

# Pitfalls and reliability/replicability issues with clinical fMRI

Roland Beisteiner

Department of Neurology  
High Field MR Center

Medical University of Vienna  
Austria

Austrian Society for fMRI  
[www.oegfmrt.org](http://www.oegfmrt.org)

Organisation for Human Brain Mapping  
(OHBM Alpine Chapter)  
[www.humanbrainmapping.org/i4a/pages/index.cfm?pageid=3823](http://www.humanbrainmapping.org/i4a/pages/index.cfm?pageid=3823)

# What are typical problems for clinical fMRI.....

## Patient problems:

- Compliance may change quickly and considerably
- The patient may not be the „same“ from one day to the other (altered vigilance, effects of pathology and medication, mood changes – depression, exhaustion)
- Clinical state, compliance and brain pathology may vary largely between patients with the same diagnosis

## Methodological problems:

### Execution of investigation:

- Careful selection of paradigms required (note paresis, neglect, aphasia)
- Performance control – particularly important in compromised patients

### Signal variability:

- Head motion artifacts may be very large
- Patient signals may vary largely from run to run

### Data analysis:

- Problems with image registration of often massively pathological brains
- Problems with image normalization
- Problems with defining adequate regions of interest
- Effects of data smoothing and problems with localizing essential functional cortex

### Validation of clinical fMRI procedures:

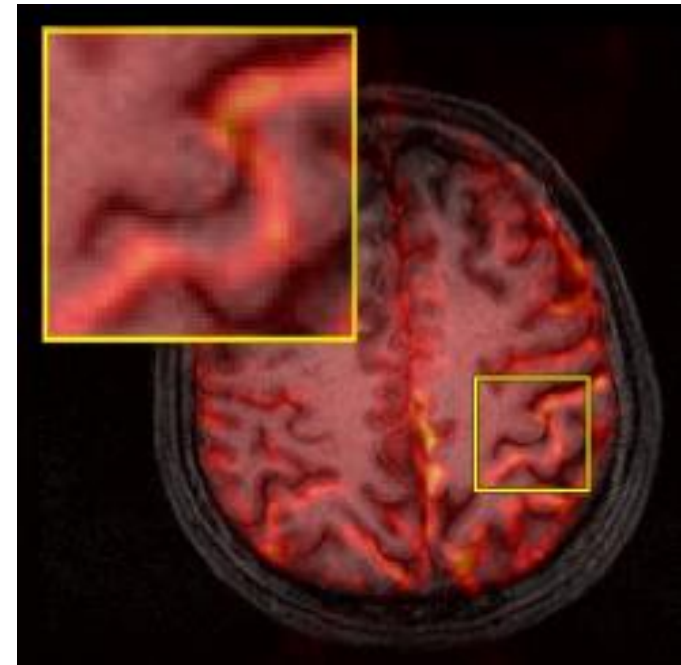
- Perform electrocortical stimulation

# What are possible solutions for clinical fMRI.....

„Problems with image registration of often massively pathological brains“

## Individual Control of Registration results!

- Comparison of fMRI coregistration results between human **experts** and **software** solutions in patients and healthy subjects. *Gartus et al., Eur Radiol. 2007*
- Hierarchical segmentation-assisted **multimodal registration** for MR brain images. *Lu et al., Comput Med Imaging Graph. 2013*



# What are possible solutions for clinical fMRI.....

„Problems with image registration of often massively pathological brains“

**Apply new methods for Distortion correction:** Dynamic Distortion Correction based on unmodified single echo EPI

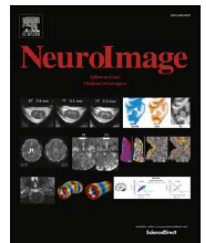
NeuroImage 168 (2018) 490–498



Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

NeuroImage

journal homepage: [www.elsevier.com/locate/neuroimage](http://www.elsevier.com/locate/neuroimage)



## The clinical relevance of distortion correction in presurgical fMRI at 7 T



Pedro Lima Cardoso<sup>a</sup>, Barbara Dymerska<sup>a</sup>, Beáta Bachratá<sup>a</sup>, Florian Ph.S. Fischmeister<sup>a,b</sup>,  
Nina Mahr<sup>a,b</sup>, Eva Matt<sup>a,b</sup>, Siegfried Trattnig<sup>a</sup>, Roland Beisteiner<sup>a,b</sup>, Simon Daniel Robinson<sup>a,\*</sup>

<sup>a</sup> High Field Magnetic Resonance Centre, Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Lazarettgasse 14, A-1090 Vienna, Austria

<sup>b</sup> Study Group Clinical fMRI, Department of Neurology, Medical University of Vienna, Währinger Gürtel 18-20, A-1090 Vienna, Austria

# What are possible solutions for clinical fMRI.....

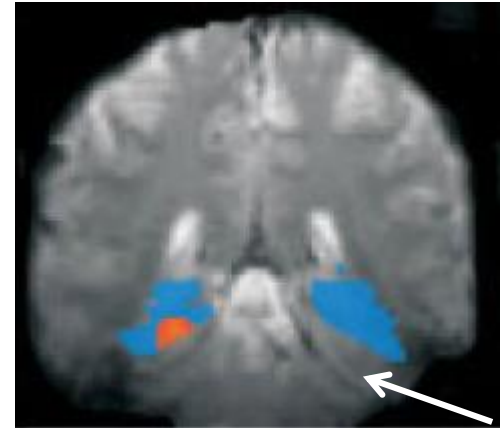
„Problems with image normalization“  
„Problems with defining adequate regions of interest (ROI)“

**Individual Control of Normalization results (for group studies)!**

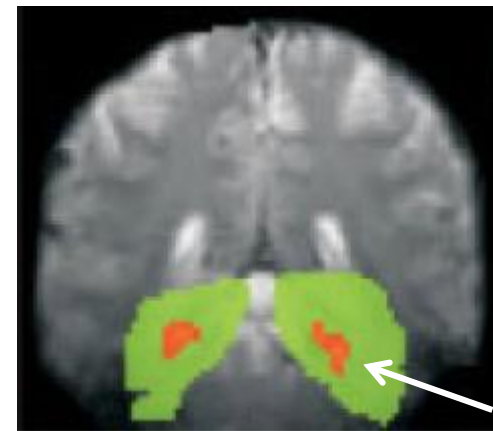
**Individual ROI delination!**

- An investigation of normalization and region of interest effects in the medial temporal lobe. *Beisteiner et al., Hum Brain Mapp. 2010*
- The benefits of skull stripping in the normalization of clinical fMRI data. *Fischmeister et al., Neuroimage Clin. 2013*

Automated ROI definition



Individual ROI definition



# What are possible solutions for clinical fMRI.....

„Patient signals may vary largely from run to run“

## **Reliability Mapping:** Risk map procedure (Beisteiner et al. 2000):

- Minimize head motion artifacts by helmet fixation (avoid artifacts instead of correcting them)
- Every task: 5- 20 runs (140 sec), block designed with 20 sec phases (3 on, 4 off)
- Realign raw images
- No smoothing, no normalization (minimize number of model assumptions applied)
- Correlate time course of every voxel and every run with various reference functions (step, HRF, delays 1-3 TR, Pearson correlation)
- Evaluate reliability maps from various perspectives:
  - Various correlation thresholds (e.g.  $r > 0.5$  to  $r > 0.9$ , effect: „bad“ runs do not contribute)
  - Various reliability thresholds ( $> 75\%$ ,  $> 50\%$ ,  $> 25\%$  of runs active)
- Concentrate on definition of regionally most reliable voxels (= functional high risk voxels)  
Definition of „clinically secure“ activation extent is not possible!
- Consider regional characteristics (pathology, artifacts)

# What are possible solutions for clinical fMRI.....

„Patient signals may vary largely from run to run“



ELSEVIER

Neuroscience Letters 290 (2000) 13–16

Neuroscience  
Letters

www.elsevier.com/locate/neulet

## Improvement of presurgical patient evaluation by generation of functional magnetic resonance risk maps

R. Beisteiner<sup>a,\*</sup>, R. Lanzenberger<sup>a</sup>, K. Novak<sup>b</sup>, V. Edward<sup>a</sup>, C. Windischberger<sup>c</sup>,  
M. Erdler<sup>a</sup>, R. Cunningham<sup>a</sup>, A. Gartus<sup>a</sup>, B. Streibl<sup>a</sup>, E. Moser<sup>c,d</sup>,  
Th. Czech<sup>b</sup>, L. Deecke<sup>a</sup>

<sup>a</sup>Department of Clinical Neurology, General Hospital and University of Vienna, Währinger Gürtel 18-20, A-1090 Vienna, Austria

<sup>b</sup>Department of Neurosurgery, General Hospital and University of Vienna, Vienna, Austria

<sup>c</sup>NMR-Group – Institute for Medical Physics, General Hospital and University of Vienna, Vienna, Austria

<sup>d</sup>MR unit, General Hospital and University of Vienna, Vienna, Austria

frontiers  
in Neurology

OPINION

published: 14 June 2017

doi: 10.3389/fneur.2017.00237



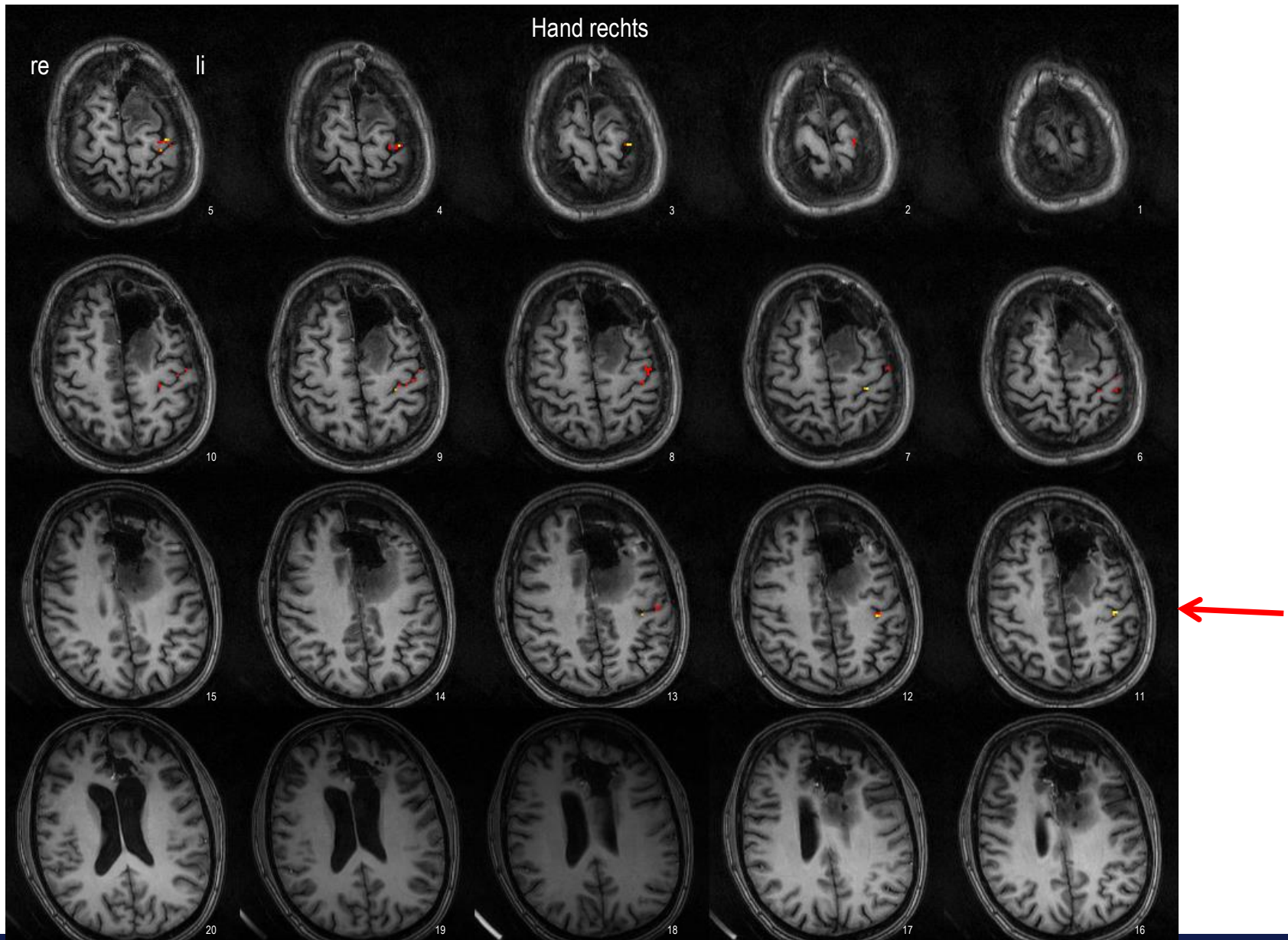
## Can Functional Magnetic Resonance Imaging Generate Valid Clinical Neuroimaging Reports?

Roland Beisteiner\*

Study Group Clinical fMRI, High Field MR Center, Department of Neurology, Medical University of Vienna, Vienna, Austria

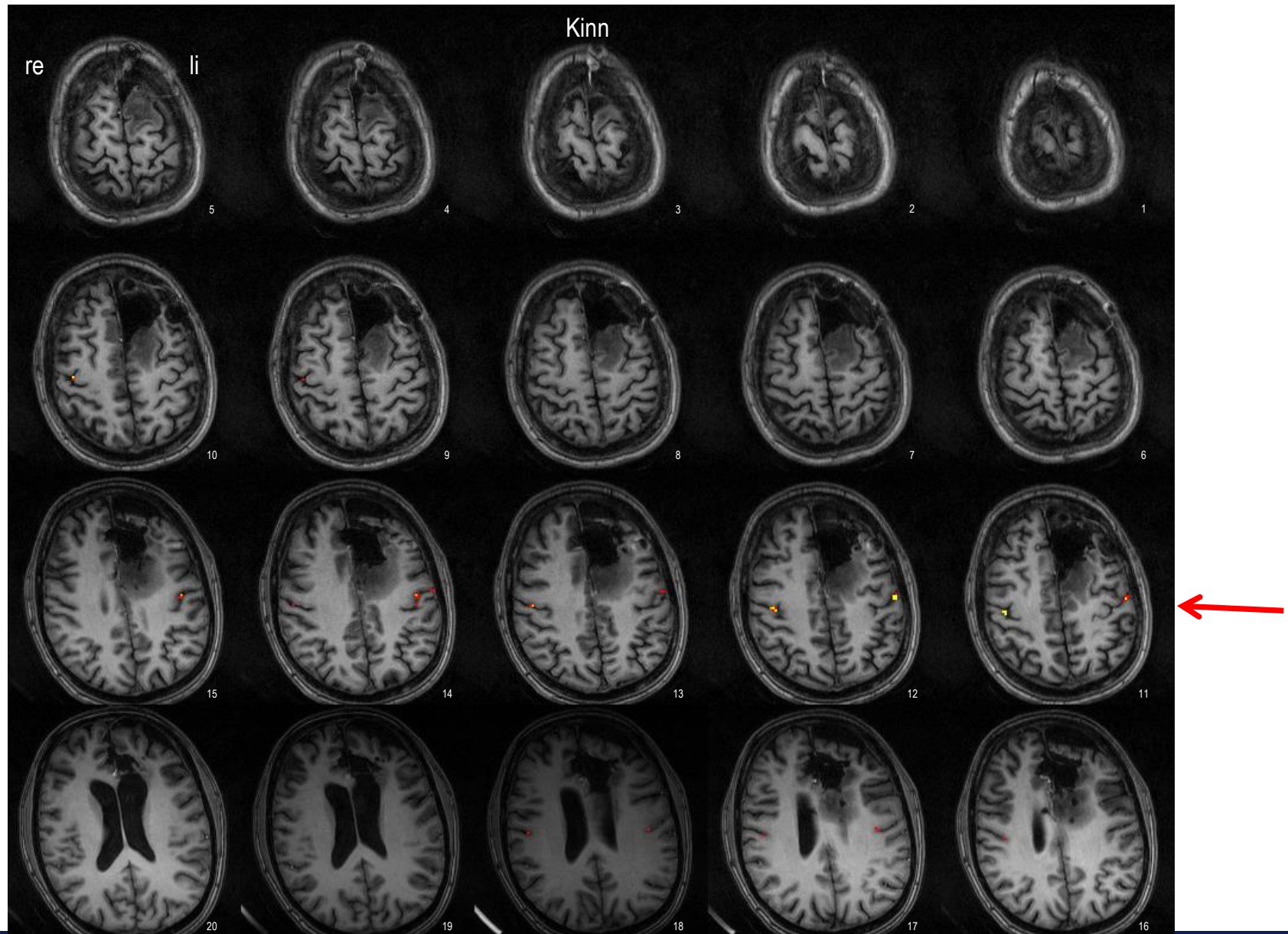


# Patient Hand Motor Localisation by Risk Maps

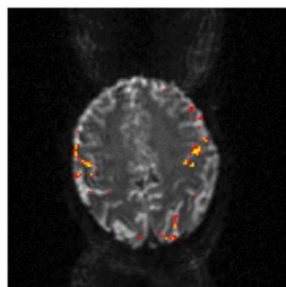
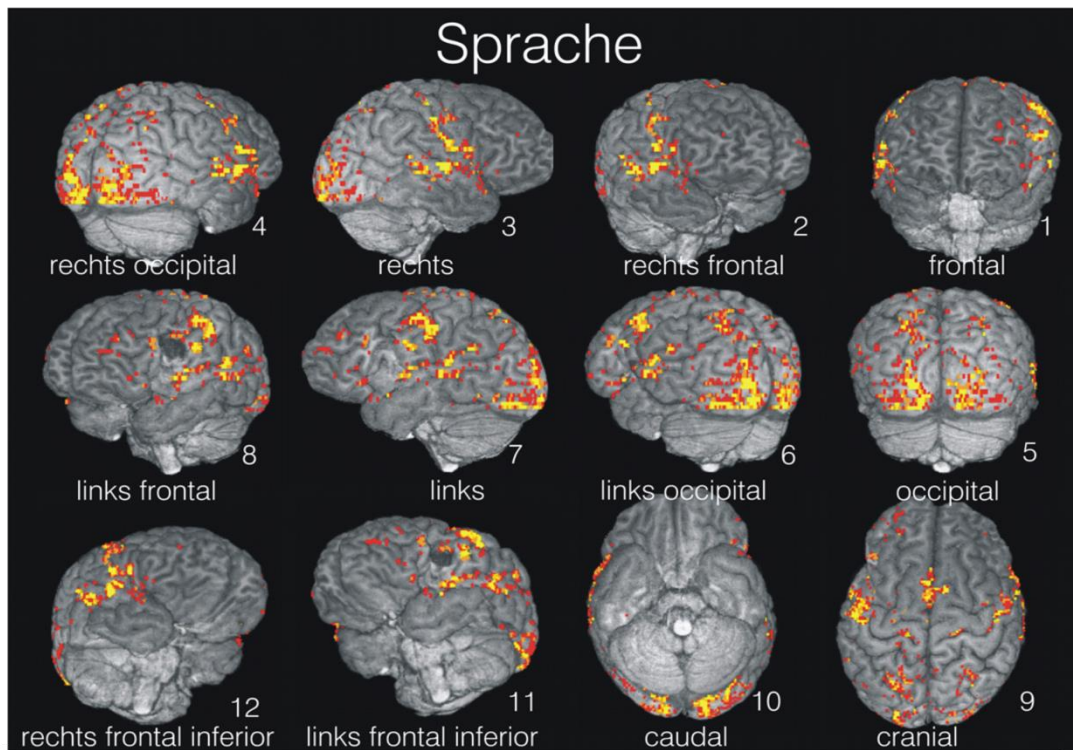




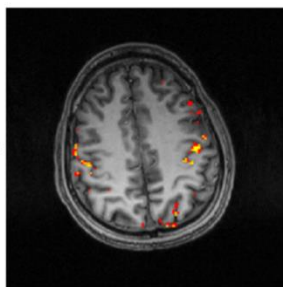
# Patient Chin Motor Localisation by Risk Maps



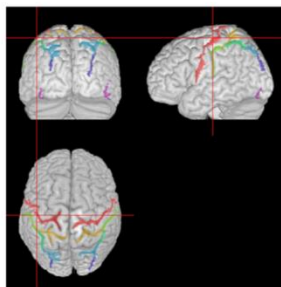
# Risk Map based Patient Report



**A**



**B**



**C**

## Funktioneller MRT Befund - Sprachlokalisation

AG klinische FMRT an den Universitätskliniken für Neurologie und Radiologie  
Medizinische Universität Wien  
AKH Wien, Währinger Gürtel 18-20, A-1090 Wien  
[roland.beisteiner@meduniwien.ac.at](mailto:roland.beisteiner@meduniwien.ac.at), Tel.: +43-1-40400-3117, FAX: +43-1-40400-3141

Patient:

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Untersuchungsdatum:

XXXXXXX

Zuweiser:

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

Zuweisungsdiagnose:

Temporallappenepilepsie rechts

**Funktionelle MRT:**

Block Design mit 20 sec Phasen, EPI Sequenz bei 3 Tesla, 35 Transversalschichten in AC-PC Orientierung, Auflösung 1.8\*1.8\*3 mm. Essentielle Kortextareale für Sprachstimulation (vokalisierendes Lesen von Sätzen mit Semantik- und Syntaxaufgaben versus motorische + visuelle Kontrollstimulation) wurden mittels funktioneller Risikokarten (Beisteiner et al. 2000-2005) bestimmt. Dargestellt sind die Kortextareale höchsten Risikos für funktionelle Schädigung bezüglich der durchgeführten Stimulation soweit mittels fMRT deduzierbar. Farbenkodierung: Ausgeprägte Aktivierung mit sehr hoher (gelb), hoher (orange) und mittlerer (rot) Reliabilität.

**Befund:**

Gemäss der Komplexität realitätsnaher Sprachproduktion wie im hier angewendeten Paradigma untersucht, findet sich Aktivität in verschiedenen essentiellen Kortextarealen.

1.) Primär sprachrelevante Areele:

deutlich linksdominant: *Sulcus frontalis inferior, Gyrus frontalis inferior, Sulcus lateralis Ramus anterior ascendens* (inkludiert Brocaareal, Schicht 6-17)

rechtsdominant: *Sulcus lateralis Ramus posterior ascendens* (inkludiert Wernickeareal, Schicht 13-15)

bilateral: *Gyrus temporalis superior, Sulcus temporalis superior* (Schicht 18-20)

bilateral: *Sulcus collateralis, Sulcus occipitotemporalis lateralis, Gyrus fusiformis* (Schicht 24-28)

2.) Primäre + sekundäre sensorische Areele (Aktivierung der Sprachmuskulatur, Motorprogrammierung, Sensible Rückkopplung):

linksdominant: *Sulcus centralis, Sulcus präcentralis, Sulcus postcentralis* (Schicht 2-11)

3.) Primäre + sekundäre visuelle Areele (Sprachrelevant für Leseaufgaben):

bilateral: *Sulcus calcarinus, extrastriale Okzipitalappenanteile* (Schicht 18-29)

4.) Integrative parietooccipitale Areele:

leicht linksdominant: *Sulcus intermedius, Sulcus parietooccipitalis, Sulcus intraparietalis, Sulcus intraoccipitalis* (Schicht 2-17)

**Zusammenfassend** finden sich die klassischen Sprachareale dissoziiert: das Brocaareal deutlich linksdominant, das Wernickeareal bei bilateraler Aktivierung rechtsdominant.

**Anmerkung:**

Die funktionelle MRT befindet sich als relativ neue Methode in kontinuierlicher Weiterentwicklung, so daß die hier beschriebenen Ergebnisse durch unabhängige Alternativmethoden (z.B. intraoperative kortikale Stimulation, Magnetoenzephalographie) validiert werden sollten. Spezifische Hirnaktivität kann sich auch ausserhalb der hier dargestellten Hochrisikoareale befinden.

(Prof. Dr. R. Beisteiner)

# What are possible solutions for clinical fMRI.....

## Better Contrast to Noise Ratio (CNR) with Ultra High Field MR



### Clinical fMRI: Evidence for a 7 T benefit over 3 T

R. Beisteiner <sup>a,c,\*</sup>, S. Robinson <sup>b,c</sup>, M. Wurnig <sup>a,c</sup>, M. Hilbert <sup>a,c</sup>, K. Merksa <sup>a,c</sup>, J. Rath <sup>a,c</sup>, I. Höllinger <sup>a,c</sup>, N. Klinger <sup>a,c</sup>, Ch. Marosi <sup>d</sup>, S. Trattnig <sup>b,c</sup>, A. Geißler <sup>a,c</sup>

<sup>a</sup> Study Group Clinical fMRI, Department of Neurology, Medical University of Vienna, Austria

<sup>b</sup> Department of Radiology, Medical University of Vienna, Austria, Währinger Gürtel 18-20, 1090 Vienna, Austria

<sup>c</sup> MR Center of Excellence, Medical University of Vienna, Austria, Währinger Gürtel 18-20, 1090 Vienna, Austria

<sup>d</sup> Department of Medicine I, Medical University of Vienna, Austria, Währinger Gürtel 18-20, 1090 Vienna, Austria

NeuroImage 103 (2014) 163–170



### Differential functional benefits of ultra highfield MR systems within the language network



A. Geißler <sup>a,b,c</sup>, E. Matt <sup>a,b,c</sup>, F. Fischmeister <sup>a,b,c</sup>, M. Wurnig <sup>a,b,c</sup>, B. Dymerska <sup>b,d</sup>, E. Knosp <sup>e</sup>, M. Feucht <sup>f</sup>, S. Trattnig <sup>b,d</sup>, E. Auff <sup>c</sup>, W.T. Fitch <sup>g</sup>, S. Robinson <sup>b,d</sup>, R. Beisteiner <sup>a,b,c,\*</sup>

<sup>a</sup> Study Group Clinical fMRI, Department of Neurology, Medical University of Vienna, Austria

<sup>b</sup> High Field MR Center, Medical University of Vienna, Austria

<sup>c</sup> Department of Neurology, Medical University of Vienna, Austria

<sup>d</sup> Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Vienna, Austria

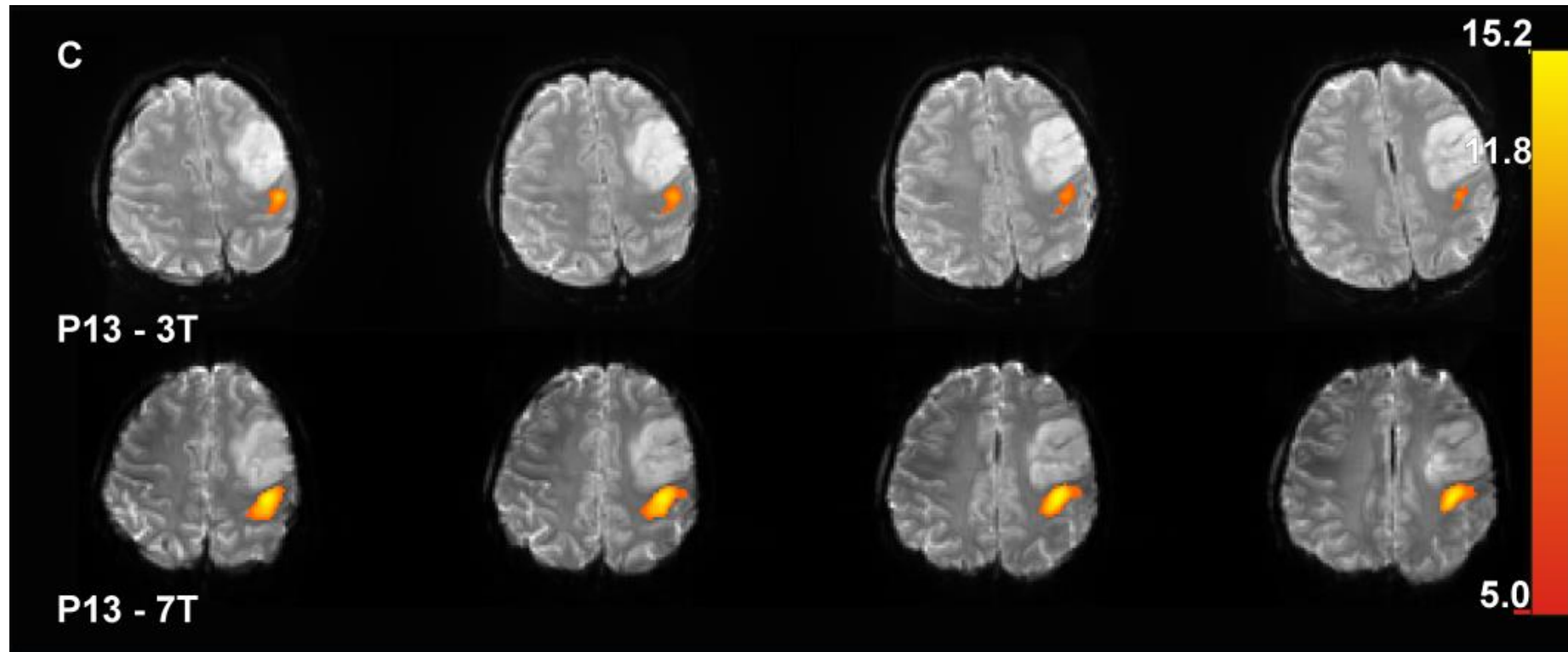
<sup>e</sup> Department of Neurosurgery, Medical University of Vienna, Austria

<sup>f</sup> Department of Pediatrics, Medical University of Vienna, Austria

<sup>g</sup> Department of Cognitive Biology, University of Vienna, Vienna, Austria



# Hand Motor Localisation in Tumor Patients



# What are possible solutions for clinical fMRI.....

## Model Free Reliability Mapping „UNBIASED“

◆ Human Brain Mapping 38:3163–3174 (2017) ◆

## Robust Presurgical Functional MRI at 7 T Using Response Consistency

**Pedro Lima Cardoso,<sup>1</sup> Florian Ph. S. Fischmeister ,<sup>2</sup> Barbara Dymerska,<sup>1</sup>  
Alexander Geißler,<sup>2</sup> Moritz Wurnig,<sup>2</sup> Siegfried Trattnig,<sup>1</sup>  
Roland Beisteiner,<sup>2</sup> and Simon Daniel Robinson<sup>1\*</sup>**

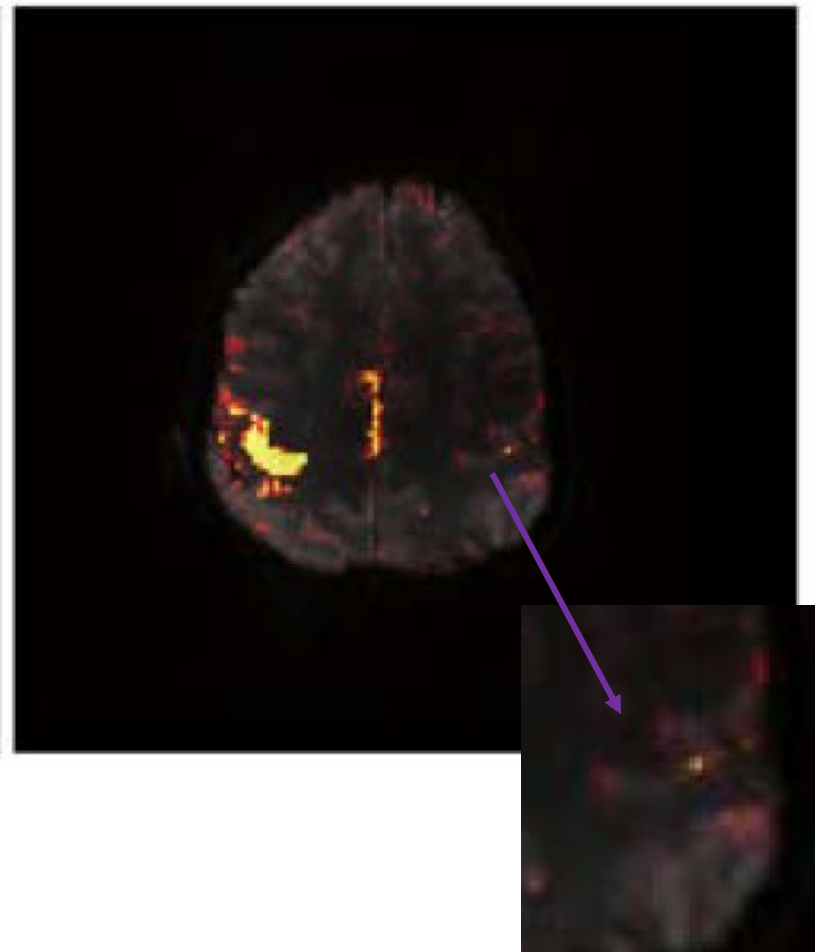
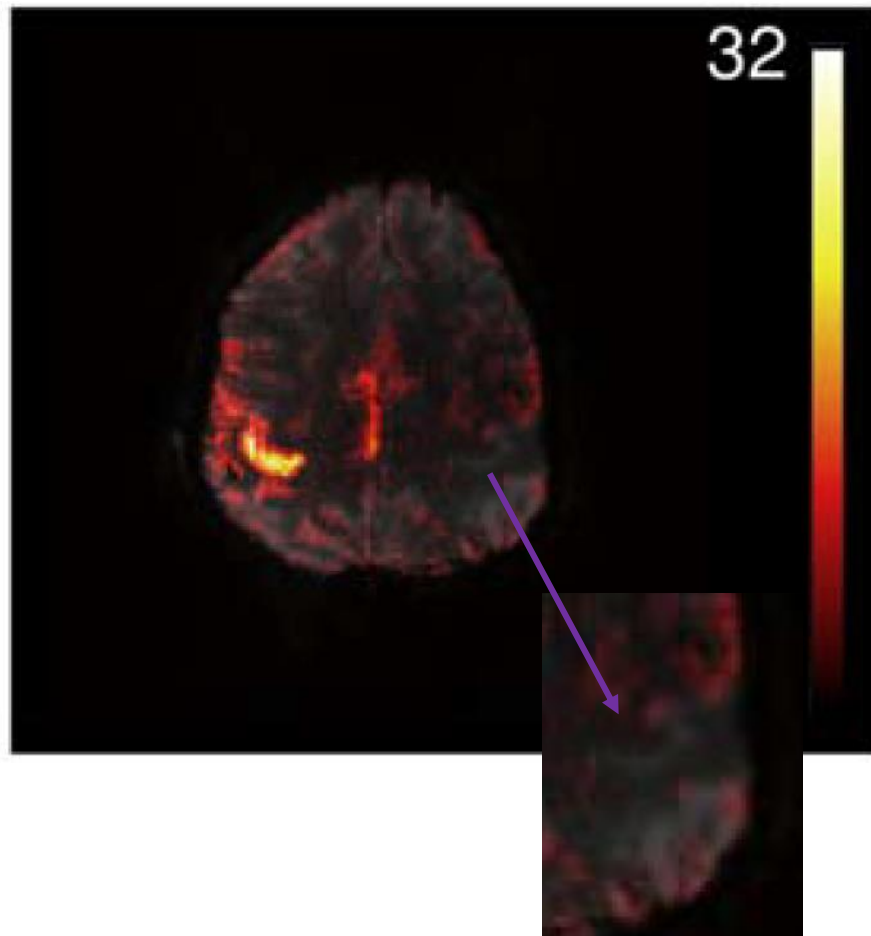
<sup>1</sup>*High Field Magnetic Resonance Centre, Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Lazarettgasse 14, A-1090, Vienna, Austria*

<sup>2</sup>*Study Group Clinical fMRI, Department of Neurology, Medical University of Vienna, Währinger Gürtel 18-20, A-1090, Vienna, Austria*

GLM

UNBIASED

P4



**Better CNR and higher Sensitivity**



MEDIZINISCHE  
UNIVERSITÄT WIEN



Organization for Human Brain  
Mapping



Alpine  
Chapter



Austrian Society  
for fMRI



## Scientific Program

Member initiated scientific sessions and individual contributions provide an overview about current topics in alpine brain mapping research. An advanced course in clinical fMRI will be offered on the first day.

OHBM Alpine Chapter ([www.humanbrainmapping.org](http://www.humanbrainmapping.org), [www.oegfmrt.org](http://www.oegfmrt.org))

## Registration / Contact

For registration or submission of 60 min scientific sessions (3 speakers) or individual presentations please contact the local congress executive Dr. Ruth Steiger ([office@oegfmrt.org](mailto:office@oegfmrt.org))

Submission Deadline will be August, 1<sup>st</sup> 2018. Online congress registration until September 1<sup>st</sup>, 2018. Registration fee Course & Symposium: 250,00 Euro, Symposium: 200,00 Euro all including Austrian Evening Event and Catering. Reductions: OHBM Members 50%, OHBM Chapter members 25%, Students free. Membership applications: [www.oegfmrt.org](http://www.oegfmrt.org) and [www.humanbrainmapping.org](http://www.humanbrainmapping.org). On Friday On-site registration will be possible.

## Local Organisation

Department of Neuroradiology: Prof. Dr. Elke R Gizewski, Dr. Ruth Steiger, Dr. Christian Siedentopf, Sandra Wackerle ([office@oegfmrt.org](mailto:office@oegfmrt.org))

## Venue

Auditorium 2, Frauenkopfklinik, Anichstr. 35, A-6020 Innsbruck

## Faculty OHBM Alpine Chapter (from July 2018)

Basel: Christoph Stippich (Chair)  
Graz: Anja Ischebeck (Chair Elect)  
Vienna: Roland Beisteiner (Chair Past)  
Graz: Christian Enzinger (Secretary)  
Switzerland: NN (Secretary Elect)  
Geneva: Patrik Vuilleumier (Secretary Past)  
Bern: Roland Wiest (Treasurer)  
Innsbruck: Elke R. Gizewski (Treasurer Elect)  
Salzburg: Stefan Golaszewski, Martin Kronbichler (Treasurer Past)



Organisation for  
Human Brain Mapping



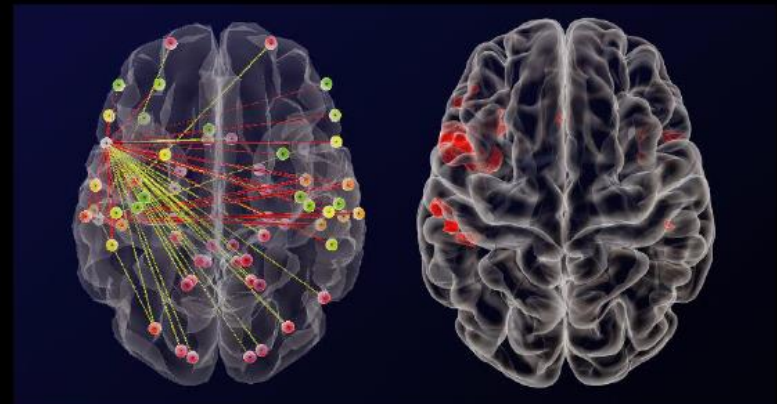
Alpine Chapter



Austrian Society for  
fMRI

## 4th ALPINE CHAPTER SYMPOSIUM

## + Clinical fMRI Course



November 9th & 10th, 2018

University Hospital Innsbruck