

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

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BACKGROUND

- Disruptive behavior, such as intense temper tantrums, presents a major challenge for caregivers
- Behavior therapy such as parent-child interaction therapy (PCIT) is difficult to apply during a tantrum episode
- Smartwatches measure physiological biomarkers of emotional dysregulation, e.g., heart rate, in real time
- Closed-loop control systems continuously monitor output (behavior) and adjust input (digital interventions) to maintain a desired steady state

METHODS

- 50 children, ages 3 to 7, with disruptive behavior problems, wore Garmin smartwatches for up to 20 weeks¹
- A reference “HR range” model based on prior work predicts a tantrum when 10-minute mean heart rate (HR) is between 105-129 BPM¹
- Parents log tantrums using a mobile app
- Physiological data, demographics, medical history, and tantrum logs were used in training XGBoost (XGB) models to predict tantrums
- Individualized models were trained per-participant, per-week, using a combination of the population-level training data and the individual’s data up to that week
- When the model predicts a tantrum, an alert is delivered to parents via the mobile app

METHOD INNOVATION: CLOSED LOOP MACHINE LEARNING FOR DIGITAL HEALTH INTERVENTIONS

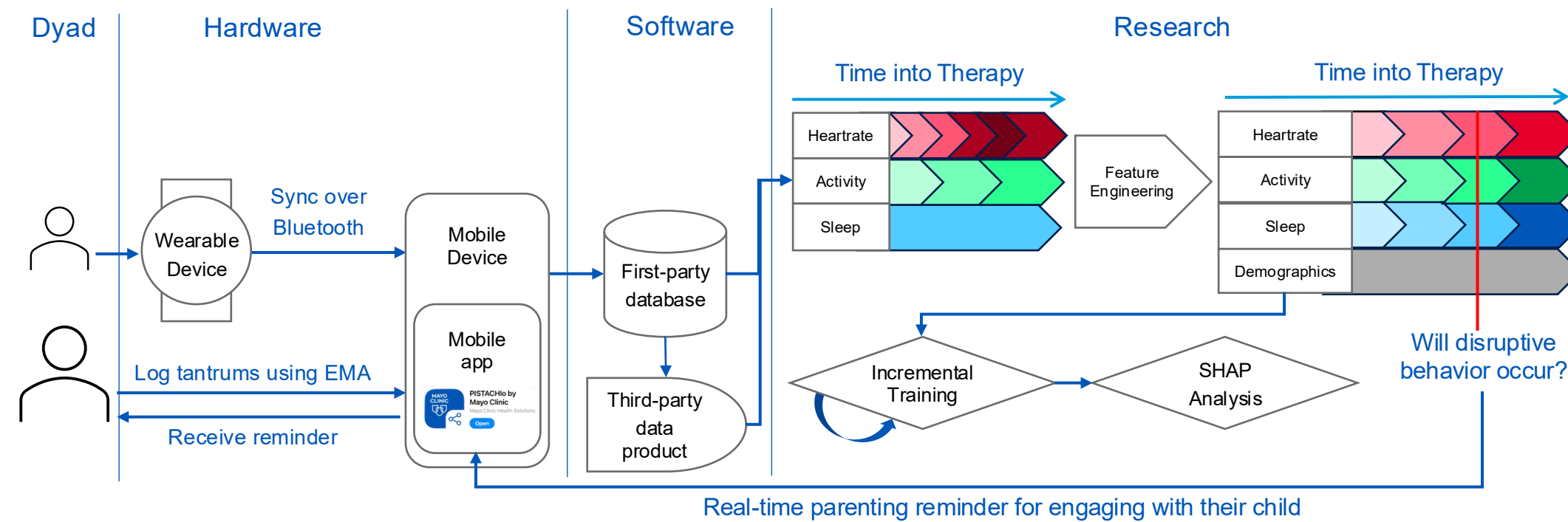
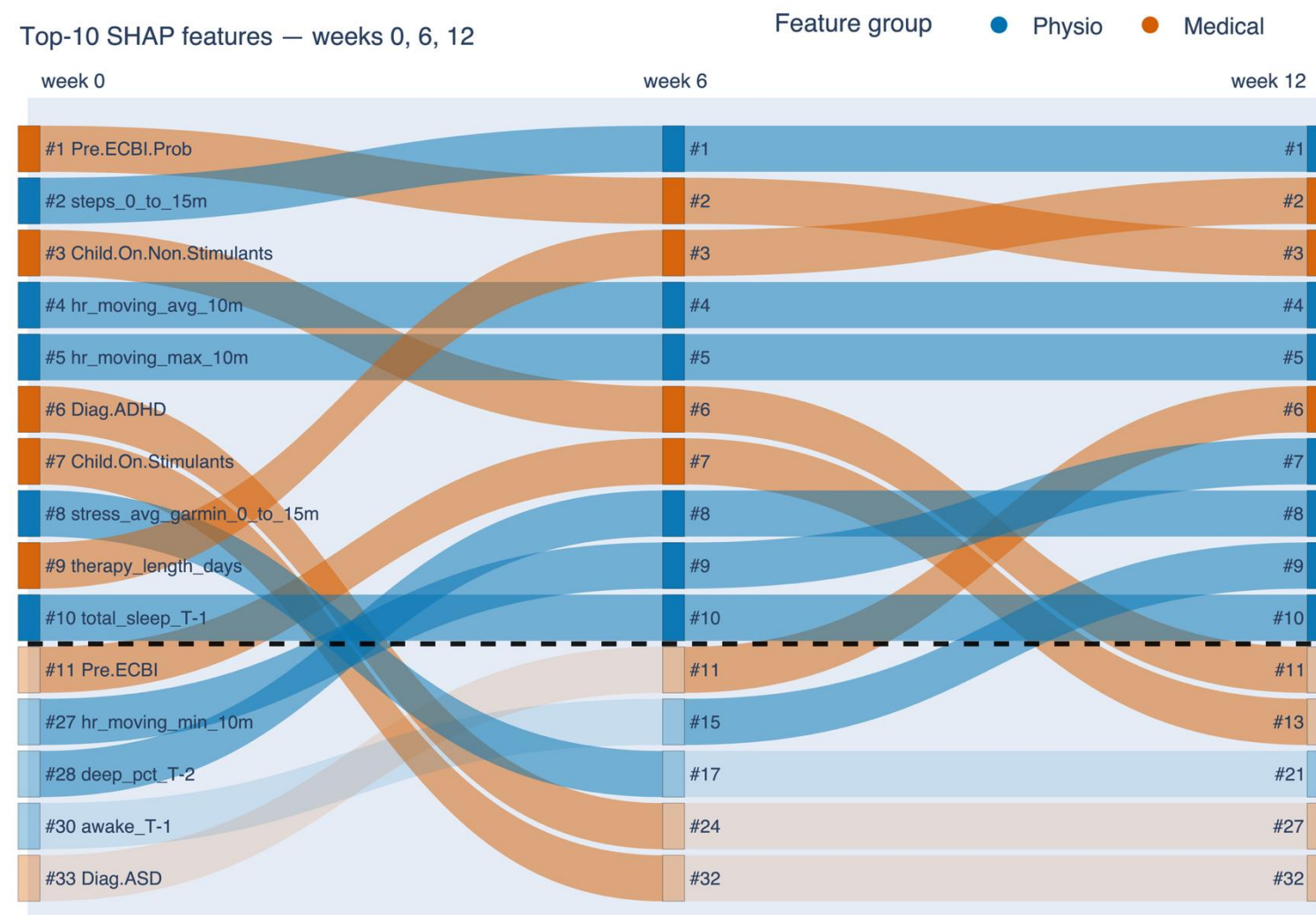


TABLE 1: PREDICTIVE MODEL FEATURES

Feature set	Example features
Physiology	Heart rate, step count, stress, sleep
Medical history	Neurodevelopmental disorder (ADHD, ASD), medication, ECBI
Demographics	Child age and sex, parent education level, marital status, age

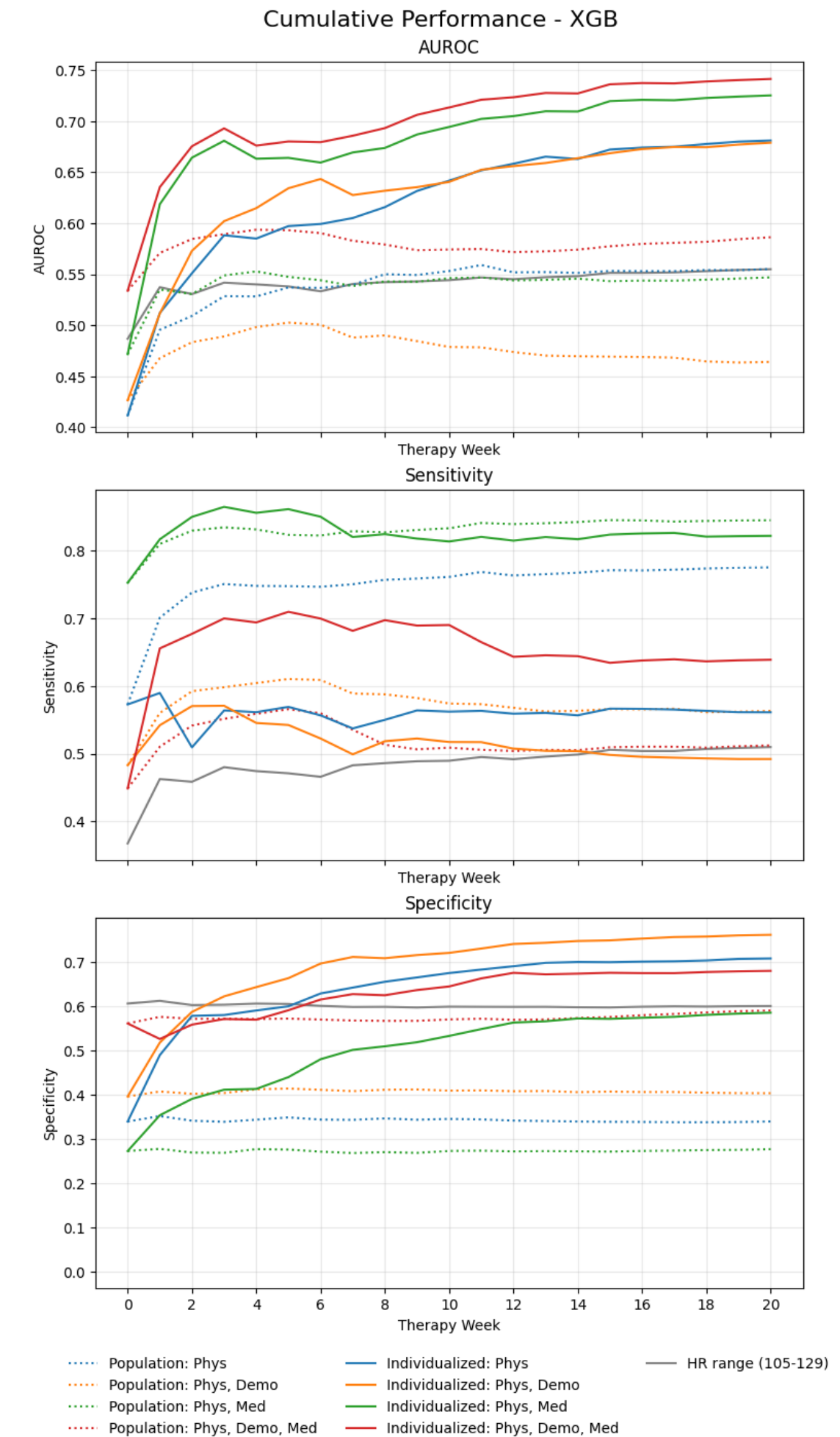
Fig 1. Change in importance of physiology and medical history features in individualized models



CONCLUSIONS

- Individualized models, regularly retrained to incorporate new data, adapt to participant- and time-varying physiology changes
- Accurate and timely tantrum predictions enable proactive parental intervention rather than reactive management

Fig 2. Individualization improves accuracy over time



REFERENCES

- Romanowicz M, Saliba MT, Wilton AR, et al. Feasibility of Digital Augmentation of Parent-Child Interaction Therapy. *JAMA Network Open*. 2025/12/01