Automatic control of home environment responsive to individual user's emotional state using EEG-based passive BCIs

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Introduction

- **Recognition of human emotion** is becoming an important research topic in the field of **human-computer interaction** as it can be used for various practical applications such as human care robot, intelligent personal assistant, and treatment of emotional disorders.

- Recently, increasing interest has been drawn toward regulation of emotion as well as the emotion recognition [1, 2 ,3].

- However, they did not consider the user's current emotional state, or the user had to enter emotions manually rather than the emotion is automatically recognized.

- In this study, we developed a novel system to automatically control home environment responsive to individual user's emotional state estimated using EEG-based passive brain-computer interface (pBCI) technology

- Then, we evaluated the performance and effectiveness of the proposed system via online experiments.

Methods
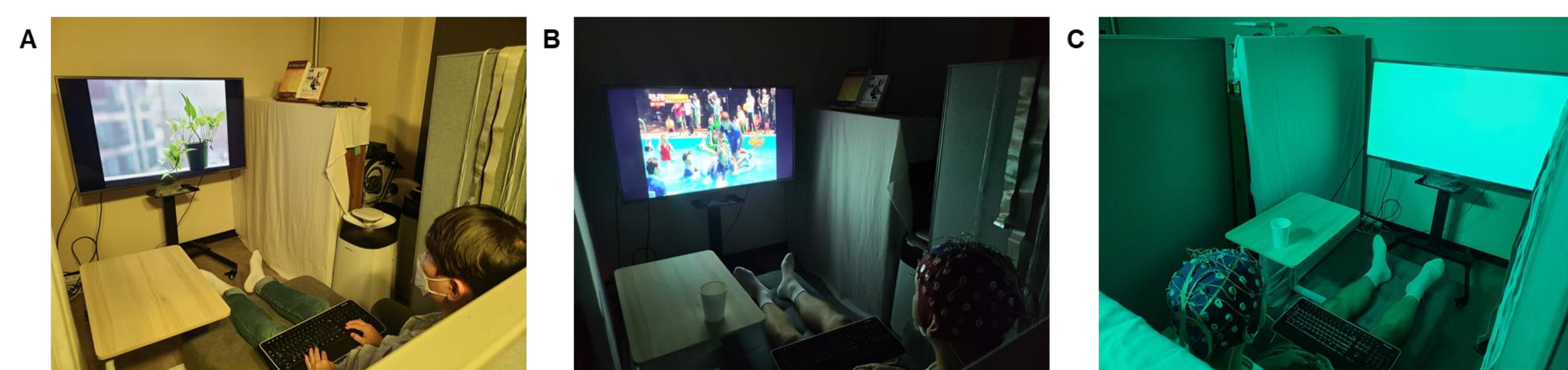
Figure 1. A: Experiment environment (demo)
B: Watching an emotional video in the experiment,
C: Providing feedback (color light (cyan) and music) in the experiment.

- 19 healthy participants (M: 10, F: 9), Age: 23 ± 2.5 years

- EEG: 32 electrodes located according to the international 10-20 system

- Preliminary experiment data of 10 participants were analyzed for parameter optimization in the online experiment.
  - Window size: 10 s, Overlap: 90 %
  - n (optimal number of windows to be inspected): 14 ⎤ Threshold (m/n):
  - m (optimal window matching limit for output): 13 ⎦ 0.93

➢ **Experiment paradigm**
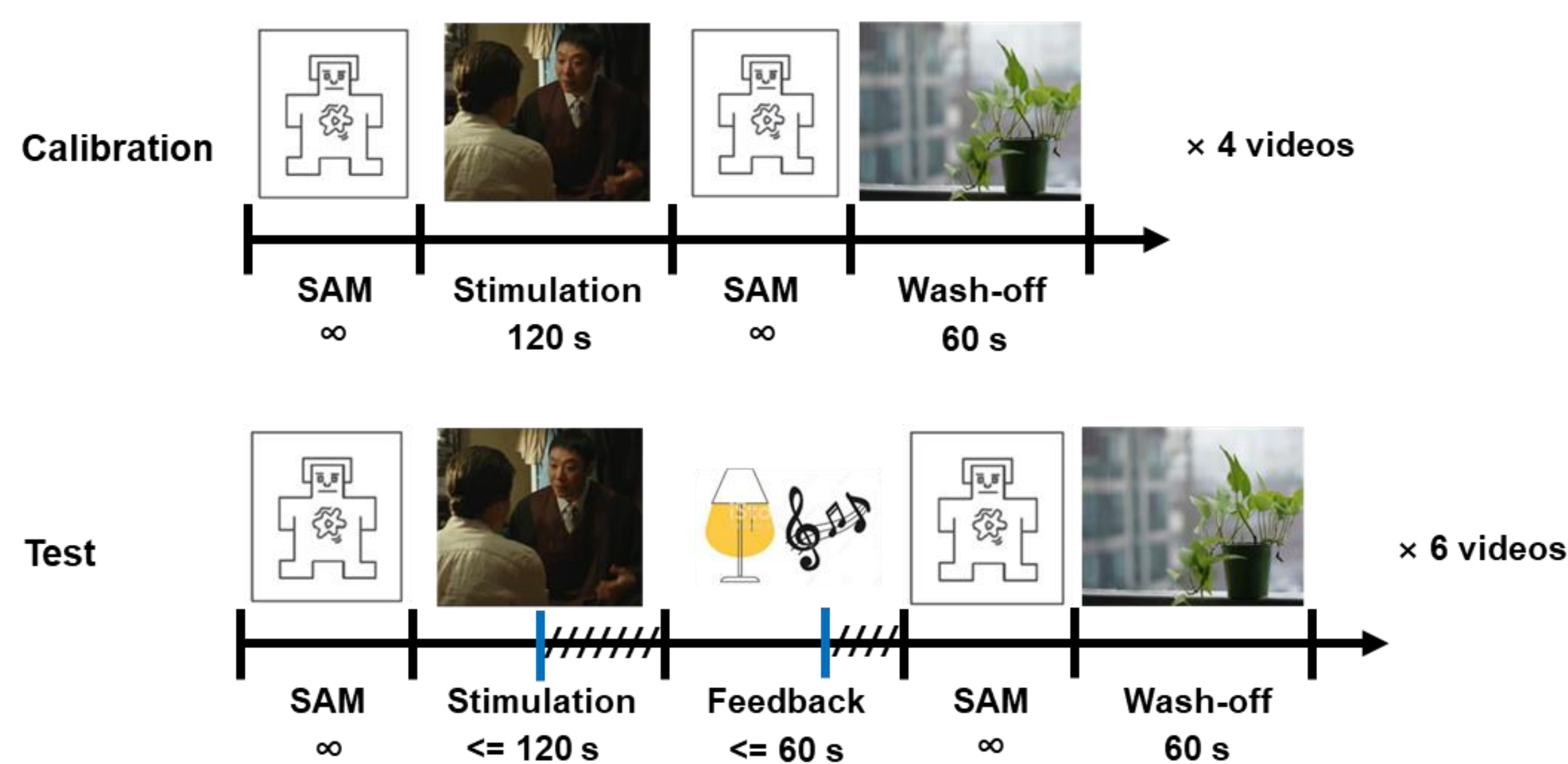
- Calibration
  - Stimulation: 4 emotional videos
  - SAM: valence self assessment range from 1 (negative) to 9 (positive)
  - SVM model to classify the binary emotional states (positive vs. negative)

- Test
  - Emotional state was classified for every second while they were watching six emotional videos
  - The time stamps when the ratio of one emotional state to the other exceeded the threshold (0.93) were detected.
  - Once the user's emotional state was determined as negative, a colored lighting and a designated music were provided as feedback.
  - Once the user's emotional state was determined as positive, the colored lighting and the music sound faded off.

Results
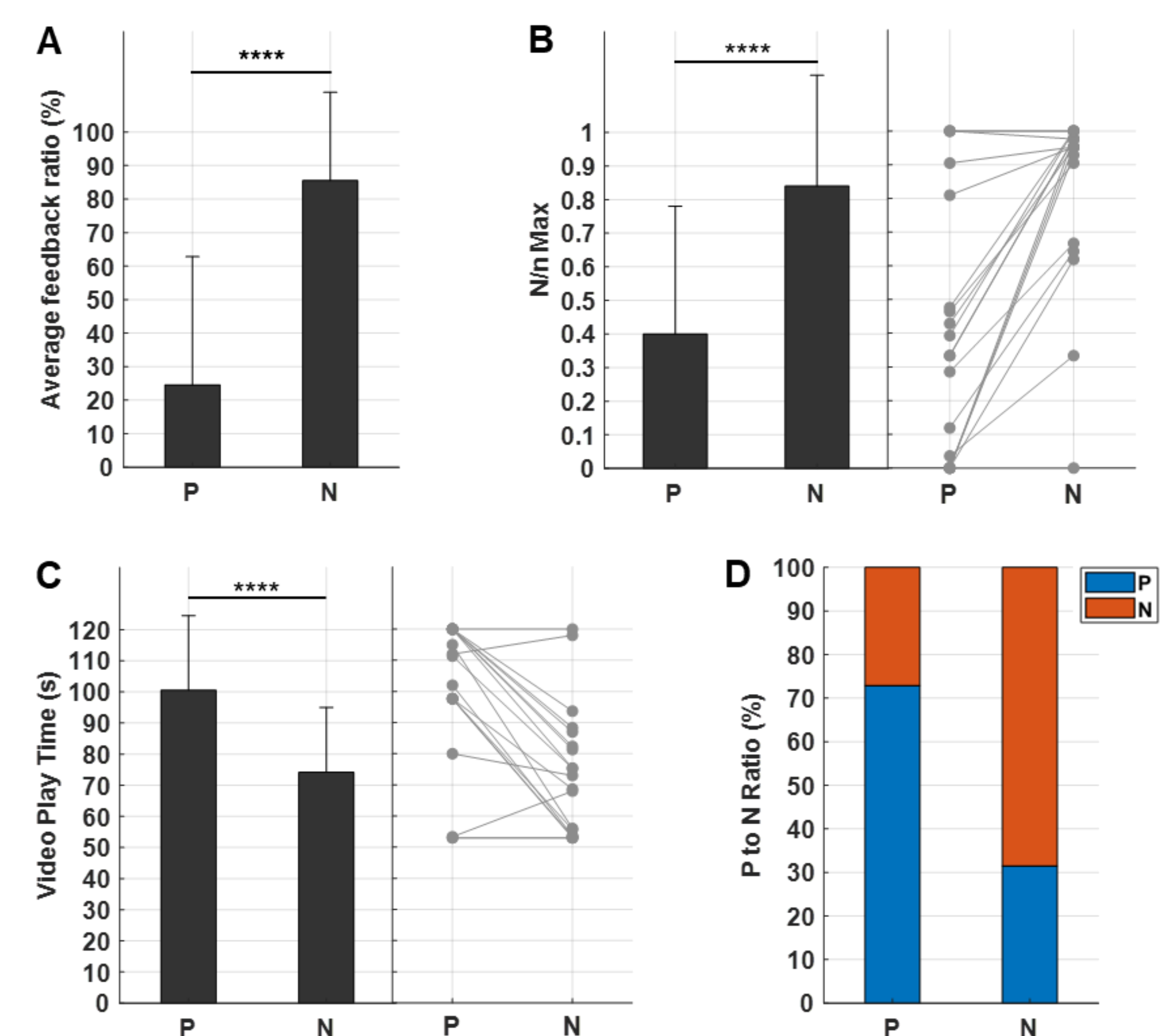
Figure 2. Comparison of experimental results between positive (P) and negative videos (N). A: Feedback ratio in average; B: The average max value of the number of windows classified as negative in the last 14 (**n**) windows (N/**n** Max); C: The average video play time for each video; D: positive to negative ratio of the number of classified time windows. The gray dots in B and C denote individual results.

- **The emotional videos induced the emotions as intended.**

- **Also, the proposed system showed a reliable performance for recognition of the participants' emotional state.**
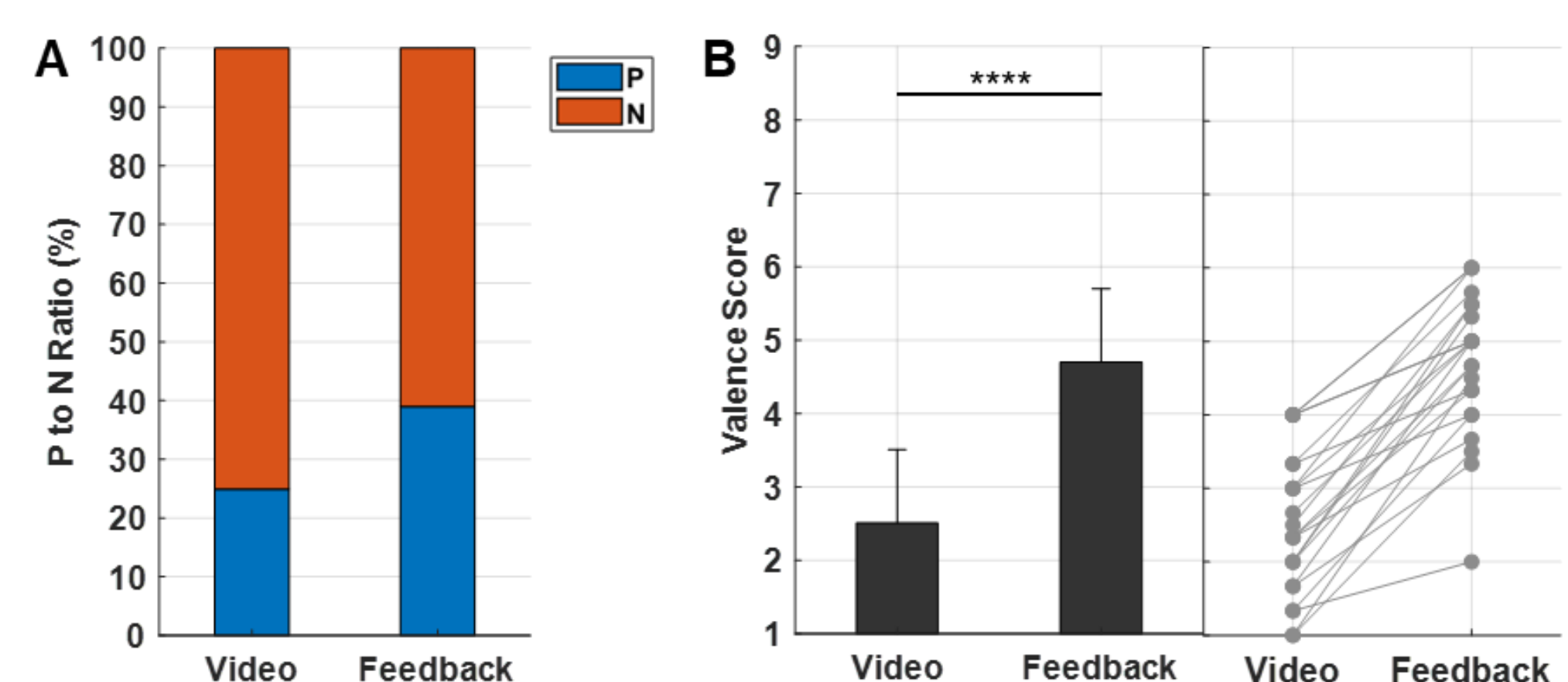
Figure 3. A: The ratio of the number of time window classified as positive to that as negative, in which P and N indicates positive and negative each; B: The averaged valence score that each participants evaluated. The gray dots denote individual results.

- **The proposed system also could successfully divert the participants by a feedback with environment control.**

Conclusions

- We proposed a home environmental control system responsive to the user's emotional state and evaluated the system through a real-time experiment.

- **The proposed system showed a potential to be used to regulate the user's emotional state with automatic control of home environment.**

Acknowledgement

References

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