Using Machine Learning Models to Predict Receptive States for Physical Activity Behavioral Support

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Purpose: Push notifications are a key component of mHealth interventions, enhancing user engagement, promoting adherence, and delivering behavioral support. Personalizing notification delivery—when users are most in need and receptive (ready to act)—requires real-time contextual data and complex decision rules. However, collecting and processing such data is challenging and notifications often fail to arrive 'just-in-time'. Machine learning (ML) models leveraging passive smartphone sensing data could predict when users are most receptive, offering an alternative to complex rules and improving notification timing. This presentation explores the challenges and opportunities of developing ML models that predict 'receptive states' in mHealth physical activity interventions.

Methods: We developed a smartphone sensing module that uses feature representations such as location, acceleration, Wi-Fi, Bluetooth, screen usage, and temporal data to infer user receptivity. Preliminary studies were conducted using the LvL UP mHealth intervention to analyse user behaviour patterns in everyday life. We tested high-performing tree-based models and compared them with other ML architectures to determine which were most effective for predicting user receptivity using different sensor representations. Different data aggregation schemes—like hourly phone usage distributions and frequently visited locations—were evaluated to understand how data granularity affects model performance. Data availability, user engagement, and battery drain were considered to balance predictive accuracy with computational feasibility for real-world applications.

Results: Optimizing notifications in mHealth physical activity interventions and evaluating their long-term impact presents several challenges. ML models must perform robustly within real-world constraints like data sparsity or user disengagement. Algorithms need to be adaptive (learning over time) which introduces computational and operational challenges. Evaluating the effectiveness of notifications in rigorous trials requires control conditions where notifications are intentionally sub-optimal or withheld, potentially affecting intervention efficacy. Confounding variables such as time and spill-over effects further complicate assessment.

Conclusions: The challenges and opportunities highlighted in this presentation will inform future research using ML models to optimise engagement and effectiveness of behavioral prompts. Such considerations are crucial for overcoming the challenges associated with deploying interventions across large populations, where the cost and complexity of real-time monitoring and model inference can be prohibitive.