INTRODUCTION

fMRI is limited by its ability to distinguish neurally interesting signal fluctuations from artifacts and noise. A recently introduced and practical multi-echo approach to fMRI (MfMRI) seems to empirically correct artifacts (Kanda 2011 & 2012). In this study we show how multi-echo denoising affords the signal quality and reliability of the very common BOLD fMRI block design study. We also use our data to validate the finding that multi-echo and multi-echo fMRI are better than single-echo fMRI (Kand & Peltier 2002). ME-ICA denoising splits multi-echo data into its independent components and removes components that are unlikely to be BOLD weighted. This could be because they have high variance, making them likely to correspond to physiological artifacts or noise. The multi-echo fMRI is limited by our ability to distinguish neuronally interesting signal fluctuations from artifacts and noise. A recently developed technique uses multi-echo fMRI to improve task-based contrast-to-noise (Gonzalez-Castillo 2012). Here, we replicate the key finding in Gonzalez-Castillo 2014, which used single-echo data. The percent of significantly active voxels does not asymptote as more data is included in the analysis. We show that multi-echo fMRI provides more CNS than single-echo fMRI and can be used to increase the number and consistency of significantly active voxels.

METHODS

Group Collection

Data were collected for each run using a 3T 32-channel head coil. Scan parameters were as follows: T2-weighted GRE EPI, TR=2s, TE=15.4, 29.7, & 44.0ms, FA=75°. Subject motion was monitored with the first echo time series used as a reference frame. Each subject underwent 5 minutes of task each run starting from the first stimulation period were used in all General Linear Models (GLM) analysis. The GPU-COEFFICIENTS model with the option to define a mask was used in the generation of the GLM coefficient maps as an alternative to the covariates. The images were transformed into the standard Montreal Image Model (MNI) space using SPM5 via the non-linear registration tool. The images were then normalized to the MNI 152 template using ANTs. The task involved a 2-choice reaction time task involving a button press. A letter or number appeared on the display for approximately 2-3 seconds. The subject had to press a button indicating if the letter or number appeared on the display was black or white. The numbers were presented in a randomized order. Each of the three colors appeared an equal number of times. The middle echo time series (Echo 2) with TE=29.7ms was considered a standard single-echo fMRI run for comparison analysis.

Programming

ME-ICA denoising was then performed using code from https://bitbucket.org/prantikk/me-ica. The optimally combined time series, removing components that were deemed unlikely to be BOLD weighted, was then used for the fMRI analysis. The subtraction of the components deemed unlikely to be BOLD weighted from the optimally combined time series created a new time series that could then be used for a more practical amount of time. EMICA with the options to define a mask was used in the generation of the GLM coefficient maps as an alternative to the covariates. The images were transformed into the standard Montreal Image Model (MNI) space using ANTs. The task involved a 2-choice reaction time task involving a button press. A letter or number appeared on the display for approximately 2-3 seconds. The subject had to press a button indicating if the letter or number appeared on the display was black or white. The numbers were presented in a randomized order. Each of the three colors appeared an equal number of times. The middle echo time series (Echo 2) with TE=29.7ms was considered a standard single-echo fMRI run for comparison analysis.

Contrast to noise

The middle echo time series (Echo 2) with TE=29.7ms was considered a standard single-echo fMRI run for comparison analysis.

Results

Contrast to noise

The middle echo time series (Echo 2) with TE=29.7ms was considered a standard single-echo fMRI run for comparison analysis.

Gray Matter Masks

The model for each subject was used to calculate the task-related contrast-to-noise for each subject. The percent of significantly active voxels for each subject was calculated by the number of voxels that were significantly active divided by the standard deviation of the residuals. The percent of significantly active voxels for each subject was calculated by the number of voxels that were significantly active divided by the standard deviation of the residuals. The percent of significantly active voxels for each subject was calculated by the number of voxels that were significantly active divided by the standard deviation of the residuals.

Percents of significantly active voxels in gray matter

The middle echo time series (Echo 2) with TE=29.7ms was considered a standard single-echo fMRI run for comparison analysis.

Conclusions

We present additional evidence that the number of voxels that are a significant feature is positively correlated to the amount of data included in the analysis. We show that multi-echo fMRI provides more CNS than single-echo fMRI and can be used to increase the number and consistency of significantly active voxels.

We also see evidence that ME-ICA denoising improves results for individual runs in almost all regions with robust reliability and in many cases in areas with low robustness. Future work will focus on better ways to use the multi-echo information to empirically identify and keep relevant signal and remove noise.

Acknowledgments

Portions of this study utilized the high-performance computational capabilities of the Biowulf Linux cluster at the NIH (http://biowulf.nih.gov). We thank the two amazing volunteers who participated in this study.

References

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USING MULTI-ECHO FMRI TO INCREASE TASK-BASED CONTRAST-TO-NOISE AND RESPONSE STABILITY

Using multi-echo fMRI to increase task-based contrast-to-noise and response stability

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