Drift in the magnetization transfer signal: effect on quantitative MT experiments

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Introduction: We have observed drift in the magnetization transfer (MT) MRI signal obtained with short-TR GRE sequences and pulsed off-resonance saturation, used in quantitative MT imaging (QMTI) at 1.5 T. At one site, a 2-3% signal decrease was seen in same-session scan-rescan experiments using one method [1]. In experiments where more MT points (> 10) were acquired in succession [2] at a second site, a drift of -6% was observed far off-resonance (Fig. 1). The effect was present in phantoms and *in vivo*: it appears to depend on the duration of the acquisition, and likely affects QMTI parameters. Potential causes include drops in RF amplifier and/or coil performance, and temperature-related T1 increases.

Methods: Two phantoms (4% agar and water doped with Ni^{2+}) were scanned in a transmit/receive head coil with a 3D GRE sequence, TR/TE/α = 32ms/5ms/10°, 128×28 phase encodes, scan time = 2 min. A reference GRE scan was acquired, followed by 10 successive scans incorporating a Fermi MT pulse (Δ = 1.2 kHz) at every repetition, and finally a second reference scan immediately following the MT acquisitions. To explore drift in the B1 pulse amplitude as a potential cause of this signal drift, simulations of a MT-weighted GRE sequence in a model of 4% agar were performed with TR/α/T_{MT}/α_{MT} = 25ms/7°/10.24ms/600°, with scaling the B1 of the excitation and MT pulses down to -20%, for various off-resonance frequencies. To quantify the potential impact on QMT parameter estimates, the effect of drift in B1 amplitude of both RF pulses was incorporated in simulations of QMTI experiments for 2 experimental protocols: 1) a 60-point protocol [2] with B1 amplitude decreasing down to -6.75%; 2) a 10-point protocol [3] with B1 amplitude decreasing to -5%.

Results: The results of the repeated MT-MRI scans are plotted in Fig. 2. The signal drifts by -4.5% in the agar phantom, and slightly less in the water phantom (-3.5%). The magnitude of the drift is similar to that presented in Fig. 1. The signal difference between the pre-/post-MT reference scans was about -4%, consistent with previous observations. Simulations of B1 scaling effects on MT-MRI are shown in Fig. 3. Simulations of QMTI with linear drift in the B1 amplitude resulted in behaviour similar to that seen in Fig.1 (not shown). QMTI parameter estimates are shown in Table 1. Temperature-related T1 increases might also cause MT signal drift: our calculations, based on published data [4], indicate that a T1 increase of 150 ms, or a temperature increase of 4°C, would be required to explain a signal drift of -5% in WM.

Discussion: Signal drift occurs reproducibly over the course of MT experiments. This may not be obvious in QMTI experiments without reference or far-off-resonance data. Drift might affect QMTI parameter accuracy, repeatability, and cross-site comparisons. The exact cause remains to be isolated. Simulations indicate that a change in B1 pulse amplitude, perhaps due to a drop in performance of the RF amplifier or coil, might be responsible. The effect of scaling B1 amplitude depends on the off-resonance frequency of the MT pulse, likely due to competing effects of the excitation and MT pulses. Temperature-related T1 increases might explain drift in phantoms, but are unlikely to explain the effect *in vivo*. Experiments are underway to isolate the cause and identify solutions. Candidate solutions to avoid drift include scaling back MT pulse power or modifying the order of MT acquisitions.

Table 1. QMTI parameters from simulations without and with B1 drift.

	F	kf (s^{-1})	T2f (ms)	T2r (μs)	T1f (s)
Input (true)	0.122	3.97	27.2	11.0	0.584
60-pt	0.120	4.79	29.5	10.8	0.584
60-pt, -7% drift	0.142	4.08	28.5	9.5	0.579
Error (%)	**19%**	**15%**	**3.4%**	**12%**	**0.9%**
10-pt	0.117	4.63	29.6	10.8	0.585
10-pt, -5% drift	0.130	4.46	28.9	9.3	0.582
Error (%)	**11%**	**3.7%**	**2.4%**	**14%**	**0.5%**

References: [1] Yarnykh and Yuan, NeuroImage (2004) [2] Sled and Pike, MRM (2001) [3] Cercignani *et al*. NeuroImage (2005) [4] Nelson and Tung, MRI (1987)

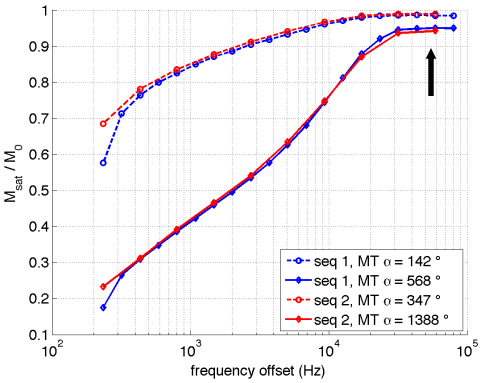

Figure 1. Image data from WM in a healthy subject scanned using a 60-pt protocol. Arrow indicates the apparent signal drop for the far off-resonance points, especially for the high-flip-angle MT pulse.

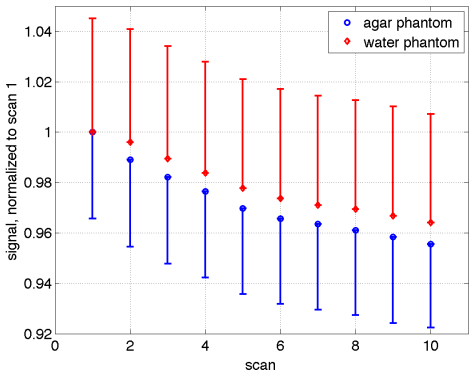

Figure 2. Average signal from 10 repeated scans in a 4% agar phantom, using a 3D GRE sequence with MT pulse, normalized to the first scan. Error bars = standard deviation across the ROI. Final signal drift = -4.5%.

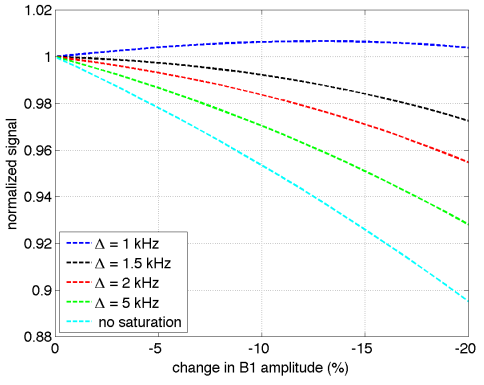

Figure 3. Simulation of MT-weighted GRE signal vs. scaling of the B1 amplitude, for 4 off-resonance frequencies and no saturation.