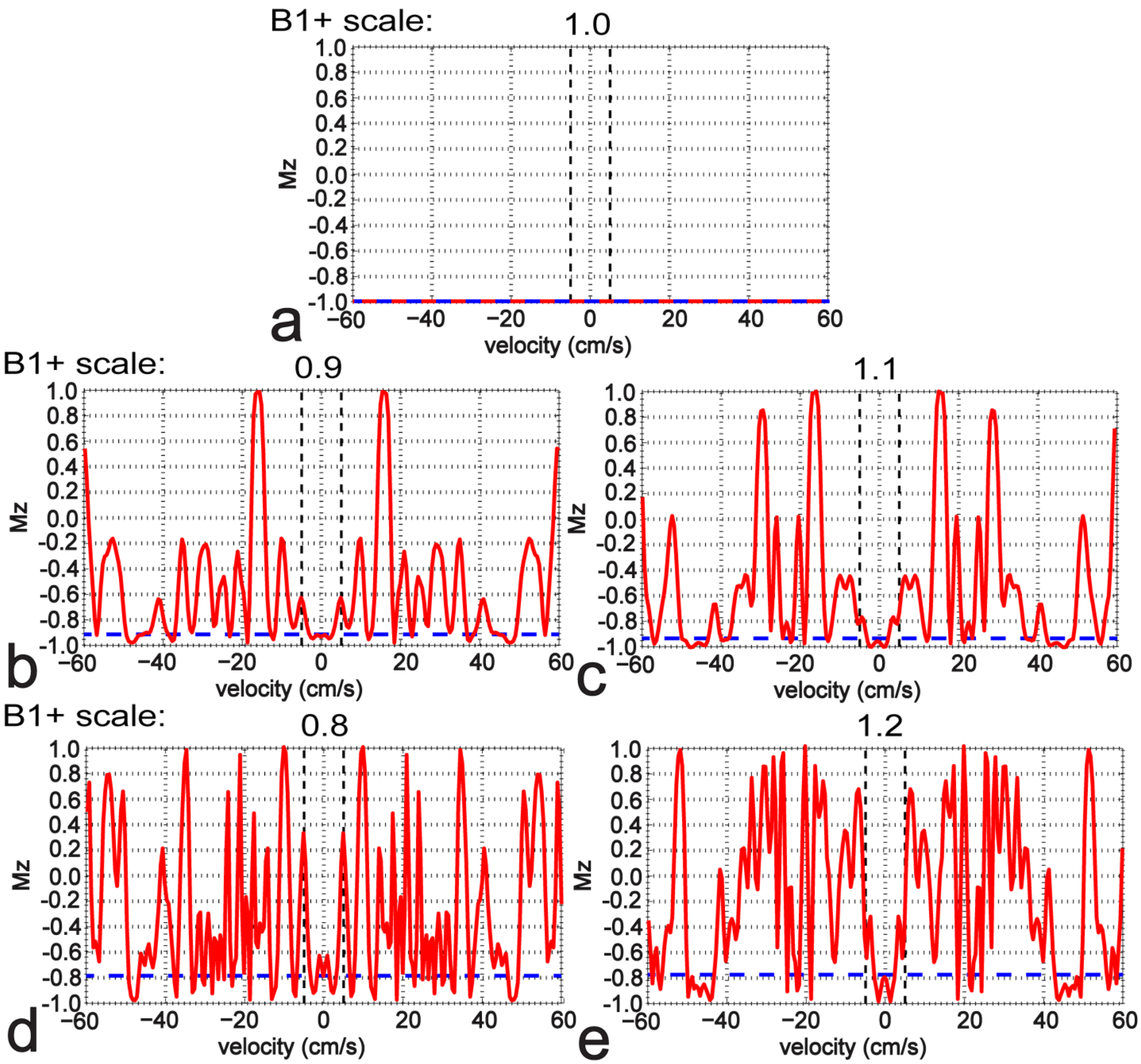
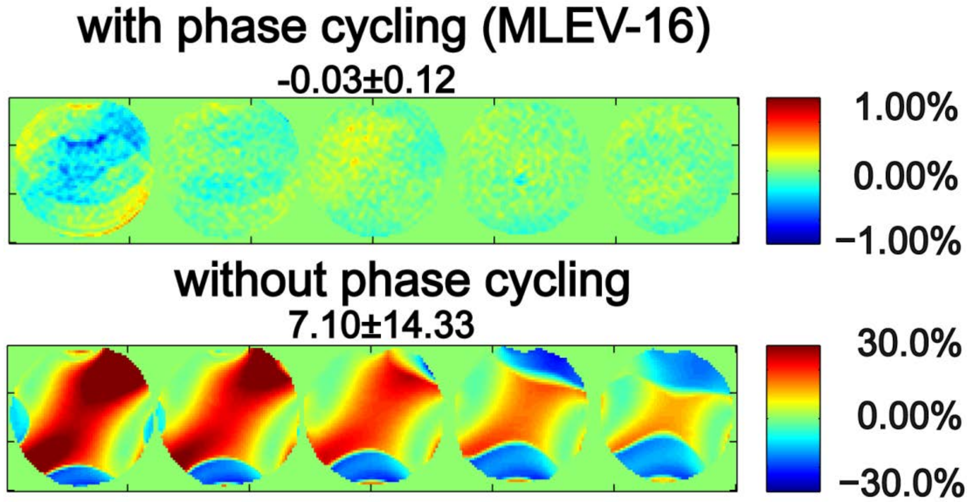
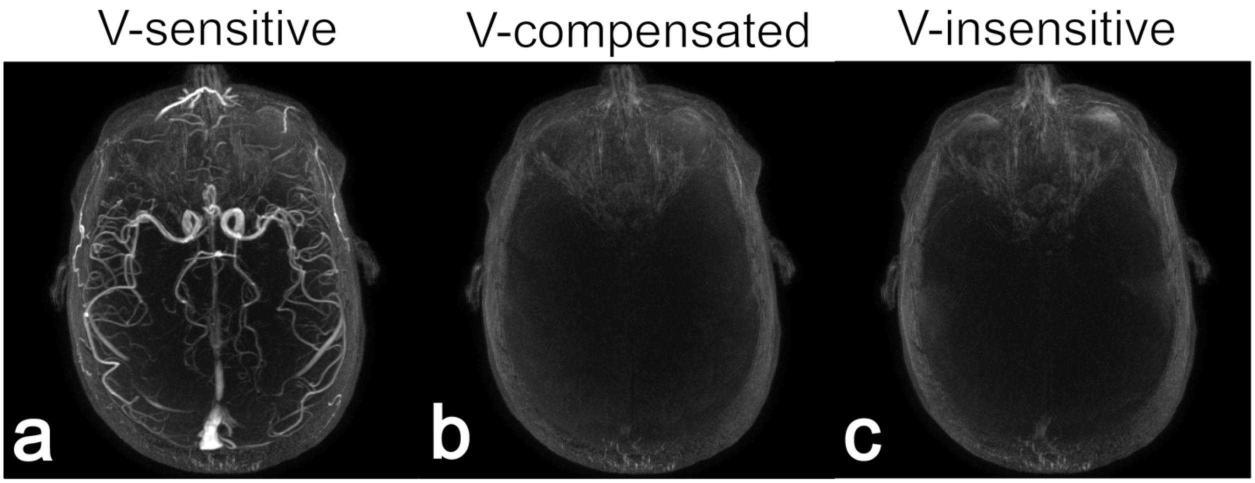


Supporting Figure S1: The simulated Mz-velocity responses of the employed velocity-compensated control pulse train (red solid lines) for different B1+ scales of (a) 1.0, (b) 0.9, (c) 1.1, (d) 0.8, and (e) 1.2. The blue dashed lines illustrate the corresponding responses of the velocity-insensitive pulse train. When B1+ scales depart 10% (b,c) or 20% (d,e) from the correct setting (a), the Mz-velocity responses of the velocity-compensated pulse train increasingly deteriorate for the flowing spins, as compared to the Mz responses of the velocity-insensitive pulse train where the only changes are in the inversion degree.



Supporting Figure S2: Gradient-imperfection induced subtraction errors on a phantom of the 48 ms FT-VSI pulse trains, velocity-sensitive (V-sensitive) labeling paired with velocity-compensated (V-compensated) controls, with (top row) and without (bottom row) MLEV-16 phase-cycling scheme. Note that the scale of the normalized error percentage in the bottom row is 30 times more than in the top row, indicating great reductions of gradient related artifacts by complete phase cycling of refocusing pulses.



Supporting Figure S3: MIPs of VS-MRA from one subject: double implementation of the 48 ms FT-VSS pulse train encoded along superior-inferior direction using (a) velocity-sensitive (V-sensitive), (b) velocity-compensated (V-compensated), (c) velocity-insensitive (V-insensitive) waveforms.