Observation Scale Dependent Variability in Functional Magnetic Resonance Imaging

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Introduction: In the last decades, advances have been made in the development of so-called scale space approaches to search for brain responses in imaging data such as from functional magnetic resonance imaging (fMRI) (Poline, 1994b; Worsley, 1996; Lindeberg, 1999; Coulon, 2000). In these approaches, responses are statistically detected using a range of Gaussian filter widths instead of using a single one. Despite the elaboration of these multi-scale approaches, current fMRI studies typically report results only for a single filter width, and the filter widths used vary considerably between studies. Furthermore, only few fMRI studies exist about the effect of filter size on statistical response maps. Our aim was to investigate whether in the analysis of the same fMRI data set using smoothing filters of different widths may produce different response patterns, potentially leading of different functional interpretations.

Methods: Two fMRI data sets were obtained using a 3 Tesla scanner and using simple visuomotor tasks involving right hand movement, both a conventional data set with 3 mm isotropic resolution and a high resolution data set with 1.5 mm isotropic resolution. Several differently smoothed functional data sets were created using Gaussian kernels from 4 mm to 16 mm (for the conventional data set, Fig.1) and from 2 mm to 20 mm (high resolution data set) full width to half maximum (FWHM), respectively. We then investigated the degree of variability in anatomical assignments of response peaks based on statistical analysis of the differently smoothed data sets. Significant response peaks were assigned to anatomical areas based on a probabilistic atlas system. Preprocessing and data analysis was performed using SPM5 and self developed MATLAB code.

Results: We found substantial filter width related variability in both experiments. For example, based on the conventional resolution data set, using filters of 6 to 8 mm, highly significant responses in right secondary visual cortex were detected, but in right primary visual cortex if larger filter sizes were used. In many cases, we were able to detect responses using either small or large, but less well using filter widths in the medium ranges.

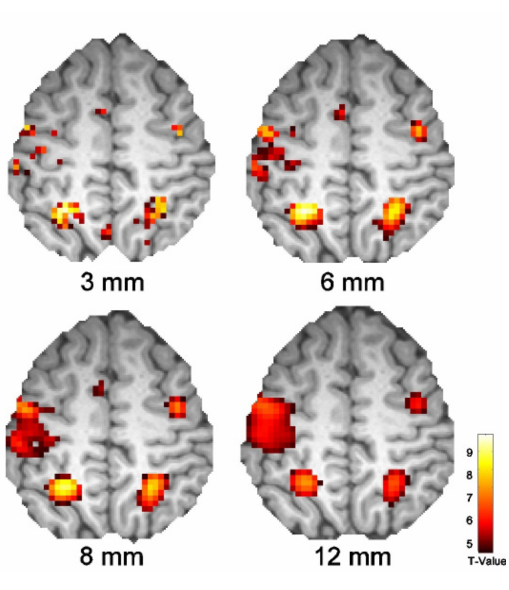

Figure 1: Response patterns related to right hand movement observed using different filter widths (FWHM)

Conclusions: Varying filter width may have a substantial impact on the response pattern observed in fMRI studies. Depending on filter width, we found significant peaks in different constellations of cortical areas. Our findings illustrate the importance of multi-scale fMRI analysis and selection of filter width (or a range of filter widths) appropriate for interpreting the analysis results. Moreover, multi-scale analysis may reveal novel features of the spatial organization of human brain responses: e.g. our findings could indicate a spatial organization of brain responses in local clusters of multiple distinct activation foci. Therefore, in summary, implementation of methods for scale space searches in fMRI analysis software packages such as SPM would be highly desirable and would facilitate a more widespread application of these methods by the fMRI community.

References:
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