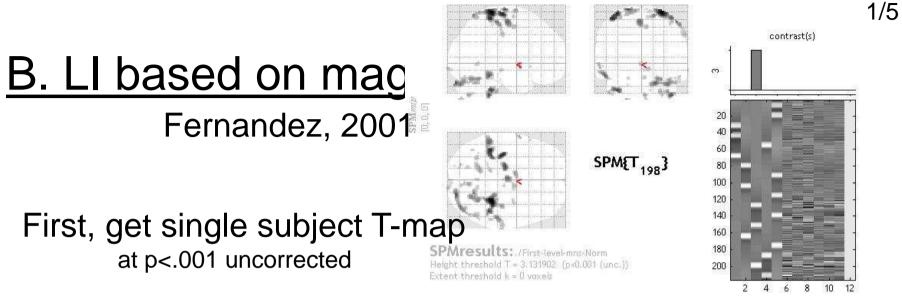




#### Bootstrap output:

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

#### **ER - All Sessions**



Design matrix

#### Statistics: p-values adjusted for search volume

set-lev	/el		luster-lev			peak-level							-
P	٢	P <sub>TWE-carr</sub>	Q FDR-carr	k <sub>c</sub>	Puncarr	P <sub>TWE-carr</sub>	9 FDR-carr	T	$(Z_{\mathbf{g}})$	Puncarr	.0001)	пт п	
0.000	39	0.003	0.007	272	0.000	0.000	0.000	8.14	7.55	0.000	30	-36	1
						0.002	0.001	5.72	5.50	0.000	44	-38	
						0.143	0.027	4.55	4.53	0.000	36	-22	13
		0.592	0.209	54	0.054	0.000	0.000	7.05	6.65	0.000	-36	-20	2
		0.199	0.110	97	0.013	0.000	0.000	7.04	6.64	0.000	-42	-38	1
		0.768	0.311	41	0.088	0.000	0.000	6.41	6.10	0.000	-34	-36	14
		0.540	0.209	58	0.047	0.000	0.000	6.37	6.07	0.000	-20	-16	13
		0.553	0.209	57	0.048	0.000	0.000	6.24	5.95	0.000	44	-40	-
						0.073	0.015	4.84	4.70	0.000	38	-35	-
						0.431	0.075	4.30	4.20	0.000	28	-30	15
		0.086	0.097	129	0.005	0.000	0.000	6.01	5.75	0.000	20	-88	-
						0.005	0.002	5.48	5.28	0.000	38	-82	-
						0.700	0.134	4.07	3.98	0.000	45	-72	24
		0.424	0.184	68	0.033	0.002	0.001	5.75	5.52	0.000	-52	-40	÷
						1.000	0.647	3.34	3.29	0.000	-44	-38	-
		0.117	0.097	117	0.007	0.005	0.001	5.51	5.31	0.000	-2	-12	3
						0.709	0.134	4.05	3.98	0.000	8	-4	13
		0.393	0.184	71	0.030	0.010	0.003	5.33	5.15	0.000	52	-28	1.3
						0.845	0.175	3.93	3.85	0.000	54	-20	1.2
		0.857	0.339	34	0.117	0.017	0.004	5.21	5.03	0.000	18	-62	1
						0.998	0.441	3.53	3.47	0.000	10	-58	- 3
		0.210	0.110	95	0.014	0.042	0.010	4.99	4.83	0.000	24	-64	-
						0.058	0.013	4.90	4.76	0.000	28	-56	÷-;

table shaws 3 local maxima more than 8.0mm apar	tabi	le si	haws	3	lacal	maxi	ma.	more	than	8.0	mm	apar	2
---	------	-------	------	---	-------	------	-----	------	------	-----	----	------	---

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</k>
Expected number of clusters, <c> = 16.6</c>
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

< >

#### LI based on magnitude

		cluster-lev	vel			2005083						
P C	P <sub>TWE-car</sub>		k <sub>c</sub>	P <sub>uncar</sub> ,	P <sub>TWE-corr</sub>	9 FDR-carr	T	$(Z_{e})$	Puncarr	.mm.r	100-0	999. 999.
2	0.003	0.007	272	0.000	0.000	0.000	8.14	7.55	0.000	30	-36	
	2010/00/00/00		10000		0.002	0.001	5.72	5.50	0.000	44	-38	
					0.143	0.027	4.55	4.53	0.000	36	-22	
	0.592	0.209	54	0.054	0.000	0.000	7.05	6.65	0.000	-36	-20	
	0.199	0.110	97	0.013	0.000	0.000	7.04	6.64	0.000	-42	-38	
	0.768	0.311	41	0.088	0.000	0.000	6.41	6.10	0.000	-34	-36	92
	0.540	0.209	58	0.047	0.000	0.000	6.37	6.07	0.000	-20	-16	
	0.553	0.209	57	0.048	0.000	0.000	6.24	5.95	0.000	44	-40	17
			634307		0.073	0.015	4.84	4.70	0.000	38	-36	84 -
					0.431	0.075	4.30	4.20	0.000	28	-30	-

#### Statistics: p-values adjusted for search volume

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

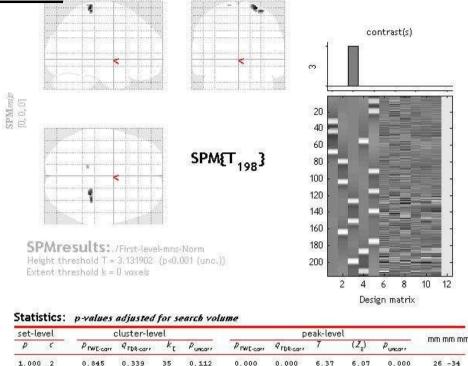
2. Take half the mean maximum T value (T/2)

T/2 = 7.73/2 = 3.87

 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..

#### Libased on magnited de Sessions (masked [incl.] by LI-BA-4ap-Bilateral\_roi.mat.nii)



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 apara

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

1.000

0.772

3

0.653

0.889

0.201

3.88

3.80

0.000

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) 72

76

-14 -38

## LI based on magnitude

set-lev	/el	9	cluster-lev	/et			peak-level						Ê.
P	0	P <sub>PWE-corr</sub>	Q <sub>FDR-carr</sub>	k <sub>c</sub>	Puncarr	P <sub>FWE-corr</sub>	Q FDR-carr	7	(Z <sub>=</sub> )	Puncarr	30,013	nm mi	923 -
1.000	2	0.845	0.339	35	0.112	0.000	0.000	6.37	6.07	0.000	26	-34	$\mathbf{z}$
		1.000	0.772	8	0.653	0.889	0.201	3.88	3.80	0.000	-14	-38	30

Statistics: p-values adjusted for search volume

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 -.{

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 I

\*slightly different meaning, depending on your question, rec

#### **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, <sup>1</sup>
- 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.