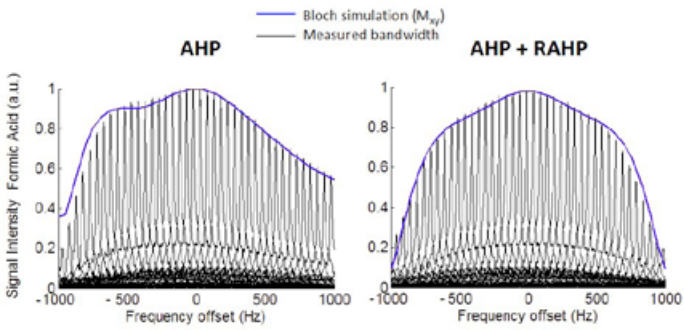

Figure 1: Bloch simulation (M_{xy}) and ^{13}C-MRS excited bandwidth measured in vitro on formic acid 99% ^{13}C-enriched (γ*B_1=122Hz), using an adiabatic-half-passage **(AHP)** pulse-acquire (left), and a adiabatic-half-passage (AHP) combined with a phase-inverted reverse-AHP **(RAHP)** in alternate scans (right), together with Waltz16 ^{1}H-decoupling. Parameter settings: pulse duration 2ms, vector size 2048, TR 10s, 1 average (AHP) and 2 averages (AHP + RAHP).

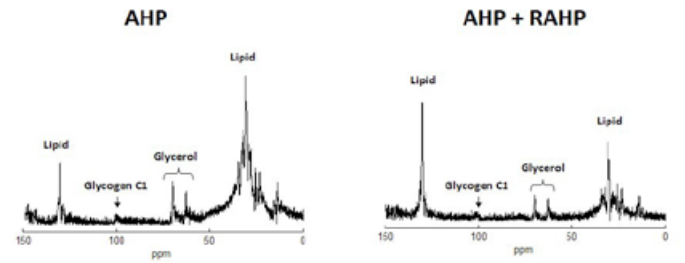

Figure 2: ^{13}C-NMR spectra showing detection of the calf muscle glycogen (100.5ppm), Glycerol (62 and 69ppm), and fatty lipids (30 and 130ppm) from a male subject, using a ^{13}C-^{1}H surface coil and FID sequence with an adiabatic-half-passage (AHP) pulse-acquire (left), and an adiabatic-half-passage (AHP) combined with a phase-inverted reverse-AHP (RAHP) in alternate scans (right), together with Waltz16 ^{1}H-decoupling (20ms), TR = 1s, BW=20kHz, 256 scans, Vector size=2048, Zero filling=2048. Both spectra are shown with the same vertical scale.

Discussion/Conclusion: We conclude that it is feasible to apply two phase-inverted adiabatic-half-passage pulses for ^{13}C excitation to achieve a flatter-phase-response to off-resonance, and this will allow further extension of this technique for ^{13}C-MRS measurements such as in human brain.

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633

Hierarchical non-negative matrix factorization applied to in vivo 3T MRSI prostate data for automatic detection and visualization of tumours

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Purpose/Introduction: Non-negative matrix factorization (NMF) [1] is hierarchically applied to *in vivo* three-dimensional 3T MRSI prostate data to automatically extract characteristic patterns for tumour and benign tissue, and to visualize their spatial distribution.

Subjects and Methods: NMF is a blind source separation technique imposing non-negative constraints on the extracted sources and corresponding weights. Specifically, given a non-negative matrix $X \in R^{mxn}$, and an integer k ($0<k<min(m,n)$), two non-negative matrices $W \in R^{mxk}$ and $H \in R^{kxn}$, minimizing the functional $f(W,H)=0.5(\|X-WH\|_F)^2$, are estimated. Here, NMF is embedded into a hierarchical scheme (HNMF) by setting k=2 at each step:
Step1) NMF is applied to the dataset X, containing spectra as columns: two patterns (W columns) and corresponding weights (H rows) are obtained. Signals are divided into two new datasets based on the maximum weight value.
Step2) NMF is applied to each dataset obtained in Step1 and, as above, signals are divided into four datasets. Similarly, one more NMF step is performed, thereby providing eight patterns. The two most correlated patterns with given theoretical models for tumour and benign tissue are selected.
Step3) non-negative least squares (NNLS) [2] is applied to X by using the final patterns of Step2. Two coefficient vectors are obtained which, reshaped and encoded as color channels in an RGB image, provide a visualization of the pathological area.

Results: HNMF is applied to an *in vivo* 3T 16x16x16 MRSI dataset measured by a Siemens Magnetom Trio scanner (TE=145ms, TR=790ms, voxel size: 6mmx6mmx6mm, signal length: 512 data points). Based on histopathology, the tumor is located on the left-hand side of the prostate (Fig.1).

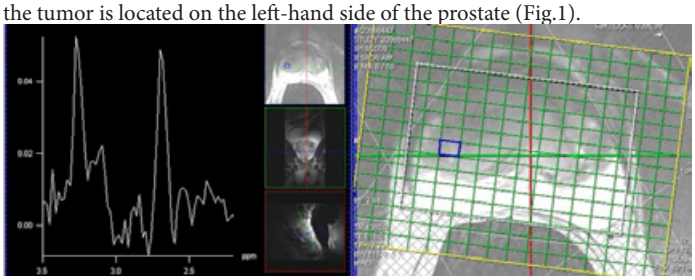
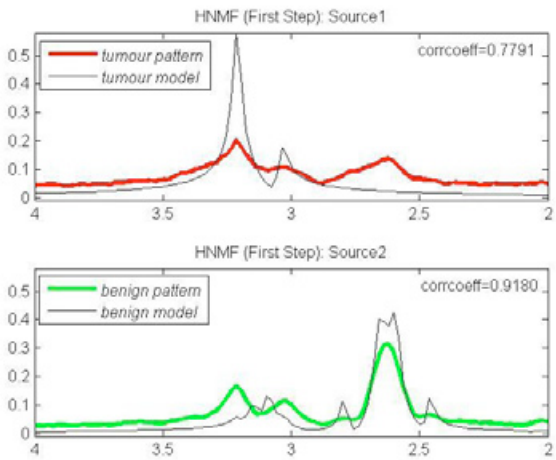
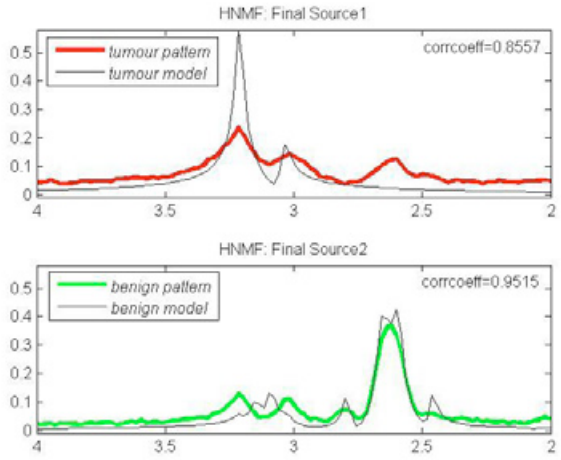


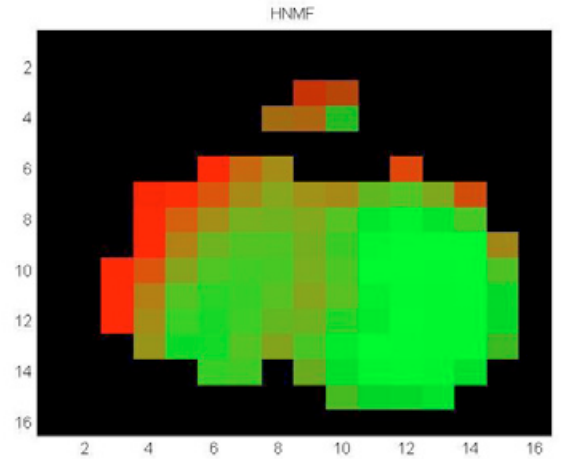
Fig.2



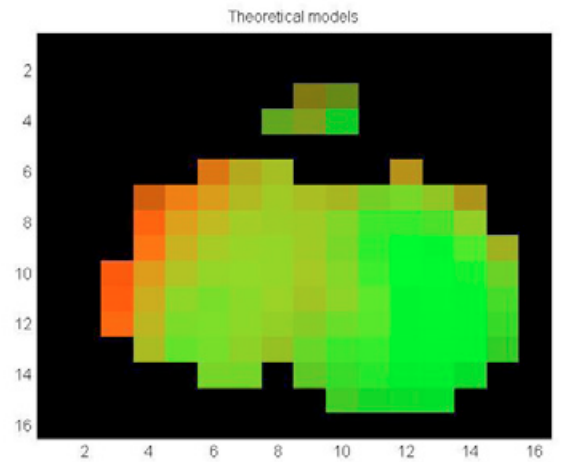
and Fig.3



show the tumor and benign patterns provided by Step1 and Step2, respectively, along with their correlation coefficients with the theoretical models. Such values show that Step2 provides the most correlated patterns with the given models. Fig.4



and Fig.5



show the results of Step3 for one slice by exploiting the HNMF patterns and the theoretical models, respectively. In Fig.4 the pathological region is more enhanced than in Fig.5. The required HNMF computational time is 2.1*s*.

Discussion/Conclusion: HNMF is applied to *in vivo* MRSI data to detect prostate tumours. Our study shows that, potentially, HNMF is efficient and accurate, and provides higher quality results than applying NNLS directly with theoretical models. Indeed, HNMF is able to adapt the given models to the specific patient dataset and, therefore, to describe its spectral content more appropriately.

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634

Impact of salbutamol on muscle metabolism assessed by 31P NMR spectroscopy

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Purpose/Introduction: The potential ergogenic effect of oral administration of salbutamol on exercise performance has been demonstrated for decades (1) but the underlying mechanisms are not completely elucidated (2). We hypothesized that an acute oral dose of salbutamol may improve muscle metabolism and increase endurance during a localized exercise in moderately trained subjects.

Subjects and Methods: Twelve healthy, non-asthmatic, physically active, male subjects were recruited to compare in a double-blinded crossover randomized study an oral dose of salbutamol (4mg) and a placebo intake before a calf fatigue test. Subjects were requested to perform plantar flexions against a progressively increasing resistance at a frequency of 0.5 Hz (maintained with the aid of a visual feedback and a rhythmic soundtrack) until exhaustion in the magnet. A continuous ^{31}P NMRS assessment was performed for 2 min at baseline before the exercise, during the exercise and during the recovery period.

Results: No significant difference was detected in metabolites concentration (PCr, Pi/PCr, ADP and ATP) at baseline, during exercise and during the recovery period ($p>0.05$). The oxidative potential indicated by the PCr resynthesis after the end of the exercise was not modified (tPCr: 38 ±8 and 39 ±9 s for salbutamol and placebo respectively; $p=0.80$). However, while the intracellular pH (pH_i) was not significantly different at rest with salbutamol compared to placebo ($p=0.43$), the decrease in pH_i values was significantly lower with salbutamol than placebo during the incremental test ($delta_{pHi}$: -0.09 vs. -0.19 for salbutamol and placebo respectively; $p=0.018$). Moreover, the P_{max} (28 ±7 W vs. 23 ±7 W for salbutamol and placebo, respectively; $p < 0.001$) and the total work performed (1702 ±442 J vs. 1381 ±432 J respectively; $p < 0.001$) during the incremental test were significantly increased with salbutamol compared to placebo.

Discussion/Conclusion:

Oral administration of salbutamol induced significant improvement in calf muscle endurance with similar metabolic responses in moderately trained sportsmen, except small changes in pHi. These results suggest that mechanisms beyond the muscle (e.g. at the CNS level) may account for the increase exercise performance with oral salbutamol intake.