Mixing motor skills with MRI Modalities Towards Machine Learning Evaluation of ADHD

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Summary

This study presents a new biomarker metric for ADHD by integrating four MRI modalities, including anatomical, functional, diffusion, and spectroscopic, with fidgeting-related motor skills, in a machine learning model. The model achieved a prediction accuracy of 73%, highlighting the potential of this approach in enhancing ADHD diagnosis.

Introduction

Structural and functional neuroimaging studies have demonstrated promising potential for MRI biomarkers of ADHD [1]. However, no studies have integrated motor skill differences, such as fidgeting, with MRI. This study integrates four MRI modalities including anatomical, functional, diffusion, and spectroscopic, with task-based fidgeting, to develop a machine learning model aimed at enhancing ADHD prediction.

Methods

Ethical approval was received from the New Zealand Health and Disability Ethics Committee, and 73 participants were included in this study. The MRI setup used a 3T (GE Discovery Signa Premier) with a AIR™ 48-channel head coil. The lower limb was isolated with knee supports to prevent motion artifacts in the head coil. To explore the effect of fidgeting, the Eriksen Flanker task [2] was used together with functional MRI (fMRI) to evaluate higher executive functioning of the prefrontal cortex (PFC). The default mode network (DMN) correlations were inspected using both task-related fMRI and resting-state fMRI. In addition, a resting-state fMRI sequence was collected to investigate the default mode network (DMN) correlations while resting. For other modalities, processing focused on three region-of-interest (ROIs), including the PFC, striatum, and cerebellum. Analysis on the volume, morphology, and chemical signature was performed on the three ROIs and the structural connectivity was tested along the tract connecting three ROIs. Machine learning models were built using support vector machines (SVM) with features selected to achieve the highest accuracy in predicting ADHD.

Results and Discussion

A summary of key findings is presented in Figure 1. Regarding the impact of fidgeting, 64% of ADHD participants showed heightened PFC activation, and 63% successfully transitioned away from the DMN while fidgeting. In contrast, 63% of neurotypical participants were distracted by fidgeting during the Flanker task and transitioned away from the DMN without requiring fidgeting. Structural connectivity analysis, based on the tract template developed in this study, revealed alterations along the PFC-striatum-cerebellum tract in ADHD participants, primarily indicated by decreased fractional anisotropy. Volumetric analysis showed reduced PFC volume, while morphological analysis identified shape variation in the striatum and cerebellum in ADHD groups compared to neurotypical controls. However, findings from spectroscopic MRI were less robust as biomarkers of ADHD. Combining all potential biomarkers, an SVM model trained on selected MRI features achieved 73% accuracy in predicting ADHD as defined by clinical diagnosis.

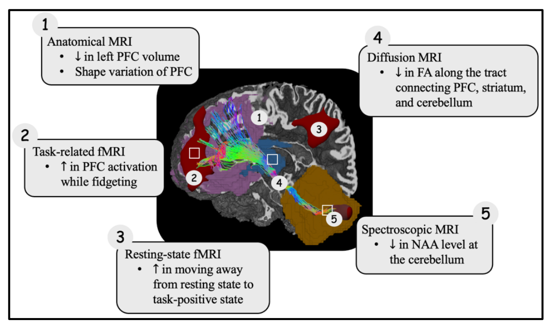

Figure 1: Key observations in ADHD participants compared to neurotypicals from each MRI sequence.

Conclusions

This study successfully identified key neurobiological markers of ADHD. Combining motor skills and MRI features appears to enhance prediction using an SVM model.

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References

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