Physiologic noise at 7T: PESTICA for 3T obtains signals for pulse and respiration at ultra-high field

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Target Audience/Purpose: fMRI/connectivity researchers at ultra high field. To test the performance of PESTICA, a physiologic signals-obtaining software package that uses 3 Tesla spatial priors, on 7 Tesla BOLD data.

Introduction:

Physiologic noise can present a problem for fMRI and RS-fMRI analyses[1-3] and the level of physiologic noise has been shown to increase with field strength[4]. The current best method to reduce spurious connectivity or noise due to cardiac and respiratory cycles is to regress signals corresponding to both from the data using, e.g. RETROICOR[1] or IRF-RETROICOR[3]. To do so, one must monitor heart and respiration using a pulse oximeter or plethysmograph and a respiratory bellows to track both processes in parallel with the BOLD acquisition. If this was not done, then a regression based on the cycles is not possible. There are alternate correction methods based on data-derived measures, but these are not comparable to actually measuring the pulse and respiration. Fortunately there is a fully retrospective method that obtains pulse and respiration signals comparable to real monitored pulse and respiration: PESTICA[2]. The critical test for comparability is whether it obtains the same periodicity, as accurate periodicity is the central requirement for RETROICOR. At lower field strengths, PESTICA has been used successfully to obtain signals for a wide range of data. Although it is reasonable to expect spatial pattern of noise to be similar at 7T, there may be substantial differences and it is unknown whether the existing 3T-based spatial priors would work at 7T.

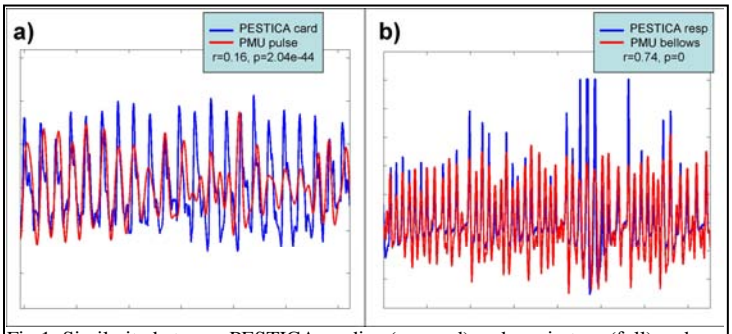

Fig 1: Similarity between PESTICA cardiac (zoomed) and respiratory (full) and parallel monitored pulse and respiration for representative subject. Similarity of PESTICA cardiac to pulse appeared variable, but correlation was significant and more important, the periodicity was accurate. Respiratory was similar even in amplitude, and correlated strongly for 7524 timepoints (p < machine precision).

Methods:

RS-FMRI data from 5 subjects at 7 Tesla in a 1 ch transmit, 32ch receive coil was passed through PESTICA for AFNI v2.0 with default settings as obtained at http://www.nitrc.org/projects/pestica. The EPI protocol was 132 volumes of 57 axial slices, 96x96 matrix, 2mm isotropic voxels, TR/TE=2600/20msec, GRAPPA=2 and 7/8ths partial Fourier. For each dataset, the default temporal filtering was used in PESTICA. Parallel monitored pulse and respiration (denoted by PMU for physiologic monitoring unit) was acquired using a pulse plethysmograph and respiratory bellows provided as scanner equipment. For comparison, the PMU data was synchronized to the BOLD acquisition and resampled to the slice acquisition frequency. The Pearson linear correlation between each PESTICA measure and PMU signal was recorded.

Results:

Fig 1 shows the PESTICA-derived measures plotted alongside the parallel monitored pulse and respiration for a) cardiac and b) respiration for a representative subject. The correlation between PESTICA and PMU was strong and significant for both (7524 timepoints). Table 1 shows the correlation and significance for each subject. We also computed the correlation between 1st order RETROICOR regressors generated from PMU and PESTICA and in all cases correlation was greater than 0.5 for the full timeseries.

Subject	r(card)	p(card)	r(resp)	p(resp)
1	0.025	0.03	0.71	0
2	0.16	2.04E-44	0.74	0
3	0.045	9.33E-05	0.82	0
4	0.095	1.87E-16	0.86	0
5	0.051	8.07E-06	0.92	0

Table 1: correlation between PESTICA and PMU for each subject. All are significant, but subject 1's cardiac barely significant. Only subject 2 and 4 obtained good periodicity for cardiac. Respiration estimators were excellent in each case.

Conclusions:

We have shown that PESTICA using the existing spatial priors generated using 3 Tesla BOLD data is capable of obtaining signals usable as pulse oximeter and respiratory bellows signals in 7 Tesla BOLD data. This suggests that PESTICA has immediate applicability at 7T. However, we caution that the performance of the cardiac estimation is somewhat poorer and PESTICA would likely benefit from spatial priors generated using 7T data. Our future plans are to generate several such priors for emerging acquisition protocols at 7T.

References: 1) Glover et al, MRM 44 (2000) 162-167. 2) Beall, EB and Lowe, MJ, NeuroImage 37 (2007) 1286-1300. 3) Beall, EB, J Neurosci Methods 187 (2010) 216-228. 4) Triantafyllou, C et al, NeuroImage 26 (2005) 243-250.