

Determinants of EPI Noise

- EPI = loud(est) MR pulse sequence (up to 120 dB)
- EPI noise primarily generated by Read-Outs [G_x]

RF
 G_z
 G_y
 G_x

→ just to the disadvantage* for FMRI ?

*Haller et al., *Magma* 2005 / *Brain Res* 2009

Continuous EPI = Low Impact Noise Acquisitions

Lowering EPI Noise ...

'pulsed'

'continuous'

Seifritz et al., *NeuroImage* 2006 (courtesy of K. Scheffler)

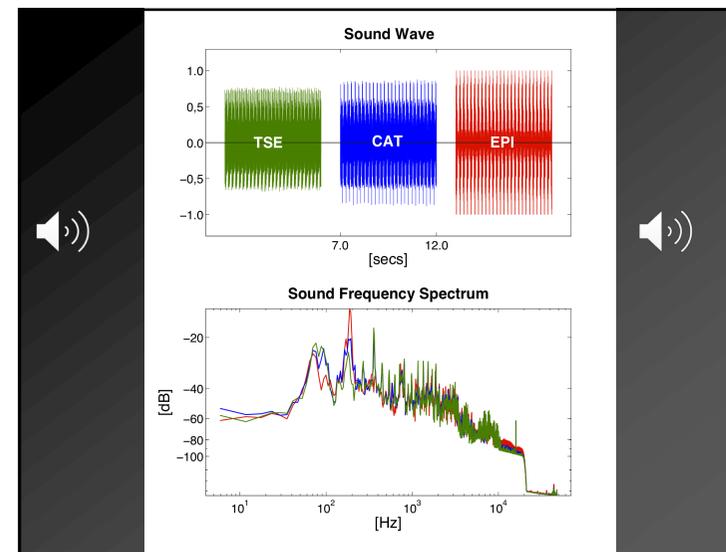
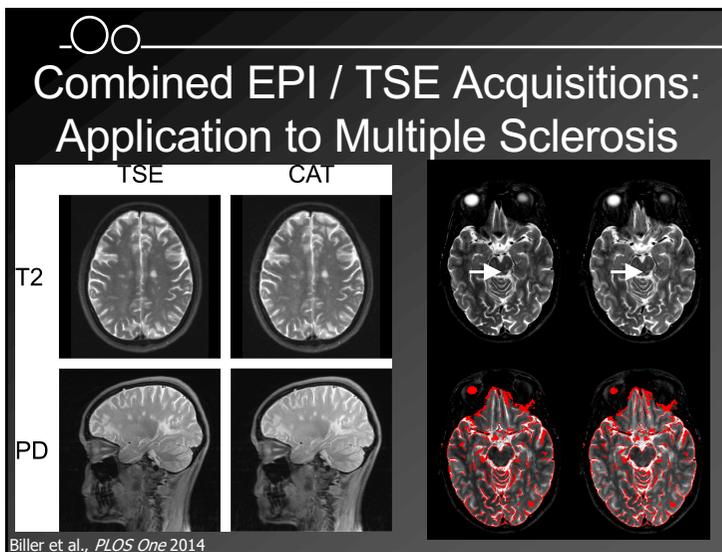
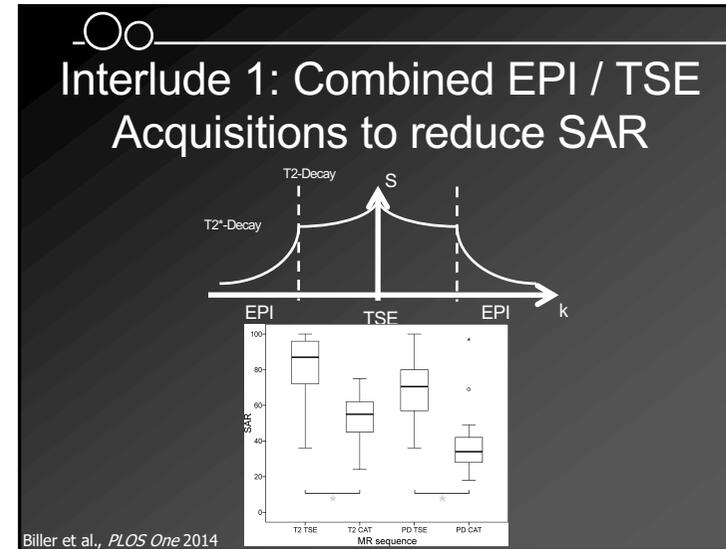
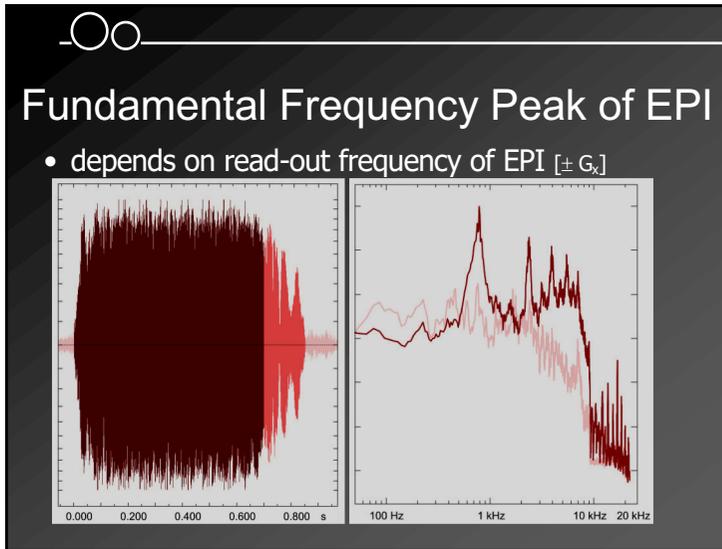
... can increase FMRI responses

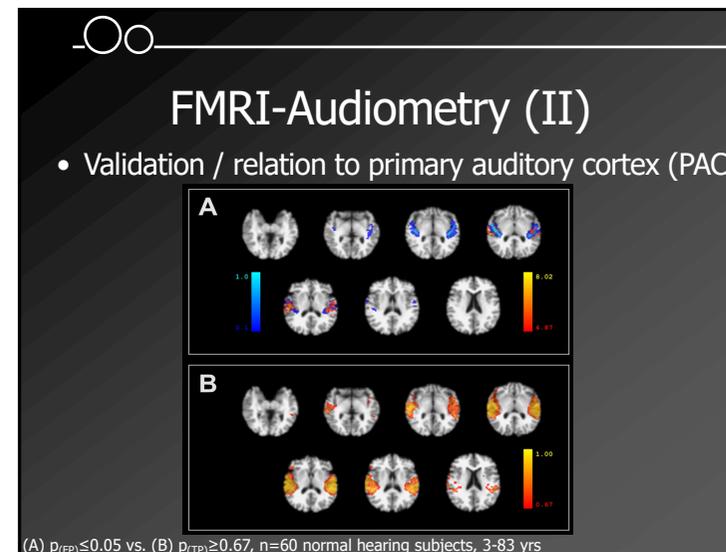
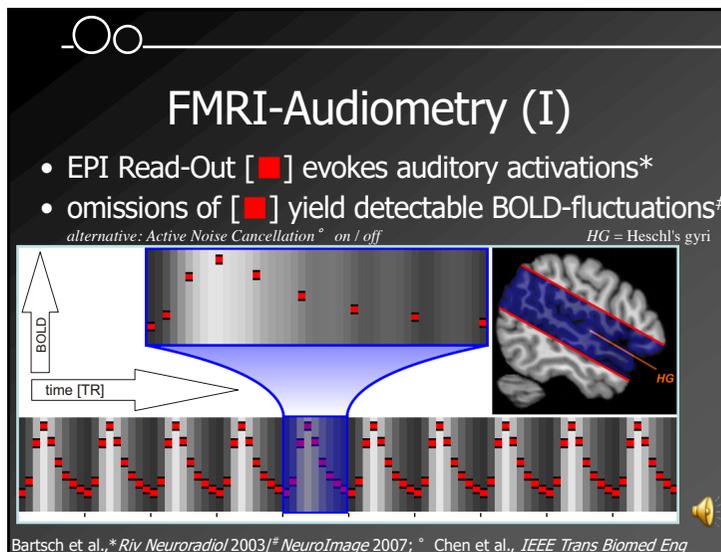
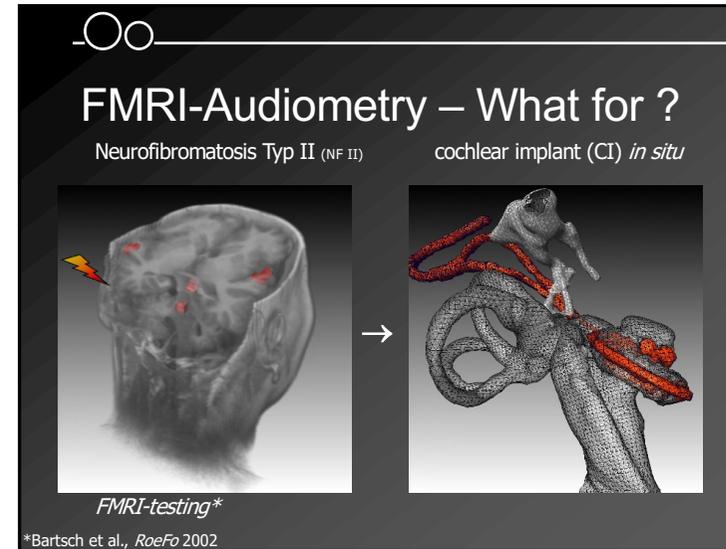
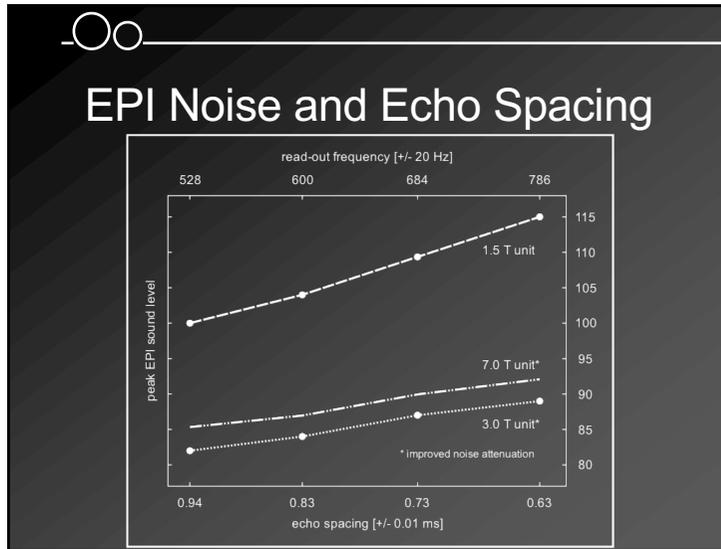
thresholded Z-map

response [normalized units]

pulsed EPI continuous

Haller et al., *Brain Res* 2009

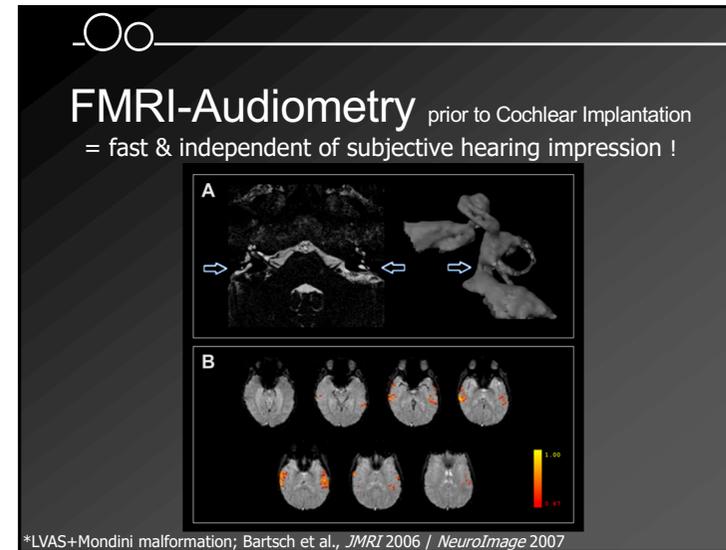




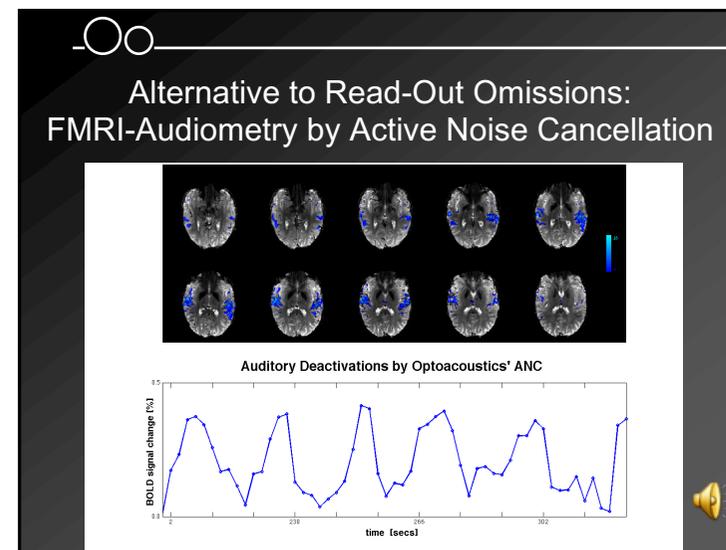
FMRI-Audiometry (III)

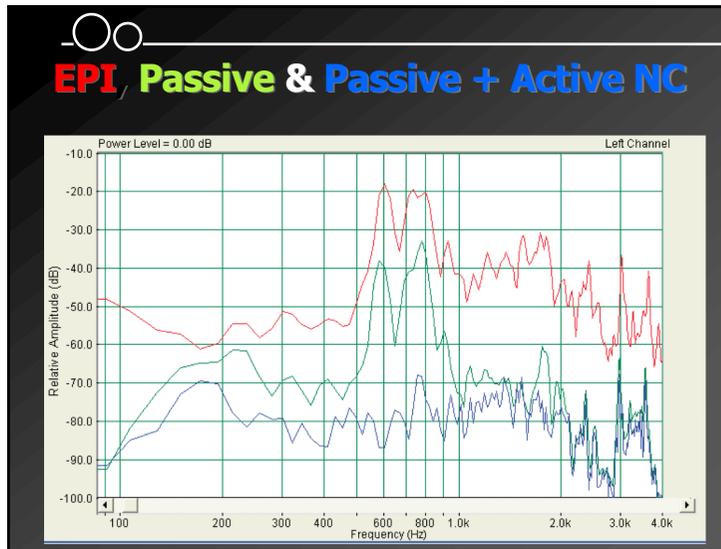
subjects	no complete deafness	FMRI-sensitivity	complete deafness	FMRI-specificity
normal hearing / awake (n = 60)	n = 60	97 %	none	-
SNHL / awake (n = 36)	n = 33 (at least unilateral residual hearing)	94 %	n = 2	100 %
SNHL / sedated (n = 12, propofol)	n = 9 (at least unilateral residual hearing)	≥ 78 %	none	-

Bartsch et al., *DGMR* 2007 (Kurt-Decker-Price)



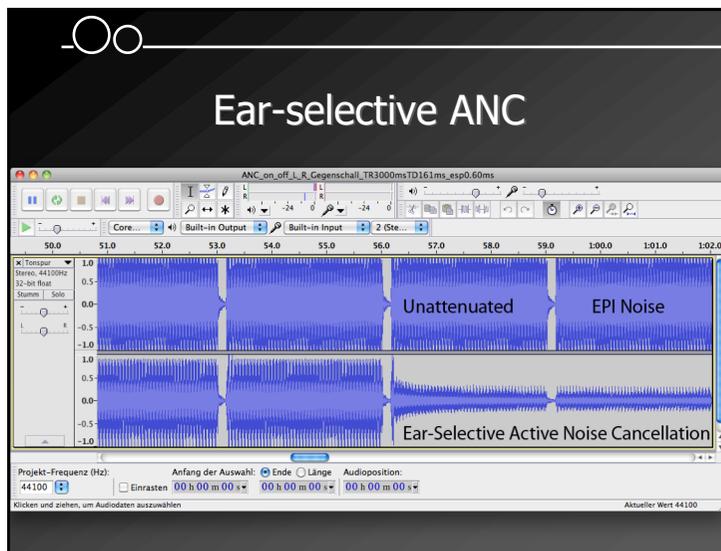
- ## Disadvantages of Read-Outs and their Omission
- Auditory Discomfort (*related to Read-Outs*)
 - Startle Movements (*related Read-Outs*)
 - Sparse Sampling (*related to Read-Out Omissions*)
 - Ear-unselective (*both*)



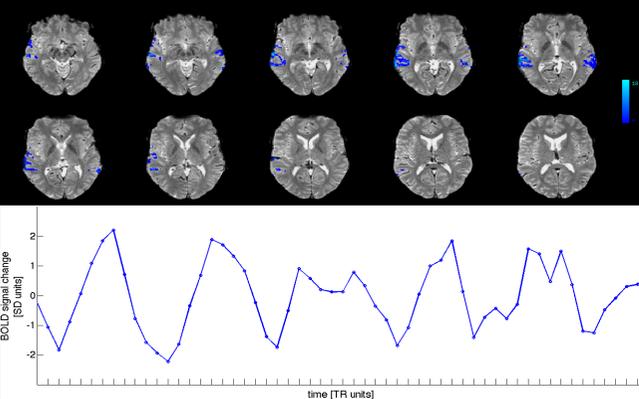


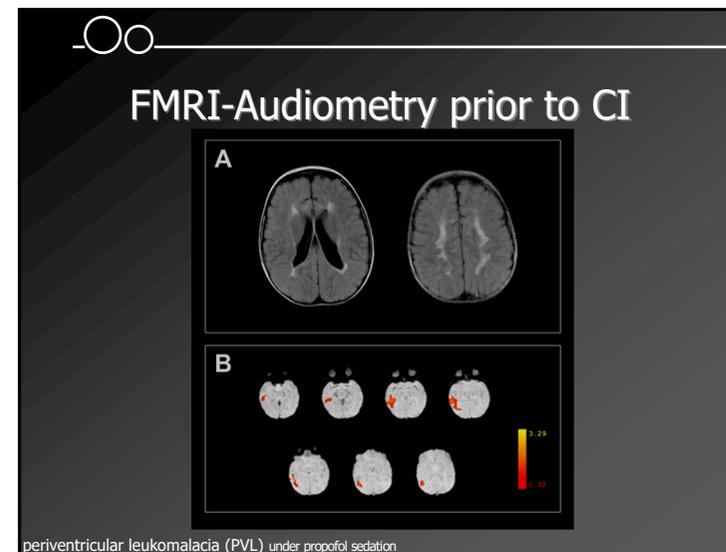
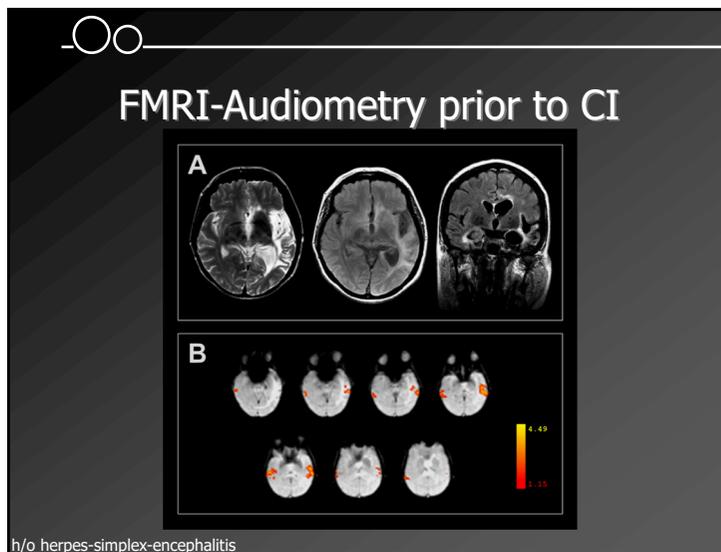
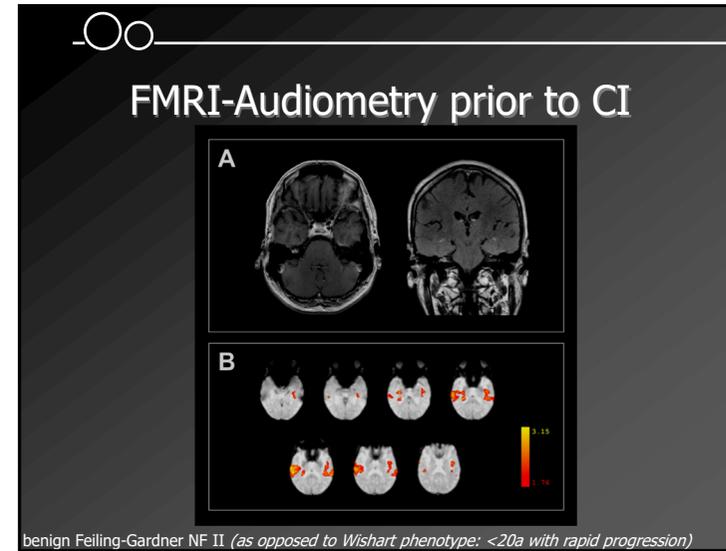
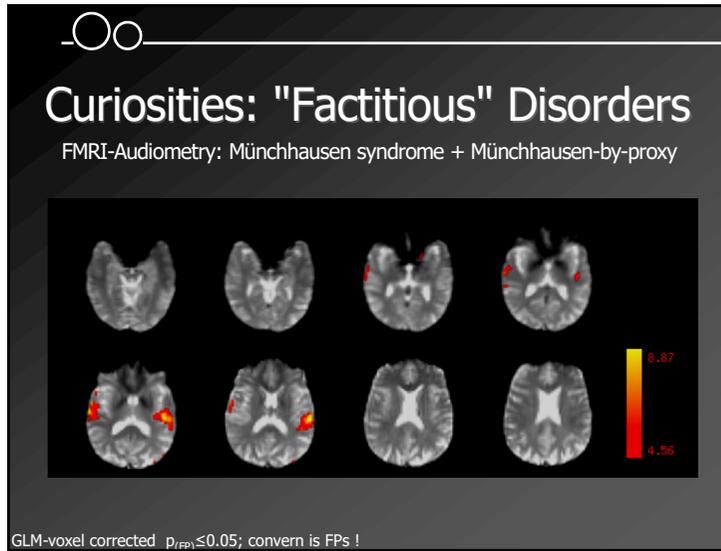
Advantages of ANC

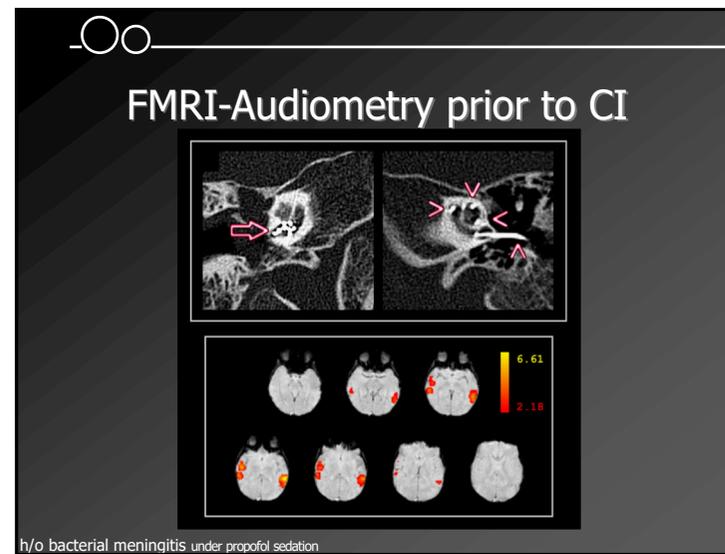
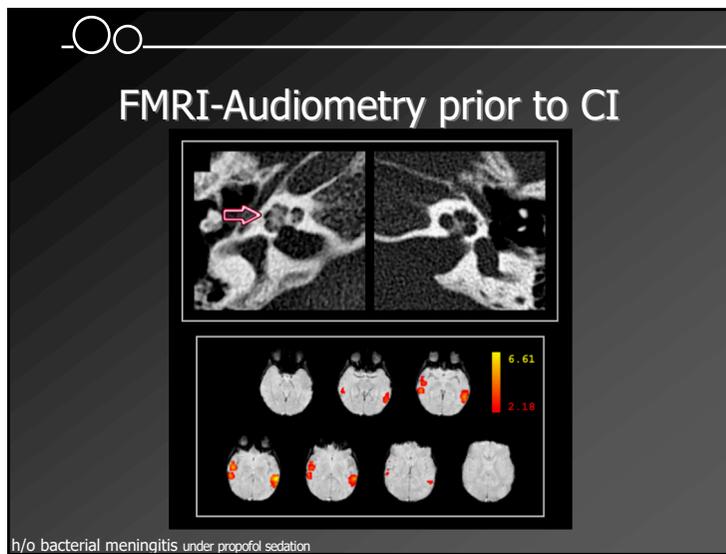
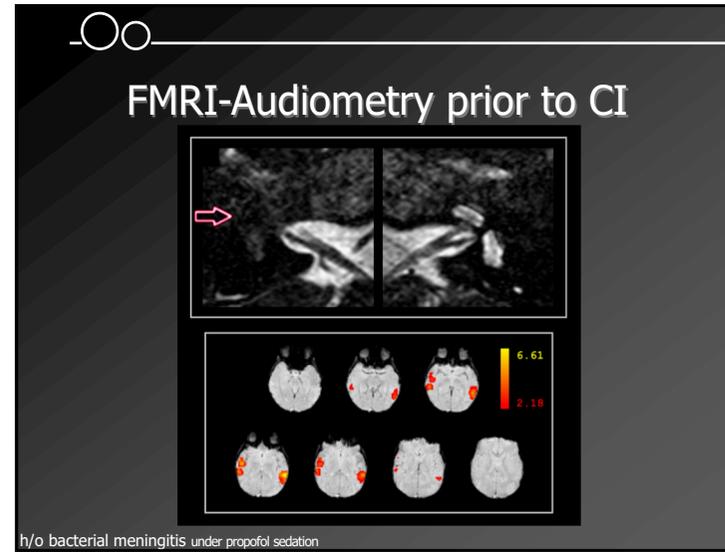
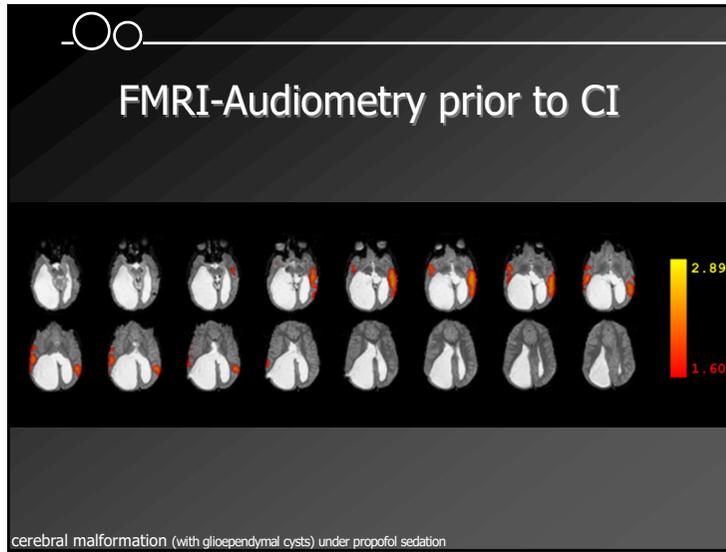
- Patient / subject comfort
- Minimizes startle movements
- Facilitates transmission of auditory stimuli
- Continuous recording, no sparse sampling
- Ear-selective application possible

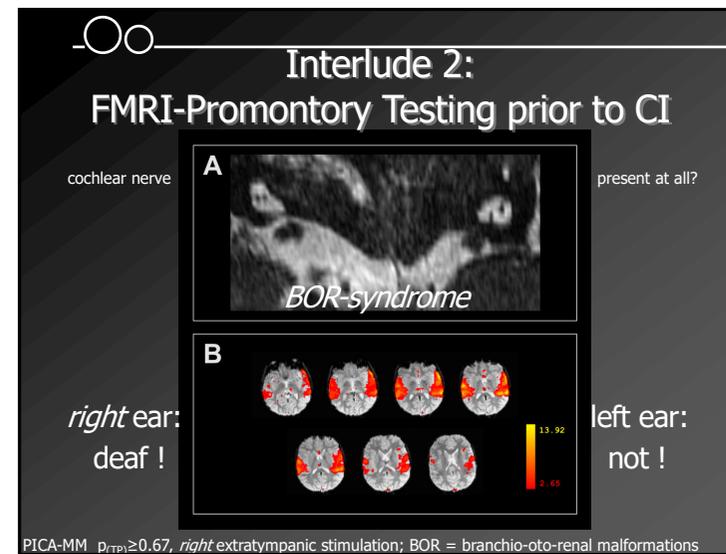
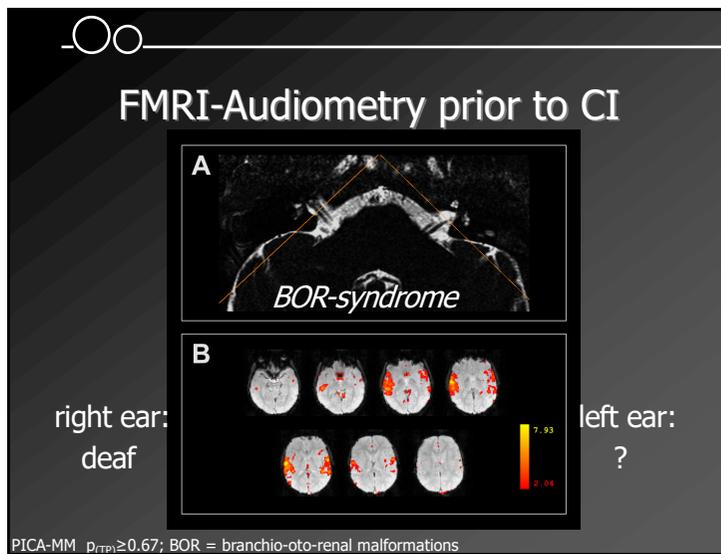
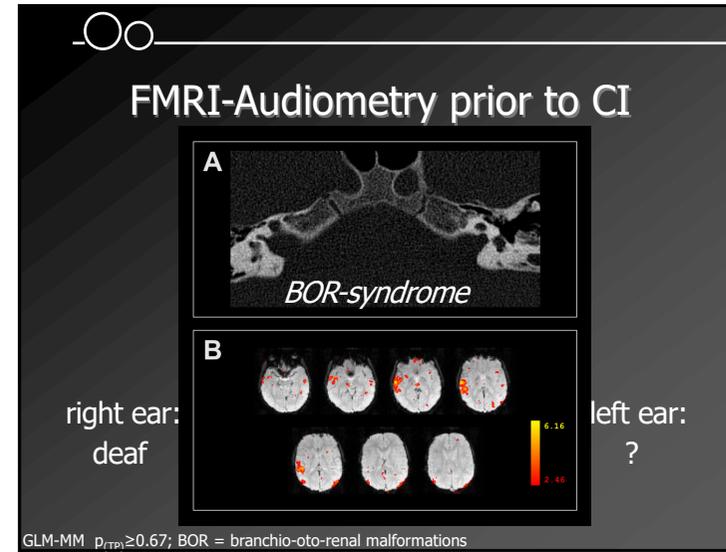
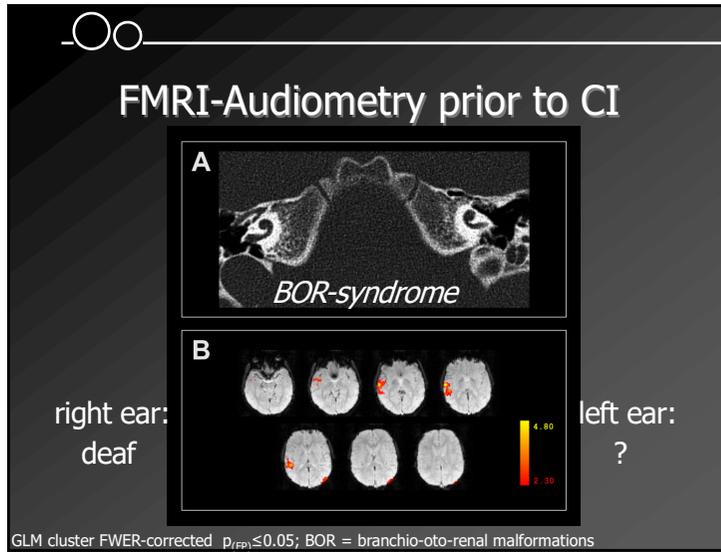


Ear-selective FMRI-Audiometry









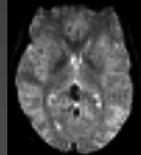
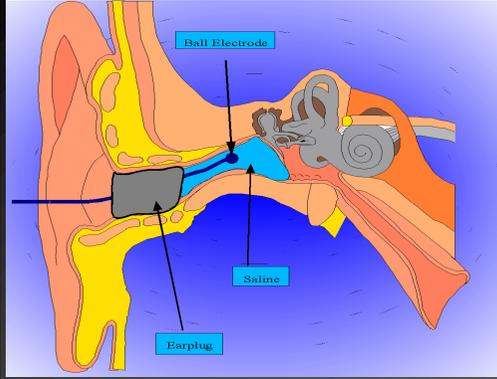
History of Promontory Testing (PT)

Alessandro Volta self-test ~ 1800



*1745, suffering from presbycusis ?

Extra- vs. Transtympanic PT



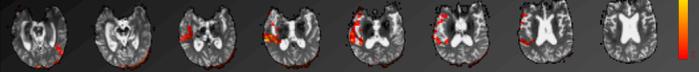
Hofmann et al., *AJNR* 1999; Obler et al., *MRM* 1999

Extratympanic PT prior to CI

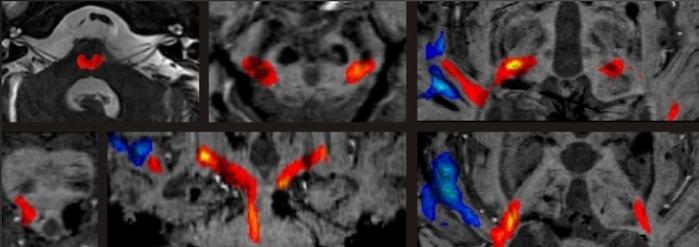


Combining Functional & Diffusion-weighted EPI

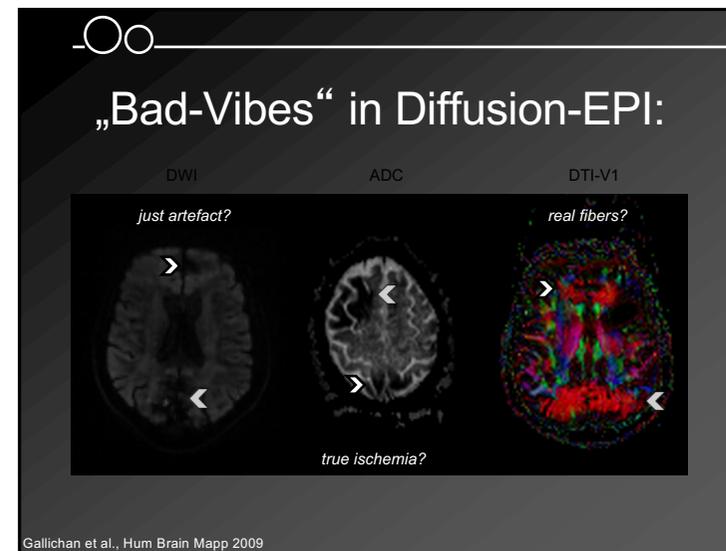
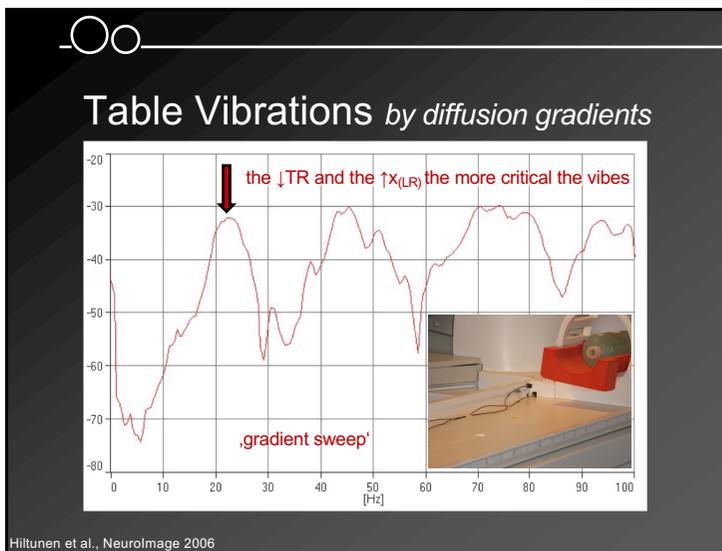
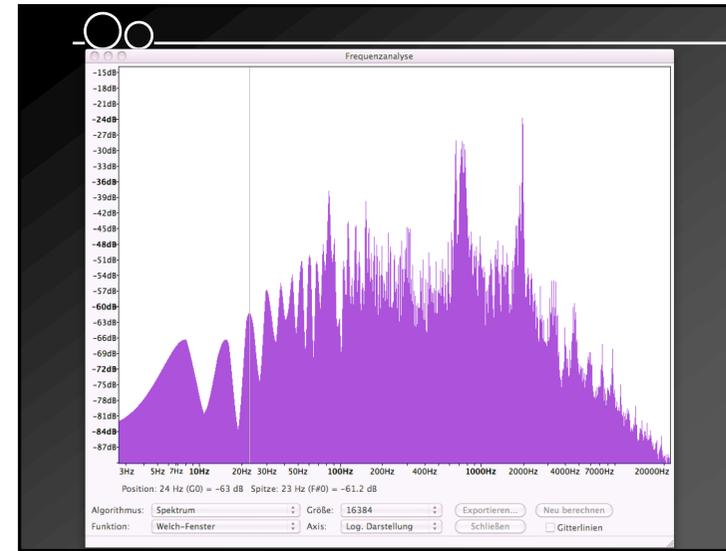
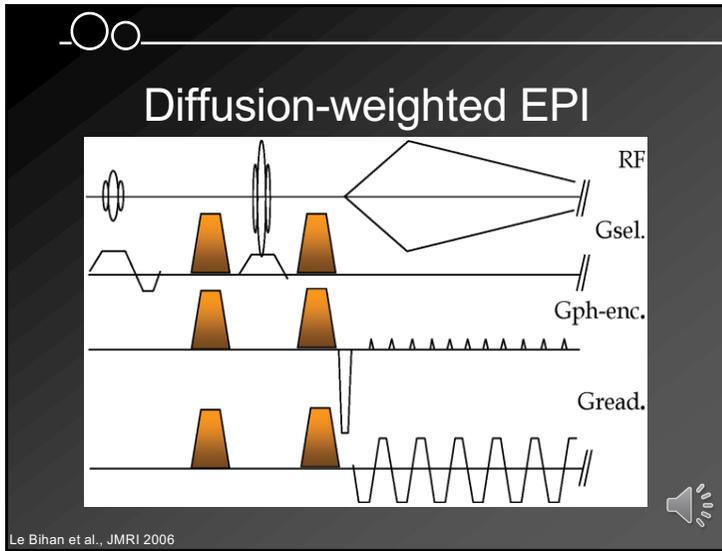
Diffuse Axonal Injury after MVA, FMRI-Audiometry (red-yellow)



extratympanic FMRI-PT left (blue-lightblue) in propofol sedation + radiatio acoustica (red-yellow)



Bartsch et al., 2009 (in Johansen-Berg / Behrens: Diffusion MRI, Elsevier)



„Bad-Vibes“: False-negative Diffusion-EPIs

3 Tesla, $b = 1000\text{s/mm}^2$
acute embolic stroke
clinically silent

no DW: B0

DW: L>>R (x) A>>P (y)

Magnitude Image

k-Space

Gallichan et al., ISMRM & Hum Brain Mapp 2009

„Bad-Vibes“: Avoiding the Artefact

- Data Acquisition:
 - increase TR
 - scan full k-space (no partial Fourier, TE_{\downarrow} by PPI)
 - NE1+2 ?

Magnitude Phase k-Space

Standard setup

Double TR

Gallichan et al., ISMRM & Hum Brain Mapp 2009

„Bad-Vibes“: Avoiding the Artefact

- Scanner / Table Upgrades

1: anterior rolls on the body-coil (isocenter)
2: middle rolls
3: elevation angle *
→ 'dancing feet'

SNR vs. Hz

gms
gms
"loosening"

* by courtesy of Siemens Medical Solutions

„Bad-Vibes“: Eliminating the Artefact

- mathematically: --cni flag in dtifit (part of FSL; www.fmrib.ox.ac.uk/fsl/)

$$\begin{pmatrix} \ln(S_1) \\ \ln(S_2) \end{pmatrix} = \begin{pmatrix} -b_{e,1} - b_{f,1} - b_{g,1} - 2b_{h,1} - 2b_{i,1} - 2b_{j,1} - 2b_{k,1} - 1 \ln(A(r_{e,1})) \\ -b_{e,2} - b_{f,2} - b_{g,2} - 2b_{h,2} - 2b_{i,2} - 2b_{j,2} - 2b_{k,2} - 1 \ln(A(r_{e,2})) \end{pmatrix}$$

$$\begin{pmatrix} D_e \\ D_f \\ D_g \\ D_h \\ D_i \\ D_j \\ D_k \\ \ln(S_e) \\ k \end{pmatrix}$$

Gallichan et al., ISMRM & Hum Brain Mapp 2009

„Bad-Vibes“: Misinterpretation of the Artefact

Voss et al., JCI 2006 (Impact factor: 14 !)

„Bad-Vibes“: Misinterpretation of the Artefact

transitional stage of axonal regrowth –
the fall of a medical dogma ?

Voss et al., JCI 2006 (Impact factor: 14 !)

Is Our Scanner Affected ??

Lesson: Do not just save the TRACE !

„Bad-Vibes“ in Diffusion-EPI can:

- **mask** diffusion abnormalities / ischemic strokes
- **mimic** diffusion abnormalities / ischemic strokes
- cause **false-positive** DTI results / fibre trackings

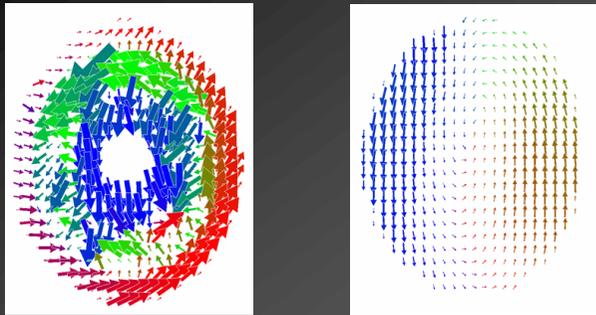
but can such vibes be used ?

T_{able-}R_{esonance-}E_{lastography} with MR =

„Turning the Bad into Good Vibes“

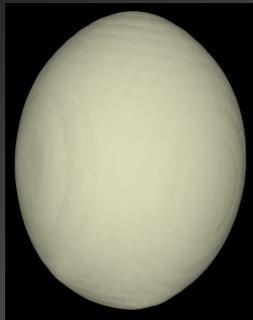
○○

How stiff is our Brain ?



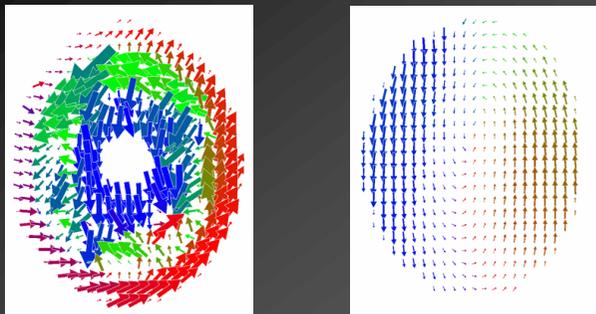
○○

How do *you* like your egg ?



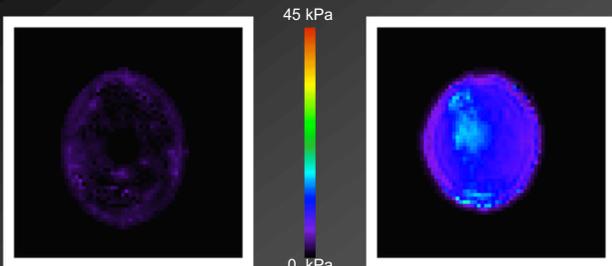
○○

Soft- or Hard-Boiled ?

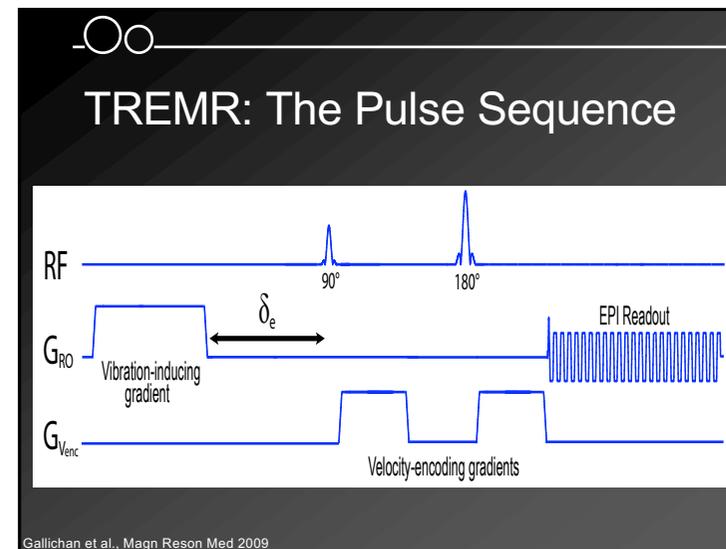
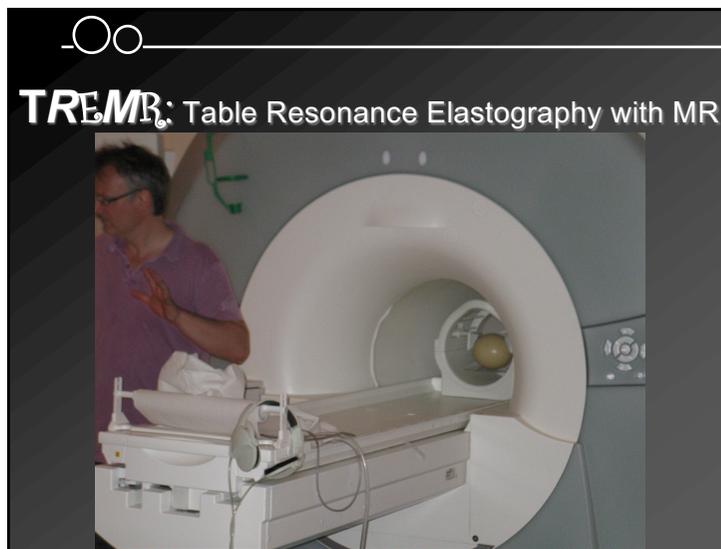
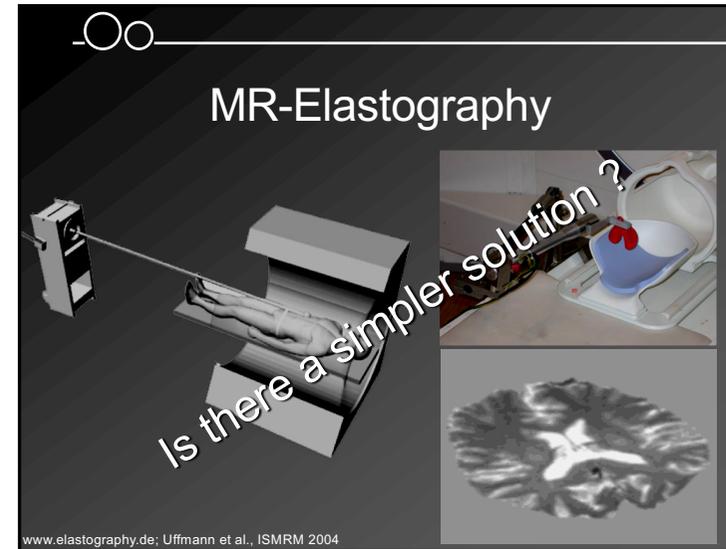
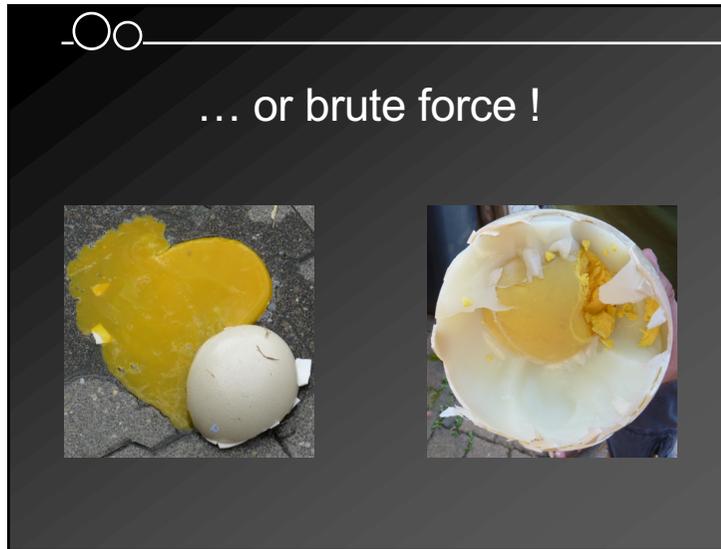


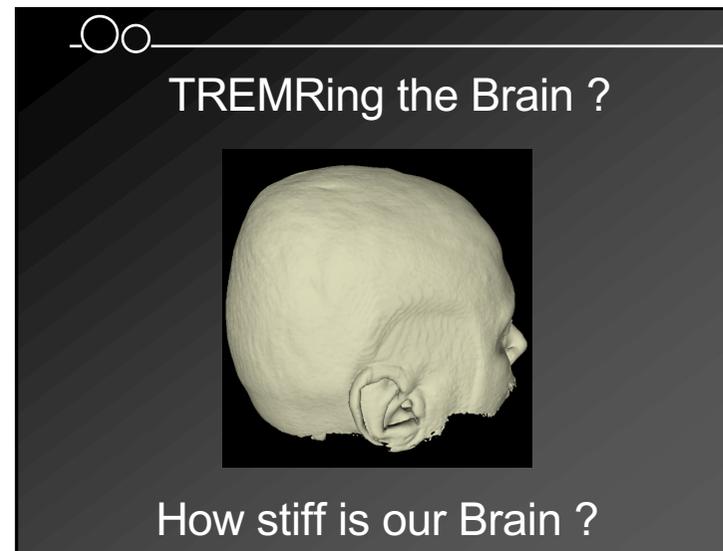
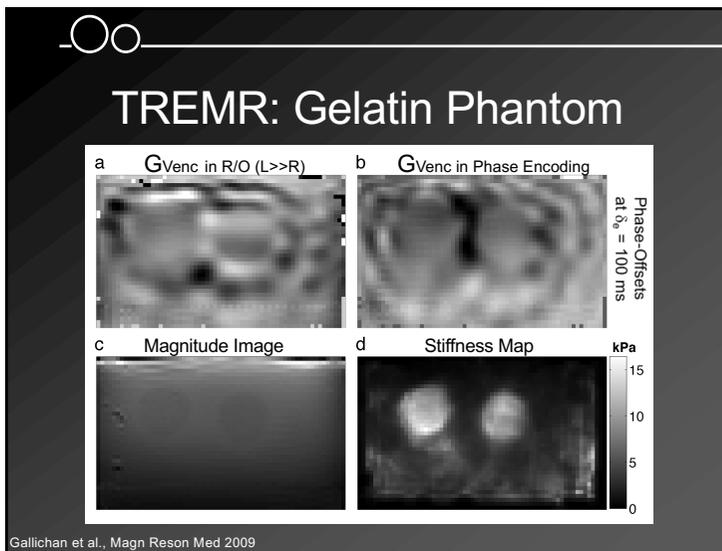
○○

A Case for MR-Elastography ...



35'-boiled ostrich eggs 105'-boiled



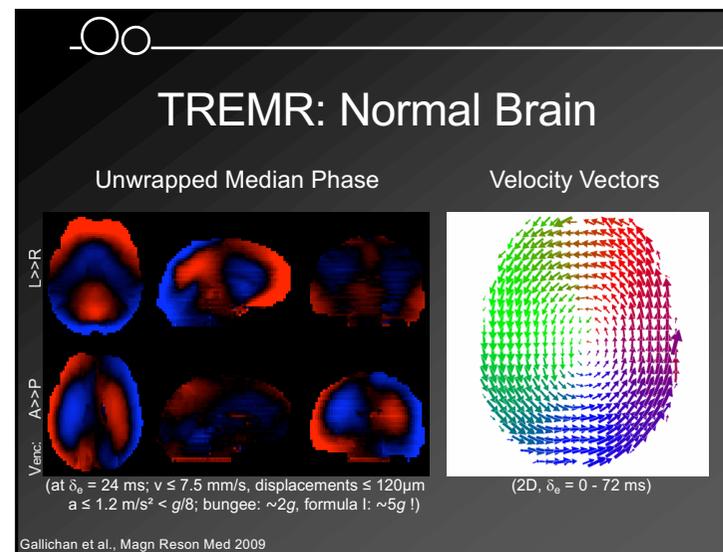


DON'T PANIC !

42

*The Ultimate Answer: "That's it. That's all there is."
"I always thought something was fundamentally wrong with the..."
brain ?*

Adams, 1980 & 1993

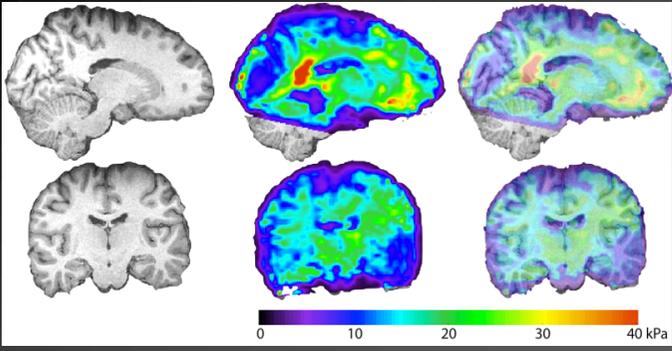


TREMR: No Need to be Afraid!



(at $\delta_0 = 24$ ms; $v \leq 7.5$ mm/s, displacements $\leq 120\mu\text{m}$
 $a \leq 1.2$ m/s² < $g/8$; bungee: $\sim 2g$, formula 1: $\sim 5g$!)

TREMR: Normal Brain



Gallichan et al., Magn Reson Med 2009

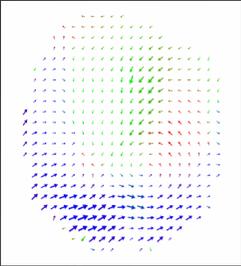
TREMR: Pathology?

Phase Images



(L>>R)

Velocity Vectors



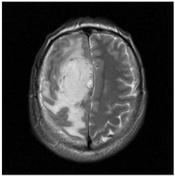
(2D, $\delta_c = 0 - 72$ ms)

TREMR: Meningeoma

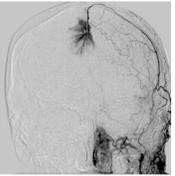
a T1 (Gd+)



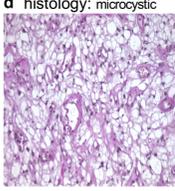
b T2



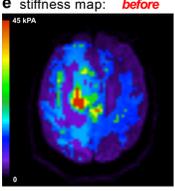
c ACE ii



d histology: microcystic

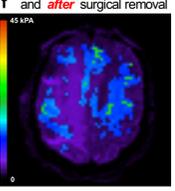


e stiffness map: *before*

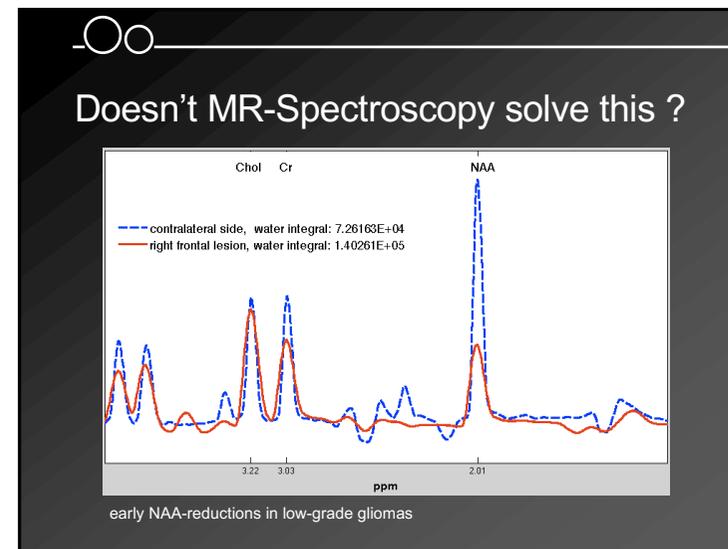
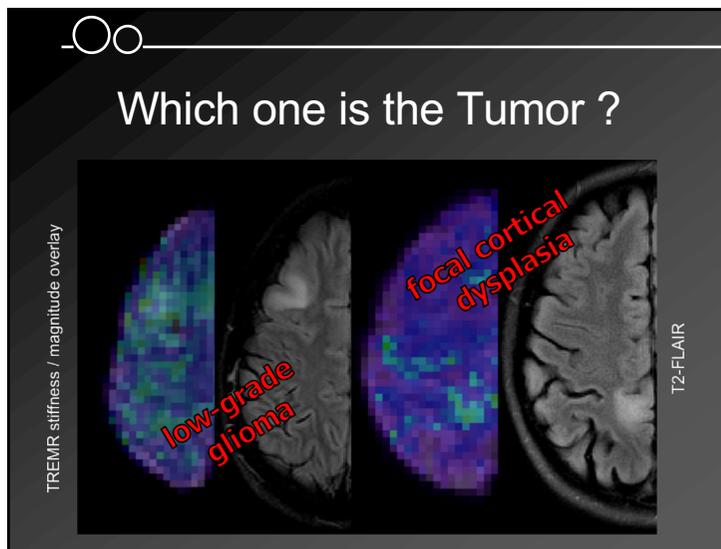
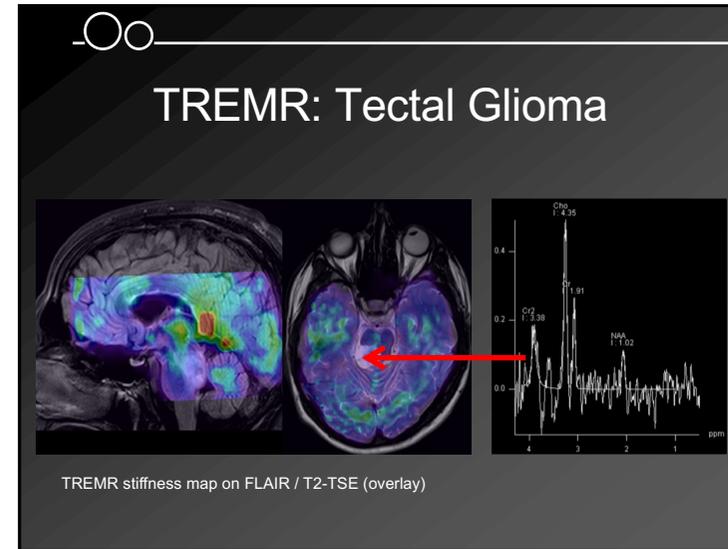
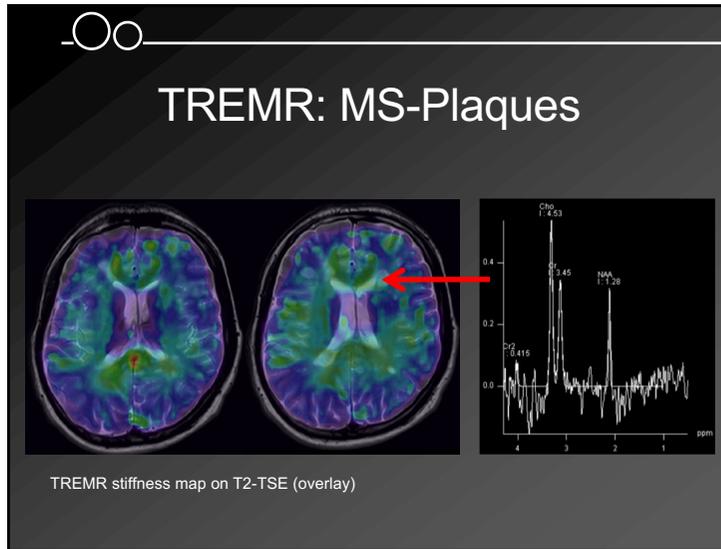


45 kPa

f and *after* surgical removal

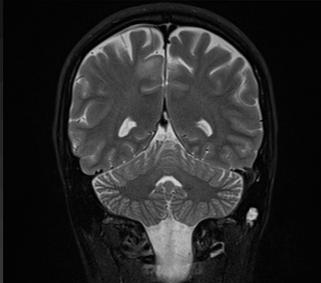


45 kPa

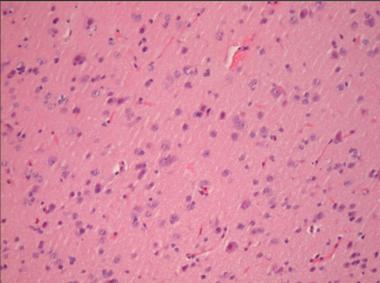


Histology of FCDs ?

FCD

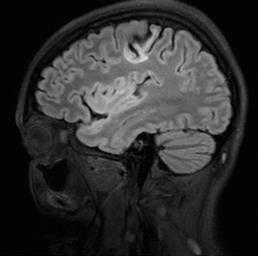
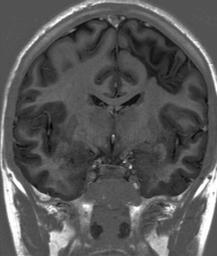
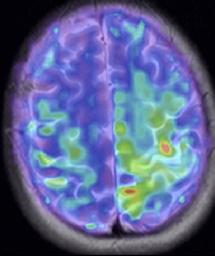


Hematoxylin-Eosin Stain



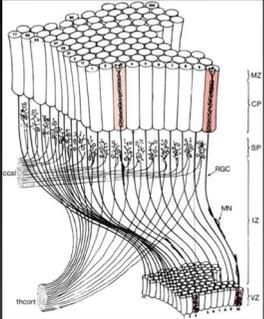
... is largely reminiscent of cortical tubers in tuberous sclerosis !

Tumor ? Or Infarction ??

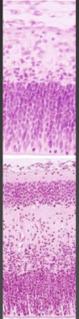
Another stiff FCD !

Why are FCDs stiff ?

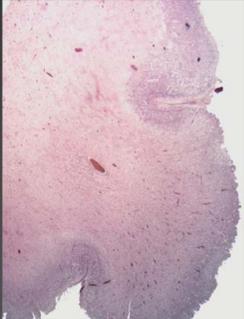


protocortex*

7. GW



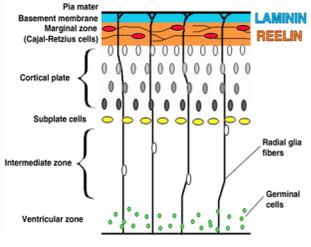
11. GW

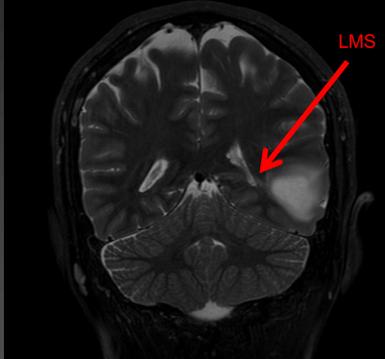


TSC

*Rakic, Science 1988; Taylor et al., JNNP 1971; Yasin et al., Acta Neuropathol 2010

And what about DNETs ?





LMS

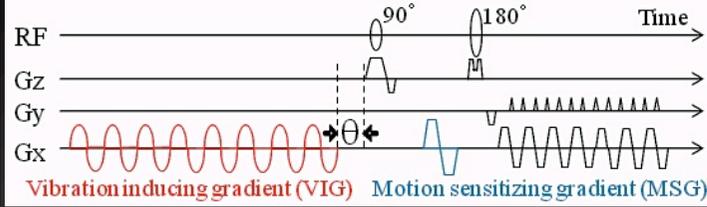
... we don't know yet.

TREMR: Limitations

- by-product of vibrations from MR gradient switching
- glitches in unwrapped phase data
- stiffness maps: semiquantitative, limited resolution, "smooth"
- table vibrations limited to 15-30 Hz resonance, yet these seem to be sufficient even after "decoupling"

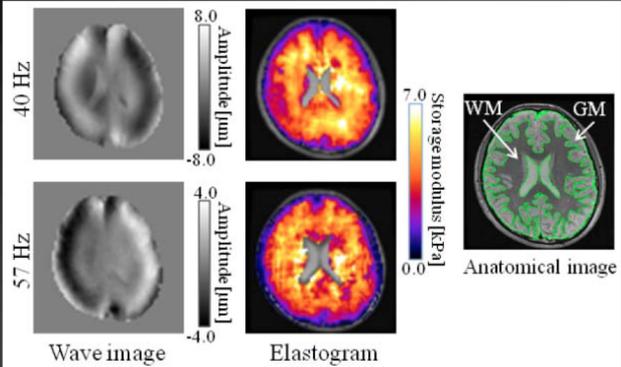


TREMR: The New Pulse Sequence

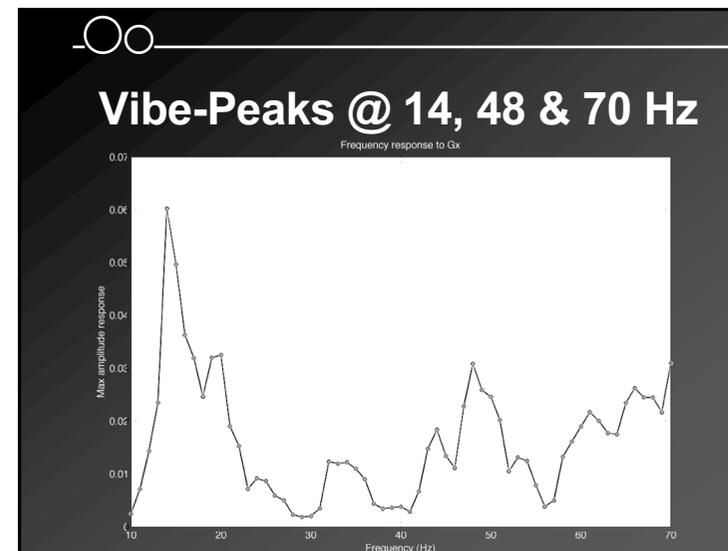


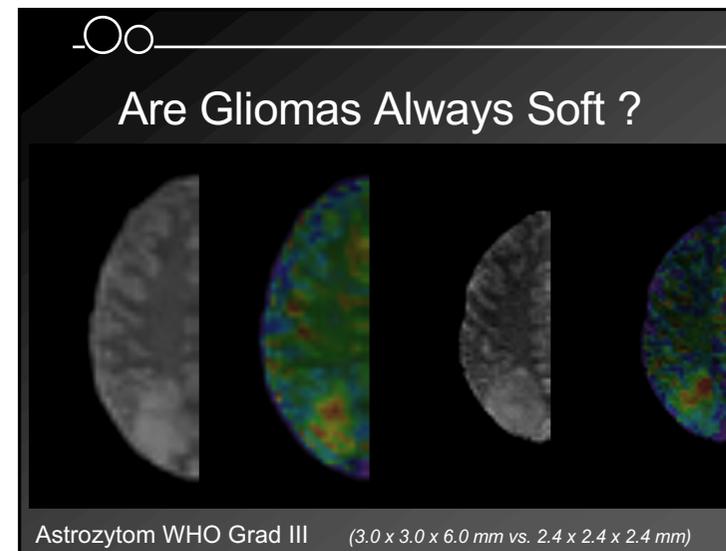
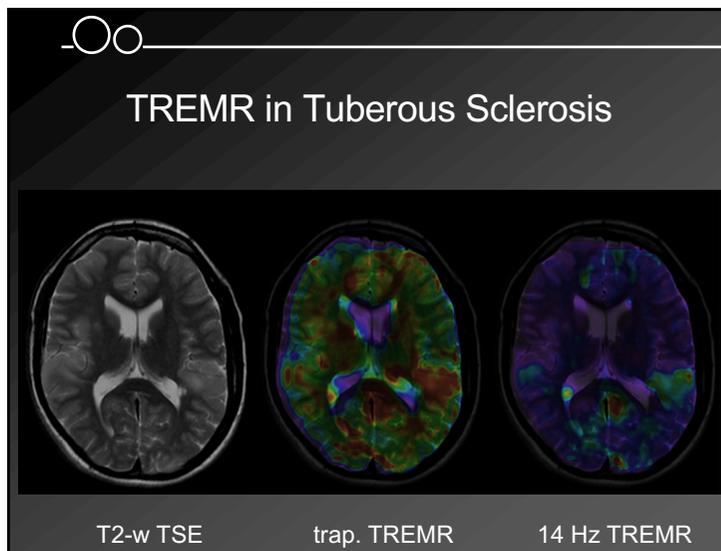
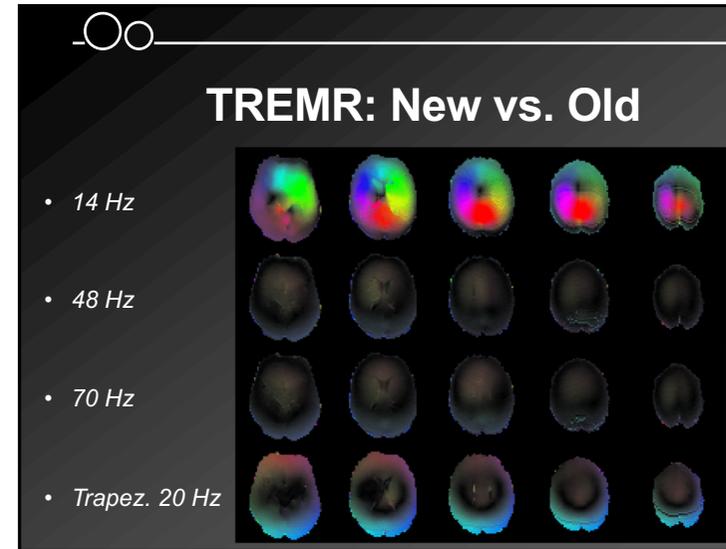
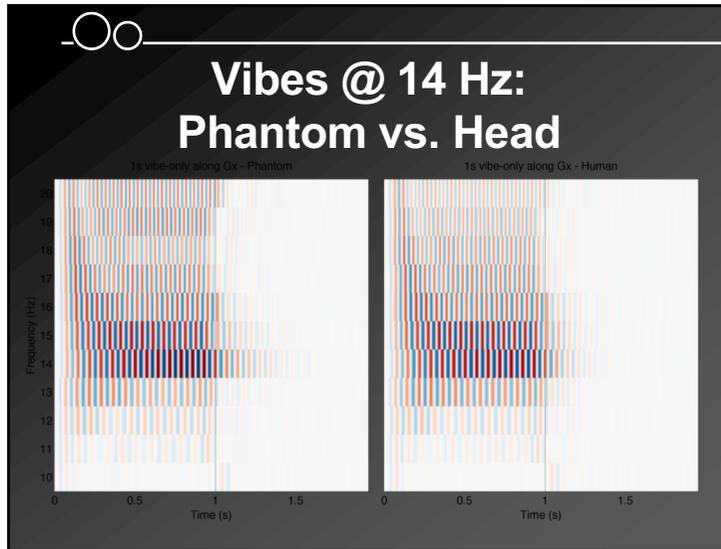
Suga et al., ISMRM 2012

TREMR: The New Pulse Sequence



Suga et al., ISMRM 2012





“Take-Home” Messages:
Mechanical Vibes

Table Vibrations for TREMR	Mono-/multifrequent Exc., reproducible
1	2
3	+

No „differentia specifica“ between FCDs and glioma!
Are there „soft“ FCDs?

Relevance:
surgical strategy – „supporting suture“ vs. sonographic aspiration?

The Egg of the Columbus

uncooked ostrich egg

left / right gradient

Who finds the missing "O"?

TREMOR

Finally...

There's Optimus Prime..
and then there's his retarded cousin Larry

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