

Differences in visual fMRI activation and OCT metrics between affected and unaffected eyes after recovery from optic neuritis

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Target Audience: MS researchers, fMRI users

Purpose

Optic Neuritis (ON) is demyelination in the optic nerve, causing partial or complete loss of vision. ON is a common manifestation of Multiple Sclerosis (MS) affecting almost 50% of patients with MS. Recovery from ON is variable with most patients making good visual recovery but some noticing residual deficits. Functional MRI (fMRI) may be useful in understanding the recovery through cortical adaptation, and/or local remyelination which will help in planning better treatment therapies. While previous studies have looked at fMRI activation and clinical measure of visual acuity [1-3], correlation between neuronal activation and physiological measures, e.g. axonal integrity namely macular volume (MV), and retinal nerve fiber thickness (RNFL) has not been investigated, within our knowledge. In our study, we explore the relationship of primary visual cortex (V1) activation volume with MV and RNFL.

Method

Seventeen MS patients with ON (chronic i.e. > 6 months) were scanned at 3T using a 12 channel head coil with a bite bar. Scans included fMRI scans with two different visual stimulus paradigms. (voxel size = $2 \times 2 \times 4 \text{ mm}^3$, 31 slices, TR/TE=2800/29ms. The first visual stimulus i.e. the contrast fMRI paradigm was a radial checkerboard with three different contrast levels of 100% (black on white), 2.5% (gray on white), and 1.25% (light gray on white), which was sequentially displayed to fill the monocular visual field. The second visual stimulus i.e. the quadrant fMRI paradigm was a black and white checkerboard split into four quadrants with each quadrant flashing at a rate of 7.5 Hz. Total 4 fMRI scans were conducted with two paradigms on each eye (affected and unaffected eye) stimulated independently. Each fMRI data set was corrected as described in [4]. Student t map was calculated using AFNI's 3dDeconvolve [5]. Student t maps in contrast fMRI paradigm were the difference in activation between 100% stimulus, and the lower contrasts levels. V1 template (V1T) was created for each hemisphere by OR'ing the activated voxels derived from quadrant paradigm in 14 studies transformed to Talairach template [6]. Using V1T, the number of activated voxels (i.e. activation volume) within V1 were counted (1 sided, Student $t > 3.5$, $p < 3 \times 10^{-4}$). The purpose of using V1T is to ensure that the activated voxels were limited to the occipital cortex unlike what we previously reported in [7] from whole brain. Each patient underwent clinical measurements of RNFL thickness, and MV by Stratus Optical Coherence Tomography (OCT).

Results and Discussion

Figure 1 shows an example of fMRI result with different contrast visual stimuli. Figure 2 presents a representative activation to quadrant visual stimulus. Figure 3.A shows that MV from ON affected eye was correlated with the activation volume in 2.5% contrast (black circle, $r=0.487$, $p<0.049$), and 1.25% contrast (gray circle, $r=0.674$, $p<0.003$), and mean quadrant activation volume (white circle, $r=0.563$, $p<0.020$). Figure 3.B shows the average RNFL thickness from affected eye correlated with 1.25% contrast stimuli (gray circle, $r=0.549$, $p<0.024$), and mean quadrant (white circle, $r=0.674$, $p<0.003$) activation volumes of the same eye. No such correlations were observed in the unaffected eye.

Conclusion

MV and RNFL thickness are significantly correlated with visual function of the affected eye. This finding suggests that visual fMRI can help understand the underlying process of cortical reorganization in recovery after ON and in augmenting rehabilitation strategies.

References

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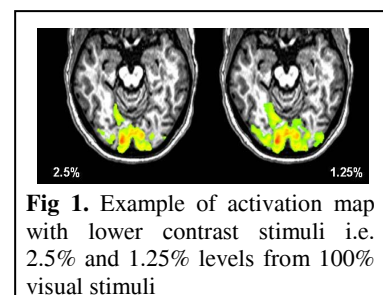


Fig 1. Example of activation map with lower contrast stimuli i.e. 2.5% and 1.25% levels from 100% visual stimuli

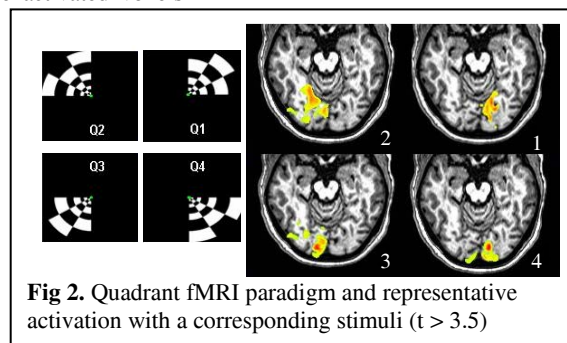


Fig 2. Quadrant fMRI paradigm and representative activation with a corresponding stimuli ($t > 3.5$)

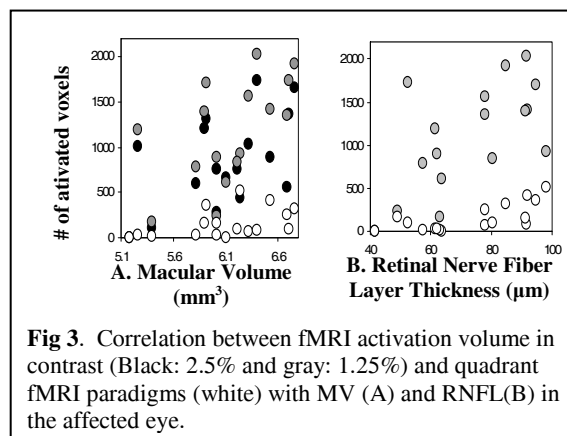


Fig 3. Correlation between fMRI activation volume in contrast (Black: 2.5% and gray: 1.25%) and quadrant fMRI paradigms (white) with MV (A) and RNFL(B) in the affected eye.