Head motion greatly distorts the blood-oxygenation level dependent (BOLD) signal that underlies both task-driven functional MRI (fMRI) activations and resting-state functional connectivity MRI (rs-fcMRI) [1-7]. For rs-fcMRI data it has been shown that systematic between-group differences in "micro-movements" (> 0.2 mm) significantly distort BOLD data. Unwanted head motion during MRI scanning is significantly greater in infants, children and populations with neuropsychiatric disorders.

Frame censoring or removing individual BOLD images ('frames') distorted by head movement can successfully correct motion-distorted fMRI data. Post-hoc frame censoring for frame-wise displacements (FD) of ≥ 0.2 effectively corrects for movement-distortion and has become the new gold standard for rs-fcMRI studies. Depending on age and disease-status data loss rates from frame censoring can be above 50%. The recognition that frame censoring is absolutely necessary for collecting unbiased rs-fcMRI data has massively increased the cost of such research. Therefore, our site has adopted a novel approach that greatly reduces rs-fcMRI costs by using real-time head motion information to guide data collection - **Framewise Integrated Real-time MRI Monitor (FIRMM).**

FIRMM is a new software suite that computes head motion (FD) in real-time, using frame alignment algorithms optimized for speed. FIRMM's graphical user interface (GUI) displays real-time motion (FD) in a graph and also continuously updates summary statistics about data quality metrics, namely how many usable BOLD images (FD < 0.2) have already been collected. The GUI is easy to use and protects against operator errors (Figure 1). The implementation of real-time motion monitoring now allows us to collect rs-fcMRI in a more efficient and cost effective manner.

Series	Description	Frames	TR (sec)	Time (min)	< 0.2 mm (min) (%)	< 0.3 mm (min) (%)	< 0.4 mm (min) (%)
7	REST3	120	2.5	5:00	2:55 (58.3%)	3:42 (74.2%)	4:02 (80.8%)
5	REST2	120	2.5	5:00	3:25 (68.3%)	3:55 (78.3%)	4:07 (82.5%)
3	REST1	120	2.5	5:00	4:07 (82.5%)	4:27 (89.2%)	4:37 (92.5%)

	< 0.2 mm	< 0.3 mm	< 0.4 mm
Good Time (min) (%)	10:27 (69.7%)	12:05 (80.6%)	12:47 (85.3%)
Good Frames	251	290	307
Bad Frames	109	70	53

	< 0.2 mm	< 0.3 mm	< 0.4 mm
Minutes to Criteria	1:46	0:00	0:00

Pilot studies of FIRMM have demonstrated its utility for reducing scan times and associated costs (citation). For example, a new publication that has analyzed FD data from a sample of 1134 children and adolescents with and without developmental psychopathologies (i.e. ADHD and/or ASD) have been examined with FIRMM and show improved efficiency for collecting quality data.

Frame censoring, FIRMM and an adaptive head-movement driven fMRI data collection paradigm now allow us to collect the right amount of movement-free data for each subject, simultaneously boosting subject retention and lowering costs.

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