

Evaluating the Reproducibility of STAGE Imaging: A Traveling Brain Study

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Introduction: Strategically acquired gradient echo (STAGE) imaging is a rapid multi-parametric 3D brain imaging method that provides essential qualitative images and quantitative data for evaluating various neurodegenerative disorders [1-3]. STAGE imaging employs two consecutive multi-echo spoiled gradient-echo acquisitions to generate proton spin density (PSD) and T1 weighted images from the low and high flip angle (FA) cores, respectively [1]. The multi-echo data are used for the reconstruction of susceptibility weighted images, T2* mapping and quantitative susceptibility mapping (QSM) [1]. By fitting the B_1^+ and B_1^- fields with constraints, the short echoes of the 2-FA data are used for B_1 corrected T1 and PSD mapping [2]. Consequently, these pixel-wise quantitative data enable us to simulate multiple vital weighted images including a T1 weighed image with enhanced grey matter to white matter contrast, a bias corrected PSD weighted image, a FLAIR image, a T2W-like image, and three double inversion recovery images for suppressing grey matter, white matter and CSF respectively [3]. The purpose of this study was to evaluate the reproducibility of the STAGE imaging that will be used for the multi-site protocol in studying Parkinson's disease.

Methods: A travelling brain (39 yrs, male) was imaged on 7 participating sites either has a Siemens Prisma 3T scanner or a Philips Ingeia 3T scanner. The vendor-provided spoiled gradient echo sequences were used for a high-resolution STAGE protocol with the following imaging parameters: TR = 29ms; TEs = 7.5/15/22.5ms; FAs = 6°/27°; Acquisition resolution = 0.67x1.0x1.34mm³; Scan time = 9 min 36 s for 112 slices covering the whole brain. Data were processed using an established pipeline in MATLAB with rigid co-registration using SPM [1]. The reproducibility of the quantitative T1, PSD and QSM maps were analysed on the co-registered data using one set of manually delineated ROIs for the genus of corpus callosum (CC), caudate nucleus (CN), globus pallidus (GP), substantia nigra (SN) and red nuclei (RN).

Results: Consistent results were observed from all the participating sites (**Figure 1**). The *Coefficient of Variation* across all sites were: CC=2.21%, CN=2.23%, GP=1.8%, SN=6.98%, RN=4.4% for T1 mapping; CC=2.7%, CN=2.85%, GP=2.67%, SN=4.98%, RN=4.5% for PSD mapping; and CN=9.9%, GP=3.1%, SN=4.5%, and RN=9.4% for QSM data.

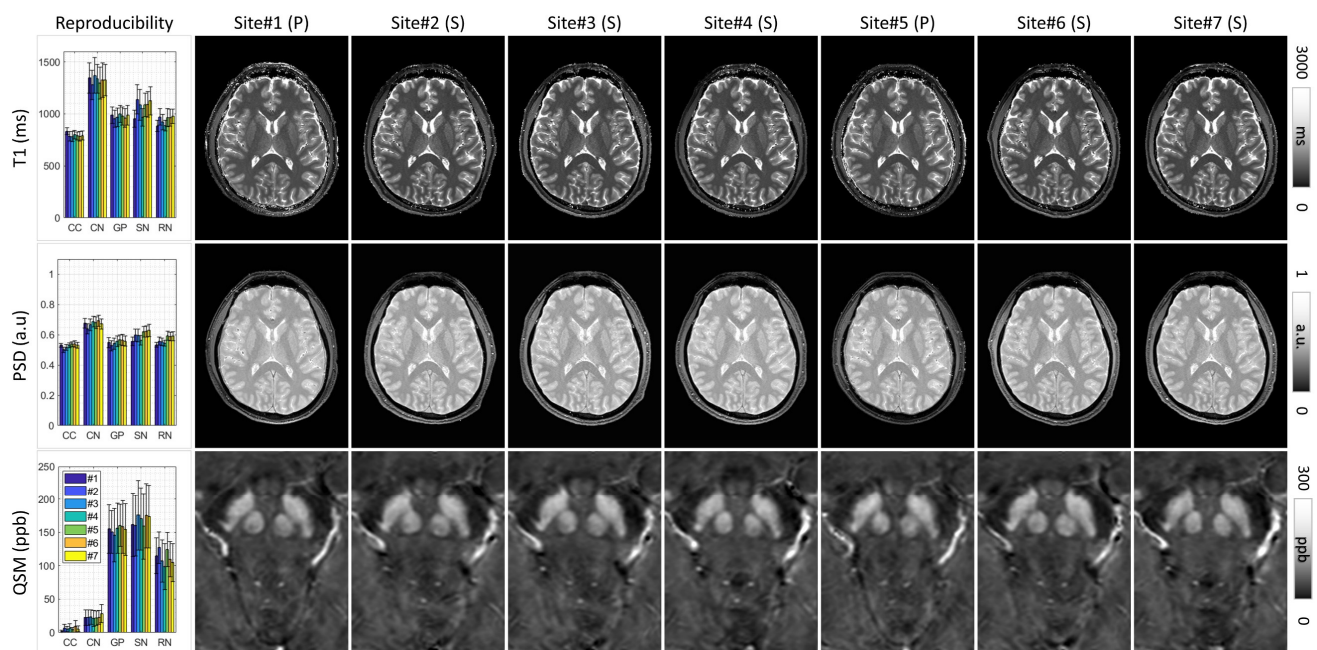


Figure 1. Reproducibility plots and representative images from each of the participating sites with a Siemens (S) or a Philips (P) scanner.

Discussion and Conclusions: Repeatability and reproducibility of the quantitative STAGE method are essential knowledge that should be evaluated in prior to the multi-centre study in Parkinson's disease. A combination of T1, PSD and susceptibility can be used to measure the complex of water content and iron content changes in the substantia nigra that could be a promising diagnostic biomarker signature in early Parkinson's disease. We have demonstrated a good repeatability of the STAGE method in previous studies on 3T [3] and 1.5T [4]. The present study concluded a very good reproducibility of the STAGE method warranting the ongoing multi-centre study.

References: [1] [Chen et al., MRI 2018](#); [2] [Wang et al., MRI 2018](#); [3] [Haacke et al., MRI 2020](#); [4] [Pirastru et al., EURA 2021](#).