Title: Evaluating the impact of respiratory related B0 fluctuations on both SILK and EPI based mesoscale resolution fMRI at 7T

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Introduction: Traditional EPI fMRI methods for acquiring sub-mm mesoscale resolution images require longer echo trains, resulting in SNR losses due to longer TEs, as well as, increased blurring in the phase encode (PE) direction, geometric distortion, and susceptibility dropout. Our recently developed technique: Stimulus Locked K-space shuffling (SILK) fMRI[1] does not suffer from the above limitations, making it ideal for studying mesoscale functional organization in conjunction with T1w and T2w anatomical images. SILK fMRI (in its 3D FLASH based form) achieves this by binning each k-space line based on the stimulus/task present at the time of acquisition. This facilitates a task-based cine reconstruction analogous to what is used for cine cardiac imaging. SILK fMRI represents a critical paradigm shift in fMRI technology enabling larger FOV, higher resolution imaging (i.e. whole brain microscale imaging) by lengthening of the scan duration (i.e. by acquiring additional stimulus repetitions) rather than by reducing the temporal resolution or FOV. Here we demonstrate the importance of mitigating respiratory related B0 fluctuations[2,3] from both SILK fMRI and traditional EPI for high resolution fMRI at 7T.

Methods: BOLD CNR, tSNR, and image sharpness was used to quantify performance of SILK fMRI with vs without respiratory gating and traditional EPI with vs without breath holds. To ensure head motion was minimized, Headcases (https://caseforge.co) were utilized in a standard 32 ch Nova coil.

Results: For EPI fMRI, respiratory related B0 fluctuations can result in ~0.5 mm, slice-specific displacements along the PE direction, which at longer TRs, cannot be fully corrected using traditional volume-based motion correction resulting in blurring and loss of effective resolution. For FLASH fMRI, these B0 fluctuations result in at least 50% lower tSNR at longer TEs traditionally used for BOLD imaging (Fig 1).

Conclusions: Subject respiration can have a significant impact on the quality (i.e. effective resolution and tSNR) of mesoscale fMRI data. Future work is needed to incorporate phase stabilization techniques and dynamic B0 shimming[3-5] into fMRI techniques to mitigate respiratory related artifacts.

References:
1) Vu et al. ISMRM 2018
2) Pfeuffer et al. Magn Reson Med 2002
3) Stockmann and Wald. NeuroImage 2018
4) Bianciardi et al. ISMRM 2014
5) van Gelderen et al. Magn Reson Med 2007

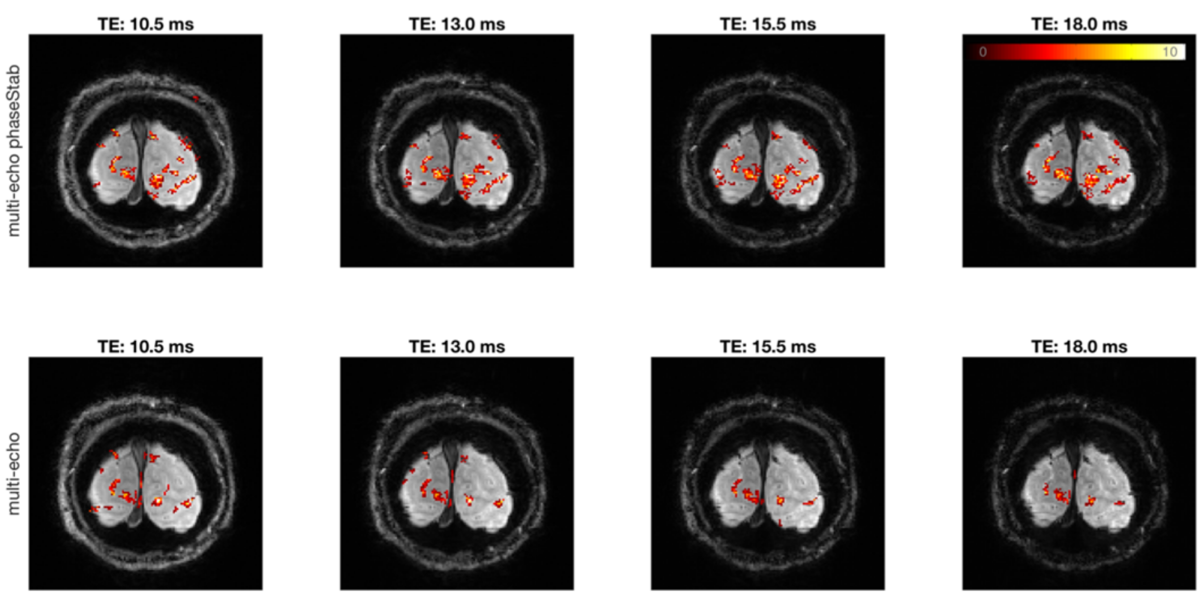

Figure 1. Effect of phase stabilization on stimulus CNR for FLASH fMRI (6 min acquisitions, 1.0 x 1.0 x 1.5 mm^3).

Highlights: Respiratory related B0 fluctuations can result in ~0.5 mm, slice-specific displacements along the PE direction, which cannot be fully corrected using traditional volume-based motion correction resulting in blurring and loss of effective resolution. For FLASH fMRI, these B0 fluctuations result in at least 50% lower tSNR.