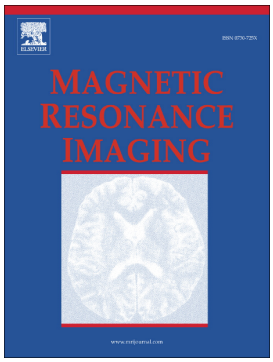

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Empirical Reproducibility, Sensitivity, and Optimization of Acquisition Protocol, for Neurite Orientation Dispersion and Density Imaging using AMICO

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ABSTRACT

Neurite Orientation Dispersion and Density Imaging (NODDI) has been gaining prominence for estimating multiple diffusion compartments from MRI data acquired in a clinically feasible time. To establish a pathway for adoption of NODDI in clinical studies, it is important to understand the sensitivity and reproducibility of NODDI metrics on empirical data in the context of acquisition protocol and brain anatomy. Previous studies addressed reproducibility across the 3T scanners and within session and between subject reproducibility at 1.5T and 3T. However, empirical reproducibility on the performance of NODDI metrics based on b-value and diffusion-sensitized directions has not yet been addressed. In this study, we investigate a high angular resolution dataset with 11 repeats of a study with five b-values shells (1000, 1500, 2000, 2500 and 3000 s/mm^2) and 96 directions per shell on a single subject. We validated the findings with a dataset from second subject with 10 repeats and 3 b-value shells (1000, 2000, 3000s/mm^2). The NODDI model was estimated using Accelerated Microstructure Imaging via Convex Optimization (AMICO) for different b-values and gradient directions on two-shell High Angular Resolution Density Imaging (HARDI) data fixing the lower shell at b=1000s/mm^2. NODDI model applied to all acquired imaging data was used as a baseline gold standard for comparison. Additionally, we characterize orientation dispersion index (ODI) reproducibility using single-shell data. The experimental findings confirmed the sensitivity of intracellular volume fraction (V_{ic}) with the choice of outer shell b-value more than with the choice of gradient directions. On the other hand, ODI is more sensitive to the number of gradient directions compared to b-value selection. Single-shell results for ODI are more comparable to 2-shell data at lower b-values than higher b-values. Recommended settings by region of interest and acquisition time are reported for the researchers considering using NODDI in human studies and/or comparing results across acquisition protocols.

Keywords: NODDI, AMICO, Microstructure imaging, Reproducibility, Advanced DW-MRI

Goals:

- Perform the first evaluation of empirical reproducibility of AMICO/NODDI metrics by b-value and diffusion sampling scheme.
- Characterize the impacts of protocol relative to acquisition time with respect to extended scan time data (gold standard).
- Optimize AMICO/NODDI protocol settings to strike a practical balance of scan time and reproducibility.