# INS-PRESS for functional MRS: simultaneous with- and without-water suppression spectral acquisition on visual cortex of human brains at 3T

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## Introduction

Functional $^1$H MR spectroscopy has been used to non-invasively observe the temporal change of metabolites in the activated human brain. The BOLD effects of water and other resonance peaks were consistently detected and reported at 4T [1]. However, reports of the time courses of some metabolites during visual stimulations at 7T [2, 3] and 3T [4] show inconsistent results. The objective of this study was to apply a method combining spectral acquisition of water-suppressed and non-water-suppressed spectra within one single repetition time to perform fMRS experiments. The goal is to monitor possible changes of the water signal (BOLD signal) as well as concentration variations of metabolites on a clinical 3T scanner.

## Materials and Methods

The measurements collected from five subjects (average age= 26.4 ± 2.5 yrs) were executed on a 3T Siemens Magnetom Trio system. An fMRI study was performed prior to fMRS experiments to determine the location of the activated visual cortex. All single-voxel spectra were acquired covering this area using an interleaved navigator scan (INS) PRESS sequence [5] (voxel size =8 cm$^3$, TE=30 ms, TR=3 sec). Two experimental protocols with identical scan time were used: (1) A stimulation period 6.4 min (128 spectral scans) followed by a rest period of the same duration, (2) Four stimulation periods of 96 sec (32 scans for each) interleaved with four rest periods of identical durations. The navigator signals from INS-PRESS were extracted to represent the water signal for calculation of possible BOLD effects, including its magnitude, linewidth, and integral value. The averaged (32 averages) metabolite signals, which were individually corrected for eddy current effects by using the navigator signals, were analyzed using LCModel [6].

## Results

The peak height change of water signal (average values of resting state show in Fig. 1) increases by 3% ± 0.5% and its linewidth decreases by 0.6 ± 0.1 Hz during the visual stimulation in both paradigms (Fig. 1). The integrals of water peaks were calculated after curve fitting, showing averagely 0.8% ± 0.29% increases during activation (not shown), which implies the raise of water contents in the voxel when activated. Fig. 2 shows the time courses of metabolites with Cramér-Rao lower bound (CRLB) smaller than 10% in every subject. The concentration change of mI shows no correlation to stimulation. However, the concentration increment of creatine is 2.3%, in agreement with water magnitude changes during visual stimulation. An average concentration increase of NAA and choline during visual stimulation of 2.7% and 6%, respectively was observed. No such changes were found using the first protocol with 6.4-mins stimulation (Fig. 2(a)).

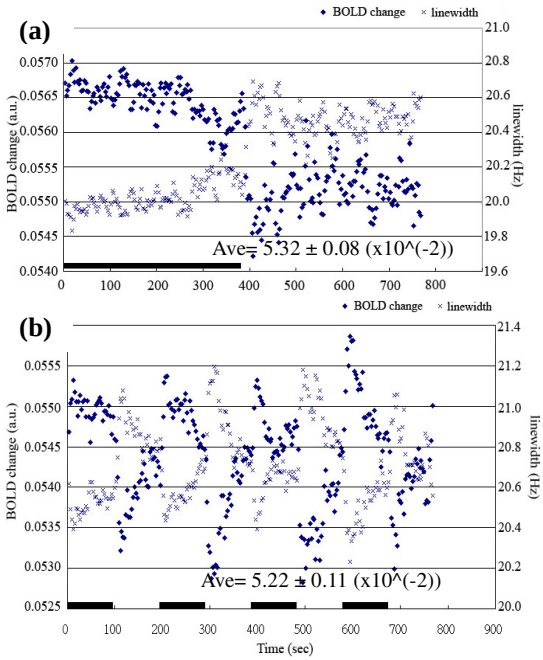


**Fig 1.** The BOLD signal (water peak height) change and the line width change vs. time with (a) 6.4-mins visual stimulation and with (b) four times interleaved 96 sec stimulation. The change of BOLD signal and linewidth shows a converse trend.

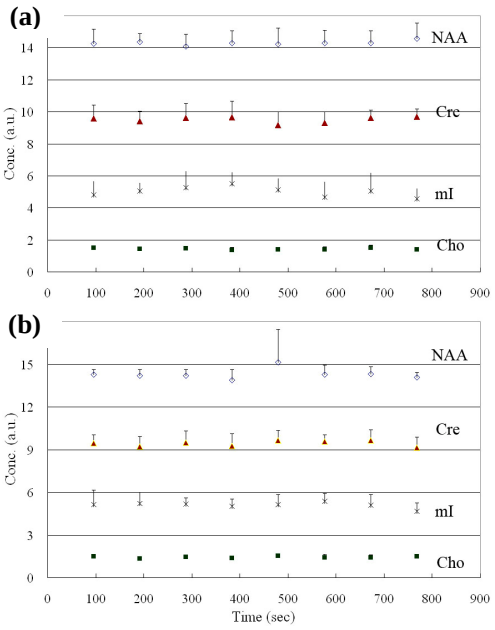


**Fig 2.** (a) Time courses of total NAA, choline, creatine and mI during the paradigm of 6.4-mins stimulation as in Fig 1(a). (b) Time courses of these four metabolites used the stimulation paradigm as in Fig 1(b). These spectra were quantitated after 32 scan averages. Error bars show the inter-subject standard deviations.

## Discussion and Conclusion

Our feasibility study shows that INS-PRESS sequence may successfully employed in fMRS to acquire spectra with and without water suppression simultaneously. This approach shortens scan time drastically compared to separated sequential acquisition. The concentrations of metabolites are reliably detected with CRLB < 10% and BOLD effects on water show results comparable to that obtained on a 4T scanner [1]. The increase of its magnitude and the linewidth narrowing directly reflect the $T_2$* change of the activation region. In spite of the increasing magnitude and the narrowing linewidth with opposite tendencies, the integral value of water peak increases, which is consistent with blood volume increase in this area. Our preliminary results suggest that the concentration of creatine is affected during the stimulation, which is not the case for mI. Result differences between the two used protocol schemes may be attributed to volunteer fatigue using the longer stimulation period. However, since fMRS results are controversial discussed [2, 4], an improvement in acquisition methods may be helpful for further investigations.

## References

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