Identifying EEG signatures of psychological flow state using virtual reality in educational environments

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RATIONALE

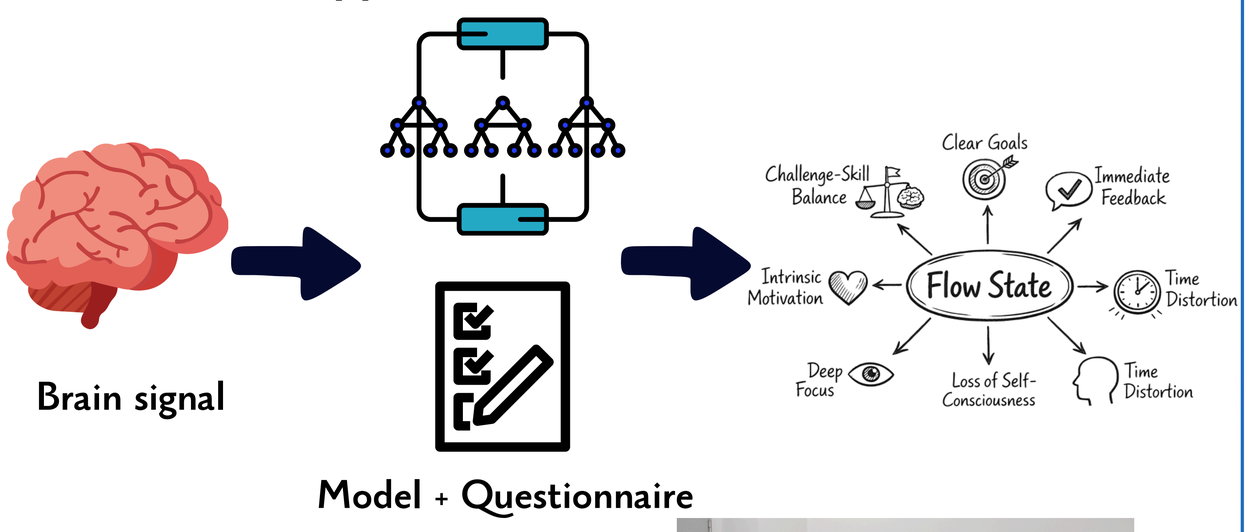
Flow is a mental state of intense absorption and optimal performance it boosts intrinsic motivation and enjoyment.

We built a multisensory VR system to induce flow while learning Japanese Kanji.

System design:

Audio cues + binaural beats to foster the flow state
Immersive VR environment for effortless knowledge acquisition.

Measurement approach:



MATERIALS

VR system

- Unity
- Oculus quest 2

Aura biosignals monitoring

Figure 1: Subject during the practice phase, displaying the AURA EEG system in use and the "eduverse" VR environment created in Unity.

METHODOLOGY

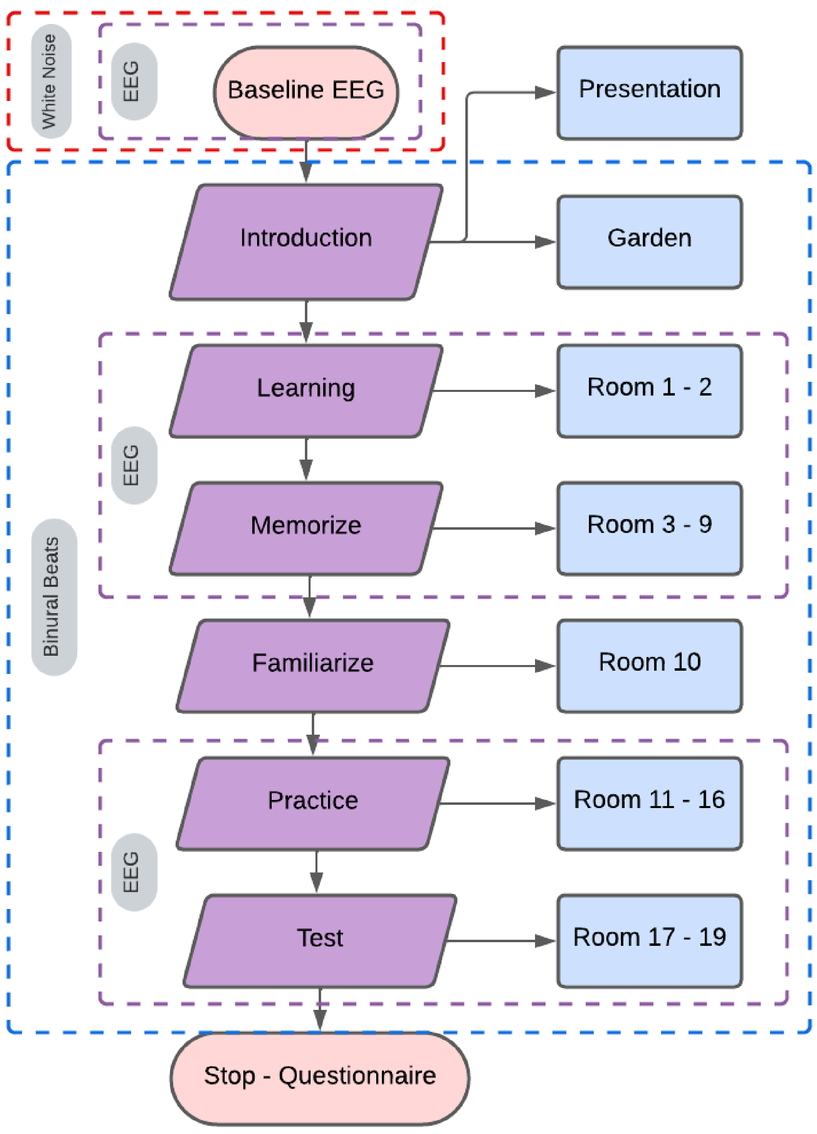


Figure 2: Steps of the VR System Design

PRELIMINARY RESULTS

The succefull development of the VR environment resulted in an ambience that enhances sense of immersion and control.

Figure 3: Sections in the VR environment with the setup used for teaching Japanese Kanji characters

Across trials, elevated Delta wave activity consistently signaled the Flow State during both Practice and Test phases, though intensity varied by phase

Using a mixed-methods approach, we compared physiological trends against qualitative questionnaire responses. Subjective reports of immersion and control tracked the observed Delta wave patterns

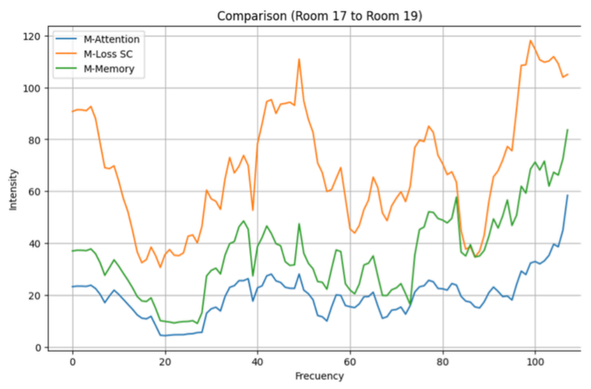


Figure 4: Increase of delta waves over gamma and alpha wave activity in the "test" phase, corresponding to average of the channels Fp1, F3, F4

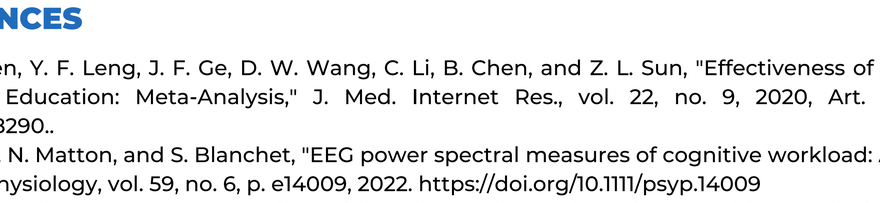


Figure 5: Sample item from the questionnaire (7-point Likert scale), adapted from Csikszentmihalyi's Flow State framework.

FUTURE DIRECTION

The next steps are

- Apply machine learning with rigorous statistical validation to decode Flow State
- Identify which physiological marker(s) actually explain the observed patterns.
- Long-term goal is an explainable adaptive learning system, where physiological signals would induce a personalized VR environment to improve knowledge

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