Region of interest analysis using an SPM toolbox

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Abstract
Most functional imaging studies use analyses that look for effects anywhere in the brain. The standard approach is to calculate a statistic relating the experimental effect of interest to the data for each brain voxel. This method has the advantage that it can detect strong effects without apriori constraint on the area that activation will occur. Problems arise when we wish to ask the question whether a particular brain area has been activated: if we know the shape and location of the expected activity, then voxel by voxel approaches have low power, because of the multiple comparisons across voxels. Whole brain analyses usually use image smoothing in order to increase signal to noise; however, the best smoothing filter will depend on the shape of the activation, which may well not be matched by a standard kernel such as a Gaussian.

The most direct answer to the question "has this area been activated" is to use a region of interest analysis. Here we define a region, and perform the statistical test on the mean time course of the voxels within the region. The contribution of the voxels may be weighted using the expected shape of the activation. This approach has two advantages. First, we increase power by avoiding the multiple comparison problem. Second, if we are correct about the shape and location of the region, the process of taking the mean is equivalent to using the best smoothing kernel to recover the signal.

This method has proved very powerful in analysing the activation in well defined regions. For example, Kanwisher et al have used screening tasks and voxel by voxel statistics to define regions of interest, and used these regions to investigate the nature of the original activation in further experiments of visual analysis of faces, scenes, objects and body parts.

We have implemented a toolbox called "MarsBar" for region of interest analysis within the SPM99 software package (available for free download from http://www.mrc-cbu.cam.ac.uk/Imaging/marsbar.html). The user can define regions using activations from previous SPM analyses, binary or weighted images, or simple shapes (boxes or spheres). Regions can be combined using a full range of algebra to give new regions. Functions include overlap between regions (logical and) or combination (logical or). The software can then extract raw or filtered time courses from the region for futher analysis outside SPM. It can also use new or previous SPM analysis files to analyze the regional time course. t or F statistics for multiple regions can be computed, and the results plotted using the SPM graphical interface. We are currently working on estimation of percentage signal change for the region data.

Region of interest analyses are likely to become more important as prior hypotheses about the location of activation become more specific. This may have many advantages in terms of statistical power and the ease of interpretation of neuroimaging data. We hope that this toolbox will make such analyses simpler to implement.