

**Title:** Comparing Cortical Layer Activation in the Human Visual Cortex

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**Structured Abstract:**

**Introduction:** High resolution functional MRI has the potential to unlock a greater understanding of cortical organization and to bridge the gap between invasive animal work and large scale network studies. One current consideration when using high resolution fMRI is the choice of which sequence to use during imaging, as every sequence comes with sensitivity and specificity tradeoffs. Two commonly used functional imaging sequences are spin-echo echo planar imaging (SE-EPI) which is more selective to microvasculature and gradient-echo EPI (GE-EPI), which is the most sensitive sequence but suffers from signal contamination from large draining veins on the pial surface of the cortex. This work seeks to explore the use of MRI signal phase as a macrovascular filter via phase regression (Menon, 2002). We hypothesize that this method could provide a more sensitive solution to SE-EPI but with higher specificity than standard GE methods, ultimately optimizing laminar functional imaging.

**Methods:** Two subjects underwent both GE-EPI and SE-EPI fMRI at 7T. Three five-minute runs of visual stimulus were completed for each of the GE-EPI and SE-EPI acquisitions using a contrast reversing checkerboard paradigm with 20 seconds of stimulus and 30 second rest blocks. A structural volume was also collected to allow for surface reconstruction. All data was collected using a resolution of 0.8mm isotropic.

The functional magnitude data was motion corrected and registered to the first functional run, and percent signal change was calculated. The functional phase data was processed by motion correcting and registering the phase images using the magnitude transformation parameters. Phase data was then regressed with the magnitude data and the resulting time series were used to filter the macrovascular signal out of the GE-EPI magnitude images. The percent signal change of these new time series was also calculated.

Structural data was intensity corrected and white matter and pial surfaces were created using Freesurfer tools. The depth of each voxel was calculated by determining the plane between the cortical surface meshes that contains the voxel centroid. This depth was then used to sample the functional results and provide depth profiles across V1.

**Results:** The depth profiles for GE-EPI and SE-EPI matched the expected response with GE-EPI showing a higher overall signal but a greater pial vessel bias (over activation near the pial surface). The filtered GE-EPI profile fell between these results with a higher sensitivity than SE-EPI and a higher specificity than GE-EPI (demonstrated by a flatter laminar profile).

**Discussion:** Our work shows that GE-EPI with macrovascular filtering has a similar laminar profile to SE-EPI than when compared to GE-EPI. This means that with the inclusion of phase processing it is possible to achieve SE-EPI type profiles with increased sensitivity using a GE-EPI sequence.

**Reference:** Menon RS. Magnetic Resonance in Medicine. 2002