Cost B21
Physiological Modelling of MR Image Formation
Szeged - Hungary

18th March 2005

WG I: Measuring Techniques:

Tissue Parameters and Physiological Data

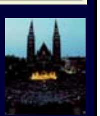
AGENDA, Szeged, Hungary March 18, 2005

Working Group 1 – Measuring Techniques:
Tissue Parameters and Physiological Data

8.55	Introduction and Draft Agenda for WG 1 Jürgen R. Reichenbach (D)
9.00	~~From 3 T to 7 T: Perspectives in brain and whole body imaging~~ ~~E. Moser (A)~~
9.20	High resolution neuro-imaging in animal models R. Dommisse (B)
9:40	~~MR characterisation of minor brain damage in children born prematurely~~ ~~O. Haraldseth (NO)~~
10:00	Recent advances in SWI J.R. Reichenbach (D)
10:20	***Discussion***
10.30	***Coffee***

AGENDA, Szeged, Hungary March 18, 2005

Working Group 1 – Measuring Techniques:
Tissue Parameters and Physiological Data



8.55	Introduction and Draft Agenda for WG 1 Jürgen R. Reichenbach (D)
9.00	High resolution neuro-imaging in animal models R. Dommisse (B)
9.30	Radial Techniques for Sodium Magnetic Resonance Imaging L.R. Schad (D)
10:00	Recent advances in SWI J.R. Reichenbach (D)
10:20	***Discussion***
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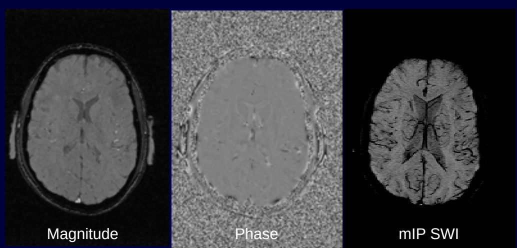
Recent Advances in SWI

J.R. Reichenbach

Institut für Diagnostische und Interventionelle Radiologie
Friedrich-Schiller-Universität Jena, Germany

Susceptibility-Weighted Imaging (SWI)

Combining Magnitude with Phase Information



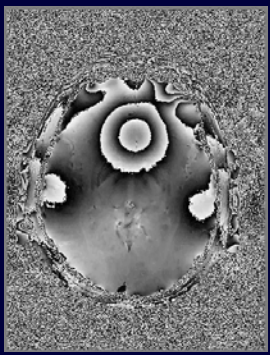
– resolution 0.5 x 0.65 x 1.5 mm^3
– conventionally acquired with a single TE

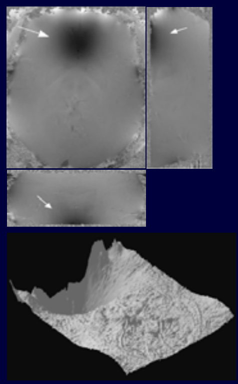
Reichenbach JR et al., MAGMA, 1998, 6(1), 62-9

Application

Phase Imaging

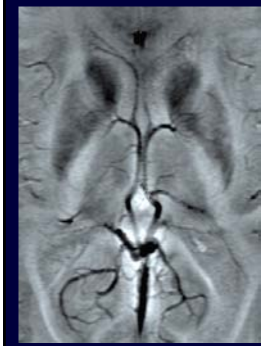
Phase Unwrapping

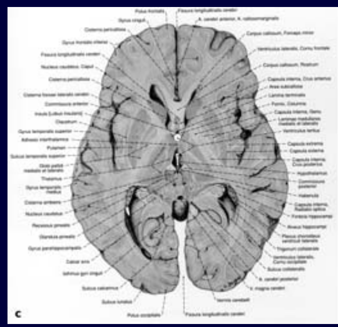




Rauscher A, Barth M, Reichenbach JR, Stollberger R, Moser E. J Magn Reson Imaging 2003 ,18:175-180

Phase Imaging



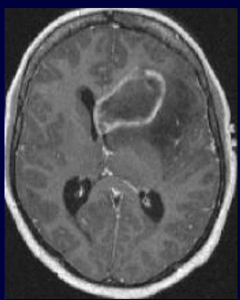


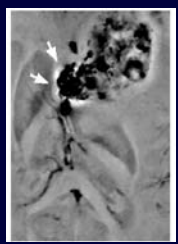
TR/TE/α=60/43/25, matrix 512 x 256, 48 Schichten á 2 mm
phase unwrapping

A. Rauscher, J. Sedlacik, M. Barth, H.-J. Mentzel, J.R. Reichenbach. AJNR Am J Neuroradiol 2005, *in press*

Tumor

Female patient with a glioblastoma multiforme



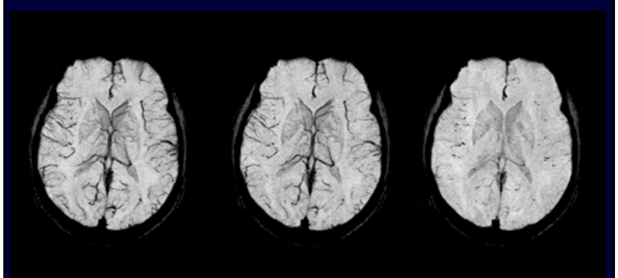


A. Rauscher, J. Sedlacik, M. Barth, H.-J. Mentzel, J.R. Reichenbach. AJNR Am J Neuroradiol 2005, *in press*

Application

Exogeneous Gases

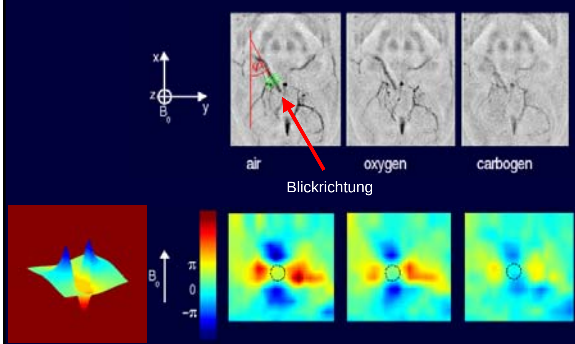
Venograms



Air	Oxygen (100 % O_2)	Carbogen (95 %O_2, 5 % CO_2)

A. Rauscher, J. Sedlacik, M. Barth, E.M. Haacke, J.R. Reichenbach. Magn Reson Med 2005, *in press*

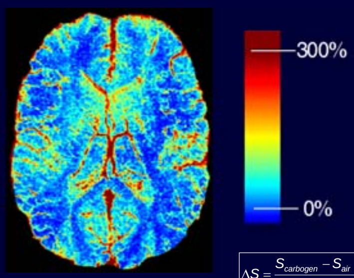
Visualisation of Field Distribution *In Vivo*



A. Rauscher, J. Sedlacik, M. Barth, E.M. Haacke, J.R. Reichenbach. Magn Reson Med 2005, *in press*

Signal Changes between Air and Carbogen

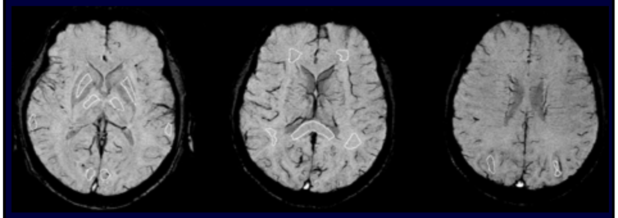
MIP over 10 mm



$$\Delta S = \frac{S_{carbogen} - S_{air}}{S_{air}} \cdot 100\%$$

A. Rauscher, J. Sedlacik, M. Barth, E.M. Haacke, J.R. Reichenbach. Magn Reson Med 2005, *in press*

Quantitative Analysis



A. Rauscher, J. Sedlacik, M. Barth, E.M. Haacke, J.R. Reichenbach. Magn Reson Med 2005, *in press*

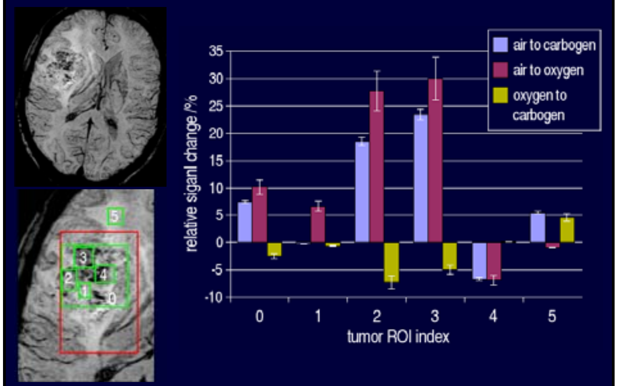
Quantitative Analysis

	occp gm		occp gm o		occ gm 1		putamen	
	L	R	L	R	L	R	L	R
a → c	5.7±1.5*	6.8±1.2*	6.4±0.9*	9.5±1.4*	4.5±1.8*	4.4±1.9*	1.8±1.2	2.6 ±0.9*
a → o	3.4±0.6*	2.1±1.0	2.8±0.6*	4.7±1.2*	0.4±0.9	2.9±1.0*	0.6±0.9	1.3 ±0.8
o → c	2.2±1.1	4.6±0.8*	4.0±0.8*	4.5±0.6*	4.1±1.5	1.5±1.8	1.2±0.9	1.3 ±0.9
a → o + o → c	5.6	6.7	6.8	9.2	4.5	4.4	1.8	2.6

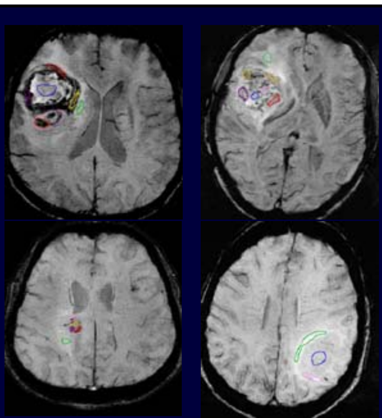
	thalamus		occip wm		frontal wm		splenium
	L	R	L	R	L	R	
a → c	0.3±0.9	4.3±1.9	-3.8±1.7	2.1±1.6	-0.6±0.7	-2.1±0.7*	-1.1±1.1
a → o	0.3±0.4	0.7±1.0	-1.8±0.9	0.9±1.2	-0.9±0.8	-0.4±1.2	0.2±0.7
o → c	0.0±1.0	3.6±1.5	-2.0±1.9	1.3±1.8	0.4±1.1	-1.6±1.4	-1.3±1.2
a → o + o → c	0.3	4.3	-3.8	2.2	-0.5	-2.0	-1.1

A. Rauscher, J. Sedlacik, M. Barth, E.M. Haacke, J.R. Reichenbach. Magn Reson Med 2005, *in press*

Tumor



A. Rauscher, J. Sedlacik, M. Barth, E.M. Haacke, J.R. Reichenbach. Magn Reson Med 2005, *in press*



A. Rauscher, J. Sedlacik, C. Fitzek, B. Walter, A. Hochstetter, R. Kalff, W.A. Kaiser,J.R. Reichenbach; RöFo 2005, *submitted*

Induced Signal Changes

		Glioblastome			Astrozytom
ROI		pat 1	pat 2	pat 3	pat 4
Ödem	(grün)	$-5.0 \pm 0.4^*$	-0.7 ± 0.3	$-2.9 \pm 0.4^*$	$-4.1 \pm 0.1^*$
Tumorzentrum	(blau)	$-3.1 \pm 0.3^*$	$-10.1 \pm 0.5^*$	—	$-3.1 \pm 0.1^*$
	(pink)	$12.7 \pm 0.6^*$	$-5.3 \pm 0.5^*$	$-8.6 \pm 3.0^*$	$-6.8 \pm 0.3^*$
Tumor-	(gelb)	$12.5 \pm 2.9^*$	$9.9 \pm 0.9^*$	$9.9 \pm 0.9^*$	—
peripherie	(orange)	$24.7 \pm 1.7^*$	$12.4 \pm 0.7^*$	$12.4 \pm 0.7^*$	—
	(rot)	$22.4 \pm 4.9^*$	$15.8 \pm 0.6^*$	$15.8 \pm 0.6^*$	—
	(lila)	$13.1 \pm 4.9^*$	$11.5 \pm 0.7^*$	$11.5 \pm 0.7^*$	—

A. Rauscher, J. Sedlacik, C. Fitzek, B. Walter, A. Hochstetter, R. Kalff, W.A. Kaiser,J.R. Reichenbach; RöFo 2005, *submitted*

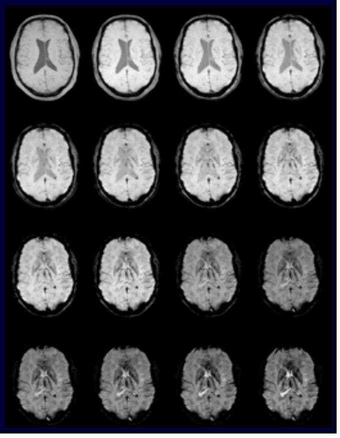
Application

Multi-Echo Acquisition

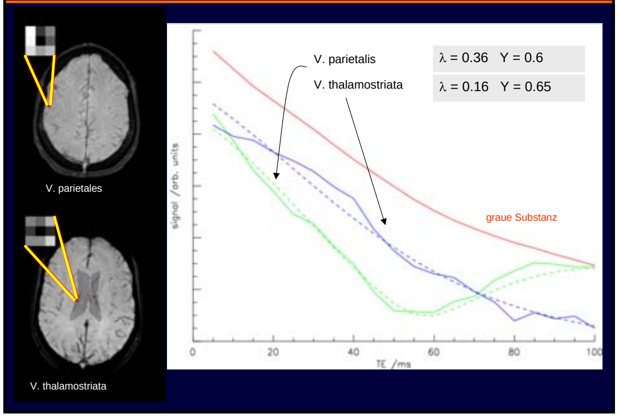
In vivo Measurement

- 1.5 T gradient echo
- flow compensation
- 16 echoes:
  - TE 5 ms - 80 ms, ΔTE = 5 ms
- TR = 80 ms
- α = 25°
- matrix: 256 x 192 x 42
- FoV: 256 x 192 x 96 mm³

mIP SWI



Signal-Time-Courses *In vivo*



MR signal for random cylinders

$$S(TE) = S_0 \cdot (1-\lambda) \cdot e^{-\lambda \cdot f(\delta\omega \cdot TE)} \cdot e^{-TE/T_2}$$

$$\text{mit} \quad f(x) = \frac{1}{3} \cdot \int_0^1 du \cdot (2+u) \cdot \sqrt{1-u} \cdot \frac{1 - J_0\left(\frac{3}{2} \cdot x \cdot u\right)}{u^2}$$

$$\text{und} \quad \delta\omega = \gamma \cdot \frac{1}{3} \cdot \Delta\chi_{do} \cdot (1-Y) \cdot B_0$$

Asymptotische Näherungen:

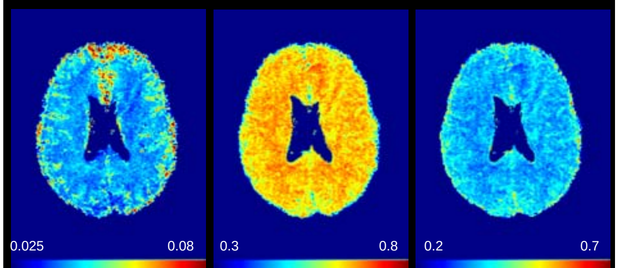
$$S_{short}(TE) = S_0 \cdot (1-\lambda) \cdot e^{-0{,}3 \cdot \lambda \cdot (\delta\omega \cdot TE)^2} \cdot e^{-TE/T_2} \quad \text{für} \quad TE \leq \frac{1{,}5}{\delta\omega}$$

$$S_{long}(TE) = S_0 \cdot (1-\lambda) \cdot e^{-(\lambda \cdot \delta\omega) \cdot \left|TE - \frac{1}{\delta\omega}\right|} \cdot e^{-TE/T_2} \quad \text{für} \quad TE \geq \frac{1{,}5}{\delta\omega}$$

$$\text{mit} \quad \delta\omega = \gamma \cdot \frac{1}{3} \cdot \Delta\chi_{do} \cdot (1-Y) \cdot B_0$$

Yablonskiy DA, Haacke EM. Magn Reson Med. 1994;32(6):749-63.

Results



λ Y OEF

Application

Caffeine

Introduction / Purpose

- Caffeine enhances the BOLD effect, as shown by fMRI studies
- BOLD is the underlying principle of vascular contrast in SWI
- to investigate the potential of caffeine to improve contrast in SWI
- to reduce scan time

Methods / Measurement

- 5 volunteers
- T_2*-weighted, velocity compensated, 3D gradient echo sequence (1.5 T)
  - TE / TR = 40/67, 30/50 or 20/34 ms
  - $\alpha = 15°$
  - FOV = 256 x 192 x 48 mm^3
  - matrix = 512 x 256 x 32

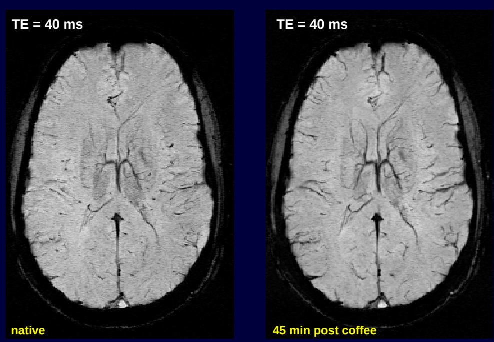
Methods / Measurement

Measurement protocol:

- long scan = 10 min (TE = 40 ms, n = 2)
- shorter scans = 5 min (TE = 20 ms, n = 2) or
  7 min (TE = 30 ms, n = 1)
- Application of approx. 300 mg caffeine
- repeated acquisition up to 45 min

Results / SWI mIP

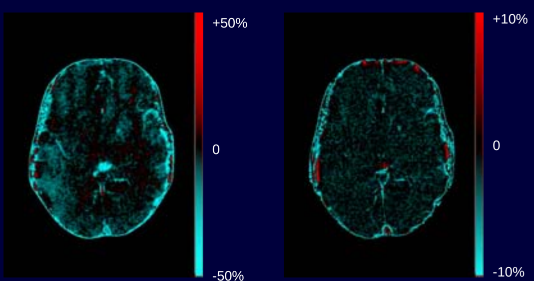
Minimum Intensity Projection (mIP) of SWI data over a 7.5 mm thick slab



Results / Relative Maps

Native *vs.* 45 min post coffee

TE = 40 ms

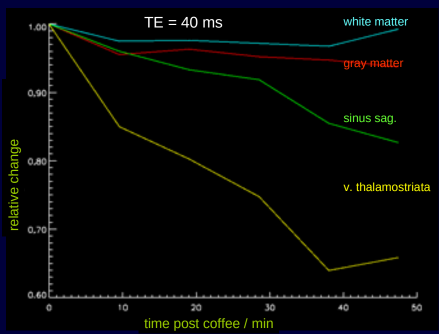


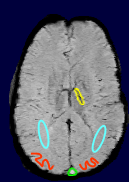
relative signal changes

relative phase changes

Results / Dynamics

Relative changes of magnitude as a function of time post coffee

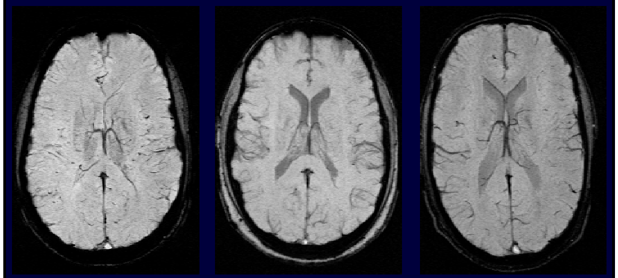




Results / mIP-SWI

Minimum Intensity Projection (mIP) of SWI data
over a 7.5 mm thick slab

TE = 40 ms | TE = 20 ms | TE = 30 ms



native | 45 min post coffee | 45 min post coffee

Discussion

- Phase is of great importance
- SWI has clinical potential
- Induced physiological changes lead to contrast changes (carbogen, caffeine)
- Caffeine as a “contrast booster” (time savings)
- Multi echo SWI allows extraction of physiological parameters
- Further studies are necessary for validation

Acknowledgement

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COST-STSM-B21-00305

COST-STSM-B21-00690

COST-STSM-B21-00861