Blood Oxygen Level Dependent (BOLD) Quantitative Susceptibility Mapping (QSM) at Different Head Orientations

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INTRODUCTION

- BOLD signal varies with changing concentration of de-oxygenated hemoglobin in the blood
- BOLD signal is primarily a qualitative measurement with arbitrary units
- We seek a more quantitative technique for assessing BOLD signal
- In recent years there have been substantial advances allowing for improved quantification of magnetic susceptibility with MRI [1-4]
- Estimates of the magnetic susceptibility can be computed from the BOLD phase information [3,4]
- BOLD-QSM imaging measures quantitative units of magnetic susceptibility
- We expect that BOLD-QSM will be more robust to changes in head orientation with repeated scanning than traditional R_2* dependent BOLD signal
- In this work we compare BOLD to BOLD-QSM time courses with different head orientations

METHODS

- Two healthy subjects were imaged on a 3 T MR scanner (GE Discovery 750)
- Each subjects' head orientation was changed by 5 to 10 degrees and imaging was repeated
- Imaging included:
  - T1-weighted anatomic imaging
  - 2D multi-slice echo planar imaging
    - TR/TE/α of 2000 ms/30 ms/80°
    - 3.5 mm isotropic resolution, 64x64x43
    - 5 min scan-time
- Motor (finger tapping) and visual (8 Hz flashing checker board) stimuli in 30 second on/off blocks
- To compute the BOLD-QSM time course:
  - the phase image was unwrapped
  - linear regression was used to remove offset and drift
  - polynomial fitting was applied to each volume [3] for background field removal
  - temporal low-pass filtering
  - induced magnetization was calculated
  - magnetic susceptibility was calculated
- BOLD and BOLD-QSM signals were examined from the motor and visual regions for each scan
- Contrast-to-noise (CNR) and correlation coefficients between BOLD and BOLD-QSM were calculated from those signals
- Statistical maps derived from the BOLD and BOLD-QSM times courses were also compared

RESULTS

- The results are shown in Figures 1&2 and table 1

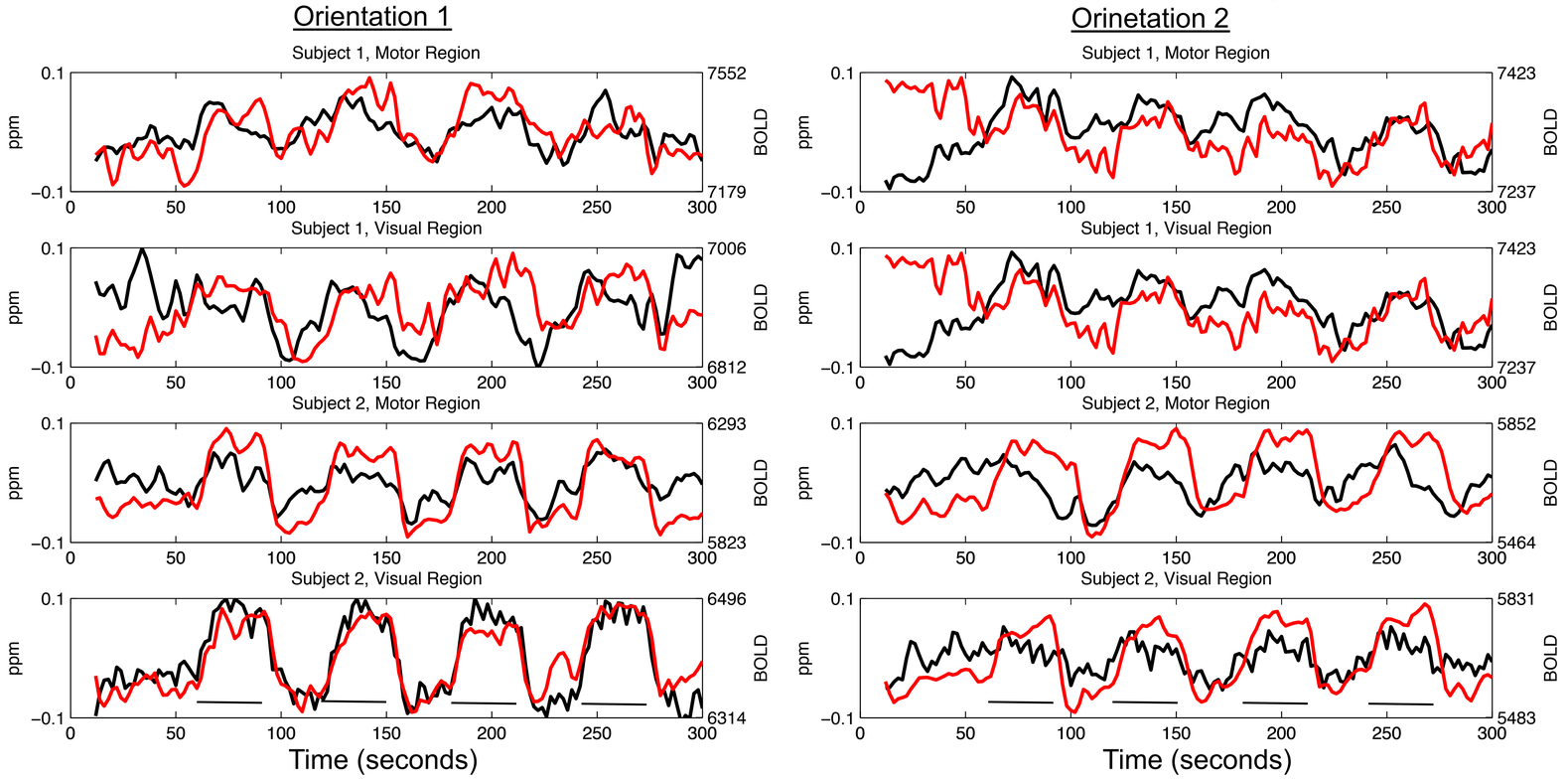

Figure 1: *FMRI time courses. Red – BOLD, Black – BOLD-QSM. Column 1 represents the first run and column 2 represents the second run after the head was moved. The stimulus duration are shown by the black bars in the bottom row.*

Table 1: *Contrast to Noise and Correlation Measurements.*

		Subject 1				Subject 2			
		Run 1		Run 2		Run 1		Run 2	
		Visual	Motor	Visual	Motor	Visual	Motor	Visual	Motor
CNR	BOLD	1.67	1.69	1.73	2.34	2.54	4.10	3.59	1.76
	BOLD QSM	2.89	2.77	2.06	2.01	3.11	2.99	2.67	3.69
Correlation Coefficient		0.42	0.62	0.73	0.27	0.87	0.71	0.63	0.38

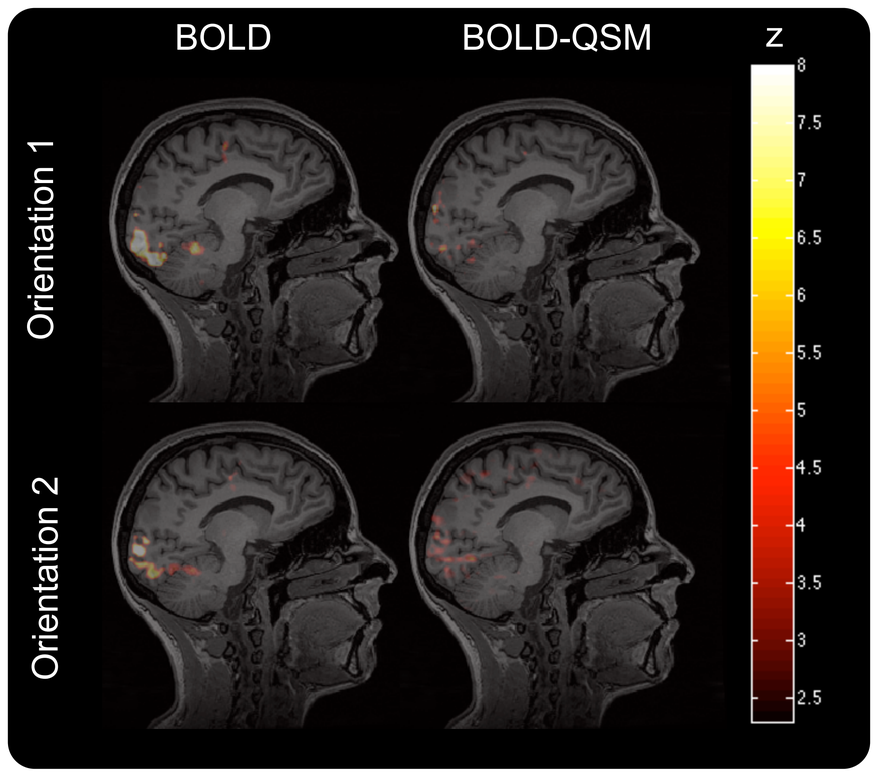

Figure 2: *Activation maps from BOLD and BOLD-QSM at different head orientations for subject 2. Image data is registered to the first orientation.*

DISCUSSION

- From the plots, CNR measurements and correlation coefficients we see that the BOLD and QSM-BOLD have similar variability
- Results are comparable to existing phase image BOLD temporal signals [3-5]
- We found the normalized BOLD and BOLD-QSM had good overlap (Fig 1), but less sensitivity on statistical maps (Fig 2)

REFERENCES

[1] Sun & Wilman, 2014, MRM, 71(3):1151-1157
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