Characterization of the motional spectrum of nuclear spins by means of spatial independent component analysis (sICA)

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Purpose

The concept of spatial independent component analysis (sICA) in the context of flow weighted experiments is introduced. For this purpose a modified stimulated echo sequence [1] was performed at different mixing times TM = 10,..,100ms at 1.5T.

Subjects and Methods

The stimulated echo sequence [1] has been extended by two inherently refocused gradient shapes (fig. 1), modulated by a function $g(t) = \cos(w_m t)t^2(1-n2\pi/w_m)^2$. The frequencies w_m are determined by the reciprocal correlation times of spin motion components $w_m=1/\tau_c$, with τ_c ranging from 10^1 ms to 10^2 ms (perfusion, flow). Placed between the first and the second excitation rf-pulse and the third rf-pulse and the ADC, they act as a sort of bandpass filter. The integrated effect q(t) of g(t), the accumulated phase (1 Hz modulated pulsation) and their Fourier transforms are shown in figure 1. At short mixing times TM = 10,..,100 ms the stimulated echo signal is strongly weighted by relaxation effects according to $S \sim \sin(\alpha)\sin(\beta)(\sin(\gamma)/2)\exp(-2\tau 1/T2)\exp(-TM/T1)$. To compensate for these effects, the relaxation times have to be quantified which entails additional measurement time. As an alternative the relevant signal contributions also can be determined via spatial ICA. Considering flow, relaxation and static J-coupling effects to depend on statistically independent physical causes - the contribution to each coherence pathway can be written as a product of related factors - the spatial ICA is able to assign the related information to different channels. A fast ICA routine was applied to a matrix S(m,k)/S0 containing the q-space (m modulation frequencies w_m) data for k voxel and a TM=50ms. S0 represents a measurement with g(t)=0.

Results

The ICA maps were sorted according to their kurtosis. In fig.2 the schematic vascular territories and a measured slice is shown. The related ICA-Maps with the highest kurtosis are shown in fig.3.

Figure 1:

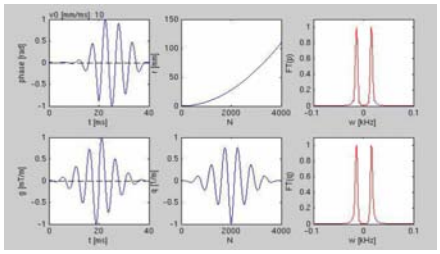


Figure 2:

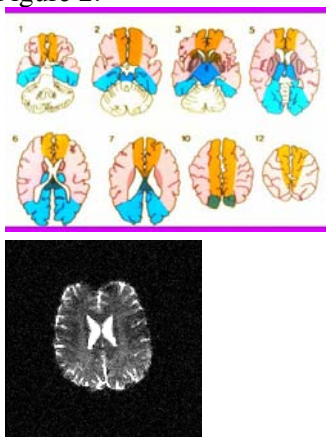
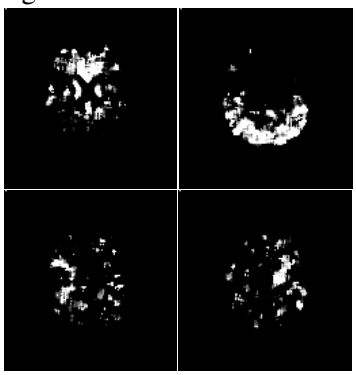


Figure 3:



Conclusion

The sICA tends to be able to separate the vascular territories, if the "bandpass" gradient shapes are modulated in a suitable way as shown in the method part.

References

[1] Kiefer C..: Extended diffusion sequence package under idea va25a : Epi with stimulated echo preparation. SSBE 2005 Annual Meeting Swiss Society for Biomedical Engineering EPFL CH-Lausanne, 1.-2. September 2005. Abstract F15