COMPARISONS OF SIGNAL CHANGE FROM INVIVO SMARTPHANTOM AND HUMAN BOLD FMRI OF LANGUAGE AND MOTOR SYSTEMS

T. Conway (VA Brain Rehabilitation Research Center); J.-Bo Gao (UF, Electrical/Computer Engineering); K. White (UF, Psychology); Q. Zhao (InVivo Corp)

Introduction

Functional magnetic resonance imaging (fMRI) using blood oxygenation-level dependent (BOLD) contrast is a powerful tool for studying human brain activity. fMRI reliability is hard to estimate. SmartPhantom [1] is a device that eliminates human participant variability from fMRI reliability tests. It generates simulated-BOLD signals electronically in a 7 inch diameter sphere containing $NiCl_2$ in H_2O, with a pair of coils at each end in the B_0 direction. Direct current flowing in the coils during phase encode or readout locally distorts the B_0 field. This induces dephasing effects analogous to those produced by paramagnetic deoxyhemoglobin, simulating the basis of BOLD contrast in a controllable, reproducible manner. We used these simulated-BOLD signals to study fMRI reliability.

Experimental

Time series of computer-controlled current flows were generated to roughly approximate the temporal frequency contents of hemodynamic responses. Gradient-echo EPI scans of the SmartPhantom were performed on a Siemens 3T Allegra (TR =1700 msec; TE = 25 msec; FA = 70° ; matrix 64x64; 25 interleaved slices covering the phantom with no gap).

Results and Discussion

Table 1 compares typical signal-to-noise ratios to simulated-BOLD contrast-to-noise ratios (measured by phase space reconstruction) in multiple runs over a one month period. Test-retest reliability of simulated-BOLD statistical parametric spatial maps (based on cross-correlation of voxel time courses with driving waveforms) was evaluated with mutual-information-based integrated squared error (ISE) divergence, both within runs and across runs separated by one month.

Table 1. Signal- and Contrast-to-Noise Ratios compared within and across runs.

Run	Signal-to-Noise Ratio				Contrast-to-Noise Ratio			
	Scan1	Scan2	Scan3	Scan4	Scan1	Scan2	Scan3	Scan4
1	449	445	473	462	15.2	14.4	15.8	15.1
2	448	451	462	461	9.1	14.2	15.5	15.8
3	484	482	494	488	16.9	14.5	17.1	16.4
4	458	457	463	457	15.8	14.0	15.6	14.9

Table 2. Spatial map ISE divergences.

Slice	Run 1	Run 4	One month
11	0.82	0.96	0.77
12	0.89	0.95	0.84
13	0.91	0.95	0.84
14	0.89	0.94	0.80
15	0.88	0.95	0.79

Conclusions

Signal-to-Noise Ratio (SNR) within each session is very similar. Contrast-to-Noise Ratio (CNR) captures different information than SNR about within- and across-session scan quality. Examples are (1) that CNR for 3 min scans (Scan 1, 3 or 4) is slightly higher than CNR for 30 min scans (Scan 2), and (2) Scan 1/Run 2 CNR was low due to an outlier that did not affect SNR but would affect fMRI. Test-retest reliability of spatial maps was somewhat variable. Some of this variability could likely be reduced by positioning the SmartPhantom in the scanner with a jig rather than positioning it by hand.

Acknowledgements

NIH R01 EB00974, Characterization of fMRI using SmartPhantom, Qun Zhao, PhD (PI).

References

[1] Zhao, Q, *et al.*, Proc. 11th Mtg. ISMRM, 1843 (2003).