



Rapid Motions in Pediatric and Clinical Populations

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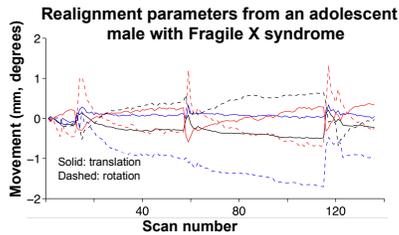
Introduction

The analysis of neuroimaging data from children with developmental disorders is key to understanding the neural correlates of impaired cognitive development. However, these subjects may not tolerate tight head padding inside the scanner, and abrupt head motions may introduce artifacts in fMRI data that can degrade the accuracy of the results.

The number of head jerks per scan session has been described for epileptic populations [1], but the frequency and types of motions exhibited by other populations has not been studied. The goal of this study was to quantify the density of rapid motion artifacts for several pediatric and clinical populations.

Methods

Pediatric and clinical subjects may have abrupt and rapid head motions. Both types of motions must be removed for a successful fMRI analysis.

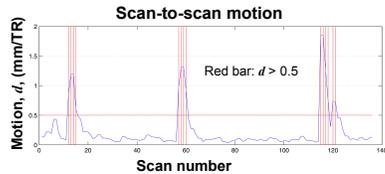


Scan-to-scan motion including rotational movements is estimated as:

$$d^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 + C^2(\Delta pitch^2 + \Delta roll^2 + \Delta yaw^2)$$

where Δ indicates the difference between successive scans, and $C = 65\pi/180$ converts degrees to radians, for a voxel assumed to be 65 mm from the origin (near the cortical gray matter). The units of d are mm.

The calculated scan-to-scan movements are shown below. Since an abrupt motion between scans may have spin history and image distortions at each end, both the before and after scans are assigned the higher value of d .



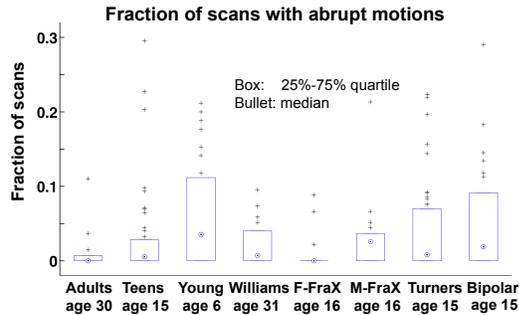
We counted the number of scans where $d > 0.5 \text{ mm/TR}$. These scans are marked with red bars (automatically by the ArtRepair software).

Subjects

The populations included healthy adults (Number of fMRI sessions, N=28, mean age m=29.7 years), healthy adolescents (N=51, m=15.0), healthy young children (N=40, m=5.7), and subjects with fragile X syndrome (N=22 female, N=26 male, m=15.9), Williams syndrome (N=28, m=31.0), Turner syndrome (N=51, m=14.6), and bipolar disorder (N=31, m=15.4) [2-7]. Data sessions (8 Turner, 8 healthy adolescents, 5 children) with more than 30% rapid motion scans or more than 10 mm maximum motion were discarded and not included in the statistics below.

All subjects were prepared before the real scan by practice in a mock MRI scanner in an effort to desensitize them to the sights and sounds of an actual MRI environment. Each subject practiced lying still in the bore of the mock scanner to become familiarized with the experience of receiving a brain MRI and underwent behavioral training to help reduce motion related artifacts.

Results

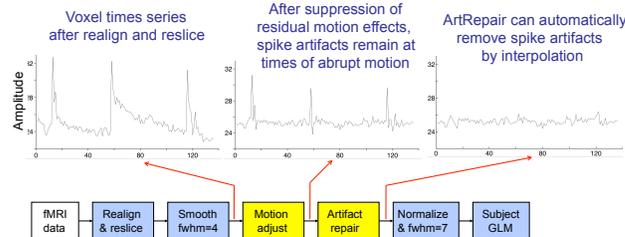


Young children and adolescents have far more abrupt motions than healthy adults. Clinical subjects usually have more abrupt motions than their healthy counterparts. For all the populations (except healthy adults, and females with Fragile X syndrome), more than half of the data sets have abrupt motions. For healthy young children and adolescents with bipolar disorder, about one quarter of the data sets had more than 10% artifacts present.

Conclusion

Pediatric and clinical subjects have abrupt and rapid motions, and both types must be removed for successful fMRI analysis. Strict quality control on the amount of allowable motion may remove too many subjects from a group analysis, and may bias the results by excluding more strongly affected subjects. Artifact suppression algorithms must be able to process data with 10% or more artifacts in order to be successful in these populations. Automated methods can greatly simplify the analysis. The ArtRepair software toolbox is one method to automatically suppress both the residual motion effects and abrupt motion artifacts that occur in high motion data.

ArtRepair Toolbox



More than 1100 pediatric and clinical subjects have been analyzed, including subjects with conditions such as fragile X, Turners and Williams syndromes, bipolar disorder, ADHD, depressive disorders, breast cancer patients, dyslexia, and post-traumatic stress disorder.

Over 1700 software downloads (validated by user name) have been made by researchers in 20 countries.

[SPM Extensions website](http://spm_extensions.stanford.edu) or www.nitrc.org
or <http://cibsr.stanford.edu>

Acknowledgements

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