Detecting signals in FMRI data using powerful FDR procedures

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Abstract

Functional magnetic resonance imaging (FMRI) has revolutionized the study of linking physical stimuli with localized brain activity. Differences between and within various demographic groups defined by gender and age have also been noted. The technology is based on measuring the delivery of oxygen to parts of the brain and ultimately produces a brain map showing voxels (volume elements) that receive increased oxygen supply. FMRI data are noisy and exhibit spatial correlation; furthermore, there are tens of thousands of voxels to be tested for the presence of signal. The notion of False Discovery Rate (FDR) has made a great impact on how to perform powerful multiple hypothesis tests, but the spatial dependence in FMRI data requires special care since, if ignored, there can be a loss of control of size as well as a deterioration in power in FDR procedures. This article advocates transforming the voxel-wise test statistics to wavelet space, where the coefficients are approximately uncorrelated. We demonstrate, through a series of experiments, that an FDR procedure in wavelet space enhanced by P-value adaptive thresholding (EPAT) maintains control of the size of the multiple-testing procedure and offers substantially increased power over an FDR procedure applied directly to the map of (spatially dependent) test statistics.