SNR and voxel bleed comparison between 3D CSI and 3D HSI

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Introduction: In light of the improved point spread function (PSF) of Hadamard spectroscopic imaging (HSI) [1] over that of chemical shift imaging (CSI) [2] we expect HSI to have improved signal-to-noise ratio (SNR) as well as lower inter-voxel signal bleed. Here we compare the SNR and bleed for the two sequences on a custom built phantom and quantify the differences.

Theory: In CSI the magnetization is weighted in each dimension by a sinc-like function. As a result, the SNR is reduced, in the ideal case, by up to 13% in each dimension [3]. Moreover, since the sinc function tails extend across the field of view (FOV), signal from a given voxel bleeds to neighboring and far voxels. These effects are exacerbated at low resolutions. In contrast, HSI has a perfect PSF: "1" inside a voxel and "0" elsewhere although hardware imperfections may cause it to deviate from that ideal. HSI is thus less susceptible to SNR loss and voxel bleed inherent to CSI.

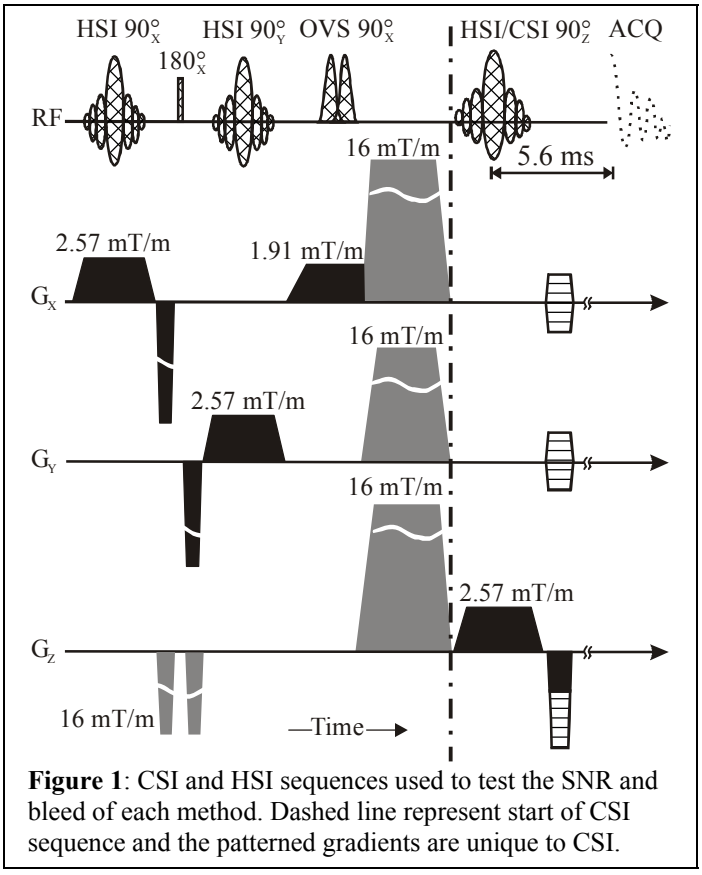

Figure 1: CSI and HSI sequences used to test the SNR and bleed of each method. Dashed line represent start of CSI sequence and the patterned gradients are unique to CSI.

Methods and Results: The comparison is demonstrated on a custom phantom in a 1.5T Magnetom Avanto (Siemens AG, Erlangen Germany) with its standard CP head coil. Phantom contained a small acetone-filled sphere surrounded by water. A VOI of 8×8×8 cm^3 (left-right (LR)×anterior-posterior (AP)×inferior-superior (IS)) was partitioned into 4×4×4 voxels with three 4th order HSI 8.2 ms pulses in all three direction. An identical pulse was used for slice selection in CSI and the encoding done using phase gradients. At TR=1.2s the 4×4×4×2=128 encoding steps took under 3 minutes. The inter-voxel bleed was computed by summing the total acetone signal in the volume of interest (VOI), subtracting the signal from the voxel containing the sphere then dividing by the total acetone signal. This yielded a bleed of 14% for HSI and 49% for CSI. Computing the relative SNR between the two methods gave a 35% increase in SNR for HSI. Metabolic maps shown in Figure 2 illustrate the extent of the bleed for each method.

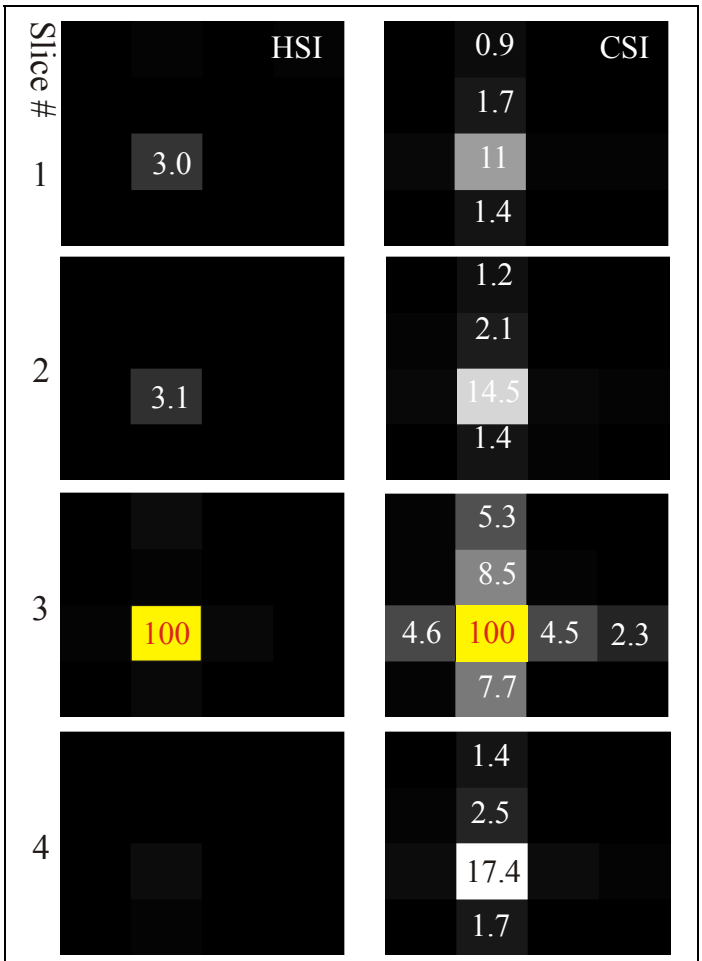

Figure 2: Bleed in % for each method (sphere-containing voxel =100) .

Discussion and Conclusions: A quantitative comparison between HSI and CSI shows that a low resolutions HSI performs better with respect to SNR and bleed. The higher SNR permits a reduction of scan time whereas the lower bleed gives improved localization.

References:

[1]Panych., IEEE Transactions on Medical Imaging 1996
[2] Truman, NMR in Biomed 1992
[3] Maudsley et al, Journal of Magnetic Resonance 1986