TE Stepping with EPI: Reliable Relaxometry

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Background Transverse relaxometry performed as TE stepped EPI measurements of T2 were first implemented in early EPI systems before 1990[1, 2]. The relaxation values measured by this technique show a strong correlation to CBV and perfusion measures in cerebellar nuclei, and although the mechanism of this correlation is not clear it has been used successfully in studies of steady state perfusion [3, 4]. Because TE stepped relaxometry is a spin echo technique that is used to measure T2* effects, it can be argued that it is neither a T2 measurement nor a T2* measuremen; additionally, studies have questioned the validity of T2 values obtained with EPI acquisitions because of the similarity of the acquisition time and the T2 values[5, 6]. In order to reconcile these two positions we have performed several T2 measurements on differently sized phantoms as well as in human striatum and thalamus.

Methods We compared regional means of T2 values calculated from spin echo scans performed with multiple TE values. Four different scan techniques were performed on sets of differently sized phantoms and on regions drawn in the human brain. These scans were performed at 1.5T and at 3.0T.

At 1.5T the following scan prescriptions were used. MRI system was a whole body 1.5T Signa scanner, CNV3 release.

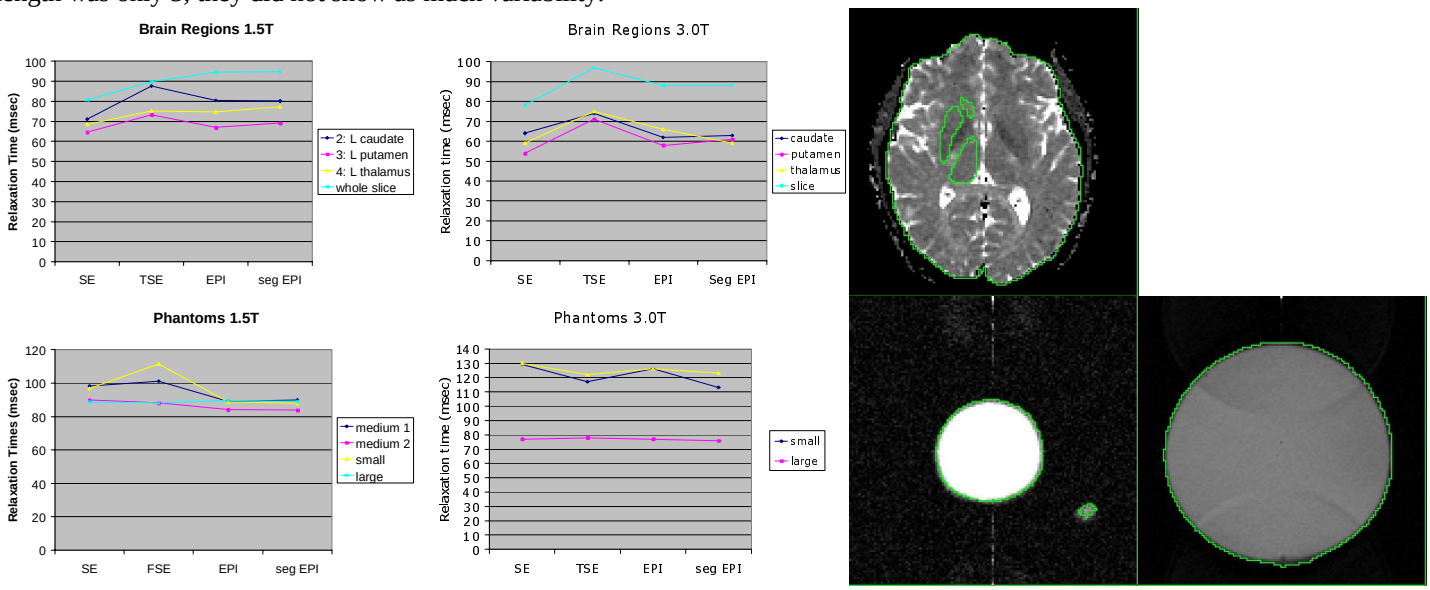
1. 2 x Single echo spin echo: TE/TR = 30, 80/3 sec; 256x256 on 20cm FOV, slice 5mm. Acquisition time is 4 msec.
2. 2 x Fast spin echo: TE/TR = 34, 85/3 sec; 256x256 on 20cm FOV, slice 5mm. ETL = 16. Acquisition time is about 64 msec.
3. 32 x Single shot TE step EPI: TE/TR = 17, 21, 25…141/5s; 128x128 on 20cm FOV, slice 5mm. Acquisition time is 92 msec.
4. 8 x Multishot TE step EPI: TE/TR = 17, 33, 49…141/5s; 128x128 on 20cm FOV, slice 5mm. 8 shots. Acq. time is 12 msec.

At 3.0 T the following scan prescriptions were used. MRI system used was a whole body 3.0T Siemens Trio scanner, V23A release.

1. 2 x Single echo spin echo: TE/TR = 30, 80/3 sec; 128x128 on 22cm, slice 5mm. Acquisition time is 5 msec.
2. 2 x Fast spin: TE/TR = 28, 84/5 sec; 256x256 on 21cm FOV, slice 5mm. ETL = 5. Acquisition time is about 70 msec.
3. 24 x Single Shot EPI scans: TE/TR = 17, 21, 25…119/5s; 128x128 on 21cm, slice 5mm. Acquisition time is 91 msec.
4. 8 x Multishot TE step EPI: TE/TR = 17, 33, 49…119/5s; 128x128 on 21cm, slice 5mm. 8 shots. Acq. time is 12 msec.

Pixel-wise relaxation time maps were prepared from thresholded images using a log-linear fit. Regions were drawn by hand, and regional mean relaxation times calculated.

Results The spin-echo single-shot EPI and multi-shot EPI scans showed repeatable relaxation measurements. Fast/Turbo spin echo sequences showed the most variability based on object size at 1.5T, where the echo train length was 16; at 3.0T, where the echo train length was only 5, they did not show as much variability.



Conclusions

Transverse relaxometry measurements made with EPI TE stepping methods do not seem to suffer from the size related measurement error as previously predicted. By contrast, long ETL fast spin echo methods do show this effect, and should be used with caution.

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