Integrative Analysis of Multimodal Interaction Data for Enhancing Communication and Engagement in Adaptive Learning Environments

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Abstract

This PhD research investigates how multimodal data—such as eye-tracking, heart rate, facial emotion recognition, and conversational patterns can be used to predict and improve Willingness to Communicate (WtC) and engagement in human-agent interactions. By integrating biometric feedback to provide real-time adaptive responses, the study explores the impact of gaze and emotion recognition on learning outcomes and evaluates strategies like Affective Backchannels (AB) and Conversational Strategies (CS). Findings indicate that using these adaptive approaches reduces stress, boosts engagement, and enhances communication, offering new ways to improve AI-driven educational and interactive systems.

Motivation

- Language learning and human-agent interaction are critical for effective communication in a globalized world.
- Traditional methods often fail to adapt to the emotional and physiological needs of learners.
- Integrating multimodal data provides a unique opportunity to enhance engagement and learning outcomes.
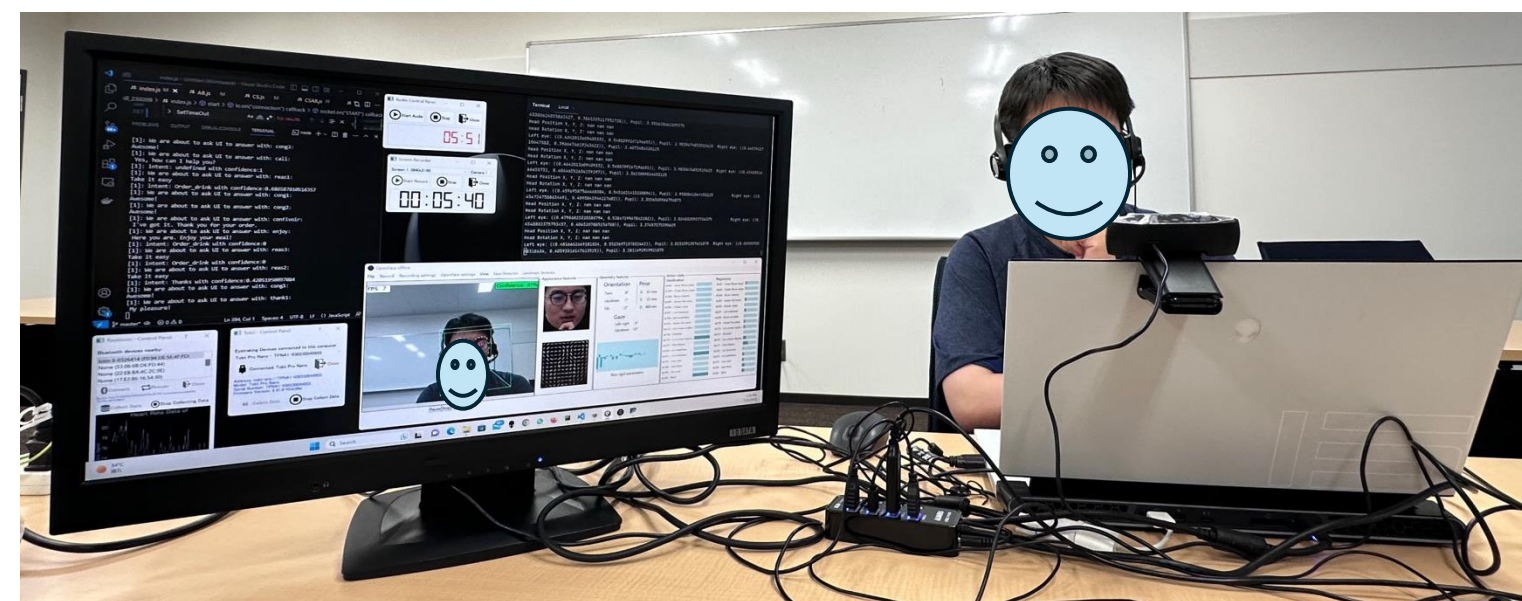
Experimental

- Participants target: 60 university students
- Tools:
  - Eye-tracking (Tobii Pro Nano),
  - Emotion Recognition (OpenFace),
  - Heart Rate Monitoring (RookMotion)
- Scenarios: Simulated restaurant conversations
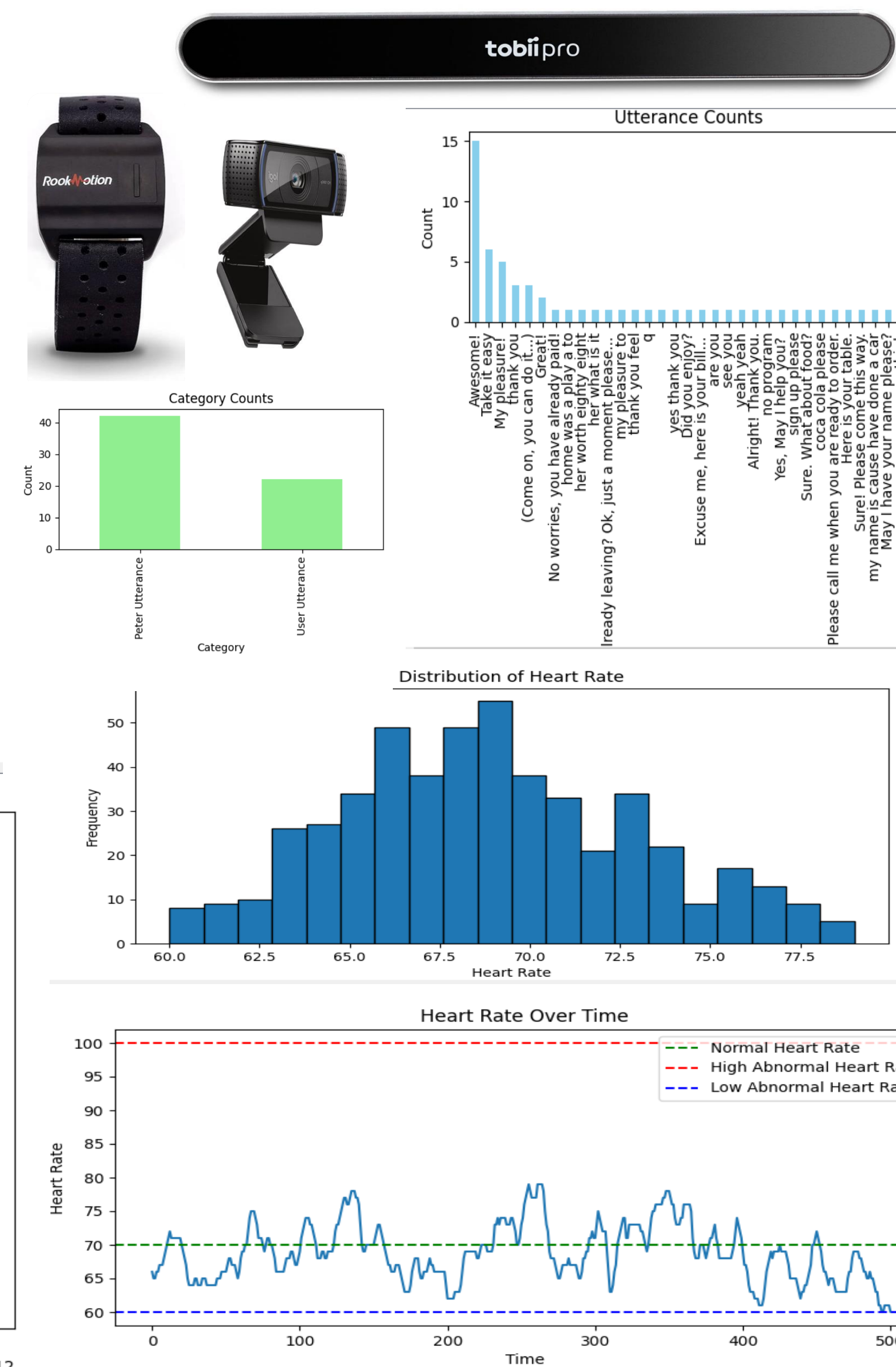
Preliminary Results

- Engagement: Heart rate decreased from 81 to 69 bpm with adaptive feedback.
- Performance: Task accuracy improved by 20% with AB+CS strategies.
- Emotional Response: Positive emotions increased significantly."

Algorithms & ML Models

- **Supervised Learning Algorithms**: Support Vector Machines (SVM), Random Forests & Neural Networks
- **Time-Series Analysis**: Segmentation & Moving Average
- **Statistical Tests**: ANOVA (Analysis of Variance) & Correlation Analysis
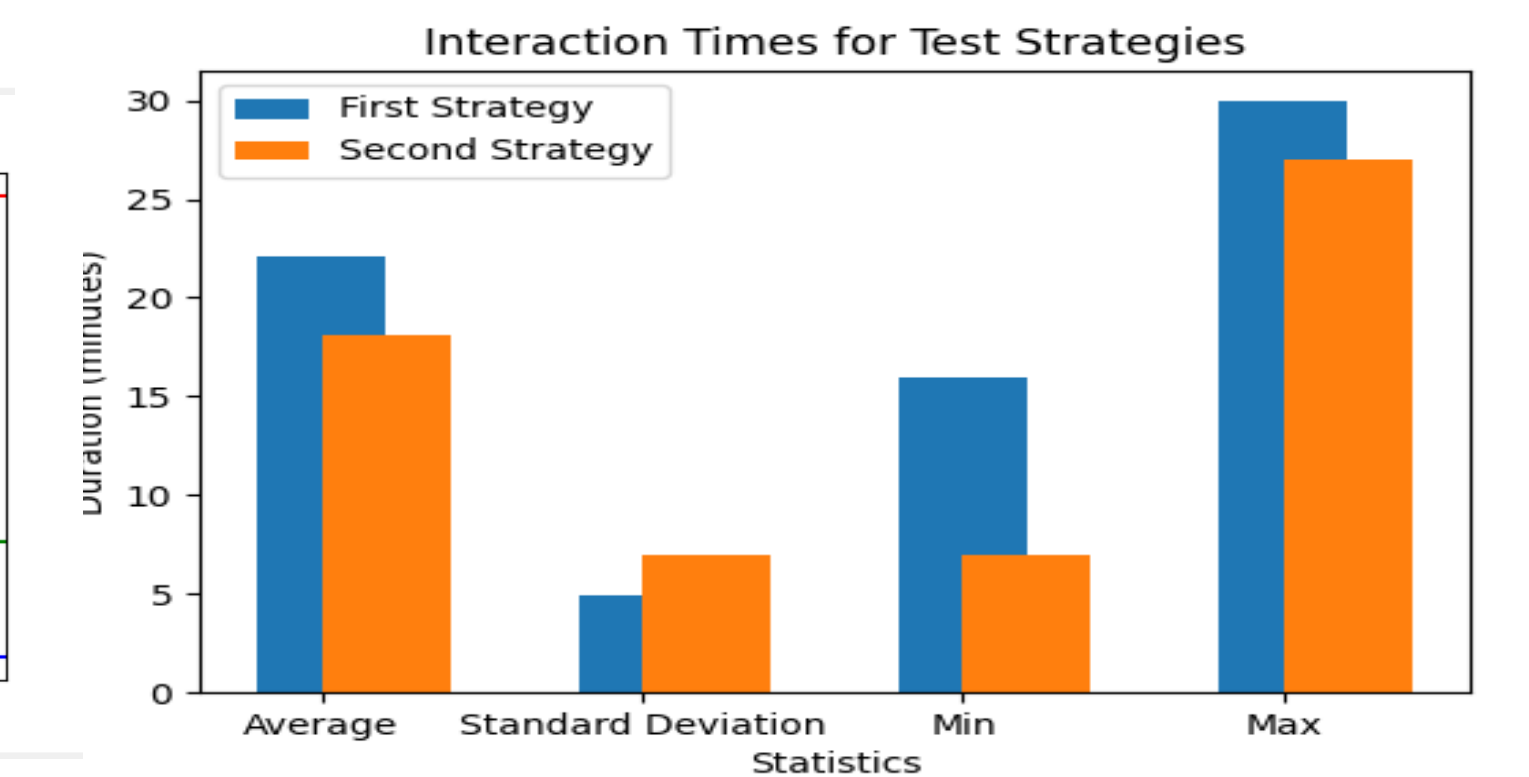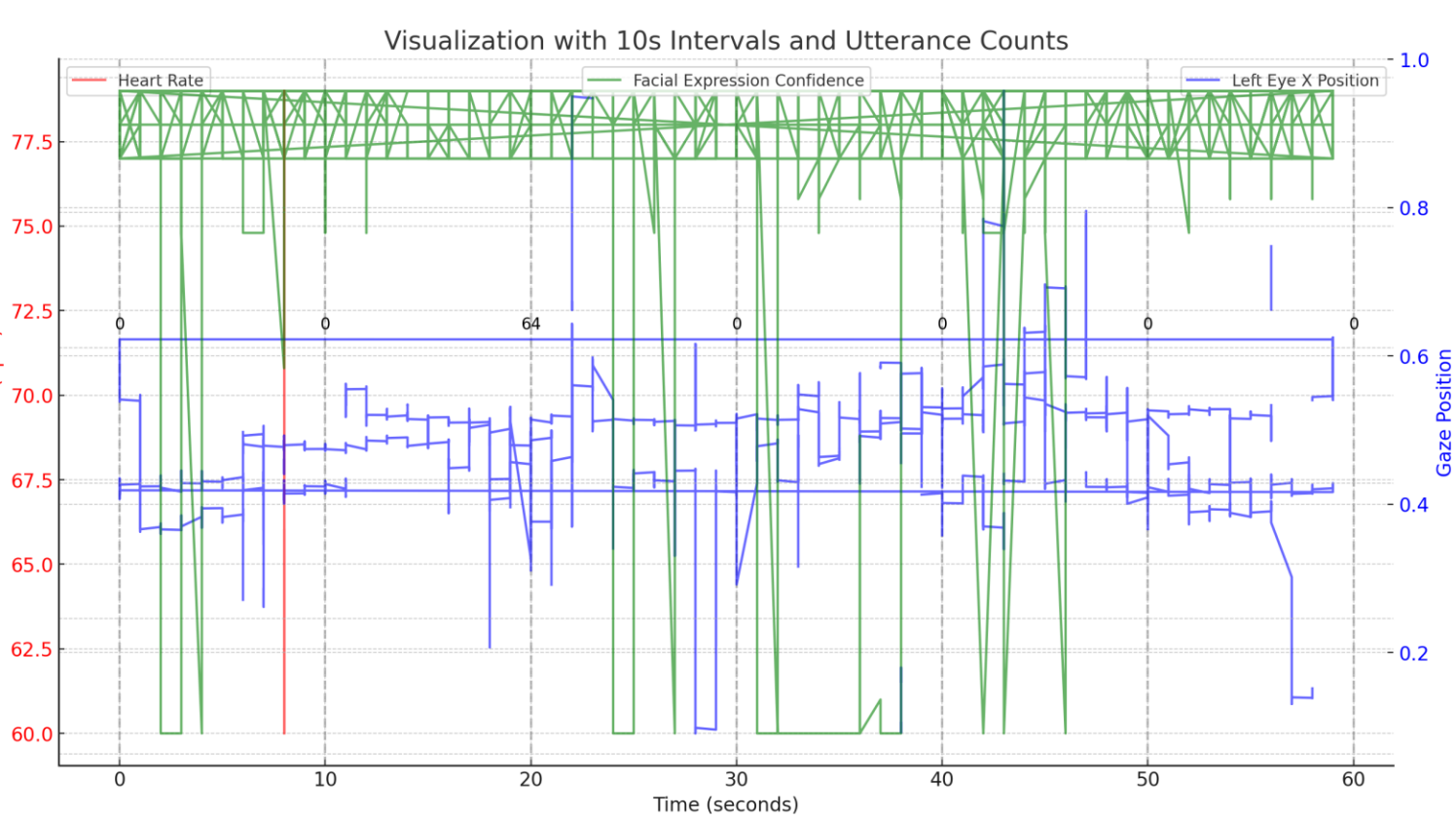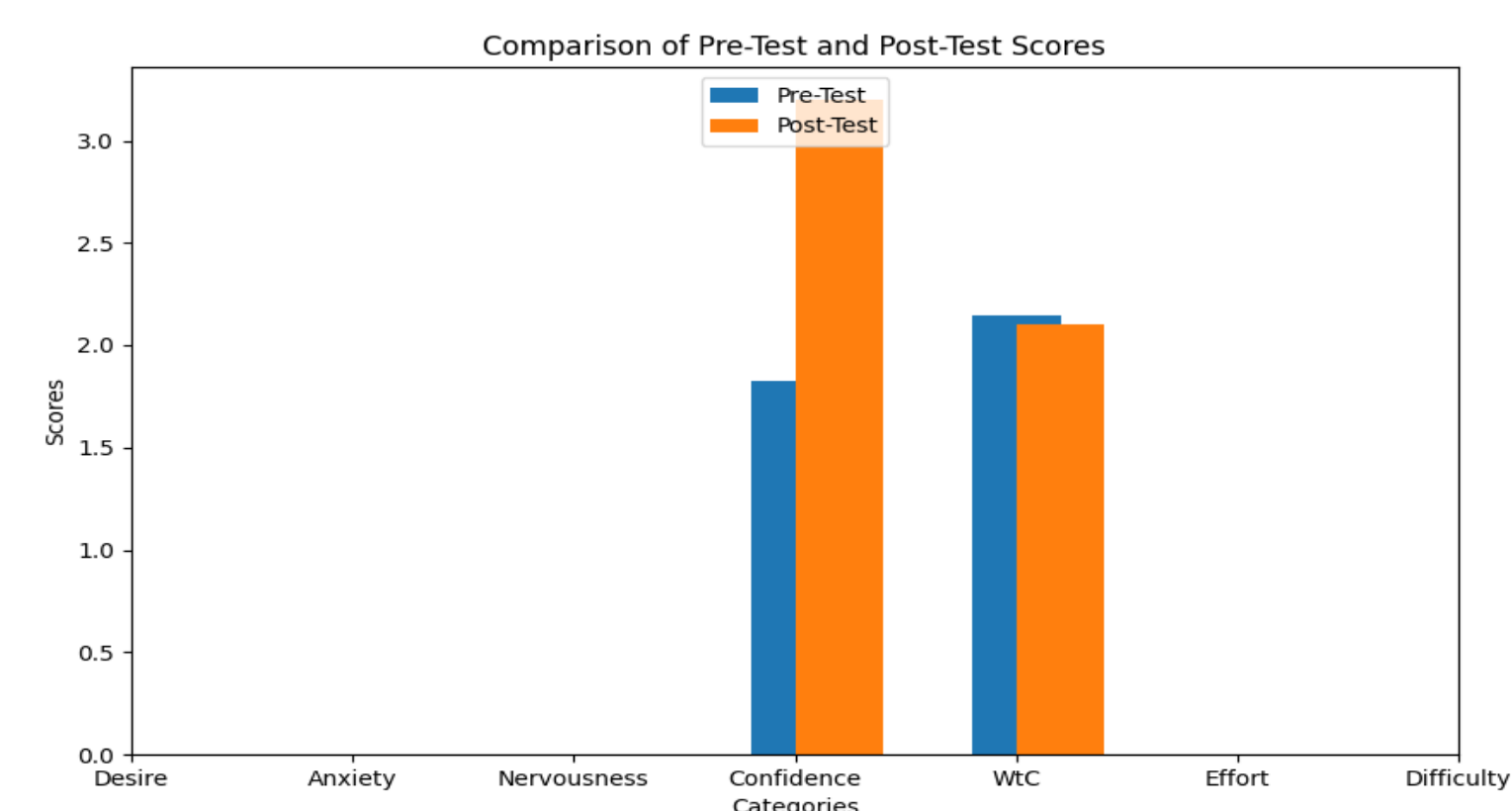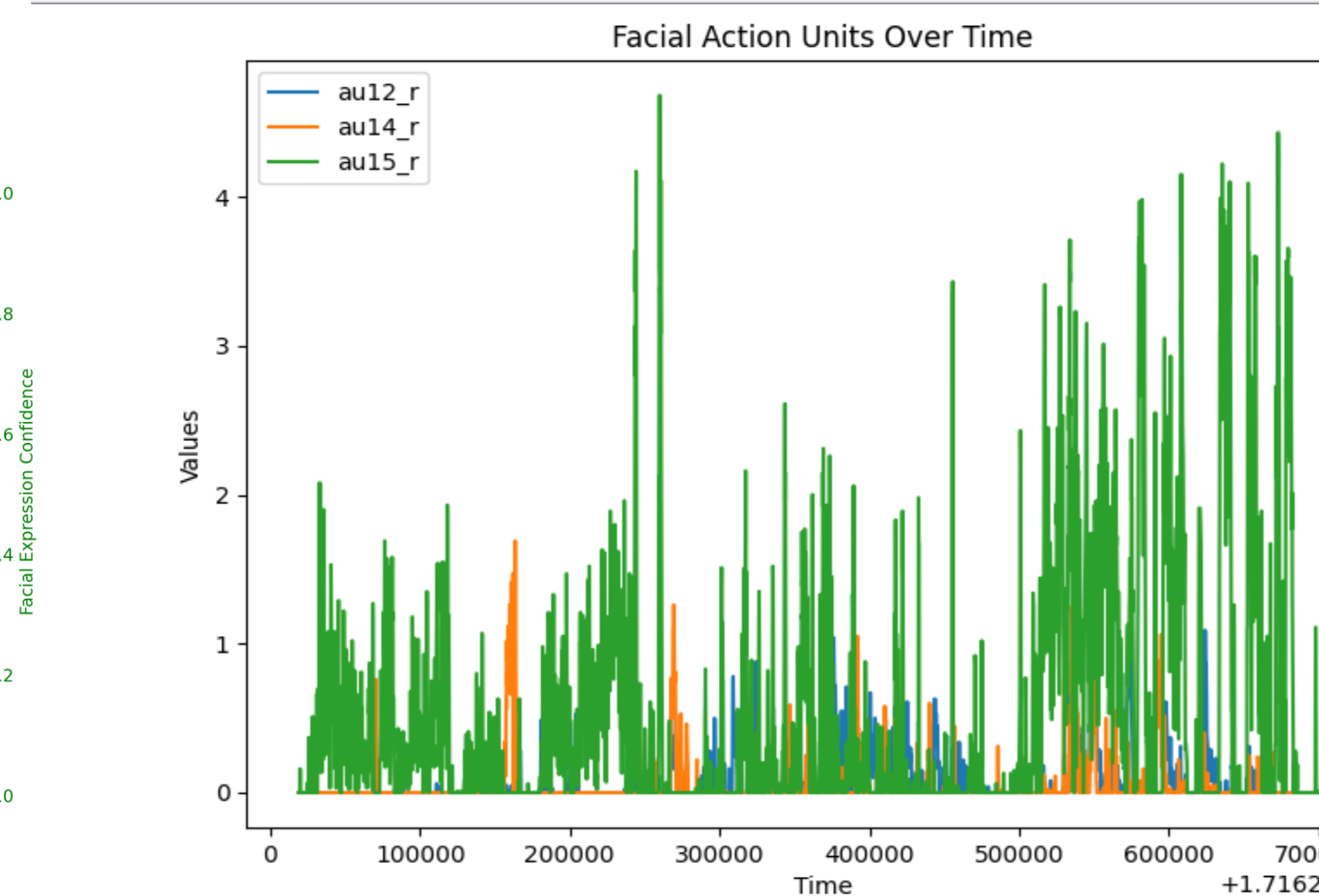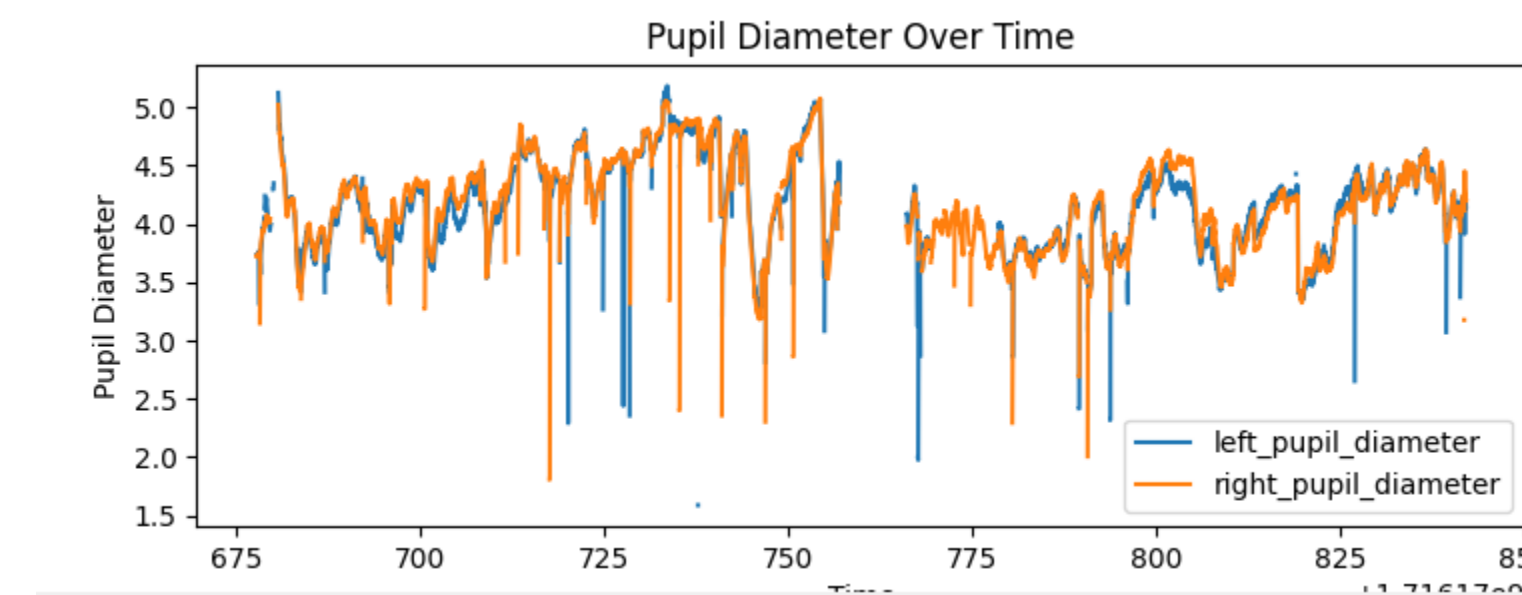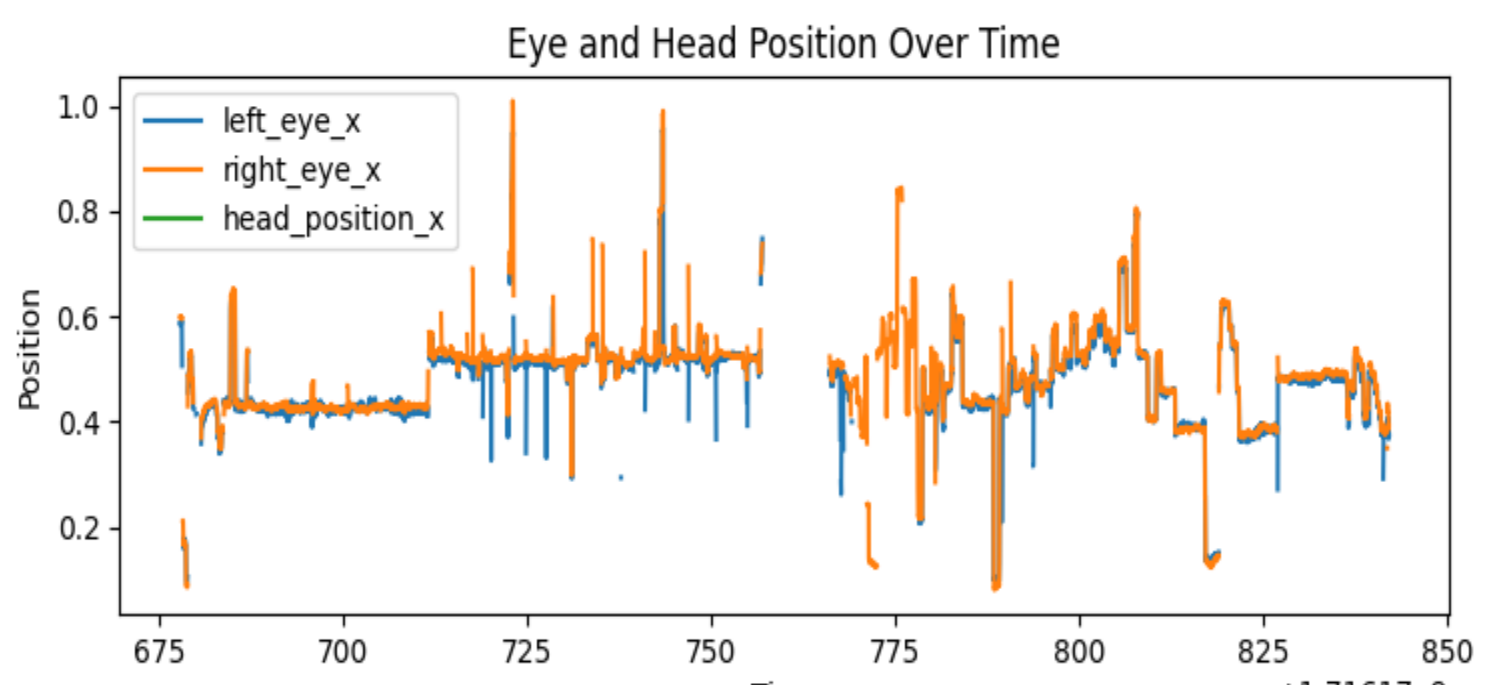
Conclusions

- Multimodal feedback significantly enhances engagement and WtC.
- Adaptive strategies using biometric data can improve language learning experiences.
- Future research will focus on expanding the dataset and testing in diverse educational contexts.

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Keywords

Multimodal Interaction, Biometric Feedback, Willingness to Communicate, Adaptive Learning, Emotion Recognition, Engagement, Human-Agent Interaction, Artificial Intelligence in Education.