Highly Reproducible in vivo T1 Maps in brain at 3T

Sofia Chavez[1,2], Stephen Kish[1,2], Tina McCluskey[1], and Nancy Lobaugh[1,3]

[1]Research Imaging Centre, Centre for Addiction and Mental Health, Toronto, ON, Canada, [2]Psychiatry, University of Toronto, Toronto, ON, Canada, [3]Neurology, University of Toronto, Toronto, ON, Canada

Purpose:

Many factors affect the accuracy of quantitative MRI methods. For T1 mapping with a spoiled-gradient echo sequence, accuracy has been shown to be affected by B1 inhomogeneity, slice profile effects, the effectiveness of spoiling and noise[1,2,3,4]. Some of these factors may vary spatially across the brain, so it is important to assess the effects of these factors in anatomically defined regions-of-interest (ROIs). Furthermore, many of these factors may vary from scan to scan due to subject placement, field inhomogeneity, scanner instability, physiological noise and/or true physiological changes. It is essential to assess the reproducibility of a method when attempting to use the resulting metric to detect differences across subjects (eg. healthy *vs* diseased) or within subjects (eg. drug induced effects, aging). An efficient method of 3D B1-corrected T1 mapping has been proposed[4], the Method of Slopes (MoS), and recent work demonstrated the accuracy of the T1 maps *in vivo*[5]. However, the reproducibility of the resulting T1 maps has not yet been determined. In this work, we assess the regionally-dependent reproducibility of T1 mapping with the MoS. Our goal is to quantify the *intra*-subject variability within a day (morning and afternoon) and across two days (subsequent mornings).

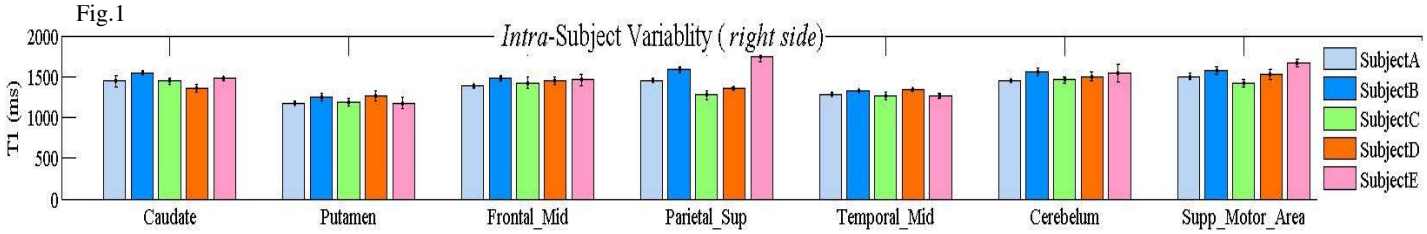
Methods:

Five healthy controls were recruited (ages: 35.6±9 years, 2 male) and consent was obtained according to the REB of the Institution. Subjects were scanned with a 3T scanner (MR750, GE Healthcare) using the fastest protocol described in ref.5, yielding B1-corrected T1 maps with an isotropic resolution of 1mm in less than 10 minutes. Subjects were scanned at the three time points: the morning and afternoon of the same day and the morning of the following day. Resulting T1 maps were co-registered within subject, using a linear registration algorithm in FSL (FMRIB Analysis Group, Oxford University, UK). 118 ROIs were identified using the AAL template[6]. T1 values were extracted per ROI. Histograms were plotted to show the distribution of T1values per ROI and an average value was calculated at each time point i=1,2,3: $\langle T1 \rangle_i$ (for each subject and ROI).

Results:

Fig.1 illustrates the mean ± std of $\langle T1 \rangle_i$ for i=1,2,3 in some representative ROIs. The *intra*-subject variability is indicated by the size of the error bars. The *inter*-subject variability is reflected in the variation between the height of the different-colored bars (per ROI). The reproducibility was quantified for all ROIs as a coefficient of variation (CV) in time for *intra*-subject variability and across subjects for *inter*-subject variability. Results, in all ROIs, gave CV<8% and CV<12% for *intra*-subject and *inter*-subject variability, respectively.

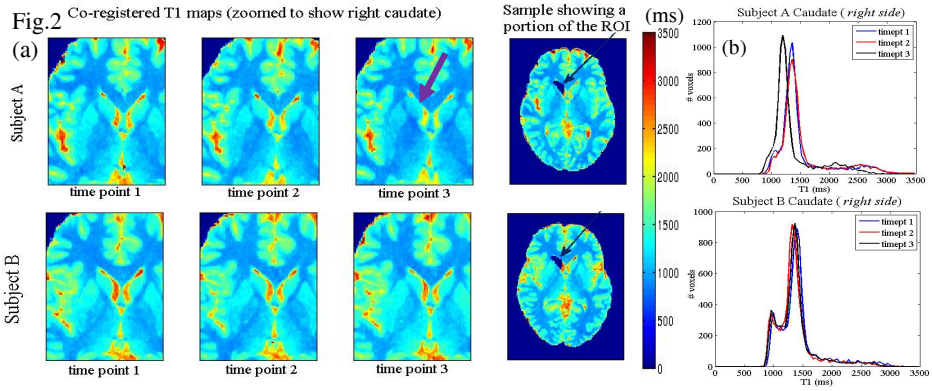
Fig.1



Discussion:

In the cases with larger *intra*-subject variability, such as the right caudate for Subject A (CV=6.95%), the histograms usually show a shift of all values for i=3 (following day) (Fig.2b). This may reflect true physiological changes that can occur over the time span of a day, possibly changes in the water content of tissue. Nonetheless, this effect is small (CV<8% for all ROIs in all subjects). Fig.2a shows the co-registered T1 maps for Subject A in the right caudate. Subject B histograms and T1 maps are shown for comparison. To better characterize the source of *intra*-subject variability and the time course of expected changes, more experiments, including phantom experiments, and repeated intra-session scans are underway. Although it was not our goal to assess *inter*-subject variability because it does not reflect a measurement reproducibility, the results for this small population have very low *inter*-subject variability in most brain regions; highest variability occurs in the superior parietal region (Fig.1) but this may reflect CSF contributions.

Fig.2 Co-registered T1 maps (zoomed to show right caudate)



Conclusion:

The results indicate that T1 maps, calculated using the MoS as described in ref.5, have very low *intra*-subject variability for the given time points. This makes T1 a well-suited metric for studies investigating effects expected to occur over a one to two day time period (eg. drug induced). The low *inter*-subject variability results suggest that T1 may be a sensitive metric to detect differences between healthy controls and diseased subjects, particularly in subcortical regions. Studies in larger populations are required to confirm this.

References: [1]Wang et al., *J Magn Reson* 2006 [2] Parker et al., *Magn Reson Med*, 2001 [3] Preibisch & Deichmann, *Magn Reson Med*, 2001 [4] Chavez & Stanisz , *NMR in Biomed*, 2013 [5] Chavez, *ISMRM* #2389, 2012 [6] Tzourio-Mazoyer et al, *NeuroImage*, 2002