A Novel Hybrid Method for Applying Independent Component Analysis to *in vivo* Paediatric Brain Tumour ^{1}H Magnetic Resonance Spectra

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Introduction

^{1}H MR Spectra can be considered to be a mixture of metabolite, macromolecular and lipid (MMLip) components plus noise. Many studies in adults have shown a high accuracy in non-invasive diagnosis of brain tumours and evidence is emerging that the technique will also be valuable in children. Independent Component Analysis (ICA) has shown the possibility to identify the individual components, and reveal hidden biochemical information [1] [2]. There are two common approaches in the application of ICA, Blind Source Separation (BSS) and feature extraction (FE). The BSS method can extract almost all the metabolite and MMLip components except where there is significant overlapping of the MMLip peaks with metabolites. The FE method tends to be better than the BSS with this condition, but it gives ICs that combine metabolite and MMLip components at other frequencies. An ICA approach involving a hybrid of Blind Source Separation (BSS) and Feature Extraction (FE) techniques for automated decomposition of MR spectra has been applied to synthesised brain tumour MRS [3], and more realistic individual metabolite and MMLip components were obtained. In this study, the proposed hybrid ICA decomposition scheme is applied to an *in vivo* paediatric brain tumour MRS dataset.

Material and Methods

The patient dataset contained *in vivo* MR spectra from children with brain tumours obtained prior to treatment and in follow-up scans between 1 January 2003 and 6 May 2008 at Birmingham Children's Hospital. All studies were performed using 1.5 T clinical scanners (Siemens Symphony Magnetom, NUM4 and GE Signa Excite & HDx). MR spectra were acquired using a point resolved single voxel spectroscopy (PRESS) sequence (TE=30 ms, TR=1500 ms). The voxel volume was 3.4 ml (1.5cm sided cube) or 8 ml (2cm sided cube) with 256 or 128 signal averages acquired, respectively. The GE spectra were shifted along the x-axis to fit with the Siemens spectra. The baseline estimated from the LCModel software package [4] was removed from each MR spectrum. Two quality control criteria were applied to the spectra: (1) the FWHM of the water reference peak had to be less than 6 Hz and (2) SNR of the spectra had to be greater than 10. The ICA method was applied to a de-noised dataset by a wavelet approach. The hybrid ICA method incorporates the advantageous aspects of both BSS and FE methods. It starts with BSS being applied to the dataset, then FE is performed to these resultant ICs where metabolite and MMLip components interfere.

Results

The BSS method reveals several metabolite and MMLip components except where there is significant overlapping of the MMLip peaks with metabolites (Fig. 1(a)). The FE method performs better than the BSS where overlapping peaks are present, in particular where broad and narrow signals overlap; but it also gives ICs that combine metabolites and MMLip at other frequencies (Fig. 1(b)). The 22 ICs obtained by the hybrid method from 117 spectra (which contained a mixture of various tumour types) are illustrated and labelled with the corresponding metabolites and MMLip in Fig. 1(c).

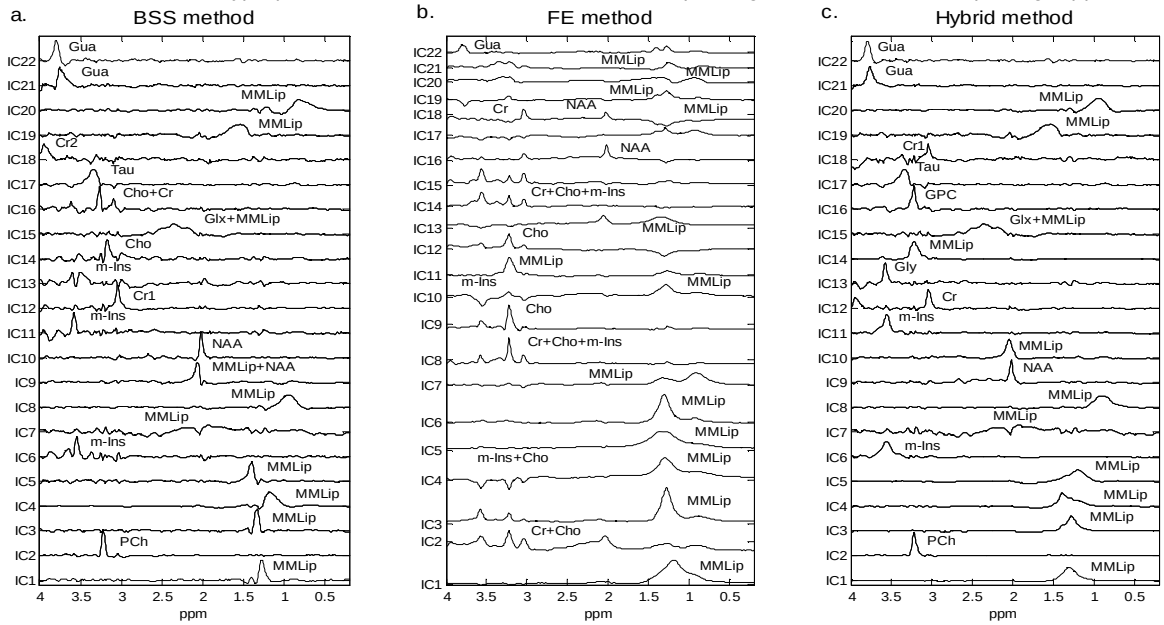

Fig. 1 The 22 ICs obtained from the 117 spectra by (a) BSS, (b) FE and (c) the hybrid methods labelled with the corresponding metabolites and combined macromolecular and lipid (MMLip) components.

Discussions and Conclusions

The results show that the hybrid method has the advantages of both BSS and FE, and provides more realistic individual metabolite and MMLip components. It can be seen in Fig. 1(c) that the ICs previously affected by the overlapping in the BSS method are restored better here. The NAA and MMLip at 2.0 ppm are separated. The IC2, IC14 and IC16 could be PCh, MMLip and GPC. The two peaks of Cr are restored in C12 and the residual component in IC18. There are multiple MMLips appearing at around 1.3ppm but no Lac was shown. The repeating metabolites in the ICs may due to the effect of various FWHMs or peak position shifting and shall be investigated in a future study. Overall, the hybrid method of IC analysis is superior to the well established IC techniques in determining individual metabolite components from brain tumour MRS.

References

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