A COMPARISON OF B_1 MAPPING METHODS FOR T_1 MAPPING AT 3T

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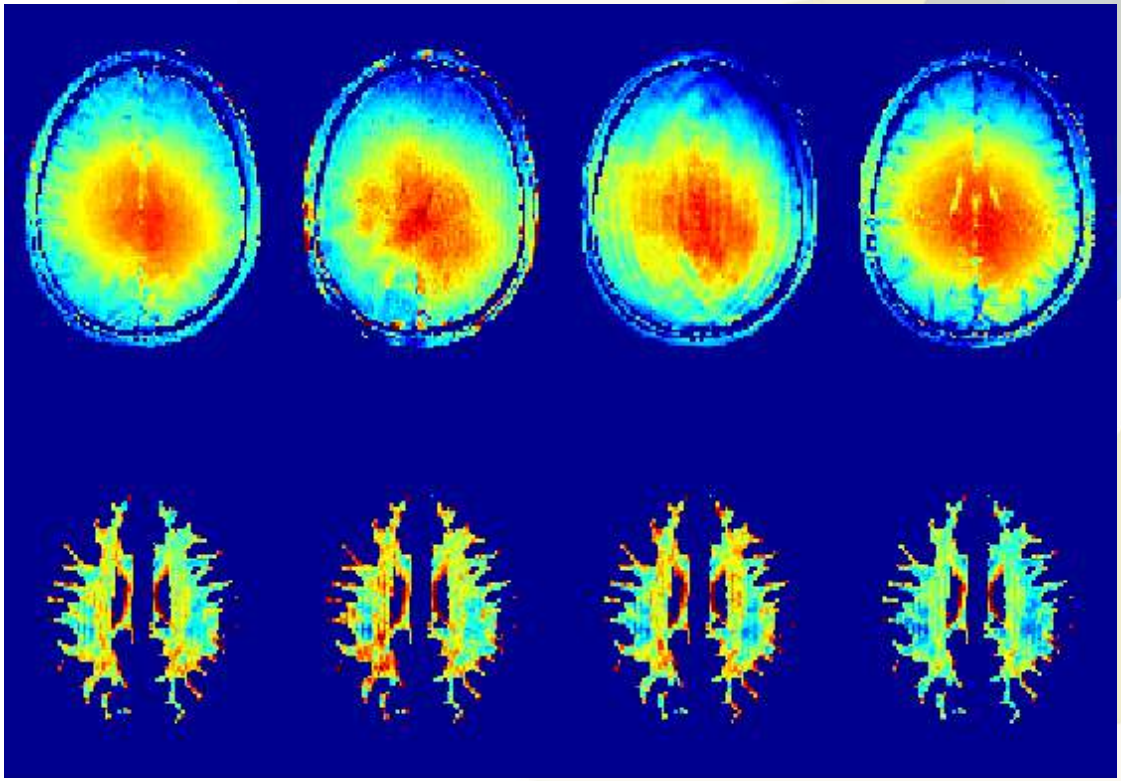
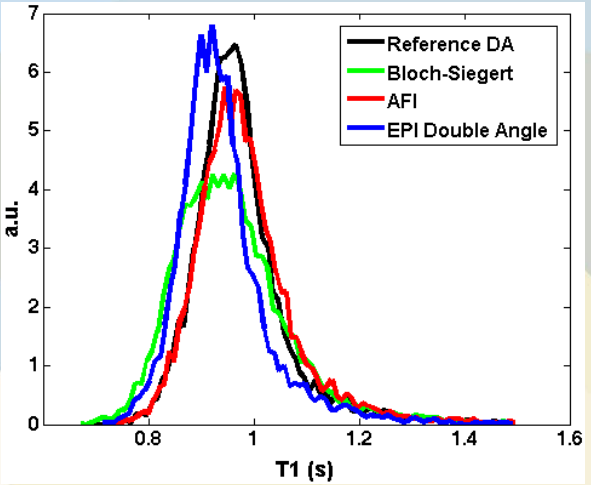
Reference DA	Bloch-Siegert	AFI	EPI Double Angle
4 m 38 s/slice	18 s/slice	11 s/slice	5 s/slice

B_1 (n.u.)

T_1 (s)





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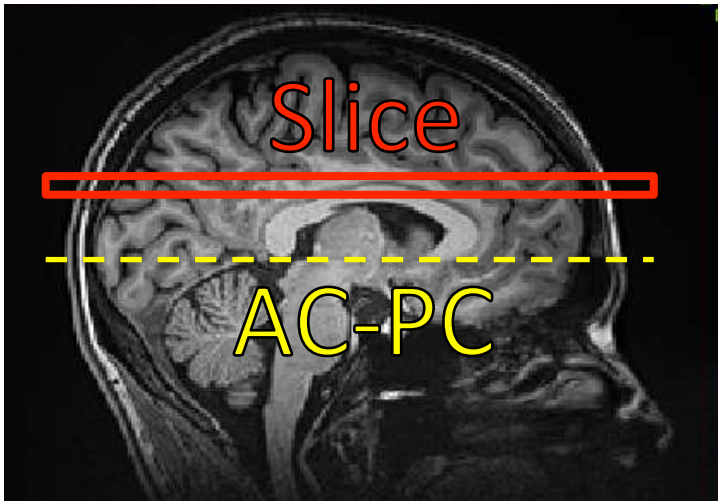
- B_1 maps are essential for Variable Flip Angle (VFA) T_1 mapping.
- Whole-brain quantitative MRI requires rapid B_1 methods.
- B_1 mapping can be accelerated with:
  - Novel pulse sequences (e.g. Actual Flip Angle Imaging[1] (AFI), Bloch-Siegert[2] (BS))
  - Fast k-space trajectories (e.g. EPI, Spiral)

Aim: Compare VFA T_1 maps in white matter (WM) produced with four B_1 methods at 3T:

1. Reference double angle (DA)
2. Bloch-Siegert (BS)
3. Actual Flip Angle Imaging (AFI)
4. DA using a stock scanner spin-echo EPI (EPI-DA)

- Six healthy adult subjects
- 3T Siemens Tim Trio MRI (32-channel coil).
- Axial slices (2x2x5 mm^3) were acquired (or extracted from 3D) // to AC-PC.



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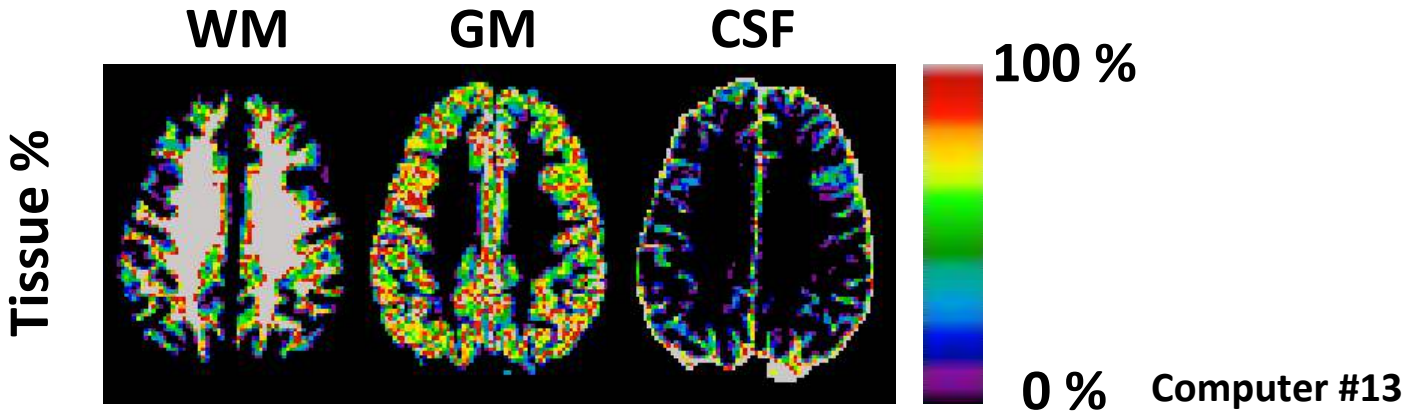
Pulse Sequences

- **Structural image**
  - T_1w MP-RAGE (1x1x1 mm^3)
- **B_1 maps**
  - 2D Reference DA B_1 map: TE/TR 12/1550 ms, α = 60°/120°.
  - 3D AFI B_1 map: TE/TR1 3.53/20 ms, N = 5, α = 60°, spoiling gradient moment A_G = 450 mT•ms/m and RF phase increment ϕ = 39°.
  - 2D BS B_1 map: TE/TR 15/100 ms, α = 25°, 8 ms Fermi Pulse of 500° at ±4kHz off-resonance and K_{BS} = 74.01 rad/G^2.
  - Interleaved multi-slice spin-echo EPI-DA B_1 map: TE/TR 46/4000 ms, α = 60°/120°, EPI Factor = 9 and echo spacing = 4.18 ms.
- **T_1 maps**
  - 3D VFA T_1 map: TE/TR 2.89/15 ms, α = 3°/20°, A_G = 280 mT•ms/m, ϕ = 169°.

- Tissue classification maps (WM, GM, CSF; 1x1x1 mm^3) were provided via INSECT[8] (ICBM-152 atlas).

- WM tissue masks were resampled to a 2x2x5 mm^3 slice using a majority voting analysis (cutoff: 75%).
  - GM and CSF were not included because of partial volume effects due to the voxel size.



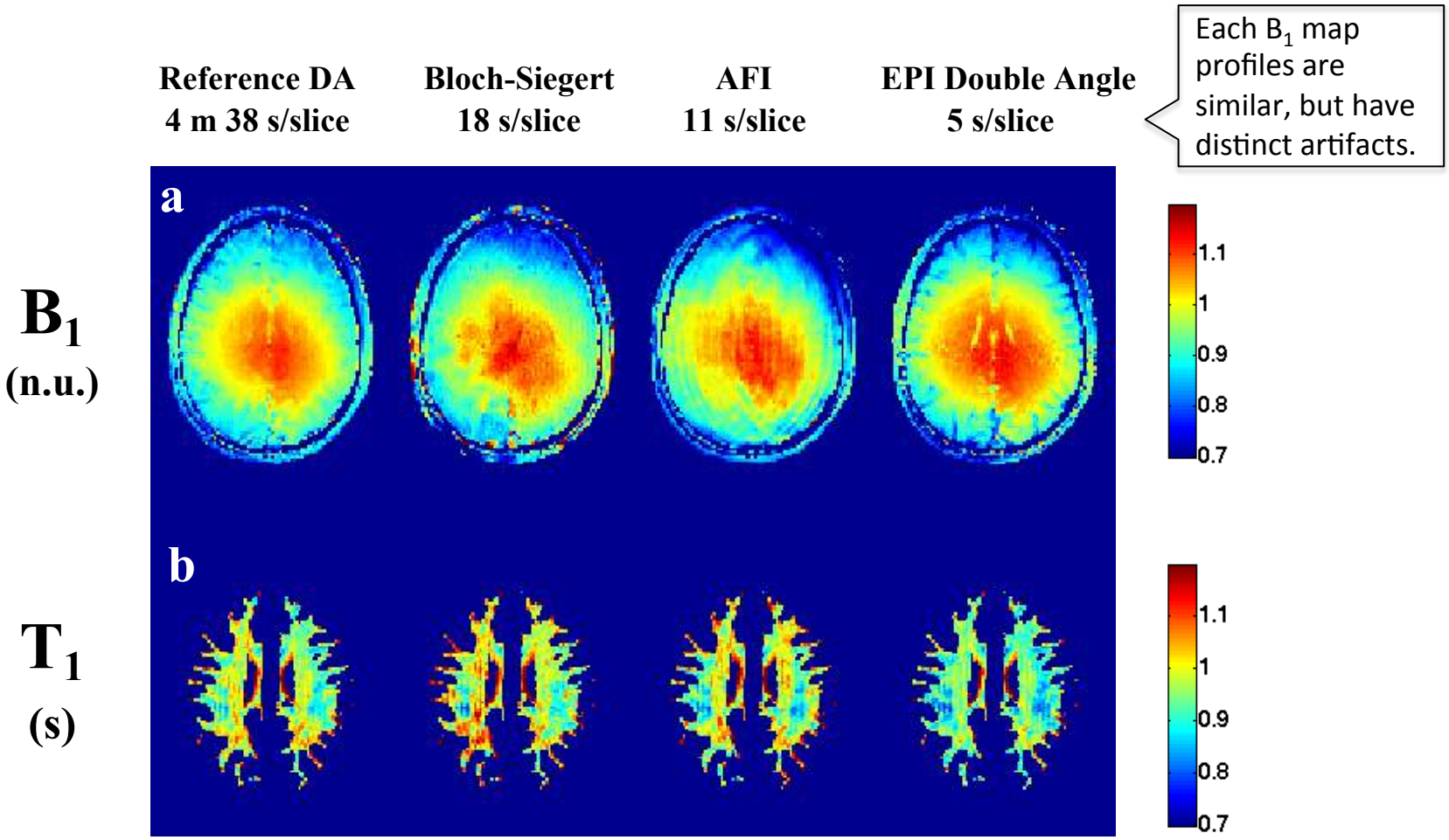


Figure 1: (a) Single slice B_1 maps from a representative subject. (b) WM VFA T_1 maps using flip angles corrected with each B_1 map.

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Each T_1 distribution overlap, with minor peak deviations relative to Ref. DA (max. 4% - EPI-DA).

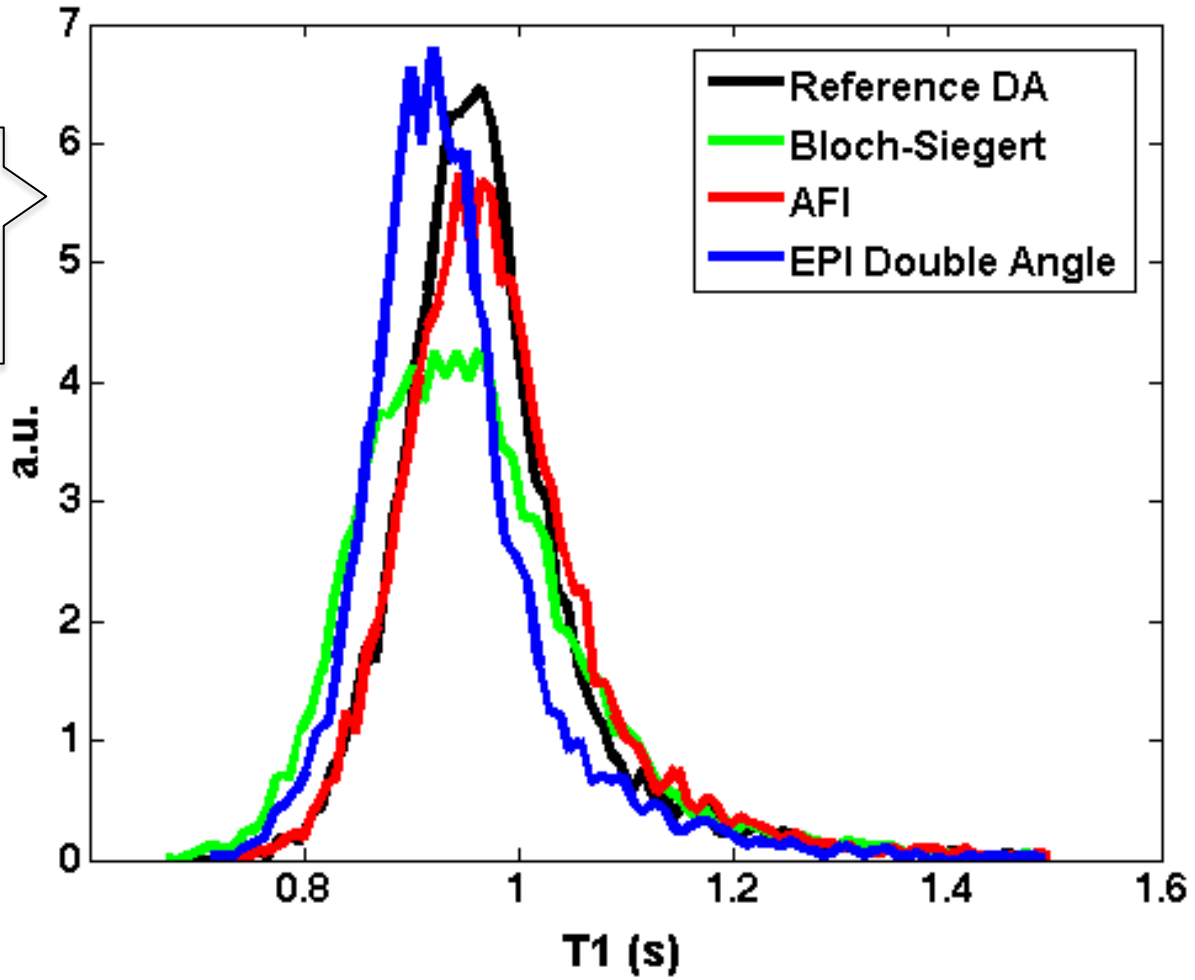

Figure 2: Normalized pooled histograms of single slice WM T_1 values for 6 healthy subjects (bin width = 10 ms).

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Table 1: Linear regression analysis of the pooled WM T_1 values (6 subjects) for each B_1 method relative to the reference DA B_1 method.

	Ref. DA	BS	AFI	EPI-DA
Pearson ρ	---------	0.963	0.972	**0.984**
Fit slope	---------	0.993	**1.002**	0.981

Signs of a fit slope for T_1 maps using AFI B_1 can also be observed in the histogram in Fig. 2.

T_1 maps using EPI-DA has the strongest voxelwise correlation with Ref. DA (see Fig 1.), but slightly underestimates T_1 (see Fig. 2, and compare fit slopes in Table 1)

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- To further investigate possible distortion artefacts in EPI-DA B_1 maps, a left-hemisphere sagittal slice B_1 map for both DA methods was acquired for one subject.

No important susceptibility artefacts are observed near the sinuses.

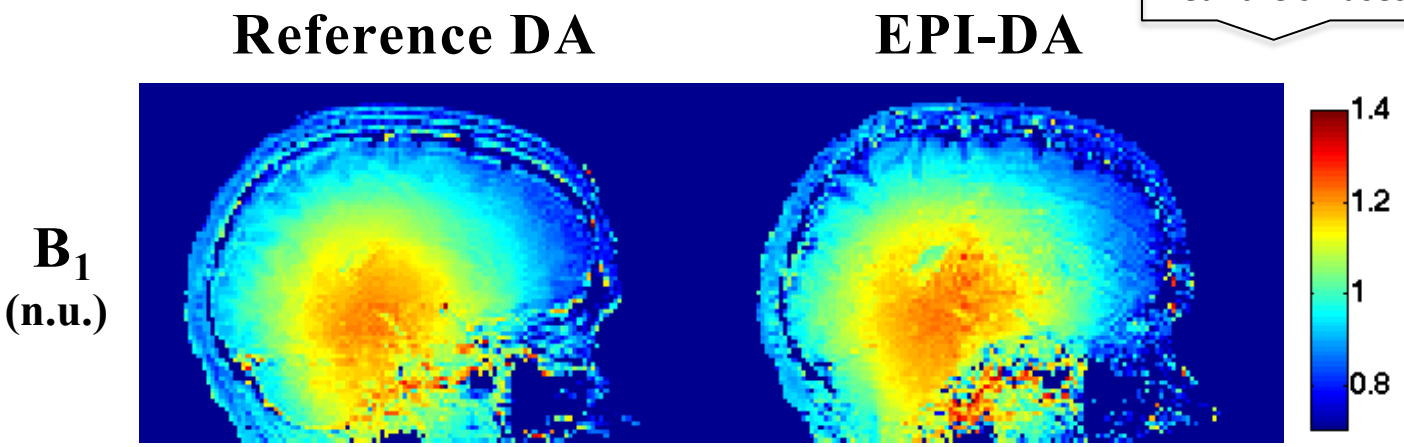


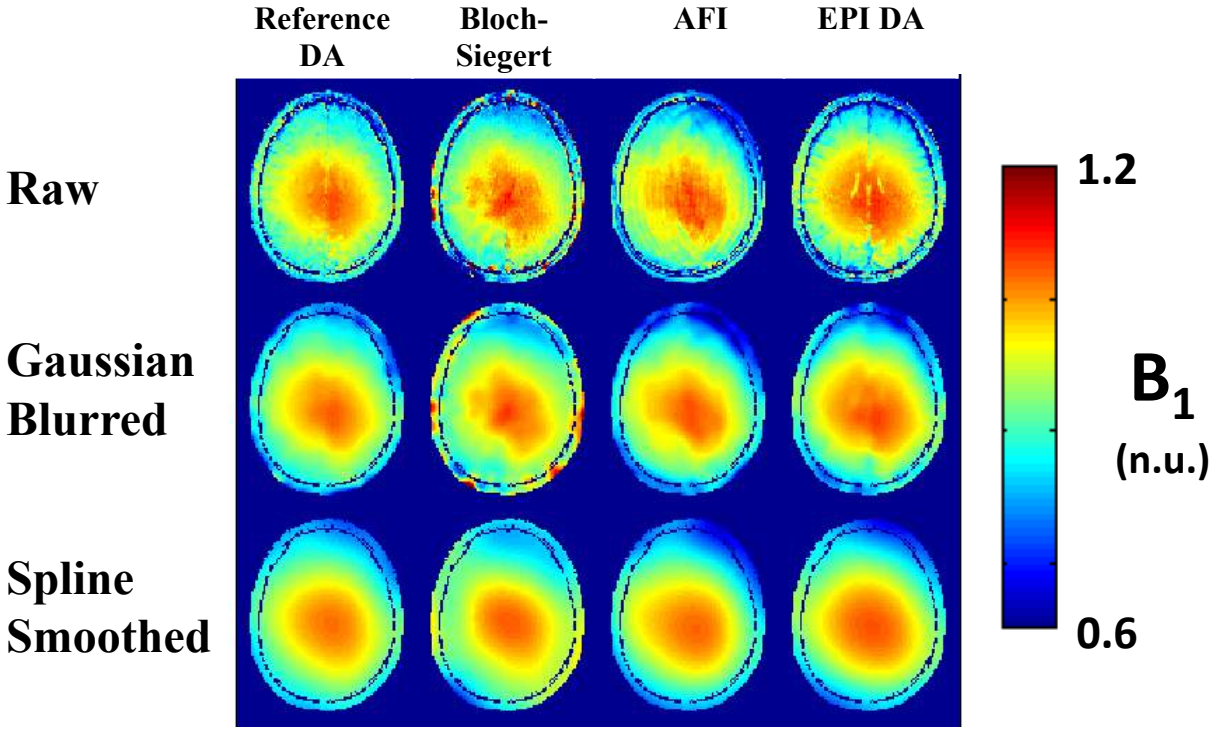
Figure 3. Sagittal (left hemisphere) B_1 maps for a single subject using the reference and EPI double angle methods.

- **All B_1 methods resulted in similar WM T_1 distributions**, and **T_1 maps fitted using each rapid methods strongly correlated with the reference DA map**.

- EPI-DA, the fastest of the techniques derived from a stock scanner sequence, had the highest correlation with Ref. DA, with no observable distortion artefacts.

- EPI-DA B_1 maps had no major artefacts due to susceptibility effects.

- Structural information can be removed by interpolating or blurring the B_1 maps.



- For multi-site studies, EPI-DA could be a good alternative to novel methods due to ease in implementation.

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- All B_1 methods provided similar B_1 and VFA T_1 maps at 3T.
- Strong correlations were observed between VFA T_1 maps using all three rapid methods compared to Ref. DA.
- Blurring B_1 maps to remove structural artefacts could be beneficial for quantitative brain MRI.
- EPI-DA could be a good alternative to novel methods due to ease in implementation, and rapid acquisition time.

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