# Improved Detection of Bilateral Visual Activity in Ventrolateral Temporal Cortex at 7 Tesla Using a Z-Shim Technique

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*Synopsis*. We describe successful application of the z-shim technique in measuring cortical activity in the ventrolateral temporal lobe at 7 Tesla. Because fMRI data acquisition is inherently sensitive to $T_2$*, the enhanced effects of susceptibility artifacts due to air-tissue interfaces increase the difficulty of high field fMRI for large field of view or whole brain imaging. We acquired functional series in whole-brain slices showing bilateral activation in higher visual areas. The z-shim technique increased the number of significant voxels by 25% over uncompensated gradient echo EPI, and the BOLD fMRI contrast to noise ratio increased 50% in this region.

*Introduction*. The limitations of functional MRI at high field are well known: increased signal drop out and distortion due to susceptibility artifacts severely limits the ability to acquire functional data series from cortical regions such as the anterior temporal lobe and ventral prefrontal lobe, which are close to air-filled cavities. The advantages of high field fMRI are also well known: increased contrast to noise ratio and superior spatial specificity. It is therefore, important to find solutions to susceptibility induced imaging artifacts at high fields. Signal drop out is caused largely by through plane dephasing, and can be compensated during data acquisition by appropriately selected gradients applied in the slice direction. This is commonly referred to as the z-shim technique. We have employed a z-shim technique with blipped gradients applied to every other phase encode line[1]; the fMRI data shows the expected signal recovery in problematic regions.

*Methods*. Imaging was performed at 7T (magnet: Magnex, console: Varian). Images were acquired with a 4-channel transceive stripline array coil described in a separate submission. Subjects were paid volunteers who participated after providing informed consent in accordance with institutional guidelines. A gradient echo EPI imaging sequence was modified by the addition of blipped slice gradients applied with alternate polarity to every other phase-encode line. Phase-encode gradient blips were applied every other line, so that k-space coverage of the odd and even lines was identical in the $k_x$ and $k_y$ dimensions. Compensated images were constructed as composites of the even and odd images, using the sum of squares technique[2]. For functional studies, visual stimulation was provided via rear projection on a screen behind the subject's head, viewed in a mirror over the eyes.

*Results*. Pictures of objects known to strongly activate higher visual areas in the inferior temporal cortex were displayed in a block paradigm. Examples of BOLD fMRI activation maps with and without z-shim correction are shown below for temporal lobe regions where signal intensity suffers from the air-filled cavities of the auditory canal. The z-shim correction provided a 25% increase in the number of voxels meeting or exceeding a SNR threshold of 5 in the EPI images. More importantly, the quality of fMRI data was significantly improved by the z-shim method. Activation maps and time courses are shown with and without z-shim correction. Strong activation is found in the composite images where there was no signal without the z-shim.

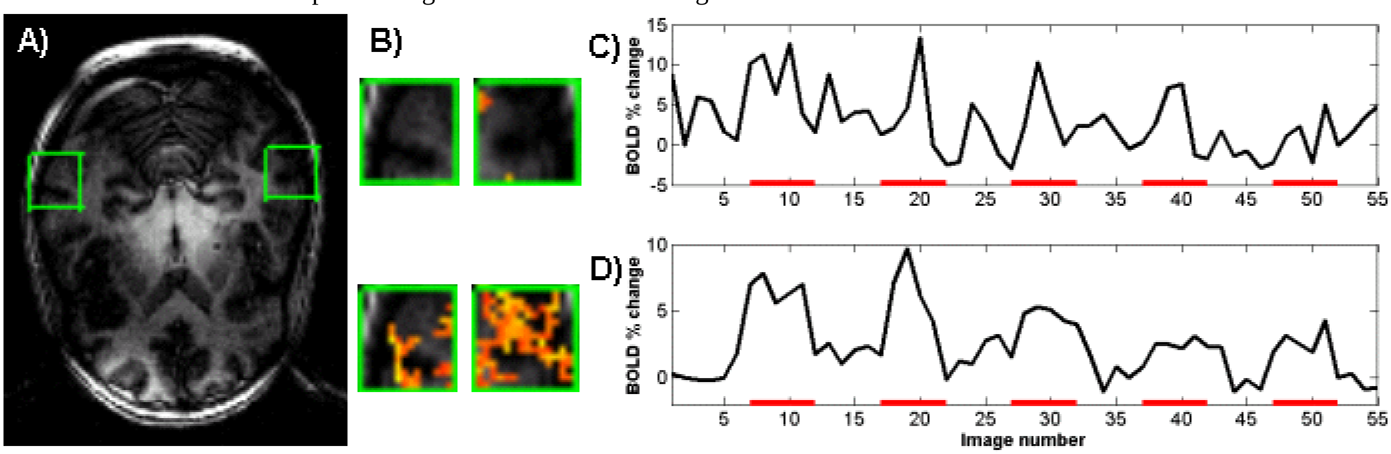


*Figure 1*. Visual activity in two regions of interest (ROIs) near the auditory canal. A) Transverse $T_1$-weighted slice with boxes showing location of ROIs. B) BOLD activation maps without z-shim compensation (upper pair) and with compensation (lower pair) overlaid on $T_1$ image. EPI acquisition parameters: $TR_{seg}$/TE 250/20 ms, 16 segments for a total TR = 4s; in-plane resolution 1.6 x 1.6 mm; slice thickness 2 mm. C) Mean activation without z-shim correction; bars indicate stimulus duration. D) Data from composite image series.

*Conclusion*. We have demonstrated that signal loss due to susceptibility artifacts can be compensated efficiently in EPI data acquired at high field. Bilateral activation maps of the extent shown could not be achieved without this compensation for $B_0$ variations.

*References*. [1]Gu *et al*. *NeuroImage* 17:1358 (2002) [2]Constable & Spencer, *MRM* 41:110 (1999)

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