^{31}P MRSI of the brain at 3T with an improved 8-channel receive array and Whitened Singular Value Decomposition for optimal combination of ^{31}P array signals

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Target audience: RF-coil designers, researchers with interest in ^{31}P MR spectroscopy

Purpose: Phosphorus MR Spectroscopy (^{31}P MRS) provides valuable information about energy and phospholipid metabolism in neurological diseases like Alzheimer's disease[1] and brain tumors[2]. The low intrinsic ^{31}P sensitivity can be increased not only by the use of higher magnetic fields, but also by the use of an array of smaller coils to receive the MR signal. This approach is particularly attractive in combination with a volume transmit coil as conventional block pulses can be used for homogeneous excitation as has been reported for 4T and 7T MR-systems with arrays of smaller receive only coils to cover the full volume of the head [3,4,5]. When signals in MRS have a low intensity, the accumulation, phasing , and weighting of the signals from an array becomes challenging [6]. Here we demonstrate an improved 8-channel ^{31}P head array insert combined with a dual-tuned ^{1}H/^{31}P birdcage transmit coil with homogenous transmit field, for ^{31}P MRSI at 3T. It allows ^{1}H decoupling and NOE to further enhance sensitivity. We also compared the performance the methods Time-Domain[7] and Whitened Singular Value Decomposition (WSVD)[8] to combine ^{31}P from our arrays.

Methods: A home built 8-channel ^{31}P head array (diameter 24.5cm) was combined with a quadrature TxRx ^{31}P/^{1}H birdcage coil (RAPID Biomedical GmbH.) detunable at the ^{31}P frequency[9]. Improvements to the head array insert consisted of replacing all ^{1}H tank circuits by an improved trap circuit[10] and removal of all fuses. Fuses were "replaced" by an electronic circuit that detects if a direct current is flowing through the PIN-diode, which prevents scanning whenever there is no direct current flowing. The probe was tested at 3T (TRIO Siemens, Erlangen) on 2 volunteers and a ^{31}P phantom . For both frequencies γB_1 was calibrated. A 3D ^{31}P MRSI dataset was acquired with a hard excitation pulse of 500µs (flip=40°, TR=2s, 10x10x10 (16x16x16 interpolated), voxel size after apodization 51.9 cc) and using WALTZ16 ^{1}H decoupling. Signal was received with the birdcage or with the ^{31}P head array when present. The ^{31}P MRSI data acquired with the receive array were combined using both Time-Domain and WSVD methods. The ^{31}P SNR was calculated by dividing the total peak integral (HLSVDpro) by the standard deviation of the time domain noise of the same voxel.

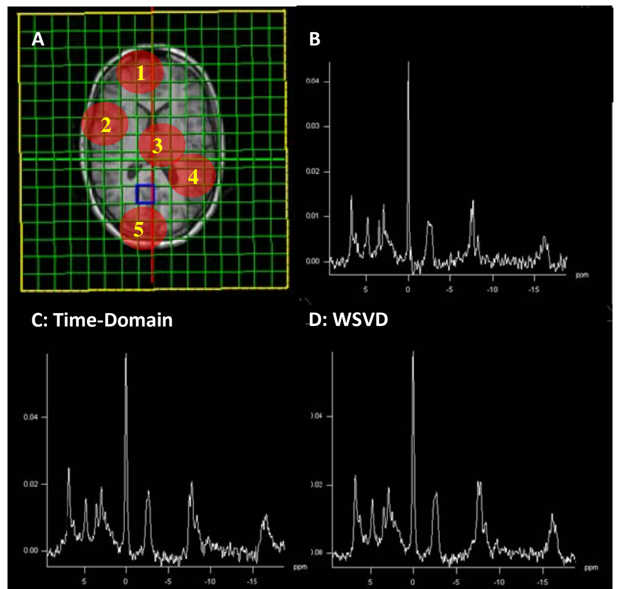

Figure. 1: a) transversal slice with ^{31}P MRSI grid voxel locations and true size; sSpectra shown from voxel 5;

Results: No loss in transmit efficiency for ^{1}H and a 20% loss for ^{31}P was detected in the birdcage after introduction of the 8-channel array coil. The SNR of the ^{31}P MR spectra varied across the brain when the array coil was used, with higher SNR closer to the individual receive elements (e.g. voxel 1, 2 and 5 in figure 1). Table 1 shows the SNR differences between the two RF-coil setups and coil combination methods for all volunteers.

Voxel	Vol 1	Vol2	Vol 1	Vol2
	WSVD/ birdcage		WSVD/ Time-Domain	
^{31}P 1	4.19	3.97	1.48	1.56
^{31}P 2	1.54	1.32	1.3	1.16
^{31}P 3	1.11	0.86	1.05	1
^{31}P 4	1.98	1.23	1.16	1.23
^{31}P 5	2.48	1.53	0.99	1.14

Table 1: ^{31}P SNR increase by WSVD of the five voxels shown in figure 1

Discussion: An improved 8-channel head array in combination with WSVD resulted in a 2 fold SNR increase with respect to earlier presented work[9]. Our alternatives for lossy circuits and components provide the gain in SNR. This gain is hard to quantify exactly because inter-element decoupling, tuning and matching all have an influence on the performance of the RF-coil and will confound such a comparison. The comparison of the WSVD and Time-Domain coil combination methods showed a substantial SNR increase (up to 56% in the frontal lobe where spectral SNR is low) for the WSVD method with the RF-coil insert configuration as detailed above.

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