Clinical Significance of Global versus Local fMRI Autocorrelation Estimation

B. Lenoski[1], L. Karam[2], L. Baxter[1], and J. Debbins[1]

[1]Keller Center for Imaging Innovation, Barrow Neurological Institute, Phoenix, AZ, United States, [2]Electrical Engineering, Arizona State University, Tempe, AZ, United States

INTRODUCTION: Various methodologies have been proposed for estimating the autocorrelation of fMRI time-series data [1]. If the autocorrelation is accurately estimated then the optimal, i.e. unbiased and minimum variance, parameter estimates can be obtained by multiplying the time-series and design matrix by the inverse square-root of the autocorrelation and performing a least squares analysis [2]. The goal in this work is to assess the clinical significance of a global versus voxel-wise autocorrelation (AR) estimate. Estimation accuracy with a 3-5 times increase in processing time is traditionally the tradeoff when using the voxel-wise estimation.

METHODS and RESULTS: fMRI was conducted on a GE 3T scanner as part of the routine pre-surgical work-up at our institution. Motor cortex activity was evaluated using a block-style finger tapping paradigm and standard EPI acquisition sequence. For each of the five patients in this study, both first order global AR(1) and multiple order voxel-wise AR(p), p=1,2,3 autocorrelation models were estimated using SPM5. The global AR(1) autocorrelation estimation is found by pooling the weighted observed autocorrelation of significant voxels in a 1st pass OLS model fit then using ReML to estimate the hyperparameters of a linearized AR(1) process with parameter $p_1 = 0.2$ [3]. The regularized voxel-wise AR(p) parameters were estimated separately for orders p=1,2,3 using a Variational Bayes technique with uninformative priors as described in [4] and subsequently used to construct voxel specific autocorrelation estimates. A WLS analysis was then performed and voxel-wise significance was assessed by comparing the resultant Z-scores against the null distribution with FWE control of p=0.05. Results were then assessed clinically by a neuropsychologist. Findings for one patient are shown in Figure 1 below and are comparable to the results from all patients in the study.

Fig 1a) cerebellum level: notice activity is not detected with global estimation, and the cluster size gradually increases with model order. This result suggests the global autocorrelation estimation was not sufficiently sensitive to detect activity in this particular region.

Fig 1b) motor cortex: at this level, the global autocorrelation estimate decreased the size of the activation cluster compared to the voxel-wise corrections. Further, both the global and voxel-wise AR(1) autocorrelation estimation methods fail to detect activity in the supplementary motor cortex, which has clinical relevance to interpreting the findings.

Fig 1c) motor cortex: at this more superior level where hand movement is represented, all estimation methods adequately detect cortical activation with slightly higher cluster sizes for voxel-wise estimates. This result suggests the global autocorrelation estimation is accurate for this targeted region.

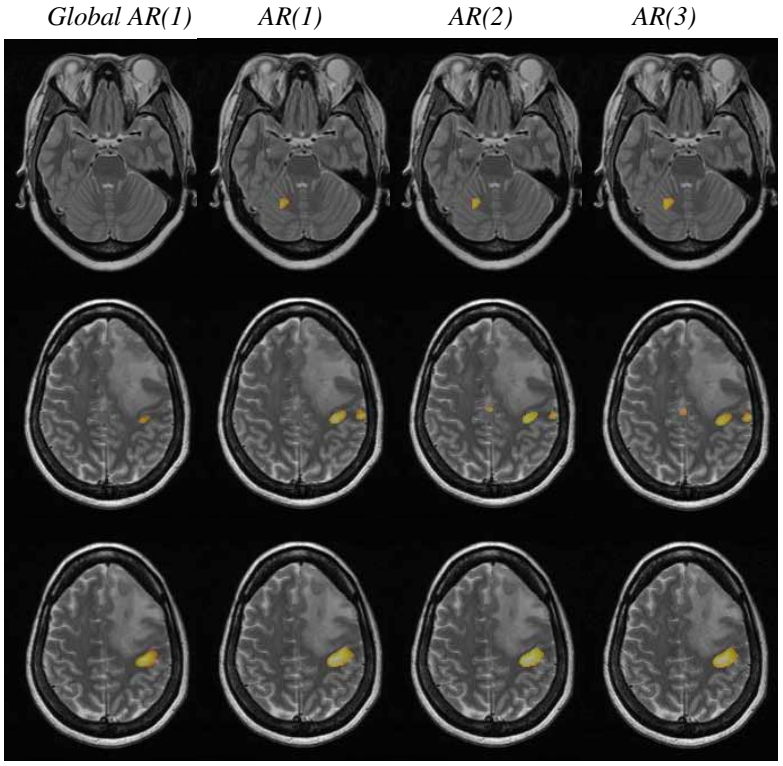

Fig. 1: Results for right finger tapping task shown at three slice locations

DISCUSSION: This pilot study found differences between voxel-wise and global autocorrelation estimates that may be clinically important in interpreting the results. Global estimation was found to be sufficiently accurate when activity was dominated by one large cluster. When multiple clusters exist, voxel-wise estimation decreases the number of false negatives. Additionally, secondary activations may require at least an AR(2) estimation to be detected. A further clinical study of the effect of different voxel-wise autocorrelation estimation techniques is currently in progress, including 1) comparisons with spectral estimation techniques, and 2) the use of unbiased wavelet de-noising to remove high-frequency autocorrelations directly from the signal prior to statistical analysis.

***REFERENCES*: 1.** Woolrich, M, et al. NeuroImage 14: 1370– 1386, 2001. **2.** Worsley K.J., et al. NeuroImage 15:1-15, 2002. **3.** Frackowiak R.S.J., *Human Brain Function*, 2 ed. New York Academic, 2003. **4.** Penny W, et al. NeuroImage 19: 727 – 741, 2003.