Reading comprehension based on visualization of eye tracking and EEG data

Shiwei CHENG*, Yilin HU, Jing FAN & Qianjing WEI

Introduction

Using eye tracking technology can help us understand reading behavior. Furthermore, sharing the teacher's eye tracking features resulted in improving the students' comprehension of the same reading material. On the other hand, a user's intention can be analyzed by physiological data, such as electroencephalogram (EEG). EEG is closely related to human cognition. Recently, researchers have tried to use EEG-based engagement measures to augment learning activities.

Purpose

This study proposed an approach to serve novice readers, *i.e.*, students, and recorded eye tracking and EEG data of the teacher and then converted the raw data into visualized measures. During the reading process, the students adjusted their reading patterns according to their teachers' visualization, and improved reading comprehension.

Method

Eye tracking related measures

- Reading speed for a single area of interest(AOI)
- Reading time for each AOI
- Switching frequency between two AOIs

EEG related measures

Reading engagement
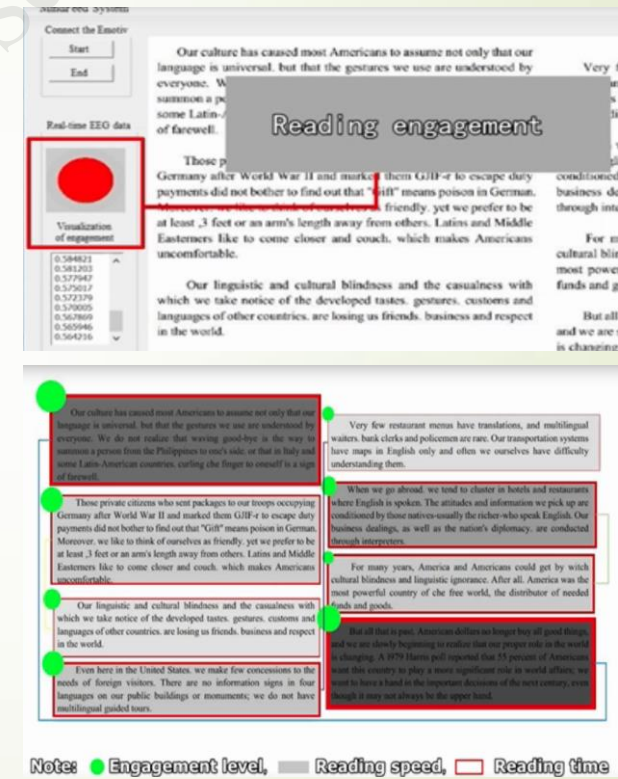$$E = \frac{\beta}{\alpha + \theta}$$

Normalization

$$E_{norm} = \frac{E - E_{min}}{E_{max} - E_{min}}$$
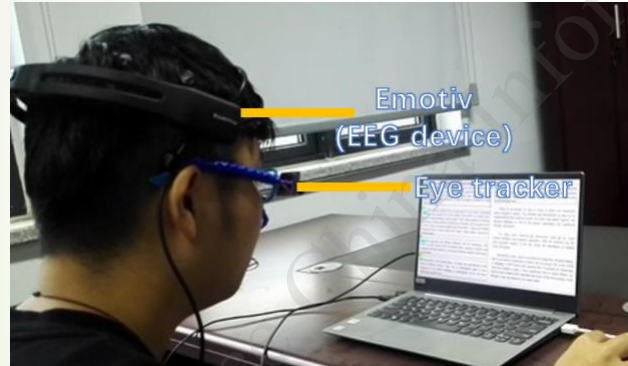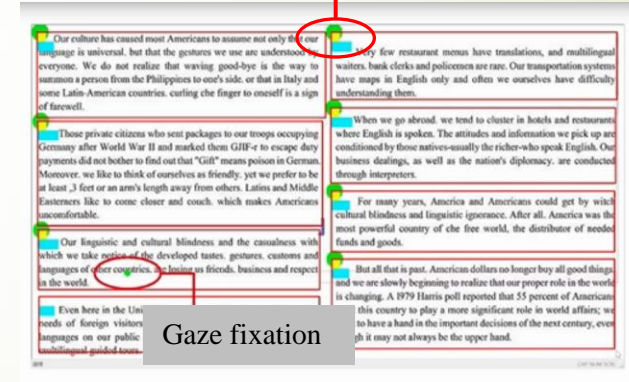
Method

Teacher module

Data acquisition

Data visualization

Method

The difference in reading time

The difference in engagement

Student module

Data acquisition

Data visualization

User Study

1 teacher

10 students in
experimental group
(can watch the visualizations)

10 students in
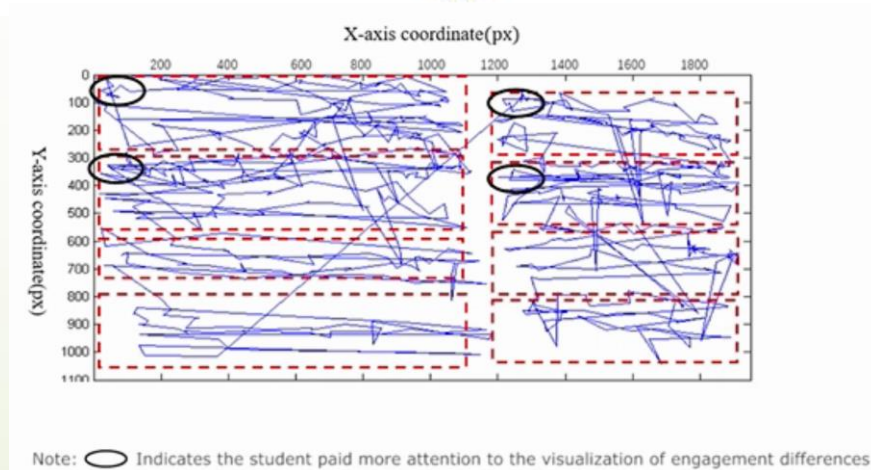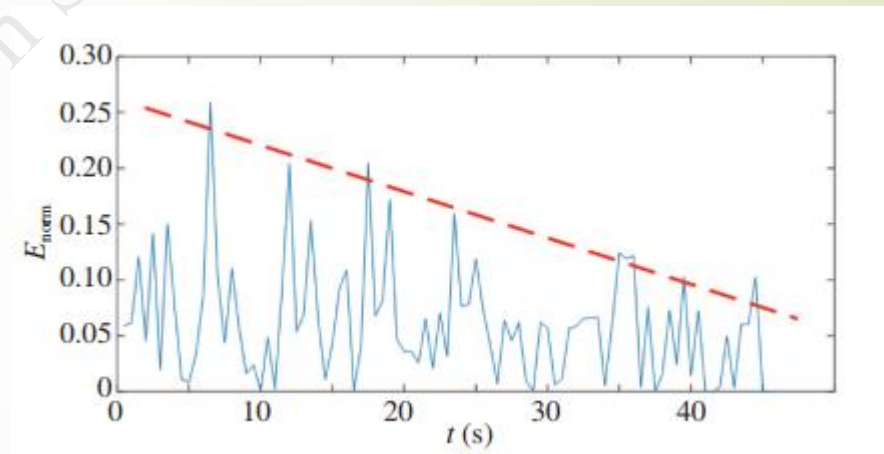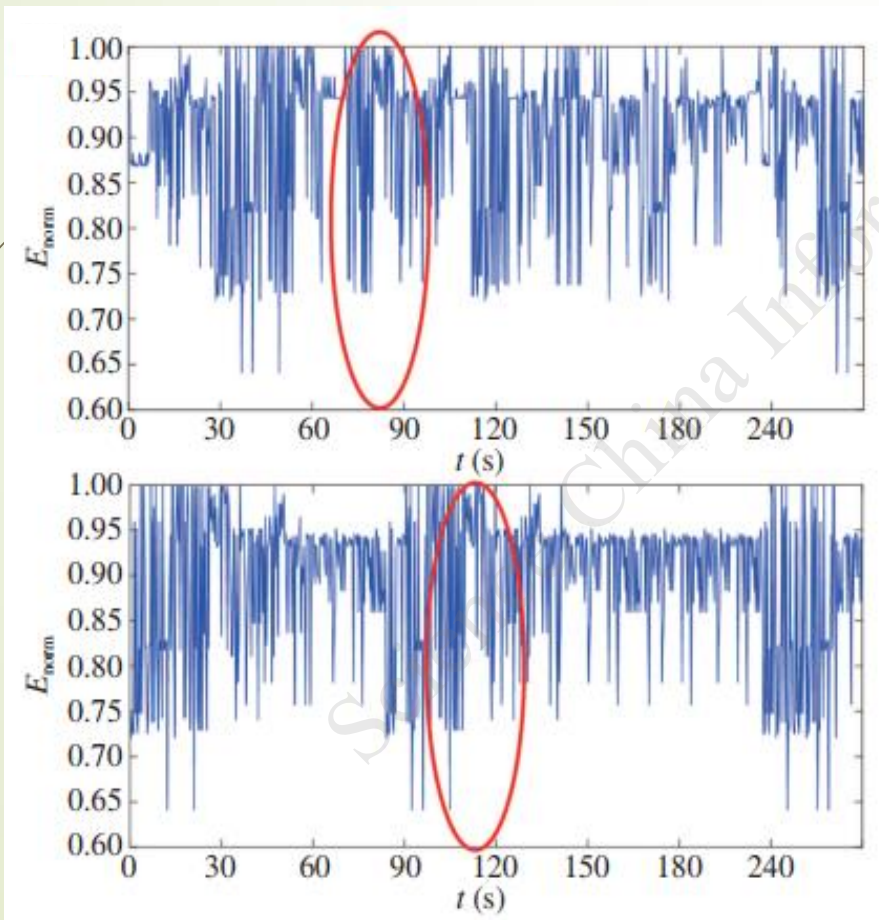control group
(can NOT watch the visualizations)

Participants

Pre-study: excluding student participants who read very fast or slowly

Formal-study: the teacher's eye tracking and EEG data were recorded and visualized for sharing with the students later. For student participants, all of them read the same paper that the teacher read with/without watching the visualizations.

Study design

Results

Note: ⬭ Indicates the student paid more attention to the visualization of engagement differences

Results

Score for comprehension questions(total score is 5) M(*SD*)	
Experimental group	3.3(0.8)
Control group	2.4(0.7)

Answer time for comprehension questions M(*SD*)	
Experimental group	409.6s(64.2s)
Control group	453.8s(69.3s)

Average engagement across all AOIs	
Experimental group	0.84
Control group	0.70

Results

Subjective feedback: we used scale to ask participants to rate each type of visualization. They rated the yellow rectangle (the difference in reading time) to be the most helpful for reading comprehension, and rated the green circle (reading engagement level) and blue rectangle (the difference in engagement) as being "very helpful" for improving their concentration. We also found that students thought the reading time for each AOI and switching frequency between two AOIs were more useful.

Conclusions

We designed the visualizations of the eye tracking and EEG data to provide a guide for the students during their reading process. Our pilot study showed that the visualization provided a good guide for students to help them grasp the important content and to understand the logical structure of the paper, which improved their reading comprehension.