

## Coil Combination of CSI Data Based on Reference Images at 7T

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### Purpose/Introduction:

Using an Array Coil (AC) increases the Signal-to-Noise Ratio (SNR) in comparison to a Volume Coil (VC). However, the combination of Chemical Shift Imaging (CSI) data of individual channels is problematic due to phase differences between the channels. Summing up the CSI signals of the channels naively leads to signal cancellation. Thus, phase information for combination is typically obtained from the first point in the FID. However, for good water suppression this method can be unreliable. In this study phase images based on a gradient echo sequence are used to phase the spectra of the individual channels.

### Materials and Methods

2D-CSI data with 64x64 voxels with a 3.4x3.4 mm<sup>2</sup> nominal in-plane resolution of the human brain (3 volunteers) and of phantoms were acquired at a Siemens 7T MR scanner with a 32-channel head coil using an FID sequence with 1.3 ms acquisition delay in 30 minutes [1]. For comparison we measured each volunteer two times: first with 32 separate receive channels (AC) and then with the VC, i.e. the coil used for RF transmission. Two gradient echo images, one of them with reversed imaging gradients to retrospectively estimate phase changes introduced by the sequence encoding, were acquired under similar conditions (i.e. same coil selection, acquisition delay, pulses, FOV) as the CSI sequence.

In the first step we verified that the phase information of the imaging sequences were consistent with the phase of the CSI data. The first point of the FID was used for phase estimation.

In the second step images were used to correctly phase and weight the CSI data for each channel so that the signals could be summed up without signal cancellation. A side benefit of our approach is that the summed spectra are already correctly phased, leading to higher reproducibility, processing speed and accuracy of the fit. Thus, all spectra were processed with fixed phase using LCModel.

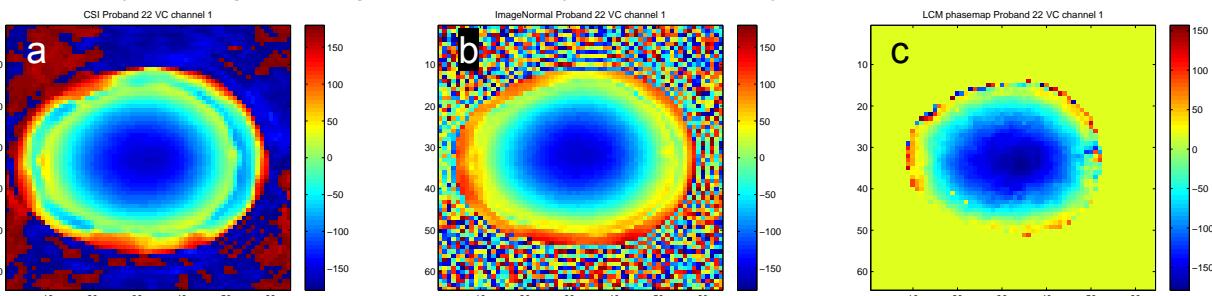
Thirdly, we compared the data quality (i.e. SNR) of the AC data processed using this method with the VC data without using the phase information of the gradient echo images. The SNR of NAA was computed by LCModel.

### Results

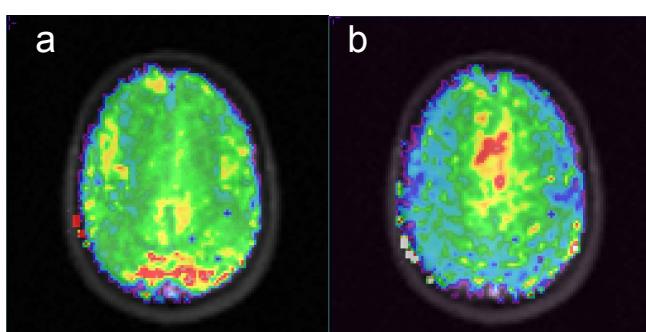
The phase maps of the CSI data, those computed by LCModel, and those provided by image based phase maps are in good agreement as seen in figure 1. The comparison of the SNR maps showed that the SNR increased by a factor of 2.1±0.6 when measuring with the AC and combining the channels with our method compared to the VC mode. Figure 2 illustrates that the SNR gain between the AC mode and the VC mode was primarily in the peripheral regions of the brain. To confirm that our method leads to reproducible results, sample metabolic maps of a volunteer are provided in figure 3.

### Discussion and Conclusions

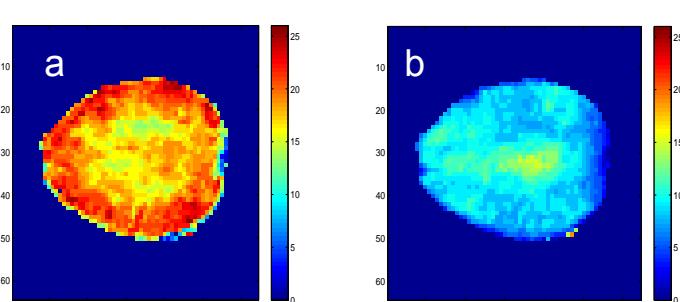
Our coil combination method provides improved combination of multi-channel coils for CSI associated with maximization of SNR. Moreover, combining the CSI data with our method enables pre-phasing of all spectra, making software-based phase estimation obsolete, thereby improving processing speed, fit accuracy, and reproducibility.



**Figures 1:** Phasemap based on the CSI data computed by the first spectrum point (a), the imaging sequence (b), the LCModel computations (c). The phasemaps are consistent with each other.



**Figure 3:** Sample metabolic map of (a) NAA and (b) tCho in a healthy volunteer using our coil combination method.



**Figure 2:** SNR map of (a) AC compared to (b) VC mode.

References: [1] Henning et al., Nmr Biomed 2009;22(7):683-696.