Relationship between fMRI signals in the resting-state (R-fMRI) and task (T-fMRI)

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Introduction: The BOLD hemodynamic response, widely used as an index of neural activity, represents the output of a filter system through which input is modulated by neural and vascular responses **[1]**. Output from the system represents the product of these inputs and modulating influences, and is reflected by the blood-oxygen-level-dependent (BOLD) response. Input to the system may come from external, periodic, organized stimuli such as occurs in the course of T-fMRI experiment, or it may come from internal, relatively unorganized (spontaneous), stimuli such as occurs in the course of R-fMRI **[2]**.

We hypothesized that BOLD activity generated in R-fMRI and T-fMRI circumstances represent a single system, the activity of which is reflected equivalently, independent of whether a subject performs a task or remains at rest in the MRI scanner. Thus we predicted linear relationships between resting signal and task-induced signal (R-T relationship) on a voxel-wise basis and across subjects. Such a result would reflect the relationship between resting- and task-induced responses that arise from a common system.

Methods: Ninteen healthy human subjects with no history of head trauma and neurological diseases were scanned at 3T using a Siemens Allegra and 3T Philips Achieva scanners. They were randomly grouped into two groups with the first group consisting of 12 subjects (6M and 6F; mean age=24 years) and the second group consisting of 7 subjects (4M and 3F; mean age=23 years). All experimental procedures were approved by the Institutional Review Boards of UMDNJ-New Jersey Medical School and University of Texas at Dallas along with subject's informed consent. Each subject performed a bilateral fingertapping (FTAP) and a breath hold (BH) task. Resting state fMRI scans were also obtained for all the subjects.

Results: Voxel and subject level relationships between the non-neural (BH) task vs neural (FTAP) task and BH vs RSFA were determined. A strong linear correlation of BH versus FTAP and RSFA versus FTAP was observed in the BOLD signal change at the voxel and subject levels within the first group. The strong linear relationship between RSFA and FTAP signals in both low and high frequencies between subjects indicated an intrinsic relationship between the resting state and task-induced BOLD changes (R-T relationship; **Figure 1**). This intrinsic relationship which was present in every subject has great significance in how a subject would respond to a task that evokes neural activity. Thus with the knowledge of the amplitude signature of the resting BOLD signal, one may predict task-induced BOLD response in clinical populations unable to perform a task. The intrinsic relationship was used to predict task-induced response in a different group of subjects (the second group) knowing the amplitude signatures of the resting state BOLD fluctuations in the low (<0.1Hz) and high frequency (>0.1Hz) ranges. It was observed that the predicted and measured values of the task-induced BOLD responses matched within a 5% error limit for high frequency RSFA and 25% for low frequency RSFA.

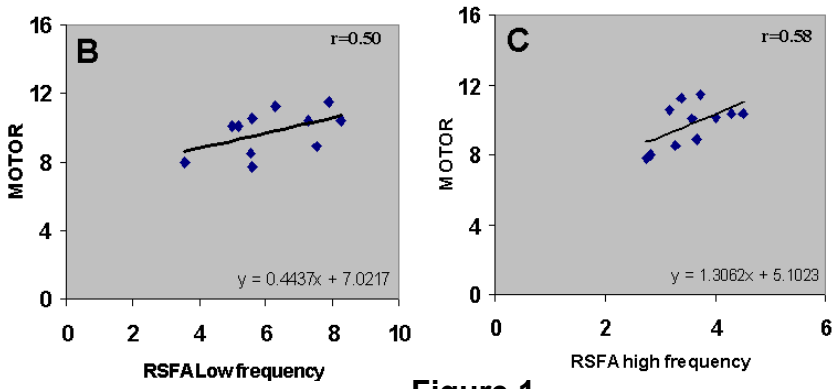

Figure 1

Conclusion: Linear rest-task (R-T) relationships were observed on the voxel and subject levels. The R-T relationship could predict task-induced BOLD signal contrast change with good accuracy that could be potentially applied to predict a subjects' or a regions' task evoked response which would include a vast clinical population that are presently excluded because of their inability to perform demanding fMRI tasks.

References:

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