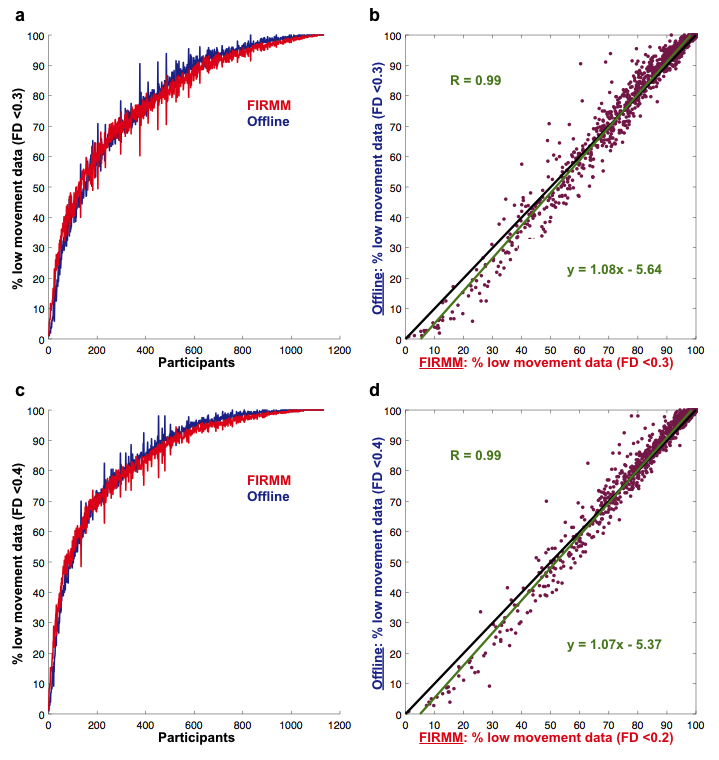
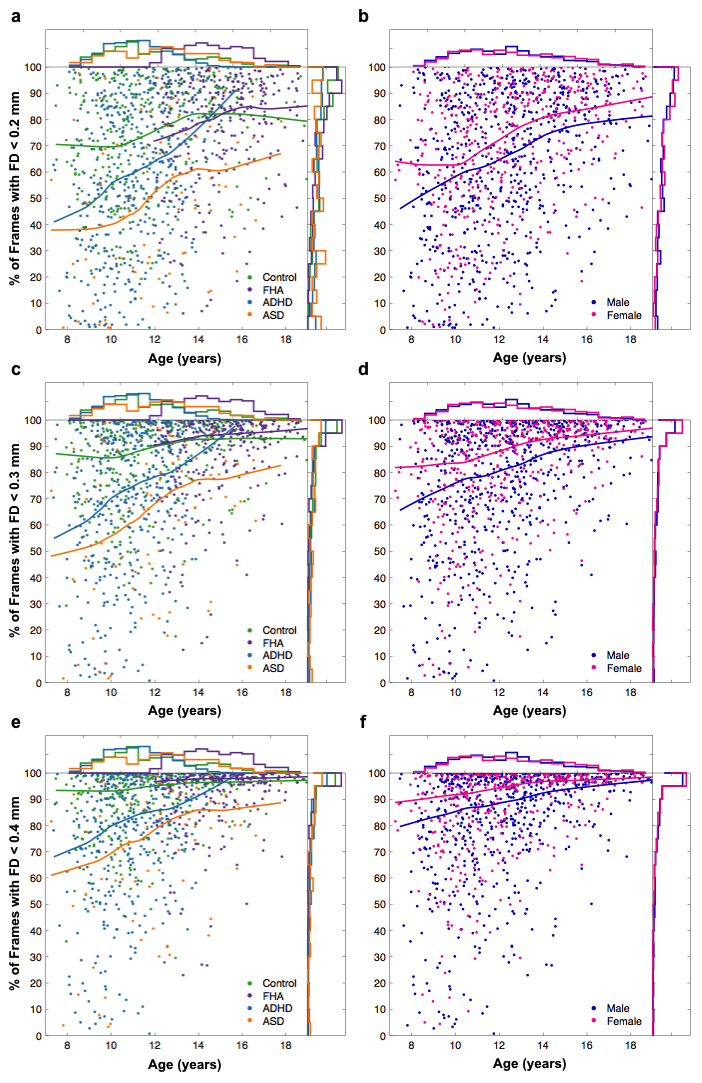
**Supplementary Movie 1.** This movie shows a sample FIRMM browser window during 15 minutes of resting state functional connectivity MRI (rs-fcMRI) data acquisition (3x 5 min. scans). The movie is sped up 16-fold relative to real-time (TR = 2.5 sec.). For this participant, the scanner operators chose 12.5 min. of low movement MRI data as the criterion and FD cutoffs of < 0.2 mm, < 0.3 mm and < 0.4 mm. This sample scanning session had very little overall head movement.

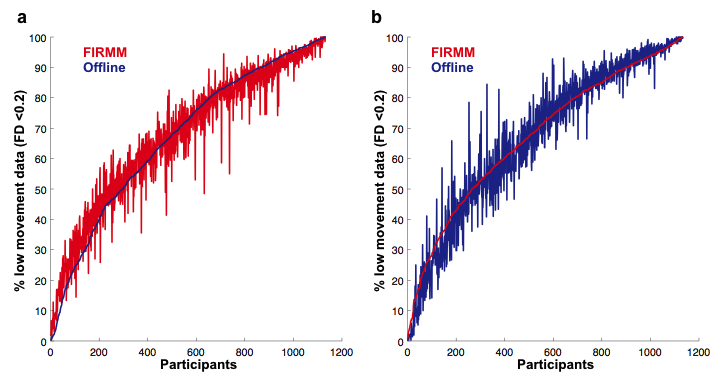
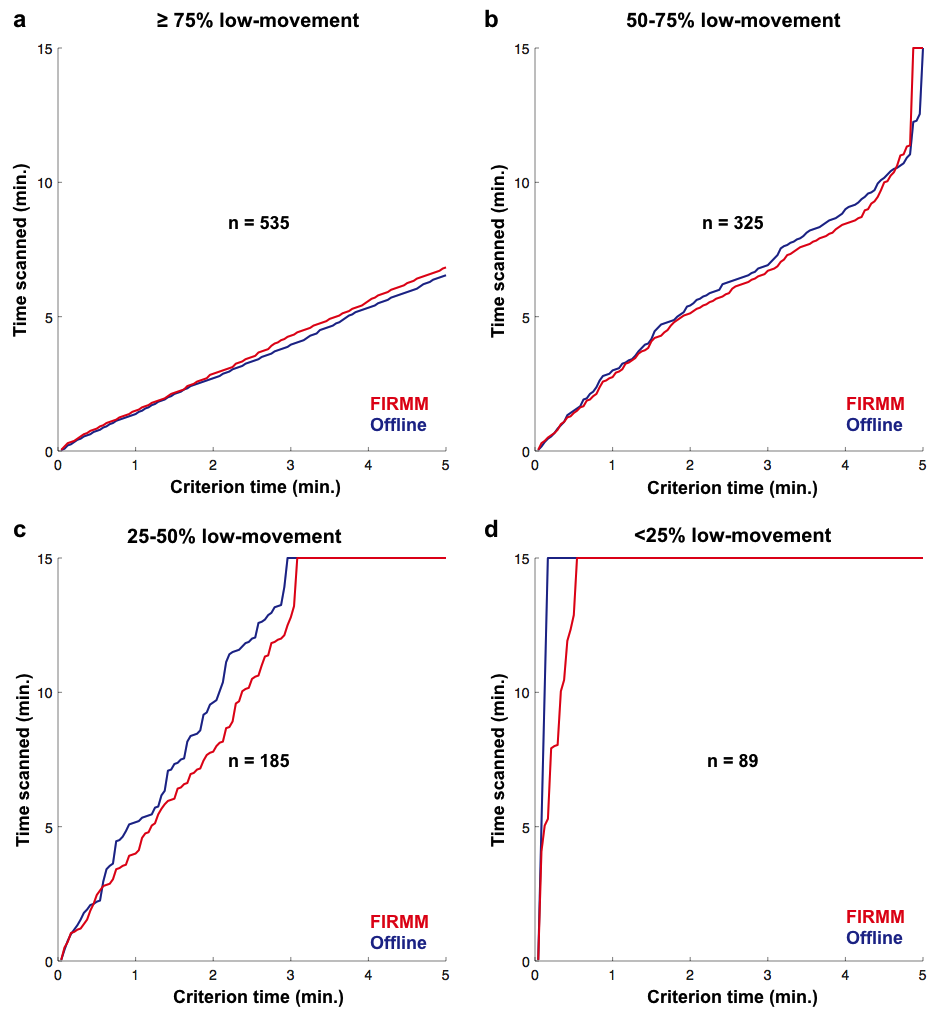


Supplementary Figure 1. Effects of age, diagnosis and gender on head motion. The percentage of MRI data frames below the FD criterion cutoff (y-axis) for 1,134 MRI scan participants are shown relative to participants’ ages (x-axis). (a, b) Show the percentage of data frames below the criterion FD < 0.2. (a) Shows the participants sorted by diagnoses (Controls, Family History of Alcoholism [FHA], Attention Deficit Hyperactivity Disorder [ADHD] and Autism Spectrum Disorder [ASD]). (b) Shows the same data sorted by gender. (c, d) Show the percentage of data frames below the criterion FD < 0.3, sorted by cohort (c) and by gender (d). (e, f) Show the percentage of data frames below the criterion FD < 0.4, sorted by cohort (d) and by gender (f). The upper and right sides of each figure plot the distributions of each cohort provided in the scatter plots. Lines represent lowess fits.



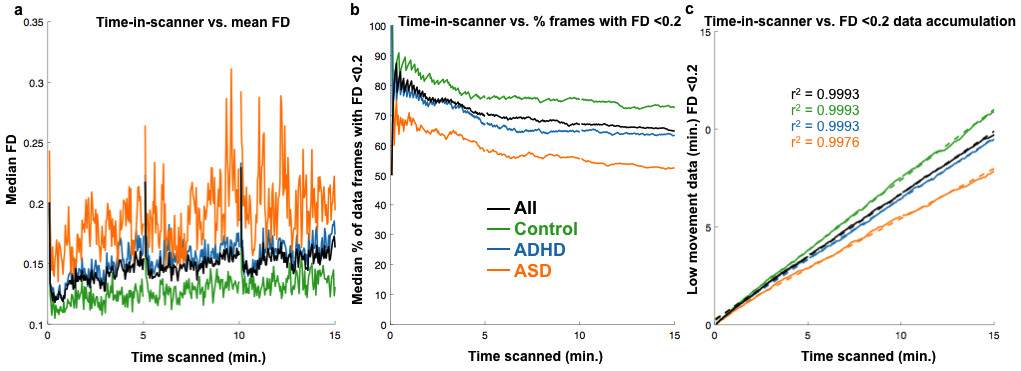
**Supplementary Figure 2.** Comparison of FD values generated by FIRMM (red) and Offline approach (blue). FD data shown are from 1,134 children and adolescents. (a) Shows the percentage of low movement data (FD < 0.3) for each participant included (y-axis), sorted by the mean percentage of low-movement frames across both methods for each participant (x-axis). (b) Shows the correlation (r = 0.99; linear fit and fit equation shown in green; identity line shown in black) between estimates of low-movement data as calculated by FIRMM (x-axis) and the standard offline post-hoc approach (y-axis). (c) Shows the percentage of low movement data (FD < 0.4) for each participant included (y-axis), sorted by the mean percentage of low-movement frames across both methods for each participant (x-axis). (d) Shows the correlation (r = 0.99; linear fit and fit equation shown in green; identity line shown in black) between estimates of low-movement data as calculated by FIRMM (x-axis) and the standard offline post-hoc approach (y-axis).

**Supplementary Figure 4.** Comparison of scanning-to-criterion with the FIRMM (red) and Offline (blue) FD calculation methods. FD data from all 1,134 scanning sessions, are separated into quartiles based on data quality (average percentage of frames with FD < 0.2 mm across FIRMM and Offline; see Fig. 3a y-axis). (a) Shows data from 535 scanning sessions with ≥ 75% low movement frames (FD < 0.2 mm). (b) Shows data from 325 scanning sessions with ≥ 50% ≤ 75% low movement frames (FD < 0.2 mm). (c) Shows data from 185 scanning sessions with ≥ 25% ≤ 50% low movement frames (FD < 0.2 mm). (d) Shows data from 89 scanning sessions with ≤ 25% low movement frames (FD < 0.2 mm). In each plot (a-d) the red line shows the required scan time based on FIRMM FD values (y-axis) in order for 95% of the sample to reach a given low-movement time criterion (x-axis) for an FD < 0.2 mm threshold. The blue line shows the required scan time (y-axis) so that 95% of the sample satisfy the criterion time if the data are reprocessed using the Offline FD calculation method. For many scanning sessions with high movement (c, d) the data criterion is never reached. Such high movement scanning sessions are typically excluded from published data sets, even without frame-censoring, simply based on rms movement within runs.



**Supplementary Figure 3.** Comparison of FD values generated by FIRMM (red) and Offline approach (blue). FD data shown are from 1,134 children and adolescents. (a) Shows the percentage of low movement data (FD < 0.2; same as Figure 3a) for each participant included (y-axis), sorted by the percentage of low-movement frames generated by the Offline method, for each participant (x-axis). (b) Shows the percentage of low movement data (FD < 0.2; same as Figure 3a) for each participant included (y-axis), sorted by the percentage of low-movement frames generated by the FIRMM method, for each participant (x-axis).

**Supplementary Figure 5**. Median FD values across scan time. (a) Shows the median FD (FIRMM processing) for each cohort (FHA excluded because only 8 min of data were collected for most subjects) and the sample as a whole (black line) as a function of the time participants have already spent in the scanner. (b) Shows the median % of data frames with FD < 0.2 at every time point in the scan for each of the cohorts. (c) Shows the relationship between the time scanned (x-axis) and the median amount of low movement data (FD < 0.2) accumulated for each cohort (actual data shown with solid lines; linear fits shown with dashed lines).



*Supplementary Discussion*

MRI scanner costs are typically either billed by 1) the actual usage time, or 2) based on the amount of pre-booked scanner time independent of how much time was actually used. For billing scenario 1) we showed that we could have reduced rs-fcMRI scan costs by 57% for entire sample of 1,134 participants, had we scanned to criterion based on FIRMM’s real-time FD information. Estimating FIRMM-driven scan time savings is more complex under billing scenario 2). Yet, scanner operators who are charged for pre-booked scanner time, not actual usage, can still greatly increase their scanning efficiency through FIRMM, by booking longer, contiguous blocks of scan time and scheduling multiple participants back-to-back, with some overlap in the appointment times. Over the span of a whole day, participants with very little head movement (shorter scan sessions) and those with more head movement (longer scan sessions) will balance each other out, so that every subject can be scanned to criterion. Even when this type of staggered scheduling is not possible under billing scenario 2), FIRMM-driven time savings will free up scanner operators to spend more time on other tasks and thus save salary costs. In addition, MRI participants will always appreciate shorter scans, which can be important for retention rates in multi-visit or longitudinal MRI studies.