

Eye movement artifact suppression via 2D spatially selective RF-excitation

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Target Audience: Researchers looking to suppress eye-motion artifacts

Purpose:

Eye movement during acquisition induces artifacts in the phase encode direction, as well as the partition direction of 3D-encoded sequences, that can negatively impact its processing and interpretation [1]. In this abstract, we explore the suppression of eye-movement artifacts using a subject-specific, spatially-selective RF-excitation pulse designed to excite only the subject's brain, ensuring no signal (and therefore no artifact) originates from the eyes.

Methods:

A 3D-encoded FLASH sequence was augmented with 2D-selective RF-excitation pulse, aligned with the slice-direction of the FLASH encoding train. The FLASH sequence had an imaging matrix of 128x128x72, in-plane resolution of 2mm x 2mm, 4mm slices, TE of 7.95ms, TR of 16ms, a 10.0 degree flip angle and a bandwidth of 260 Hz/px. The excitation pulse traversed 31 lines of k-space following a blipped-planar trajectory in 14.95ms. Additional side excitations occurred at an interval of 256mm, placing them well outside of the head of the subject. The excitation pulse was not slice selective. A single subject was tested on a 1.5T whole-body scanner using a 32-channel phased array coil. The subject-specific 2D brain-excitation shape was generated using a FreeSurfer [2] segmentation of the subject, based on an MPRAGE acquired in a previous scan session, using an image-based automatic slice prescription system [3]. Four conditions were considered: a) two volumes were acquired using the spatially selective pulse in which the subject was instructed to either keep their eyes motionless, or move their eyes in a random and continuous manner; b) two additional control volumes were also acquired in a similar manner using a FLASH scan with the same geometry and imaging parameters.

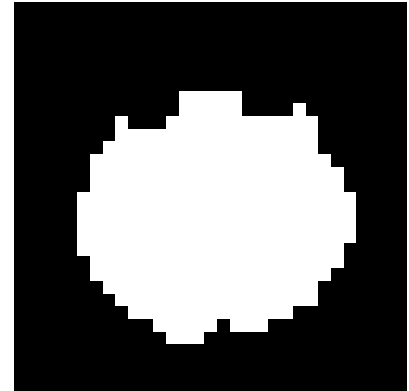


Figure 1: The shape of the excitation pulse designed to mask the subject's eyes while still exciting the orbitofrontal cortex

Results:

Figure 1 illustrates the RF-excitation map employed, which was chosen to excite a slice slightly superior to the midline of the eyes, where a portion of the orbitofrontal cortex extends anterior to the eyes, and thus no single plane can separate the eyes and the brain. Figure 2 illustrates the results of the control FLASH scan (top) and the modified spatially selective RF-excitation FLASH scan (bottom). The leftmost images were acquired with no eye motion while the center images were acquired with eye motion. The rightmost are difference images between the with- and without-eye-motion conditions.

Discussion:

The difference images in Figure 2 make clear that the eye-motion artifact is significantly suppressed using the modified spatially selective RF-excitation scan. There appears to be a slight error in the registration of the excitation shape with the subject -- in Figure 2, the eyes are not completely masked, but rather exhibit a crescent moon-like shape. Additionally, since the excitation shape is two dimensional, it is currently not a feasible way to suppress eye-motion artifacts in multiple slices as this would also suppress the frontal cortex superior to the eyes. However, the use of parallel-transmit coils to create 3D excitation pulses with practical durations, would allow this method to be extended to multiple slices.

Conclusion:

We have demonstrated the principle of employing spatially selective RF-excitation pulses to suppress eye-motion artifacts. Initial results with our modified sequence show significant artifact reduction compared to our control sequence. Further work is needed to create 3D selective pulses using parallel-transmit techniques before this method can be used to suppress eye-motion artifacts in multiple slices.

References:

1. Chen, W. et al. (1997), Suppression of physiological eye movement artifacts in functional MRI using slab presaturation. *Magnetic Resonance Medicine* 38: 546–550.
2. Fischl, B., et al. (2004), Automatically Parcellating the Human Cerebral Cortex. *Cerebral Cortex* 14(1): 11-22
3. van der Kouwe, AJ. et al. (2005) On-Line automatic slice positioning for brain MR imaging. *Neuroimage*. 27(1):222-30

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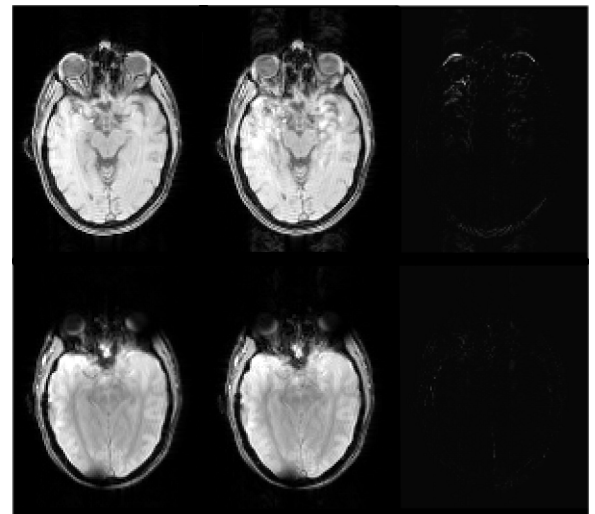


Figure 2: Comparing eye motion artifacts from a conventional FLASH scan (top) and the spatially selective RF-excitation sequence (bottom). Left: without eye motion; Center: with eye motion; Right: difference.