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NEWS

Unsupervised Discovery of Microstructural Deviations in Diffusion MRI Tractometry of Adolescents with ADHD

PURPOSE

Diagnosis of attention deficit hyperactivity disorder (ADHD) is complex, relying on criteria sensitive to subjective biases. Alternatively, structural and functional variations in imaging may reflect underlying psychopathology and etiology of ADHD and provide rich data sources enabling more objective diagnosis. Though promising, these variations are still not well understood or characterized. The purpose of this study is to discover and visualize hidden structural patterns of diffusion weighted imaging (DWI) derived white matter (WM) tractography and fractional anisotropy (FA) measurements among adolescent patients with ADHD using unsupervised deep learning.

METHODS AND MATERIALS

Diffusion weighted imaging (DWI) from a subset of 1704 patients from the Adolescent Brain Cognitive Development (ABCD) Study was gathered. DWI was processed with Automated Fiber Quantification (AFQ) to extract individual subject white matter (WM) fiber bundles for 30 major WM tracts. Fractional anisotropy (FA) was computed at 80 equally spaced nodes along the length of each tract, and used as input for the deep learning model. An autoencoder was trained to reproduce the FA values of 1371 subjects. After training, the model was evaluated on an independent testing set of 333 patients, 193 with behavior problem monitor (BPM) greater than 70, the clinical threshold for ADHD, and 140 with BPM less than 60, no ADHD. Anomaly scores using absolute error (AE) along the WM tracts were computed between predicted and inputted FA values. Anomaly score profiles were averaged and compared between all patients with and without ADHD.

RESULTS

Mean absolute error (MAE) between predicted and actual FA values was 0.041, significantly different between subjects with and without ADHD (0.042 vs 0.038, p=0.041). Comparing absolute error anomaly scores between subjects with and without ADHD along 30 WM tracts reveals significant differences in 9 tracts: left arcuate fasciculus (ARC_L, p=0.006), left cingulum cingulate gyrus (CGC_L, p=0.020), left corticospinal tract (CST_L, p=0.007), right corticospinal tract (CST_R, p=0.006), frontoparietal (FP, p=0.0168), right inferior fronto-occipital fasciculus (IFO_R, p=0.033), left inferior longitudinal fasciculus (ILF_L, p=0.002), superior parietal lobe (p=0.041) and temporal lobe (p=0.008).

CONCLUSIONS

The unsupervised autoencoder-based approach identified anomalous FA profiles in patients with ADHD, revealing significant differences in 9 out of 30 WM tracts.

CLINICAL RELEVANCE/APPLICATIONS

This method identifies microstructural deviations in patients' DWI in an unsupervised manner, providing a promising step towards finding imaging biomarkers that can be used to diagnose ADHD in a quantitative, objective diagnostic framework.