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Vendor-neutral sequences and their implications for the reproducibility of quantitative MRI

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Abstract

This living preprint (DuPre et al., 2022; Harding et al., 2023; Karakuzu, DuPre, et al., 2022; Karakuzu, 2025) encapsulates the code, data and runtime (R and Python) for an interative exploration of our findings from (Karakuzu, Biswas, et al., 2022).

Background

Quantitative magnetic resonance imaging (qMRI) holds significant potential as a tool for precision medicine, offering objective biomarkers that can enhance diagnostic accuracy and therapeutic monitoring across a broad spectrum of clinical applications (Karakuzu et al., 2024). Despite this promise, achieving reproducibility in qMRI measurements remains a major challenge, particularly in multi-site studies that rely on scanners from different vendors (Stikov & Karakuzu, 2023). Much of this variability arises from differences in pulse sequence implementations among MRI manufacturers, which can introduce systematic biases that reduce the reliability of quantitative metrics (Boudreau et al., 2024).

The development of vendor-neutral pulse sequences (Hoinkiss et al., 2023; Layton et al., 2017) marks a significant step toward standardized qMRI protocols that can be consistently applied across different scanner platforms (Karakuzu, Biswas, et al., 2022). By standardizing key acquisition parameters and sequence timing to ensure that each scanner plays out the same physics, these approaches aim to reduce inter-vendor variability while preserving the quantitative accuracy required for clinical interpretation. This standardization is especially important for multi-site collaborations, longitudinal studies, and the creation of normative databases, all of which depend on high reproducibility across diverse imaging settings (Boudreau et al., 2025).

Achieving vendor neutrality in qMRI has implications that go beyond technical consistency. Reliable quantitative measurements enable data sharing across institutions, support meta-analyses of imaging biomarkers, and contribute to the development of universal reference standards for disease assessment. Moreover, standardized acquisition protocols can help

bridge the gap between research and clinical adoption by providing validated, implementation-independent methods that are readily deployable across healthcare systems (Karakuzu et al., 2025).

Open science practices and reproducible research workflows (Niso et al., 2022) further reinforce this transition by ensuring that qMRI methods can be systematically validated across research environments. In this context, standardized data organization (Karakuzu, Appelhoff, et al., 2022) plays a central role in supporting transparency, replicability, and long-term usability of qMRI datasets.

Results

In phantom experiments, the vendor-neutral sequence substantially minimized inter-vendor differences, reducing them from a range of 8–19.4% down to 0.2–5%. This also improved accuracy relative to ground truth T1 values, lowering deviations from 7–11% to just 0.2–4%. In vivo, the use of the vendor-neutral sequence led to a significant reduction in variability across vendors for all quantitative maps assessed (T1, MTR, and MTsat), with statistical support ($p = 0.015$).

Conclusion

Our findings demonstrate that vendor-neutral imaging protocols are readily deployable on conventional clinical MRI systems. Through substantial reduction of inter-vendor variability, these transparent and reproducible measurement frameworks provide a viable pathway toward enhanced qMRI reliability and improved clinical outcomes in multicenter research settings.

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