Investigation of a dual thresholding scheme in fMRI using ROC methods with real data

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Introduction

An important consideration in constructing the activation map for an fMRI dataset is to choose the right threshold. In a parametric approach, typically a pre-assigned *p*-value is chosen as the threshold. Baudewig et. al [1] demonstrated that the conventional thresholding scheme based on a single pre-assigned *p*-value may produce undesirable results. As a remedy the authors suggested the use of two different thresholds, where the first threshold is more stringent to identify the most active voxels and the second threshold is a weaker one applied only to the voxels that are neighbors to the highly active voxels. Logically, such an approach is sensible. The conventional thresholds corrected for multiple comparison is very conservative due to the simultaneous testing involved for a large number of brain voxels. However, that means we are missing a significant number of truly active voxels although the confidence level about the detected voxels should be high. But we expect the neighboring voxels to highly active voxels to be more likely to be active than the neighboring voxels to a voxel not detected to be active with the conservative threshold. Hence, it makes sense to apply a less conservative threshold to the neighboring voxels of a voxel detected to be active with a conservative threshold. The authors presented some activation maps as evidence of the superiority of the scheme. However, due to the promise of such a thresholding scheme, it is warranted that a more detailed quantitative analysis is performed to investigate the actual benefits of the method. Nandy and Cordes [2] have recently introduced a novel ROC method for fMRI data analysis with real data. The proposed method is broad in scope and particularly suitable to investigate the potential benefits of the dual thresholding scheme.

Theory and methods

The ROC curve which is a plot of True Positive Fractions against False Positive Fractions for different values of thresholds. We collected fMRI data from a healthy subject who performed a passive language task (listening to a recorded story via electrostatic headphones). This paradigm consisted of six periods of listening interleaved with silence (rest). Each task/rest period was 32sec/32sec. The pulse sequence parameters were: EPIBOLD, FOV 24 cm x 24 cm, BW +/- 62.5 KHz, TR 2 sec, Flip 90 deg, slice thickness 6mm/skip 1mm, 64x64 resolution. We also collected a resting state data the same subject with identical scanner parameters which is needed for our ROC method. We implemented the following thresholding scheme for the ROC curve. For each specified p-value, we calculated the adjusted p-value for multiple comparison using Bonferroni correction, which served as the first threshold. The second threshold is the same p-value, but uncorrected this time and applied only to the neighboring voxels of the voxels detected to be active by the corrected threshold. We then were able to plot the ROC curve. We have used SPM to run our analysis on the two datasets.

Results

We have plotted two ROC curves in Figure 1. The first one (solid line) is the ROC curve for a single threshold and the second one (dotted line) is the ROC curve for the dual threshold scheme. It is clear that the dual threshold scheme is superior to the conventional scheme.

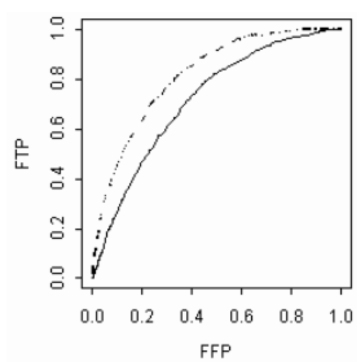

Figure 1.

Discussions

The ROC curves clearly demonstrate that the modified thresholding scheme is more sensitive without sacrificing specificity than the conventional method. We expect the method to be particularly useful for activations that are weak and hard to detect such as hippocampal activation.

References

1. Baudewig et. al. *Magn. Reson. Imaging*. 21:1121-1130 (2003).
2. Nandy R. R, Cordes D. Magn Reson Med 2003; 49: 1152– 1162.