A Travelling Heads Study Investigating qMRI Metrics on Cortical Regions

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Introduction:

Technological advances in magnetic resonance imaging (MRI) have facilitated numerous studies on neural architecture, such as studies addressing pathology, behaviour or individual differences in brain activity. It is important, however, to first ascertain what variation can arise due to site-specific scanner properties (hard- and software). A certain amount of noise in MR images can indeed be attributable to such properties, even when the same scanner is used across different sites. Reproducibility across sites is possible with the use of quantitative MRI metrics (qMRI), where physical properties assigned to voxels allow for non-invasive analysis of brain tissue including sensitivity to iron and myelin content. Leutritz et al. (2020) investigated intra-site (scan-rescan) and inter-site (between sites) variability on Siemens and Philips scanners through multi-parameter mapping techniques (MPM). The authors found intra-site scan-rescan coefficients of variance (CoV) ranging between 4% and 16% across parameters, with similar results for inter-site CoV.

The current study implements a similar strategy to Leutritz et al. (2020) in that it investigates inter-site and inter-scanner variability in a "travelling heads" type of study. Using scanners by the same manufacturer (but two different models), the study investigates qMRI metrics for inter-site and inter-scanner differences and their corresponding effects on cortical regions.

Methods:

Whole brain MRI scans were acquired across three sites: Kraków, Poland (KRK); Aarhus, Denmark (AAR); and Brno, Czech Republic (BRN). While scans in KRK were acquired using a Siemens Skyra 3T scanner, scans in AAR and BRN were acquired using a Siemens Prisma 3T scanner. A total of five healthy individuals participated in the study, two of whom were scanned at all three sites, and three underwent multiple scans at the same site.

DICOM files from a MPM protocol comparable to the one used by Leutritz et al. were first converted to NIfTI using functionalities within the hMRI-toolbox (Tabelow et al. 2019) and SPM12 framework. Using the hMRI toolbox provided separate data for each of the four parameters: magnetization transfer saturation (MT), proton density (PD), longitudinal (R1), and effective transverse relaxation (R2*). T1-weighted multi-echo data provided by the protocol and averaged with the hMRI toolbox was processed using mri_synthesize from Freesurfer to create synthetic T1 weighted images, from which atlases for each subject were created using Desikan parcellation (Desikan et al., 2006). The four MPM modalities were then overlaid with their corresponding atlas for visual inspection. Analysis of the qMRI metrics was performed with R software package v3.5.0 (R Core Team, 2021) such that mean values were calculated for each subject across all regions and MPM parameters and then examined for between-site and between-scanner differences.

Results:

The data so far indicates that region-level mean values from AAR (N subjects = 1) varied less than BRN (N subjects = 3) when compared to KRK (N subjects = 11). Region-level means from scans acquired in AAR differed from KRK by a minimum of 0.01% up to a maximum of 45.94% (mean difference = 3.79%). Region-level means from scans acquired in BRN differed from KRK by a minimum of 0.04% up to a maximum of 99.19% (mean difference = 5.67%).

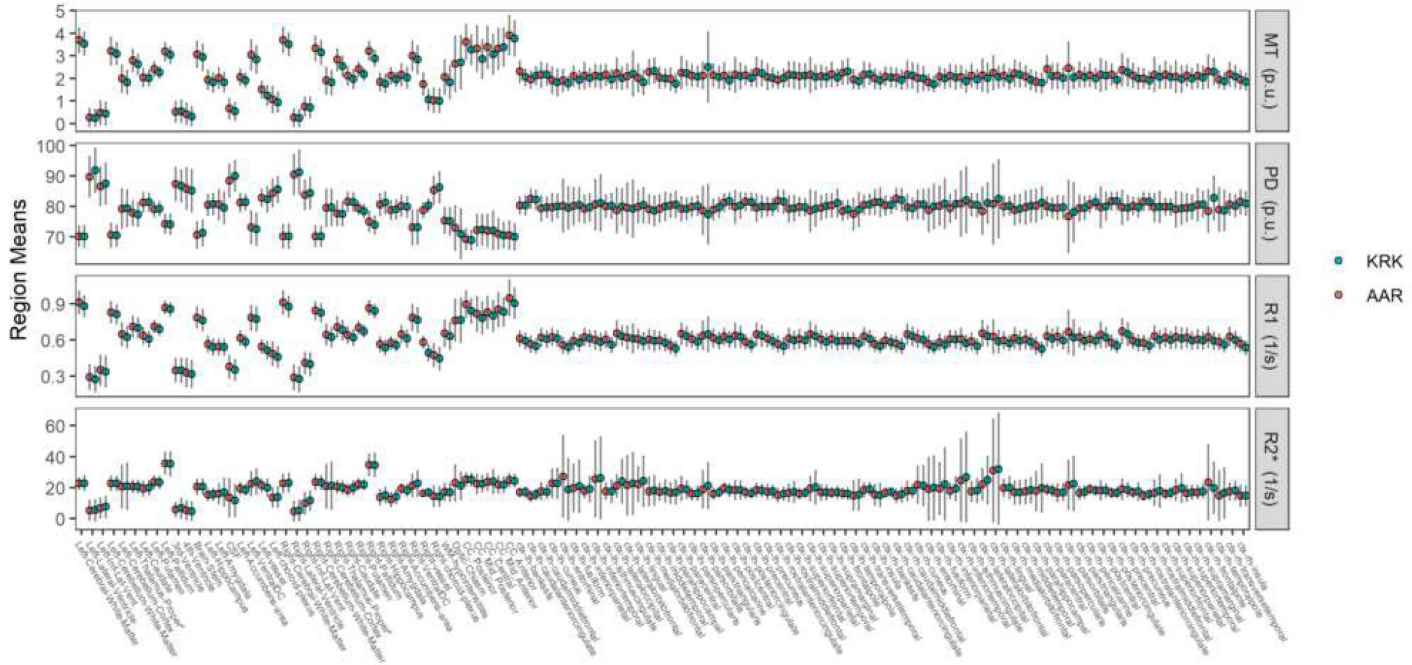

Figure 1: Grid of scatterplots, one for each of the MPM parameters, demonstrating data from one participant across two sites (KRK and AAR) and two scanners (KRK: Skyra and AAR: Prisma). The x-axis is common to all scatterplots and depicts the regions within the brain. The y-axis on each scatterplot depicts the mean value corresponding to each region.

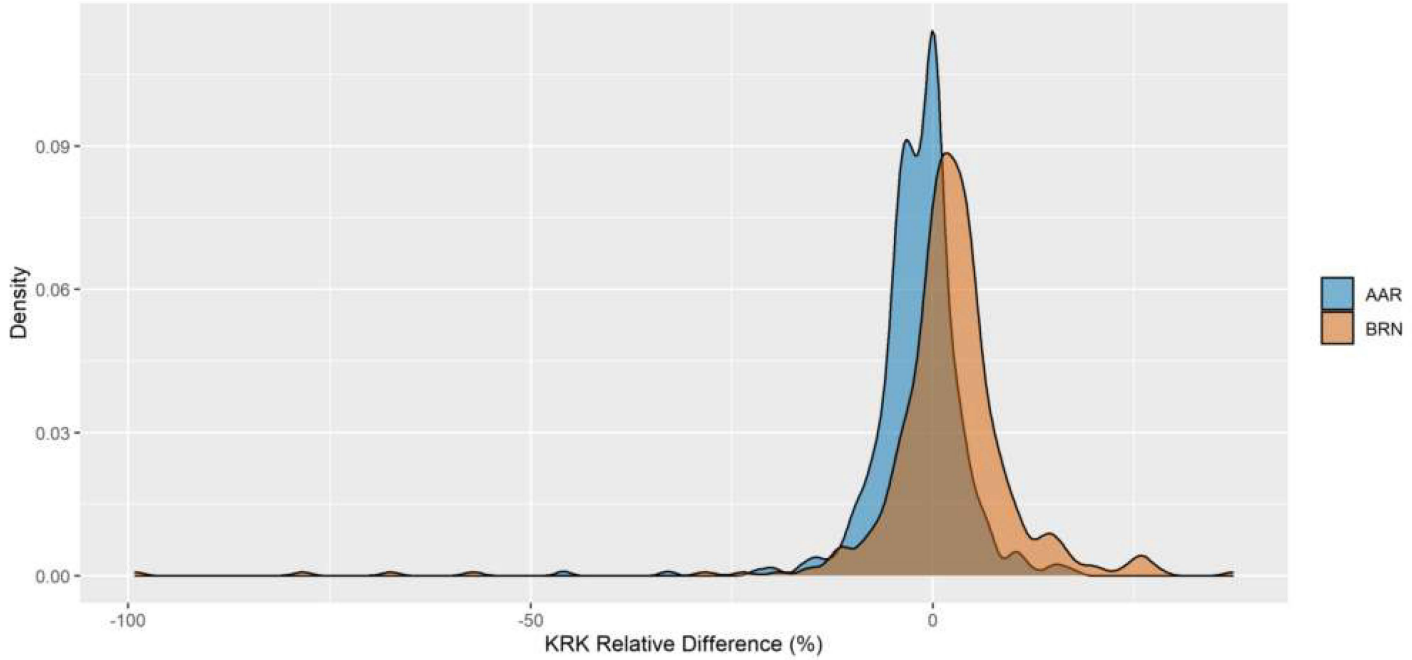

Figure 2: Density plots showing the distributions of differences in region mean values between KRK - AAR (N = 1 subject) and KRK - BRN (N = 3 subjects). Both distributions reflect differences between Skyra-Prisma scanners. Differences in region mean values were calculated as the relative difference in the means of each region i.e., absolute difference in region means/mean of parcel means, as a percentage.

Conclusions:

The current study shows that a certain amount of noise in neuroimaging data is attributable to differences between scanner properties, despite acquiring MRI data from the same machine manufacturer (two different models). Although differences appear to be small, this study provides relevant information on the nature and direction of region-level variability in MRI data between sites.

Modeling and Analysis Methods:

Other Methods [1]

Neuroinformatics and Data Sharing:

Workflows [2]

Keywords:

STRUCTURAL MRI
Other - travelling heads, quantitative mri

[1|2]Indicates the priority used for review

Abstract Information

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No

Please indicate below if your study was a "resting state" or "task-activation" study.

Other

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

Healthy subjects

Was any human subjects research approved by the relevant Institutional Review Board or ethics panel? NOTE: Any human subjects studies without IRB approval will be automatically rejected.

Yes

Was any animal research approved by the relevant IACUC or other animal research panel? NOTE: Any animal studies without IACUC approval will be automatically rejected.

Not applicable

Please indicate which methods were used in your research:

Structural MRI

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

SPM
Free Surfer

Provide references using author date format

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