Closed-Loop Machine Learning for Real-Time Engagement of Children with Disruptive Behaviors

Submitter Kyle Croarkin

Affiliation Mayo Clinic

SUBMISSION DETAILS

I agree to provide poster pdf for attendee download. Yes

What is the Methodological Issue Being Addressed? This work addresses closed-loop machine learning methods that use smartwatch data and ecological momentary assessments to personalize the prediction of temper outbursts in children for preemptive parental intervention and emotion regulation.

Introduction Disruptive behavior in children, including intense temper tantrums, presents a significant challenge for caregivers. Treatments such as parent-child interaction therapy (PCIT) are reactive and difficult to apply during escalating behavioral episodes. Digital early warning tools with machine learning methods enable proactive intervention instead of reactive management. A key methodological challenge is integrating parental ecological momentary assessments (EMAs) on child behavior that can tune machine learning methods that adapt to child's physiology that changes with behavioral improvements.

Methods Closed-loop machine learning methods were developed using 5million minutes of smartwatch and over 900 EMAs collected in a randomized clinical trial conducted at the Mayo Clinic (NCT05077722). The trial enrolled 50 children receiving PCIT, aged 3-7 years, with Externalizing Behavior Problems (EBP) rated above the clinically significant range (I-score ≥120; T-score ≥ 60) on the Eyberg Child Behavior Inventory (ECBI). Participants had >70% adherence to both PCIT session completion and daily smartwatch wear. Parents were requested to log the timestamps of start- and end times of temper outbursts (referred to as temper tantrums in the study). XGBoost and logistic regression was retrained on weekly intervals with smartwatch measures, demographics, comorbid attention-deficit/hyperactivity disorder and stimulant use status, and parental EMAs to tune prediction models based on changing physiology in children while undergoing PCIT.

Results Mean heart rate preceding an outburst decreased over the course of PCIT and varied by participant, indicating the need for personalizing prediction of temper outbursts. This closed-loop method utilizing EMAs to retrain prediction models weekly outperformed the base model of utilizing only fixed-window of heart rate variations (AUC: 0.51; sensitivity: 0.66; and specificity: 0.37) to predict outbursts. The model at baseline achieved an AUC of 0.64 (sensitivity: 0.81; specificity: 0.38) and with each week's re-training to personalize prediction for the child, the AUC achieved at 15 weeks was 0.78 (sensitivity 0.80; specificity: 0.59).

Conclusion The study demonstrates the ability of machine learning methods to utilize longitudinal smartwatch data and EMAs to individualize predictions of temper outbursts in children with disruptive behaviors. The increase in specificity shows that the individualized models learn to

identify calm behavioral states while also improving predictability of temper outbursts. These models integrated into a mobile application are being prospectively evaluated in a clinical trial for feasibility and real-world effectiveness benchmarks.

Co-Authors

Kyle Croarkin[1], Mike Zhu[1], Magdalena Romanowicz[1], Arjun Athreya[1]

[1] Mayo Clinic

Keywords

Keywords
Digital Health
Wearables
Child Behavior
Machine Learning
Artificial Intelligence

Guidelines I have read and understand the Poster Guidelines

Disclosures This work is supported in by an award from National Institute of Mental Health (R01MH143024) and Center for Individualized Medicine, Mayo Clinic.

Related Tables and Supporting Materials <blank>