A Simple Method for Increasing the Number of Echoes and Decreasing Echo Spacing in T_2 Spectrum Analysis

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INTRODUCTION: T_2 spectra contain a wealth of information on tissue composition and pathology. They are calculated by fitting a multi-exponential curve to multi-echo spin echo data [1]. However, a key requirement of this technique is high quality data. On clinical MR systems, it is difficult to achieve this requirement [2]. As a result, T_2 spectrum assessment is rarely used in routine clinical MRI. A method capable of improving data quality would therefore bring this valuable technique closer to the realm of clinical feasibility.

Data quality is determined by three factors: SNR, numbers of echoes (N), and echo spacing (ΔTE) [2]. These parameters are constrained by the following factors: SNR is largely determined by magnetic field strength, coil design, and pulse sequence parameters. The number of echoes is limited by SAR. Minimum ΔTE is limited by SAR, hardware constraints, and peripheral nerve stimulation. As a result of these constraints, most *in vivo* implementations achieve high data quality exclusively through the use of multiple averages to increase SNR. In this study, we present a very simple technique that also uses multiple acquisitions to improve data quality. However, the novel feature of this technique is that multiple acquisitions are used to allow for more flexible echo spacing and a larger number of echoes.

THEORY: In the present technique, a series of multi-echo spin echo acquisitions are performed. The key feature is that each of the acquisitions is performed with a different echo spacing: $\Delta TE_1, \Delta TE_2, \ldots, \Delta TE_m$. The individual acquisitions are then combined into a single composite data set (Figure 1). Assuming N echoes in each individual acquisition and m total acquisitions, the echo times in the composite data set will be:

$$\textit{Echo Times} = \Delta TE_i\,,\ 2\cdot\Delta TE_i\,,\ \ldots\,,\ N\cdot\Delta TE_i\quad ;\ i = 1,\ldots,m$$

With this technique, the number of echoes increases linearly with the number of acquisitions. Moreover, it is possible to achieve an effective echo spacing that is less than the minimum ΔTE achievable on any one acquisition. Note however, that the first echo time in the composite data set is not shorter than the first echo time on any individual acquisition. Also, the composite echo spacing is not uniform.

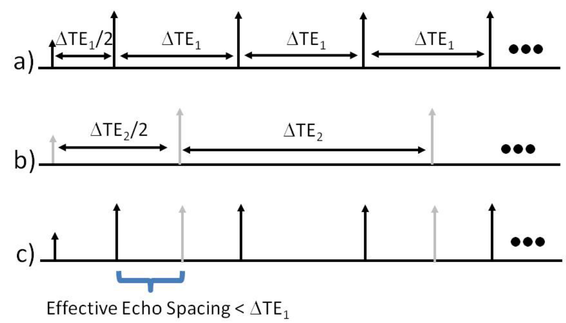

Figure 1: ***Multi-echo spin echo acquisitions at a) ΔTE_1 and b) ΔTE_2. When combined c) into a composite data set, the number of echoes doubles, and shorter (though not uniform) echo spacing can be achieved.***

METHODS AND RESULTS: Multi-echo (8 echo) spin echo acquisitions were performed in a Gd phantom and in human brain. Pulse sequence parameters were: FOV=25cm, matrix=128x128, slice thickness=10mm, TR=2500ms. Three separate acquisitions were performed for inclusion into the composite data set using ΔTE_1=6ms, ΔTE_2=10ms, and ΔTE_3=50ms. Total scan time was 16 minutes. The phantom results in Fig. 2 illustrate that the composite data set follows the expected pattern of monoexponential decay. Figures 3a,b indicate that, as expected [2], the *in vivo* white matter T_2 spectrum contains a short T_2 myelin peak, while the gray matter T_2 spectrum does not. Figure 3c illustrates a "myelin" image formed from the short T_2 components of the spectrum. By comparison to a conventional T_2-weighted image (Fig. 3d), it can be seen that "myelin" appears only in regions of white matter, as expected.

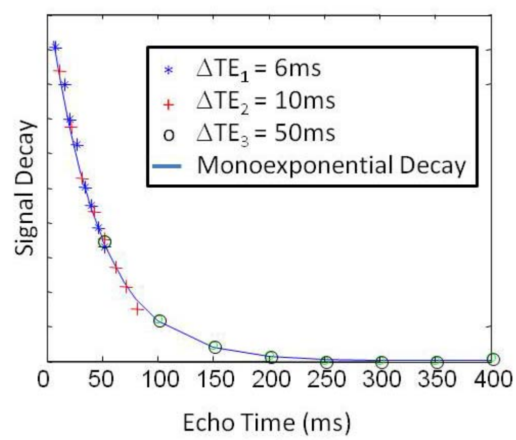

Figure 2: ***T_2 decay of the composite data set in a Gadolinium phantom.***

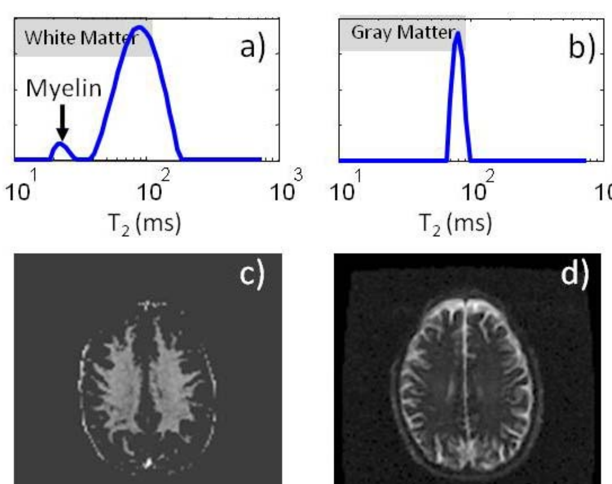

Figure 3: ***In vivo results. Examples of a) white and b) gray matter T_2 spectra. c) "Myelin" image generated from the components of the T_2 spectrum between 10 and 50ms. d) T_2-weighted image.***

DISCUSSION AND CONCLUSIONS: This study demonstrated a novel use of multiple acquisitions to improve data quality in T_2 spectrum analysis. In the past, multiple acquisitions were used to increase SNR. The present technique can be considered a generalization of this concept that uses multiple acquisitions to additionally permit more flexible echo spacing and a greater number of echoes. In the future, this additional flexibility could be used for a more generalized optimization of data quality [3]. In turn, this could bring the promise of T_2 spectrum analysis into clinical reality.

REFERENCES:
[1] K. Whittal *et al.*, *JMR* 1984; 134-152.
[2] SJ Graham *et al.*, *MRM* 1996; 370-378.
[3] MG Skinner *et al.*, *MRI* 2007; 840-847.