# Implicit Gaze based Annotations to Support Second Language Learning

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## Abstract
This paper explores if implicit gaze based annotations can support reading comprehension tasks of second language learners. We show how to use eye tracking to add implicit annotations to the text the user reads and we start by annotating physical features (reading speed, re-reading, number of fixation areas) to documents using eye tracking.

We show initial results of an ongoing experiment. So far, we recorded the eye gaze of 2 students for 2 documents. We gather initial feedback by presenting the annotated documents to two English teachers.

Overall, we believe implicit annotations can be a useful feedback mechanism for second language learners.

## Author Keywords
language expertise, mobile eye tracker, eye movements

## ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

## Introduction
Learning a new language can be quite frustrating, especially as the individual learner has often difficulties to recognize progress and to identify problem areas. Good

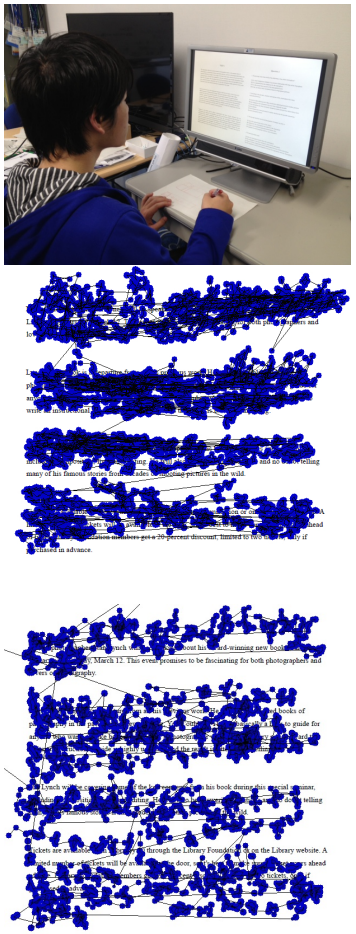

**Figure 1:** Experimental Setup: User reading the text from an English comprehension test. The gaze patterns recorded by the stationary eye-tracker for the first text (mid for the student with lower English skills, bottom higher skills).

teachers are usually essential for success, however they frequently don't have sufficient time to individualize the teaching experience towards the needs of individual students [4].

We wonder if there are ways to support the learning process and give individualized feedback about the learners performance. For the beginning we focus on reading and text comprehension. For reading comprehension tasks, eye gaze seems an interesting modality as it contains a lot of information about our reading behavior and our cognitive status [5].

We explore, if and how implicit text annotations using eye gaze can support second language learners and their teachers. We start with giving readers quantified feedback about their behavior, answering simple quantitative questions: How fast did they read a paragraph? How much re-reading did they do? Yet, finally we want to give the reader feedback about their concentration and finally text comprehension level.

In this paper, we show, how we can use eye gaze behavior to annotate paragraphs with reading speed, the amount of re-reading and aggregated fixation count in first experiments with 2 users and 2 texts. We present some ideas about representing the different metrics and evaluate our initial annotation visualizations by presenting them to 2 English teachers.

## Approach

We choose reading comprehension for English learners, as English is the most common language people study and we have easy access to students with varying levels at university. In general, we want to explore three basic types of annotations:

Word/Sentence level– we want to mark difficult words or sentence structures, keeping a list of unknown words and give students hints on how to better understand grammatical constructs. This might be the most difficult task, due to accuracy problems with current eye-tracking technology.

Paragraph-based– to give students feedback about their reading progress and how well they read a given text, we assume paragraph based analysis is useful and possible using even commercially available devices for the end user.

Reading Flow – Tracking a the high level "reading sequence" can give further insights into the comprehension skills of the learner, especially during texts assessing the reading comprehension of the learner with questions, e.g. the sequence between gazing on questions and paragraphs can give insights on how well the reader understands the question.

In this paper, we focus on paragraph based annotations only, as we think they already can give valuable support to the learner and are feasible to implement with our current technology. We select the following annotations for a start. The annotations are inspired by lab internal discussions, some of the related work and are subject to change [3].

We highlight reading speed by background color and intensity, slow speed with darker hue, faster speed with lighter hue. Reading speed is given by how long the participants eye gaze is in a paragraph region.

We estimate the amount of re-reading by comparing the line count of the paragraph with estimating the line count by using eye gaze using a method from Kunze et al. [7].

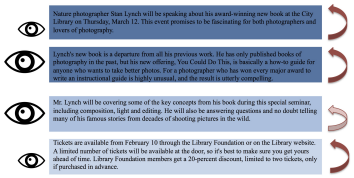


**Figure 2:** Text 1: Eye-gaze annotated document for the participant with lower English skills. Shading shows the reading speed: the darker the slower. The arrows on the right show the amount of re-reading and the size of the eye next to the paragraph the number of fixation areas.

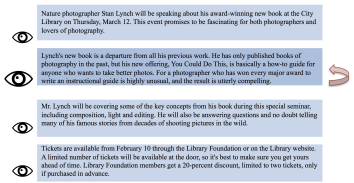


**Figure 3:** Text 1: Eye-gaze annotated document for the participant with higher English skills.

The amount of re-reading is shown by a arrow pointing back up.

We aggregate fixations in larger fixation areas applying a filtering method from Busher et al. [3]. The number of fixation areas are shown as a eye icon next to the paragraph.

## Experimental Setup

2 subjects (Japanese male, undergraduate students) took part in the experiment. One person is a high score holder of TOEIC, and the other has a low score. We used 2 English documents from standard comprehension tests as we focus on second language learning skills. An easy text from TOIEC and a more difficult text from SAT. To get the gaze data, we used stationary eye tracker SMI RED 250. The eye gaze is sampled with 250 Hz.

First of all, we performed an initial calibration and checked the calibration went well or not. And then, we asked subjects to read an English document. Documents are projected on display of stationary eye tracker. Subjects can read over as many times as they like (see Figure **??**). After reading, we asked them to solve questions related the document. At this time, both the document and the questions have projected, and the subjects can solve questions by interactive looking. Afterwards we asked them to put marks on sentences and words which they found difficult and to answer questionnaire about document's difficulty. We performed 2 sets of procedures from calibration to questionnaire.

## Initial Results

Tables 1 and 2 show the estimated metrics for each of the subjects: The paragraph id with number of lines, the number of fixation areas, the average fixation duration in milliseconds, an estimate for the amount of re-reading (estimated line numbers based on eye gaze minus real line numbers), reading speed in seconds, and how many difficult words and sentences the participant marked. We use these statistics to generate the annotated documents. You see the result for Text1 in Figures 2 and 3.

**Table 1:** Summary for participant 1 (higher score)

| | Text1(easier) | | | | Text2(difficult) | | |
|---|---|---|---|---|---|---|---|
| Paragraph | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| num of lines | 3 | 4 | 3 | 4 | 7 | 8 | 8 |
| fixation areas | 6 | 14 | 5 | 7 | 26 | 33 | 32 |
| fixation duration | 17.6 | 38.3 | 21.1 | 25.5 | 64.6 | 62.5 | 63.0 |
| re-reading | 0.5 | 1.5 | 1 | 0.5 | 2.5 | 2 | 1.5 |
| reading speed | 7.8 | 9.6 | 7.7 | 7.9 | 9.2 | 7.8 | 7.9 |
| difficult words | 1 | 1 | 0 | 0 | 9 | 6 | 11 |
| difficult sentences | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

**Table 2:** Summary for participant 2 (lower score)

| | Text1(easier) | | | | Text2(difficult) | | |
|---|---|---|---|---|---|---|---|
| Paragraph | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| num of lines | 3 | 4 | 3 | 4 | 7 | 8 | 8 |
| fixation areas | 26 | 46 | 37 | 19 | - | 23 | 16 |
| fixation duration | 55.3 | 88.1 | 44.3 | 33.6 | - | 86.5 | 89.3 |
| re-reading | 2 | 2 | 1.5 | 2.5 | - | 2 | 4 |
| reading speed | 24.6 | 22.0 | 16.1 | 10.3 | - | 10.8 | 11.2 |
| difficult words | 0 | 2 | 1 | 1 | 10 | 11 | 14 |
| difficult sentences | 0 | 1 | 1 | 1 | 1 | 2 | 0 |

We showed the resulting visualizations to two professional English teachers, both could easily identify the average level of the students given the annotated document

(without detailed explanation).In addition, they found the annotations useful to assess students and would like to use the system in a class setting to get more individual feedback about the skill level of their students.

They mentioned that the re-reading count per paragraph could be potentially very useful to assess the language skill of Japanese English learners. As some Japanese students with lower English skills seem to reconstruct the Japanese word order of the sentence. This holds also with our observations, trying to assess language expertise skill directly from eye gaze. One teacher did not like the eye icon next to the paragraphs. Additionally, both have strong interest in reading flow visualizations.

## Related Work

Reading is a well studied subject in the cognitive sciences. However, there are very few researchers recognizing and evaluating reading behavior in realistic settings [2]. Busher et al. discuss in general the feasibility of gaze based annotations for documents [3]. There are also some efforts to infer the users expertise and language skill using eye tracking [6]. Beidert et al. present the text 2.0 framework to adjust the reading experience dynamically depending on user's eye gaze [1]. We are unaware of any research that uses gaze based annotations to support second language learning.

## Conclusion and Future Work

Although the initial results are encouraging, especially in regard to the expert feedback from the English teachers, we need to record more data and see if we can find the relation between English comprehension level and resulting annotations. Eye gaze can be influenced by a lot of parameters.

Additionally, if we are successful with the stationary setup, we plan to evaluate our technology in more real-life setups, first using a mobile eye tracker together with our document image retrieval technology to associate eye gaze to the document, second using tablets and eye gaze estimation on them using only the camera. s

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