Effect of Multi-Component T1 and T2 Relaxation on Derived Single-Component DESPOT2 T2 Values

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INTRODUCTION: The recently developed DESPOT2 (Driven Equilibrium Single Pulse Observation of T_2) T_2 mapping method derives T_2 information from a series of fully-balanced steady-state free precession (SSFP) images acquired with constant repetition time, *TR,* and incremented flip angle, α[1]. A limitation of the method, however, is the assumption of single T_1 and T_2 relaxation. Several biological tissues, most notably white and grey matter, however, have been shown to exhibit multi-component T_1 and T_2 relaxation. Here we use simulations to investigate the effect of 2-component T_1 and T_2 relaxation on the single '*apparent*' T_2 values derived with DESPOT2, the influence of experimental parameters, and how the DESPOT2 values compare with those calculated using a conventional multiple-echo spin-echo approach.

METHODS: Two-component SSFP data were calculated using a linear summation expression, where,

$$SSFP_2 = M_o\left[\frac{f_a(1-E_{1,a})E_{2,a}\sin\alpha}{1-E_{1,a}E_{2,a}-(E_{1,a}-E_{2,a})\cos\alpha}+\frac{f_b(1-E_{1,b})E_{2,b}\sin\alpha}{1-E_{1,b}E_{2,b}-(E_{1,b}-E_{2,b})\cos\alpha}\right], \quad [1]$$

with $E_{1,i}=e^{-TR/T_{1,i}}$, $E_{2,i}=e^{-TR/T_{2,i}}$ and f_i is the volume fraction of component *i.* Eqn. [1] is analogous to the multi-component spin-echo expression and assumes the effect of exchange is negligible, In our first simulation, $SSFP_2$ data were generated at α = 1° to 80° for the *TR* range 1ms to 20ms with *apparent* T_2 values calculated using conventional DESPOT2 processing. In the second simulation, SSFP2 data were generated at α = 1° to 80° and *TR* = 5ms while f_a was varied from 0% to 100%. To compare with multi-echo spin echo (SE) results, SE data were also generated over the *TE* range 1ms to 320ms while f_a was varied from 0% to 100%. For all simulations, the following parameters were assumed: $T_{1,a}$=350ms, $T_{1,b}$=1200ms, $T_{2,a}$=25ms, $T_{2,}$=120ms, f_a=0.2, *TR*=5ms[2,3,4]. To provide the necessitate T_1 value required for DESPOT2 processing, a weighted average T_1 was used ($T_1 = f_a T_{1,a} + f_b T_{1,b}$) as would be calculated with a conventional inversion recovery approach.

RESULTS / DISCUSSION: Fig. 1 contains the results from the first simulation investigating the influence of *TR* on the derived *apparent* DESPOT2 T_2 values and Fig. 2 shows the comparison of DESPOT2 and SE T_2 values calculated at each f_a volume fraction.

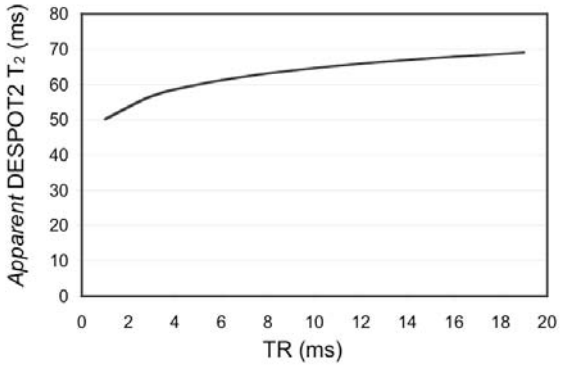

Figure 1: *Apparent* DESPOT2 T2 values derived from data with varied TR.

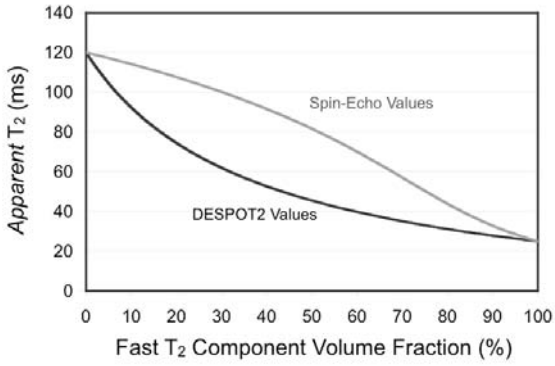

Figure 2: Comparison of apparent T_2 values calculated using the DESPOT2 and SE approaches.

From Fig. 1, as *TR* is increased, a general increase in T_2 is noted with an overall increase in T_2 from 50ms at *TR* = 1ms to 68ms at *TR* = 20ms. This result should be anticipated since, as *TR* is increased, the relative contribution of the small fast component decreases and the system progressively approximates a single compartment system with the slow T_2 value. Figure 2 demonstrates large-scale differences between the SE and DESPOT2 T_2 values (Fig. 2), with the DESPOT2 values significantly lower than corresponding SE values for all f_a. This indicates an increased sensitivity of the SSFP sequence and DESPOT2 method to fast T_2 components, compared with the more traditional SE approach. The results of Fig. 2 agree well with prior *in vivo* observations in which DESPOT2 values have tended to be lower than 'gold-standard' SE values, while *in vitro* phantom values have shown close agreement. This disparity between T_2 values suggests care should be taken when comparing DESPOT2 and SE values, particularly in tissue known to exhibit multi-component relaxation, such as white and gray matter.

CONCLUSION: In the presence of 2-component relaxation, the general DESPOT2 processing approach provides *apparent* T_2 values which are, in general, more heavily biased towards the short T_2 component than corresponding SE derived values. This increased sensitivity to short T_2 components may be advantageous for imaging application investigating myelin degeneration or brain maturation. Further work is required to determine the feasibility of using SSFP and DESPOT2 to quantify the individual components, however, the results suggest this may indeed be possible.

REFERENCES: [1] Deoni SCL*et al.* MRM 49:515-526 (2003), [2] Whittal K *et al.* MRM 37:34-43 (1997), [3] Does M et al. MRI 16:1033-1041 (1998), [4] Kreis R *et al.* Proc. SMRM 1963 (1992).