Temporal Clustering Analysis: 3D Versus 2D Approaches in Functional MRI Studies

X. Zhao[1], J. Tang[2], J-H. Gao[1]

[1]Research Imaging Center, University of Texas Health Science Center at San Antonio, San Antonio, Texas, United States, [2]Shenzhen Sinorad Medical Electronics Inc., Shenzhen, Guangdong, China, People's Republic of

Introduction

Temporal clustering analysis (TCA) is a promising technique in functional MRI (fMRI) experiments to obtain brain activation maps in conditions with unknown temporal information regarding neuronal activity (1-3). All previous TCA studies were performed on single-slice fMRI data sets. In practice, multiple-slice or 3-dimensional (3D) fMRI data acquisition are employed in clinical application. To make TCA useful as a clinical practical tool, it is essential to evaluate the effectiveness of the TCA technique when it is applied to multiple-slice data sets. Although TCA method can extend to 3D approach according to its algorithm, the sensitivity of TCA method on multiple-slice 3D fMRI data sets varies to a great degree. In this study, both 2D (single-slice) and 3D (multiple-slices) approaches of TCA method were used and compared on both simulated and *in vivo* fMRI data sets.

Methods

A group of 21-slice fMRI data sets was simulated by adding 1% Gaussian noise on the time series of echo-planar images (EPI). A 2% event-related brain response was constructed in the pre-selected region of interest (ROI) following the gamma variate function (4). Two situations were simulated: (I) ROI was only constructed on one slice. (II) Five ROIs were constructed on five sequential slices. The simulation was repeated 30 times. For *in vivo* fMRI experiments, six healthy subjects participated in a visual task invoked by a 2-second checkerboard pattern flashing with a frequency of 8 Hz. The visual stimulus was given at the 15th second during each 40-second trial. Each trial was conducted six times for each subject. 21-slice EPI images covering the whole brain were scanned using a single-shot T_2^*-weighted gradient-echo EPI pulse sequence. The imaging parameters were: slice thickness = 5 mm, in-plane spatial resolution = 2.0 mm × 2.0 mm, number of pixels = 128 × 128, and TR/TE/θ = 1000 ms/30 ms/90°. For 2D TCA processing, fMRI data was processed slice by slice. For 3D TCA approach, data was processed by including either the 21 slices or the 5 slices with ROIs (for *in vivo* data, 5 slices in the primary visual cortex) in the data analysis, respectively. Relative sensitivity was calculated as the ratio of the peak magnitude to the standard deviation of the resultant TCA curves. For the 2D approach of TCA method, the highest relative sensitivity obtained from all the slices was compared with the relative sensitivity of the 3D approach of TCA method.

Results

The TCA curves and relative sensitivities obtained from simulation study I are presented in Figure 1A, from which we concluded that 2D approach is superior to 3D approach if only one slice has the brain activation area. Figure 2B shows that for simulation study II, 2D approach and 3D approach including whole brain data have similar sensitivity, while 3D approach involving only the 5 slices having brain activations has the best performance. The results of the *in vivo* studies are shown in Figure 3C; they are highly correlated with simulation study II. 2D approach and 3D approach including the 21-slice whole brain data have similar sensitivity, while the 3D approach including the 5 slices in primary visual cortex has better performance.

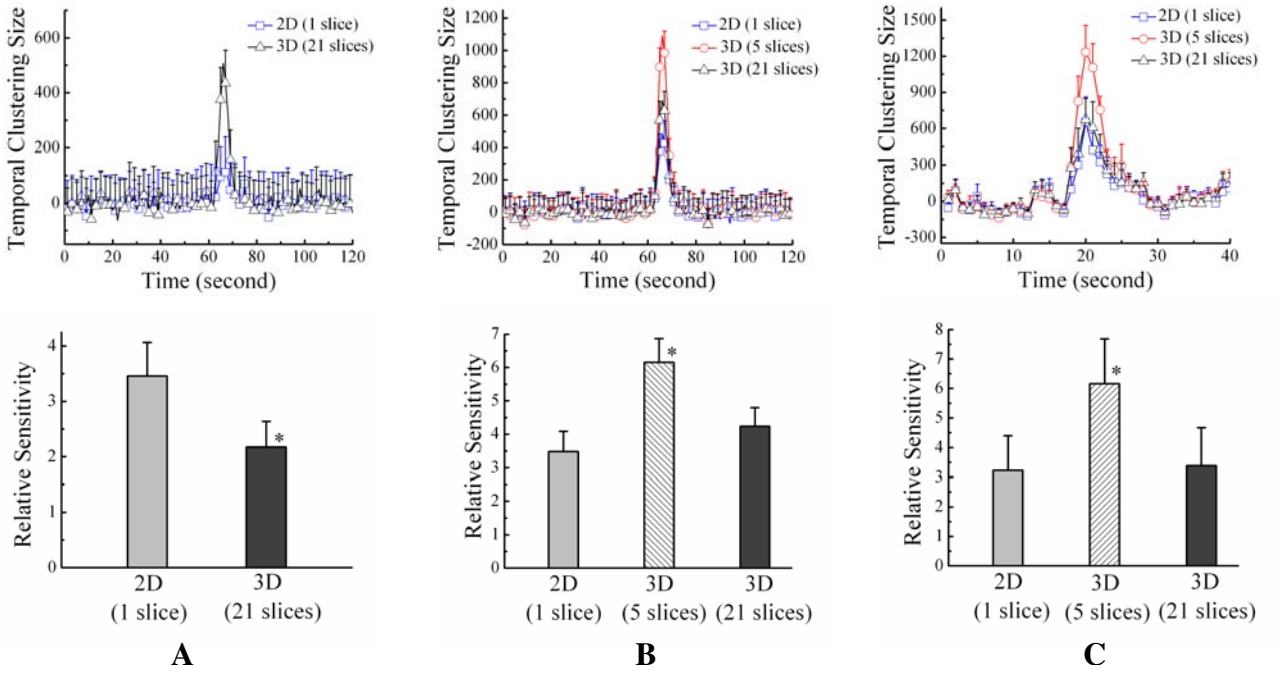

Figure 1. TCA curves (upper panel) and their relative sensitivities (lower panel) obtained from (**A**) simulation study I, (**B**) simulation study II, and (**C**) *in vivo* fMRI studies. The results are represented as mean and standard deviation of 30 averages for simulation studies and 18 trials for *in vivo* study. (*: $p < 0.05$ compared with 2D approach)

Conclusion

The results of simulation and *in vivo* fMRI studies demonstrated the best performance of TCA can be achieved by using 3D approach when only those slices having brain activations were included in data analysis.

References

1. Liu Y, Gao JH, Liu HL, Fox PT. Nature 2000; 405: 1058–1062.
2. Yee SH, Gao JH. Magn. Reson. Imaging 2002; 20: 17–26.
3. Zhao X, Glahn D, Tan LH, et al. J. Magn. Reson. Imaging 2004; 19: 397–402.
4. Boynton GM, Engel SA, Glover GH, Heeger DJ. J Neurosci 1996; 16: 4207–4221.