Background suppressed arterial spin labeling with simultaneous multi-slice echo planar imaging

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Introduction: ASL imaging with simultaneous multi-slice (SMS) or multiband (MB) EPI has recently been implemented and significantly reduces the time of multi-slice readout (1-3) and dependent variations of inflow-time. The reduced slice readout also may facilitate a practical implementation of background suppression (BS) (4-6) by providing less variation in inversion timing between slices for a more uniform suppression. Here, we are evaluating background suppression in SMS-EPI with pseudo continuous ASL (pCASL) labeling.

Methods: 3 healthy subjects, less than 35 year age were scanned on Siemens 3T Trio scanner using 32-channel head coil. The acquisition parameters are as below: TR=3-4.3ms, TE=13ms, flip angle=90°, slice number=20/28, thickness=5/3.5mm, FOV=256x256mm2, matrix size=64/74x64/74, label/control duration=1.5s, post labeling delay (PLD) is 1000-1700ms, MB-4, FOV shift factor of 3, 6/8 partial Fourier, measurement number=40/80 with 20/40 control and 20/40 label dataset, each echo train duration=23-26ms. For BS, saturation RF pulse is applied before the label/control module followed by two inversion pulses as shown in Figure 1. Two BS schemes using different inversion timing of RF pulse were used: BS1 was based on analytical equation referred (7) and BS2 based on simulations (4). The temporal SNR (tSNR) and SNR of the perfusion weighted images were compared with BS and without BS (1).

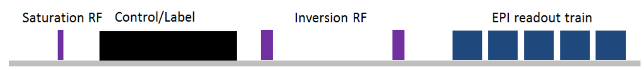

***Figure 1**. Sequence diagram. Purple is the BS module, black is control/label module, and blue is readout module.*

Results: The ASL perfusion weighted images (PWI) with and without BS scaled equally are shown in Figure 2. The BS images had reduced signal as well as reduced background noise. The tSNR maps of PWI in Figure 3 show that BS increases the tSNR in the later echo trains, with each row is from a successive echo train, acquired left to right. The mean tSNR and SNR of the different BS schemes at different PLDs, are plotted in Figure 4, by sequential echo trains index, each producing 4 slices with MB-4. Implementation of the BS2 scheme was prevented by the shorter PLD 1200ms. BS1 helps reduce both tSNR and SNR for PLD=1200ms; for PLD=1700ms, the SNR is not improved by BS except the first echo train.

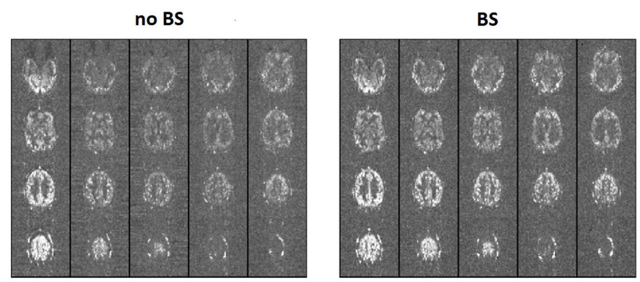

***Figure 3**. tSNR map of the perfusion weighted images with 4x4x5mm^3 resolution.*

Discussion: BS is demonstrated to increase tSNR of PWI, which agrees with earlier finding (4), and also the tSNR did not show a trend in improvement between different EPI echo trains having different BS inversion timing. All images with and without BS showed tSNR reductions progressing with later echo trains and could be attributed to the prolonged inflow times. At PLD 1700ms there was also an overall SNR loss using BS which we attribute in part to imperfect inversion pulses reducing blood signal. In this regard, tSNR gains with BS in SMS-EPI may be smaller gains than in 3D ASL sequences (6) that could better outweigh signal losses for greater SNR gains.

Conclusions: Background suppression reliably increases tSNR in pCASL SMS-EPI, whereas the SNR is dependent on both potential signal intensity loss and tSNR gain.

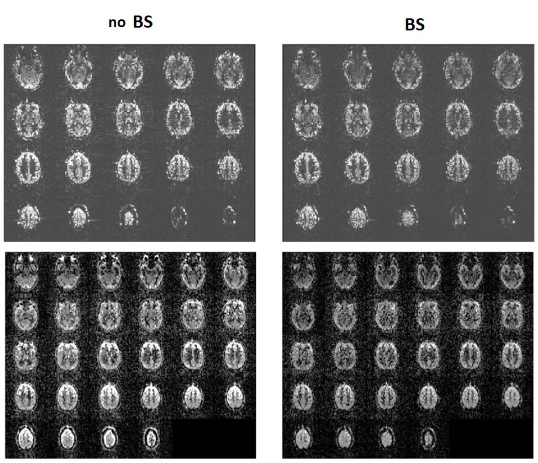

***Figure 2**. Perfusion weighted images. Upper row is 20 averages with 4x4x5mm^3 resolution; bottom row is 40 averages with isotropic 3.5mm resolution.*

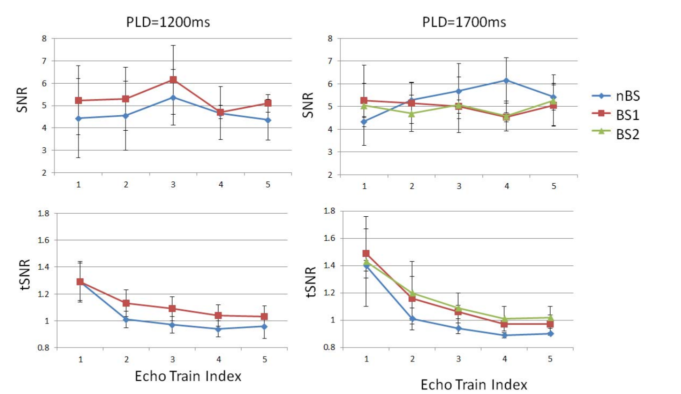

***Figure 4**. The mean tSNR/SNR plots of the perfusion weighted images with 4x4x5mm^3 resolution. The left two plots are with PLD of 1200ms, and the right two are with PLD of 1700ms.*

References: **1**. Feinberg DA, Beckett A, Chen L. Magn Reson Med 2013;70(6):1500-1506. **2**. Kim T, Shin W, Zhao T, Beall EB, Lowe MJ, Bae KT. Magn Reson Med 2013;70(6):1653-1661. **3**. Li X, Wang D, Auerbach EJ, Moeller S, Ugurbil K, Metzger GJ. Neuroimage 2014;in press. **4**. Ghariq E, Chappell MA, Schmid S, Teeuwisse WM, van Osch MJ. Neuroimage 2014;103C:316-322. **5**. Ye FQ, Frank JA, Weinberger DR, McLaughlin AC. Magn Reson Med 2000;44(1):92-100. **6**. Garcia DM, Duhamel G, Alsop DC. Magn Reson Med 2005;54(2):366-372. **7.** St Lawrence KS, Owen D, Wang DJ. Magn Reson Med 2012;67(5):1275-1284.