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Comparison of calibrated fMRI with calibration factor M determined by hypercapnia vs. gas-free R2'

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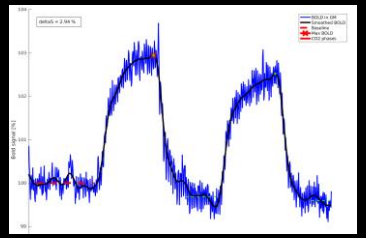
BOLD signal at hypercapnia



Session: **Probing Physiology with fMRI**

Q&A: **Thursday Parallel 4**
fMRI Physiology
Thursday, August 13, 2020
14:20 – 15:05 (UTC)

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Declaration of Financial Interests or Relationships

Speaker Name: Stephan Kaczmarz

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

Motivation

Background

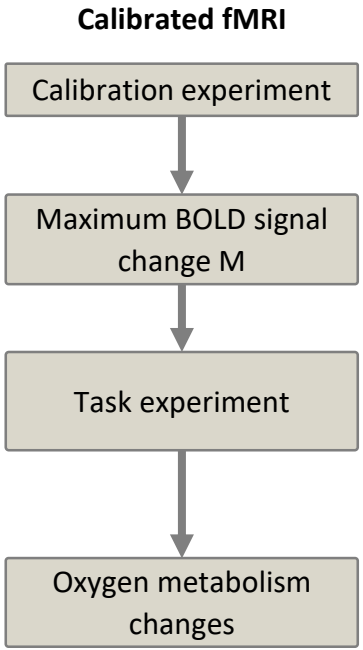
- BOLD effect[1,2] to map human brain function[3]
- Calibrated fMRI to quantify oxygen metabolism changes[3-6]
- Established measurements of BOLD and perfusion changes during hypercapnia[5,6] to calculate calibration factor M based on Davis model[7]

Issue

- Wider applications limited by complicated gas setup[6]
- Alternative gas-free R_2' calibrations[7-9] with systematic deviations[5, 10]

Hypothesis

- Methodological improvements by pseudo-continuous arterial spin labeling (pCASL)[11] with optimized timings[12]
- Improved M factor correlation of hypercapnia vs gas-free R_2'
- Evaluate perfusion effects on calibrated fMRI



[1]Ogawa et al. PNAS 1992; [2]Kwong et al. PNAS 1992; [3]Hoge & Pike, J Chem Neuroanat 2001; [4]Herman et al, ONAS 2013; [5]Blockely et al. NMR Biomed 2013; [6]Blockley et al. NI 2012; [7]Davis et al. PNAS 1998; [7]Yablonskiy & Haacke, MRM, 1994; [8]Shu et al. NI, 2016; [9]Kida et al, JCBFM, 2000; [10]Liu et al. ISMRM 2018; [11]Alsop et al. MRM 2015; [12]Fan et al. JCBFM 2016

Material & Methods

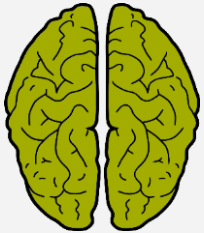
Participants

MRI

- 3T Philips Ingenia Elition
- Software release 5.6

- D-DAS
- 32ch head coil

17 YHC

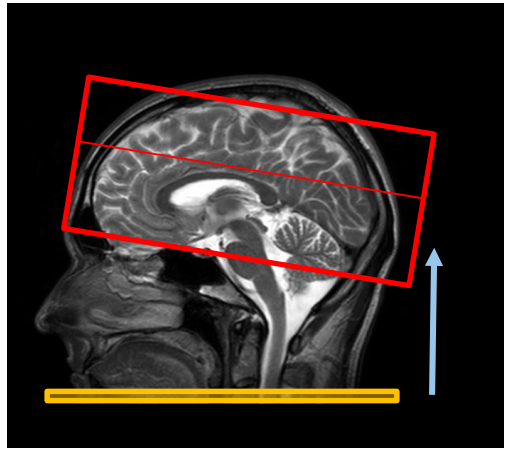


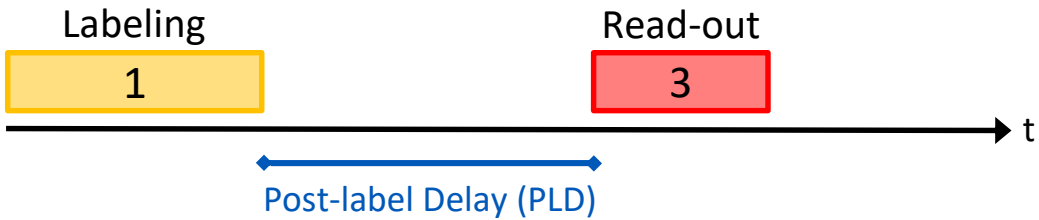
29.3 ± 10.5 y

- **Healthy**
- **No MR contraindications**

Material & Methods

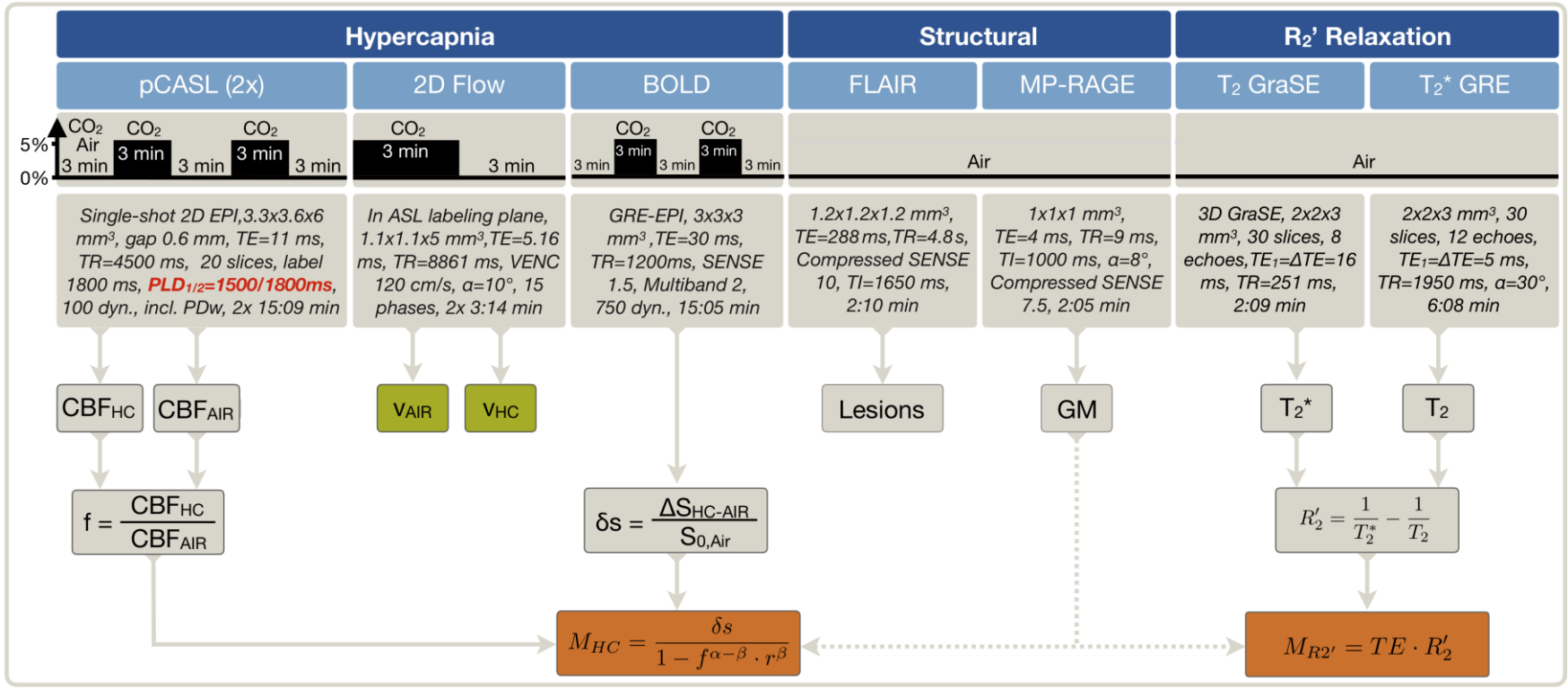
ASL Timings





Material & Methods

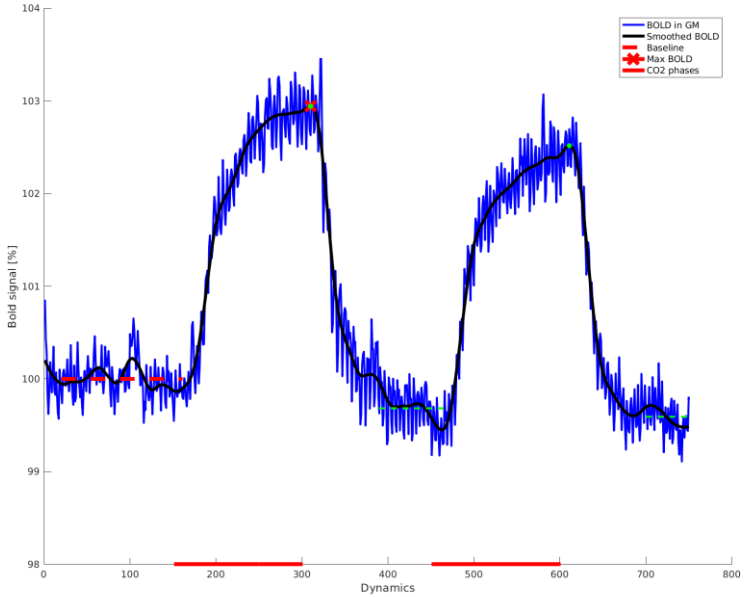
MR imaging protocol



Material & Methods

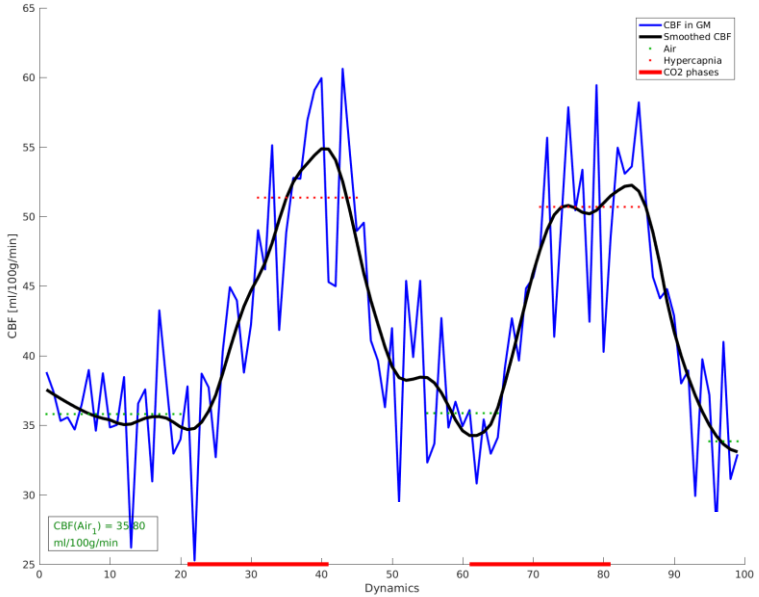
Signal time course

BOLD signal time course



average ΔBOLD = +2.7%

CBF signal time course

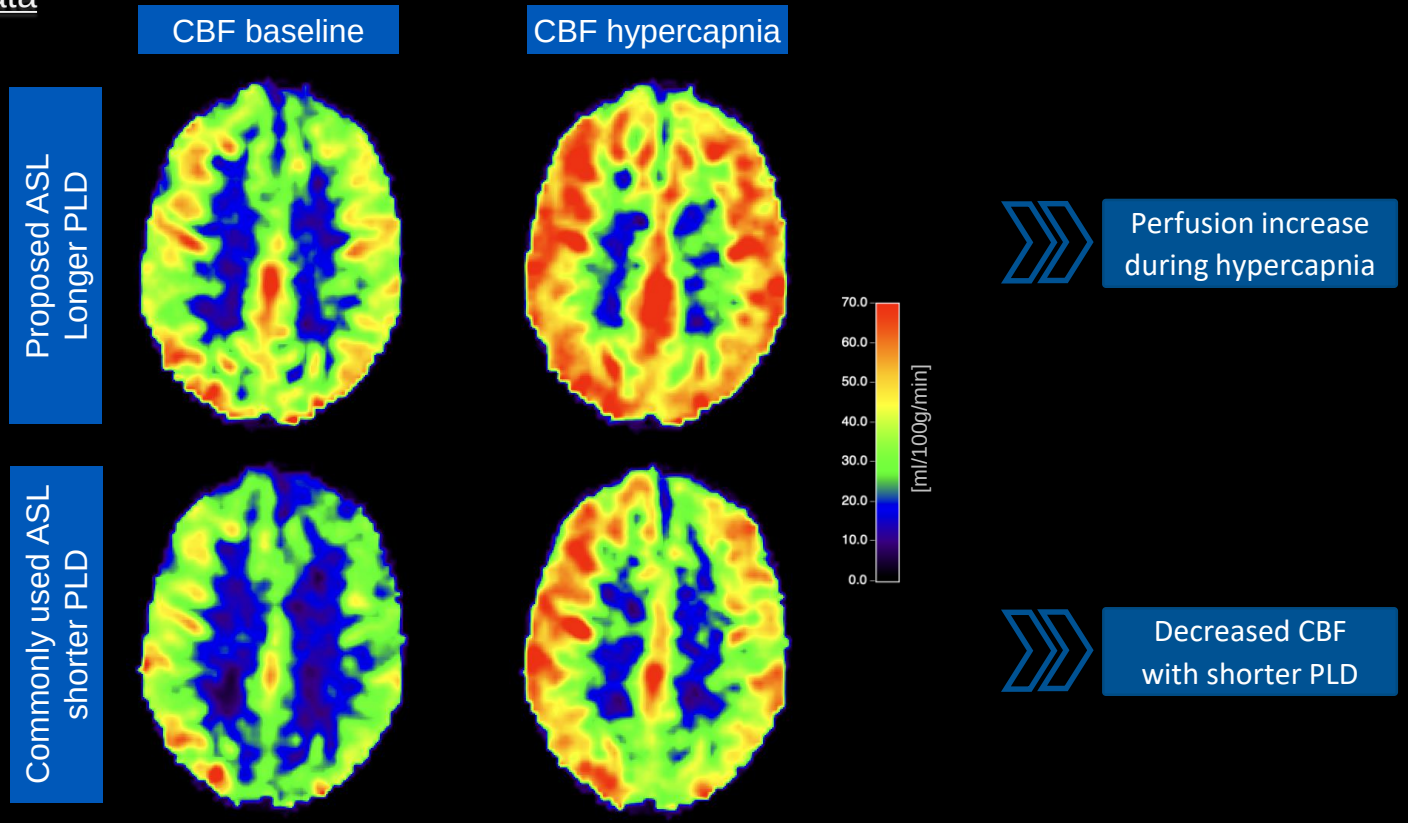


average ΔCBF = +32%

M factor for calibrated fMRI by gas-free R_2' vs. hypercapnia

Results

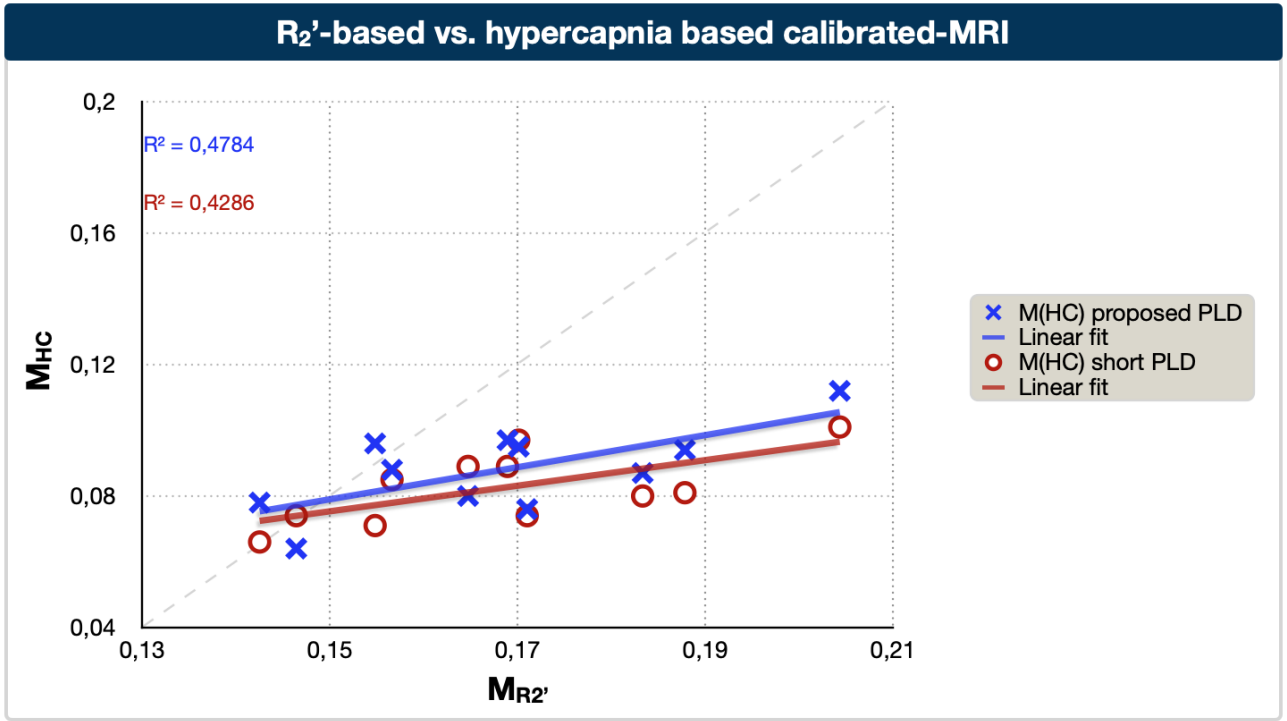
Examplary CBF Data



Images depicted by Vinci software, Max-Planck-Institute for Neurological Research, Cologne, Germany

Results

Gas-free M factor

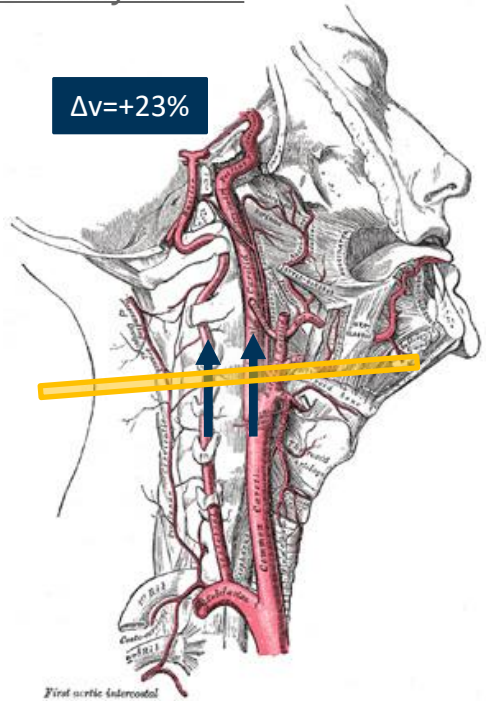


Good correlations between hypercapnia vs. R_2'

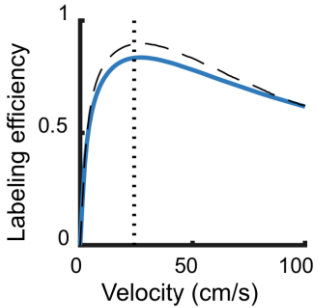
Improvements by prolonged PLD

Results

Flow velocity effects

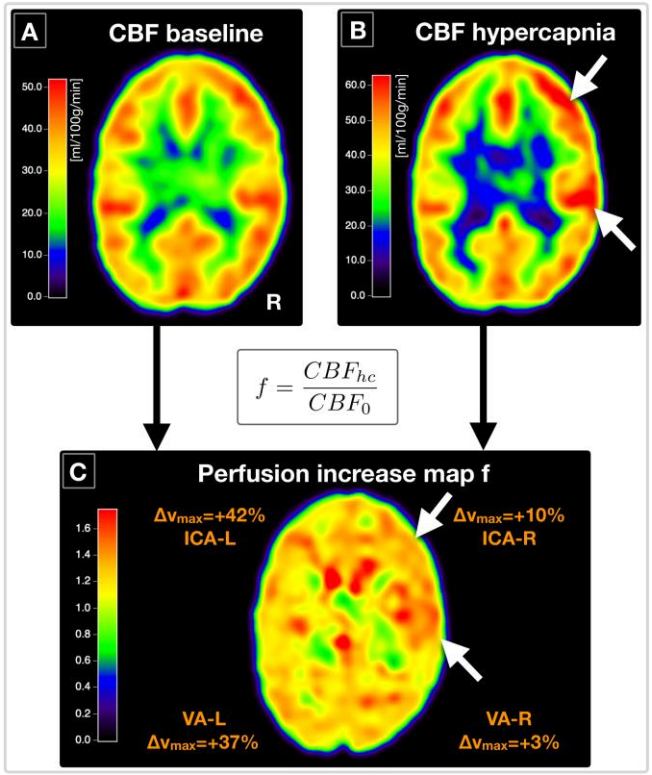


5% CO_2



-3% labeling efficiency[1,2]

9% M overestimation



Velocity increase by hypercapnia may affect M

Regional perfusion effects by hypercapnia

[1]Gevers et al. AJNR 2012; [2]Verbree et al. MAGMA 2018; Image modified from „Greys anatomy" under public domain and from Aslan et al. MRM 2010

Discussion

CVR impairments in ICAS

Gas-free calibrated fMRI

- R_2' based M factor correlates well with hypercapnia
- Signal changes under hypercapnia agree well with literature[1]
- Prolonged PLD of ASL improves M factor correlations – in line with literature[2,3]

Perfusion at hypercapnia

- Calibrated BOLD affected by too short PLD
- Blood velocity increases under hypercapnia as proposed[4]
- Regional confounding effects at hypercapnia via velocity dependent ASL labeling[5-7]

[1]Gauthier et al. HBM 2013; [2]Liu et al. ISMRM 2018; [3]Liu et al, NI 2019; [4]Sato et al. J Physiol 2012; [5]Gevers et al. AJNR 2012; [6]Verbree et al. MAGMA 2018; [7]Blockely et al. NMR Biomed 2013

Summary

Proposed prolonged PLD improved gas-free calibration

Good coorelation of R_2' vs. hypercapnia based M factors

Flow velocity effects under hypercapnia may affect calibrated fMRI

Gas-free calibrated fMRI is highly promising for future applications and requires further validations in future task studies

Acknowledgements

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Thank you very much for your attention!

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