Correction of Task-induced Motion Artifacts During Speech

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SYNOPSIS: Functional brain scans during speech contain signal artifacts arising from magnetic field changes caused by motion of the anatomical structures involved in speech. These artifacts confound statistical analysis of speech-associated brain function, as they both occur during similar time intervals. This work describes a novel technique for correcting the effects of magnetic field perturbations caused by jaw movements, allowing brain activity from a block paradigm to be measured during a speech task.

INTRODUCTION: Analysis of functional imaging data from tasks involving speech is difficult because motion of the jaw and other anatomical structures involved with speech cause magnetic field changes, which in turn give rise to signal changes not originating from changes in brain activity. However, the motion-induced signal changes occur at a similar time to brain activity associated with speech, and statistical tests cannot distinguish between these two types of signals. One feature of the artifactual signals is they tend to be prominent at edges in the image, where functional intensity changes are large.

Birn *et al*. (1) developed a technique for separating the signal changes induced by the motion of the anatomy (an artifact in these studies) from the signal changes resulting from brain activity responsible for speech (the "true" function). This technique utilizes an event-related stimulus paradigm, which enables the motion-induced signal changes to be separated in time from signal changes that result from changes in brain activity. This is possible because of the delay that occurs between the delivery of a stimulus and the change in brain activity, which is referred to as the hemodynamic delay in the BOLD signal.

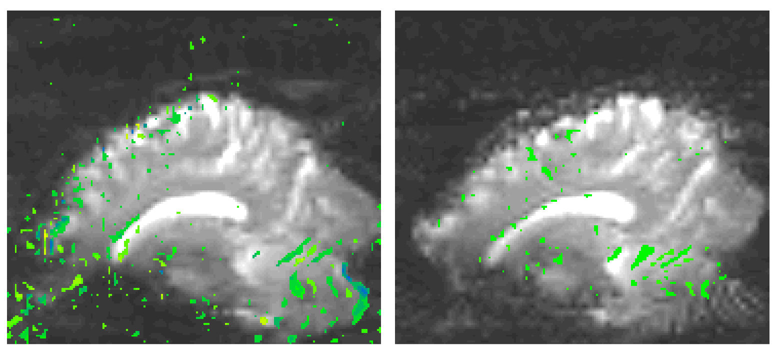
A technique is presented here for correcting magnetic field perturbations due to speaking. This scanning technique (2) collects the central region of *k*-space a second time, allowing a magnetic field map to be computed. This field map is used to correct for magnetic field changes in real time, and reduces the signal changes that result from apparent motion.

METHODS: Experiments were performed on a Bruker Biospec 30/60 3T MR scanner, using a torque-balanced local head-gradient coil and an end-capped birdcage RF coil. The following acquisition parameters were used to acquire 10 saggital slices from a subject: TR = 2000 ms, TE = 32.3 ms, image matrix = 64 3 64, BW = 125 kHz, slice thickness = 5 mm, slice separation = 7 mm, with 16 *k*-space lines acquired twice to calculate the field map.

Using a light, the subject was cued to speak the word "one" repeatedly for the speech task. The paradigm consisted of six 20-second periods of silence interleaved with five 10-second periods of speech. Data was imported into the AFNI software package (3), and motion-corrected using the volume registration capabilities of this package. To detect brain activity, a simple correlation analysis was performed using the stimulus time series as the reference waveform.

This procedure was repeated using the same data from this subject, except this time, before importing the data into AFNI, geometric corrections were performed using the additional data collected in this scan. After this initial correction, the volume registration procedure and statistical analysis were performed in the same manner as they were on the non-corrected data.

RESULTS: Figure 1a shows the activation map obtained by correlating the uncorrected data with the stimulus waveform. This analysis shows extensive "pseudo-activation" at intensity boundaries and outside of the brain, corresponding to signal changes resulting from transient magnetic field changes caused by the speech task. Correcting these transient field changes using the simultaneously acquired magnetic field map gives rise to the activation map shown in Fig. 1b. In the corrected data, almost all statistically detected "activity" at intensity boundaries and outside the brain has disappeared.



(a) (b)

Fig. 1: *Voxels correlated with reference waveform in (a) 3D registered data, and (b) geometrically corrected and 3D registered data. For voxels shown,* $p < 9.9\ 3\ 10^{-5}$.

DISCUSSION: By using a magnetic field map acquired at the same time as the functional brain data, it is possible to correct for the effects of magnetic field fluctuations caused by speech. This allows the utilization of speech responses in tasks in which a more complex response is desired for the tasks performed. This scanning and correction procedure can also be applied to other tasks in which motion-induced signal changes coincident with functional changes can confound statistical analysis of brain activity.

REFERENCES:

1. Birn RM, Bandettini PA, Cox RW, Shaker R. *Hum. Brain Mapp*. **7**(2):106-14, 1999.
2. Roopchansingh V, Cox RW, Jesmanowicz A, Hyde JS. *Proc. ISMRM 10th Annual Meeting* p. 2326, 2002.
3. Cox RW. *Comp. and Biomed. Res.* **29**:162-173, 1996.