Removal of Dynamic Magnetic Field Perturbation Effects during fMRI of Gum Chewing

D. A. Soltysik[1], V. Roopchansingh[1], J. S. Hyde[1]
[1]Biophysics, Medical College of Wisconsin, Milwaukee, WI, United States

Introduction

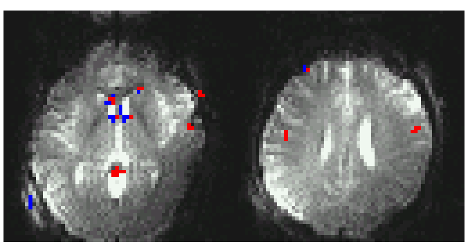
Neuroimaging of gum chewing has been explored by both PET[1] and fMRI.[2,3] PET studies suffer from low spatial and temporal resolution and require the injection of a radioactive tracer. Jaw motion in fMRI studies distorts the static magnetic field, leading to dynamic field perturbations in which motion outside the field of view can create signal changes inside the field of view.[4] Such signal changes can lead to false activation or the masking of real activation, especially in block design studies. The fMRI studies of gum chewing published so far,[2,3] both using block designs, do not address this issue, leading to the possibility of misrepresented activation. A new echo-planar pulse sequence, which can create magnetic field maps to correct the distortion in each image,[5,6] was used to probe the hemodynamic activation pattern caused by gum chewing. The long term goal of this study is to use fMRI to improve the diagnosis of temporomandibular joint disease.

Methods

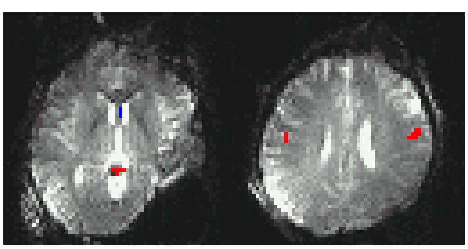
Three subjects were imaged in a Bruker Biospec 30/60 3 Tesla scanner using a local gradient coil and an end-capped birdcage RF coil. Twenty 5-mm-thick axial slices were acquired in an echo-planar sequence (TR = 2000 ms, FOV = 20 cm, matrix = 64×64, BW = 125 kHz). The center of k-space was over-sampled in a moving racetrack EPI trajectory to obtain a magnetic field map for each image.[5,6] The number of over-sampled lines of k-space was varied (16, 24, 32) for different runs, requiring a variation in the TE (32.8, 35.7, 38.5 ms). Magnetic field correction was applied before other steps of image processing. Gum chewing was performed in a block design run, with ten cycles consisting of 12 seconds of task followed by 12 seconds of rest.

Results

Following volume registration, cross-correlation analysis was performed with a reference waveform consisting of delayed gamma-variate curves. Activation maps were acquired by thresholding individual voxels ($p < 1 \times 10^{-5}$) and using a cluster size of 3 voxels (146 μL) for an $\alpha = 0.05$ as revealed by Monte Carlo simulations (AlphaSim). Activation maps acquired both with and without the correction were compared (see Fig. 1). The correction removed voxels correlated both positively and negatively with the reference waveform. Such false activation voxels typically appear near high contrast boundaries both inside and outside of the brain. Most of the voxels removed were from the inferior slices, where motion is more likely to cause magnetic field changes.[7] The corrected images show localized activation in the inferior part of the motor cortex.



(a)



(b)

Figure 1. Positive correlation shown in red, negative correlation shown in blue for (a) uncorrected EPI and (b) corrected EPI with a repeat factor of 32.

Discussion

Functional MRI can be used to locate activation caused by the task of gum chewing, which involves motion near the head, using a pulse sequence that corrects for dynamic field perturbations. Our results corroborate findings of activation in the motor cortex and reveal the elimination of correlated voxels caused by motion-induced distortions in the static magnetic field.

References

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