

A multidimensional MRI protocol for brain microstructure imaging in the Baltimore Longitudinal Study of Aging (BLSA)

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- Developed a 27-minute whole-brain MD-MRI protocol and integrated in the BLSA.
- Extended diffusion frequency range probes microstructural restriction.
- Enhanced sensitivity to microstructural length scales relevant to brain aging.

BACKGROUND

- Diffusion–relaxation multidimensional MRI (MD-MRI) enables model-free characterization of tissue microstructure.
- Current in vivo protocols, however, have limited diffusion frequency coverage, reducing sensitivity to microstructural length scales relevant to brain aging.

MD-MRI obtains information-rich distributions from each voxel

- Resolves independent components-Mean ($E[X]$) and variance ($V[X]$) of:
- Isotropic diffusivity, D_{iso}
 - Diffusion anisotropy, D_{Δ}^2
 - Frequency dependence, $\Delta_{\omega/2\pi}$
 - R_2 relaxation rate
 - R_1 relaxation rate

- Simultaneously fits the following parameters:
1. Isotropic diffusion (D_{iso})
 2. Anisotropic diffusion (D_{Δ}^2)
 3. Transverse relaxation rate (R_2)
- Multidimensional MRI is model-free and sensitive to cellular-scale features

METHODS

- Developed a 27-minute whole-brain MD-MRI protocol (2-mm isotropic).
- Extended diffusion frequency coverage using optimized tensor-valued encoding.
- Implemented in the Baltimore Longitudinal Study of Aging (BLSA) on a 3T MRI scanner.

RESULTS

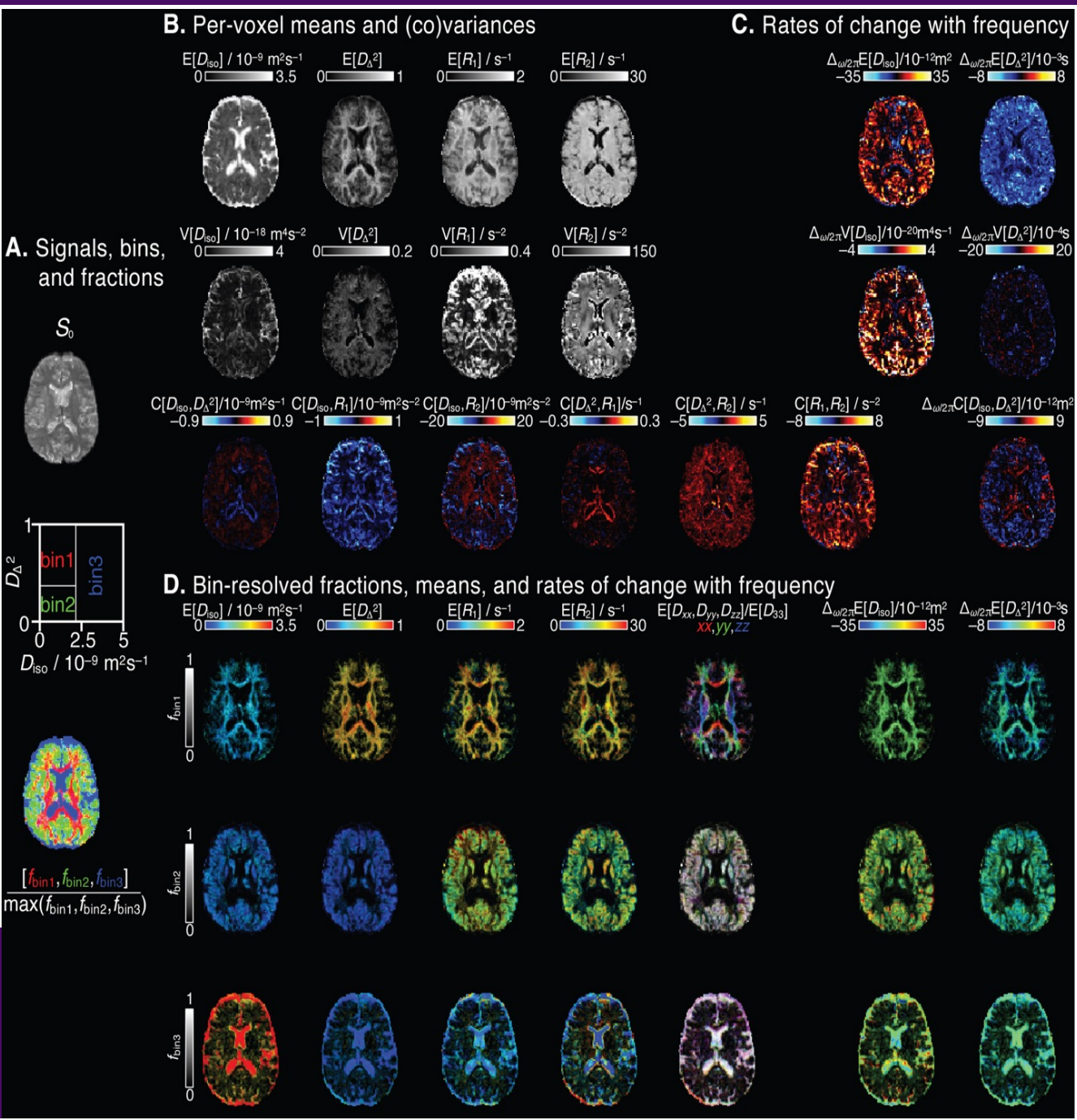


Figure 1. Representative MD-MRI parameter maps from a **46-year-old female** participant. (A) S_0 map, $D_{iso}-D_{\Delta}^2$ binning, and RGB signal fractions. (B) Mean, variance, and covariance maps at $\omega/2\pi = 4$ Hz. (C) Frequency-dependence maps ($\Delta\omega/2\pi[x]$). (D) Bin-resolved mean and frequency-dependence maps. Brightness indicates signal fraction and color represents parameter values.

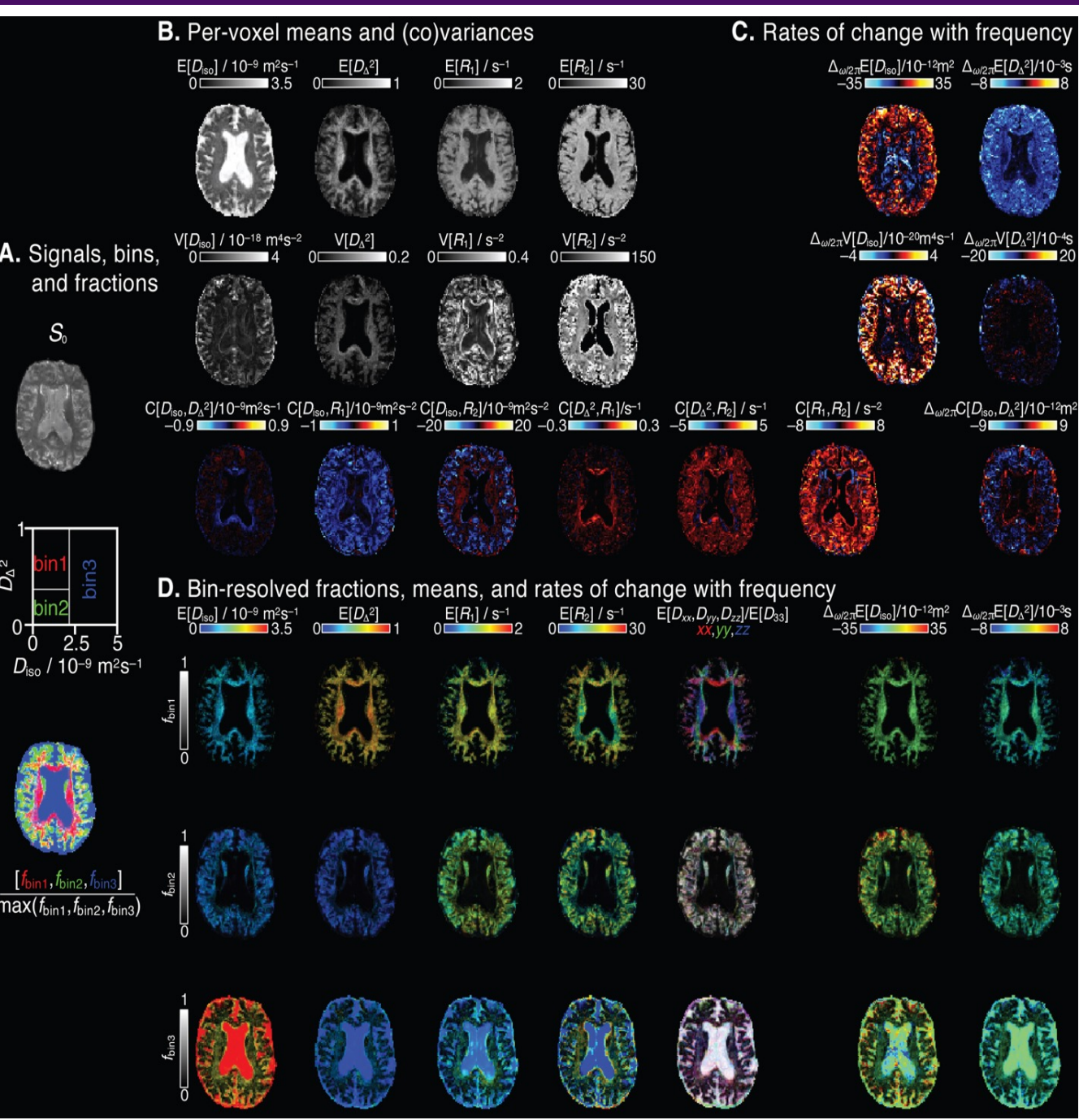


Figure 2. Representative MD-MRI parameter maps from a **95.5-year-old male** participant. (A) S_0 map, $D_{iso}-D_{\Delta}^2$ binning, and RGB signal fractions. (B) Mean, variance, and covariance maps at $\omega/2\pi = 4$ Hz. (C) Frequency-dependence maps ($\Delta\omega/2\pi[x]$). (D) Bin-resolved mean and frequency-dependence maps. Brightness indicates signal fraction and color represents parameter values.

CONCLUSIONS

- 27-minute whole-brain MD-MRI protocol
- Improved sensitivity to restricted diffusion and brain microstructure
- Scalable for large aging cohorts such as the BLSA

CONTACT

