研究論文

# Comparing look-up behavior on smartphone and tablet dictionary apps: Preliminary experiment using an eye-tracker

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**Key words**: smartphone, tablet, dictionary apps, look-up behavior, eye-tracking

## 1. Introduction

It is now impossible to imagine life without mobile gadgets. Not surprisingly, we access the Internet through smartphones or tablets rather than PCs in our daily lives. The White Paper by IIPC reports that household ownership of smartphones exceeds 90 %, which indicates that Japanese use smartphones much more than other electronic devices in almost all generations. When we direct our attention to the education field, the COVID-19 pandemic led to rapid digitalization across Japan. Using iPad, Chromebook, or Surface in the classroom is as a matter of course even at elementary, middle, and high school.

The considerable changes also led to a great impact on the use of dictionaries for Japanese EFL learners. Although pocket E-dictionaries were the leading digital tools especially at high schools and colleges in the early part of the 21st century (Koyama, 2016), JBMIA's report revealed that domestic shipments of pocket E-dictionaries have been declining since 2007. In reality, college students' ownership of pocket E-dictionaries for EFL learning has been on a downward trend over the past few years (Koyama & Nabei, 2023).

## 2. The Previous Studies

In light of the educational environment described above, Koyama (2023) examined how the differences in an interface design between a smartphone and a tablet-based dictionary apps affected their look-up behavior, learning outcomes, and their perceptions of the dictionary interface. In the study, the same dictionary apps, *Sanseido's Wisdom English-Japanese Dictionary* (3rd edition), were used for both smartphones and tablets. This was to focus not on the dictionary contents but on the

dictionary interface design in particular. A total number of 36 undergraduate students were involved in word-definition and reading-comprehension tasks using the dictionary apps on the smartphone and the tablet, respectively. The time they needed for the tasks, the numbers of lookups, and their quiz scores were compared. Also, a recognition test was conducted to investigate how much their looked-ups were retained after one week. In order to search for their perceptions of the user interface design, they answered the questionnaire and made some comments about each dictionary interface.

Based on the results of a statistical analysis, she found the following:

1) the participants were able to look up more words in a shorter period of time using tablet dictionary apps for both tasks;
2) the participants performed better in terms of the reading comprehension task when using their smartphones;
3) the looked-up words using the smartphone apps resulted in better retention than those with a tablet one.

On top of that, the participants' feedback revealed something interesting. While the participants rated the tablet apps higher in terms of dictionary interface design, they seemed not to care much about which mobile devices could be available when performing L2 tasks as long as the dictionary content was the same. Their feedback was somewhat inconsistent with the finding in Koyama (2016), in which the college students showed some preferences for the screen size and the physical keyboard when performing the similar L2 tasks.

Some questions arise here. Despite the fact that the college students looked up more words in shorter period of time with the tablet app, why were the reading comprehension quiz scores better with the smartphone app? Why was their retention of the lookups better with the smartphone app?

Cowie (1999) stated that the importance of the studies focusing on dictionary users was "…chiefly to bring to light the purposes for which students refer to their EFL dictionaries, the levels of reference skill which they display, and the implications of those findings for the future of learner lexicography" (p.176). He also pointed out that learners' expectations and criticisms of the dictionaries were related to their attitudes toward them. One of the studies conducted to find users' feedback concerning dictionary apps was Ma (2019). She examined how university L2 learners in Hong Kong made use of dictionary apps, and reported that dictionary apps have become the most used learning tools with technologies. On the other hand, some research was done to verify L2 learners' lookup behavior qualitatively (e.g., Koyama & Takeuchi, 2009; Koyama & Yabukoshi, 2021; Koyama, 2022). Focusing on pocket E-dictionaries, Koyama and Takeuchi (2009) explored L2 learners' lookup behavior with a qualitative approach. They applied the think-aloud technique to their experiment to obtain concurrent verbal reports, which have been regarded particularly as an effective method to analyze cognitive

processes. Koyama and Yabukoshi (2021) and Koyama (2022) applied video analysis to search into L 2 learners' actual lookup processes between pocket E-dictionaries and dictionary apps.

In addition, studies that examined detailed lookup processes include Tono (2011), who conducted L 2 learners' lookup process research using eye-tracking technologies. According to Tragant and Pellicer -Sánchez (2019), the eye-tracking research has shed light into our understanding of L2 learning processes. Additionally, Tono examined how lookup behavior would change in both monolingual and bilingual dictionary interfaces, and found that lookup processes within a microstructure were very complex as it depended on the nature of lexical knowledge of the question.

## 3. Purpose

The current study was aimed at examining the findings of Koyama (2023) in detail. Since analyzing eye tracking data enables us to explore how learners interact with different interfaces while obtaining information from apps, a wearable type of eye tracker was applied to the study to investigate EFL learners' actual lookup process in the experiment.

Therefore, the purpose of the study, in particular, was to investigate how actual lookup while reading was recorded with the eye tracker. To this end, the focus of this preliminary experiment was only on lookup behavior while reading among learners of different proficiency levels.

## 4. Experiment

### 4.1. Participants

The participants were two undergraduate students who majored in Education. In addition to being heavy users of smartphones, they were familiar with tablets. Based on the result of the vocabulary size test (Aizawa & Mochizuki, 2010) conducted in advance, their English proficiency was considered to range from lower intermediate to false beginner (See Table 1).

**Table 1.**
*Breakdown of the Participants*

| | Vocabulary size | TOEIC® Score | CEFR level |
|---|---|---|---|
| Student K | 5269 | 490 | A2 |
| Student J | 3731 | *Never taken* | A1 |

### 4.2. Materials

Since the objective of the experiment was to validate the findings in Koyama (2023), two kinds of the quizzes excluding ten word-definition questions in Koyama respectively were applied. Each quiz consisted of a reading text including five comprehension-questions to assess their learning outcomes while looking up. These texts were selected from *Eiken's* 2nd grade test of 2003 and 2004, which was familiar to Japanese learners of English in general. Yet the quizzes included several words and phrases that were considered unknown to the participants (See Appendix). The similar topics for each text were carefully chosen, and each readability level was approximately the same as shown in Table 2.

**Table 2.**
*Readability of the texts*

| Task | Fresch Reading Ease | Flesch-Kincaid Grade Level | Word count |
|---|---|---|---|
| Text A | 63.4 | 9.3 | 370 |
| Text B | 65.0 | 8.7 | 360 |

The same dictionary apps, *Sanseido's Wisdom English-Japanese Dictionary* (3rd edition), was used for both smartphones and tablets. The *Wisdom,* like the *Genius,* is one of the most popular learner dictionaries in Japan. The participants were accustomed to using the tablet dictionary app as they had used them in class.

### 4.3. Apparatus and Procedure

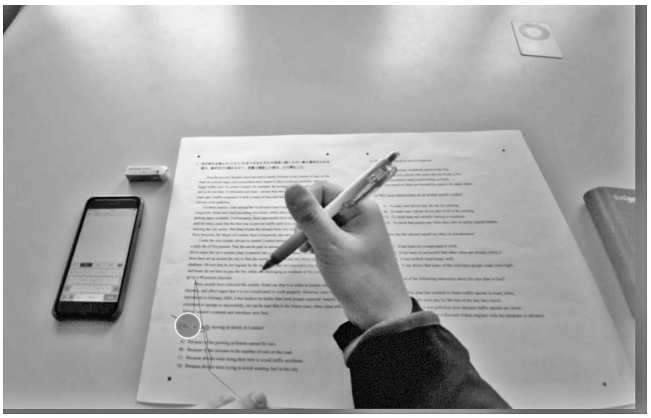
The experiment was conducted in February 2023, and the participants were tested individually. Before the experiment, the participants were informed of the purpose and the procedure of the experiment, and asked to fill in consent forms for the experiment. They were given sufficient time to become accustomed to each dictionary app just in case. In the session, they read Text A with the smartphone app first, followed by Text B with the tablet. There were no time constraints so that they could work at their own pace.

The participants' eye movements while reading were recorded with Tobii Pro Glasses 3. These wearable glasses were equipped with 16 illuminators and four eye cameras integrated into scratch-resistant lenses and enabled us to obtain a 106-degree field of view. Tobii Pro Lab ver. 1.217, an eye

tracking software was used to analyze the data. The eyeglasses and the wearer's view are shown in Figures 1 and 2. A circle and curves in Figure 2 indicates the wearer's gaze point.

**Figure 1.**
*Tobii Pro Glasses 3*


**Figure 2.**
*Field of view by Student K wearing the eyeglasses*



## 5. Results

As shown in Figure 2, the wearable glasses used in the experiment enabled us to see the detailed eye movements when they read. The lookup behavior on the dictionary apps, however, was not clearly recorded through all of the data set. Thus, in this section, their eye movements on the whole were analyzed.

### 5.1. Eye movements while reading with tablet app

The time they completed the assigned task, the numbers of their lookups, and their quiz scores with tablet dictionary app are shown in Table 3.

**Table 3.**
*The comparison of variables of look-up behavior and quiz score with tablet app*

| | The duration of reading | Number of lookups | Quiz Score (%) |
|---|---|---|---|
| Student K | 21:35 | 10 | 60 |
| Student J | 20:30 | 15 | 40 |

**Table 4.**
*Interest areas of eye movement: Student K*

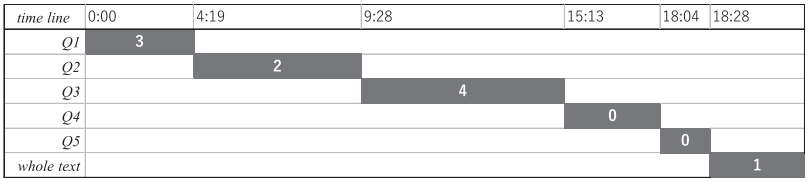
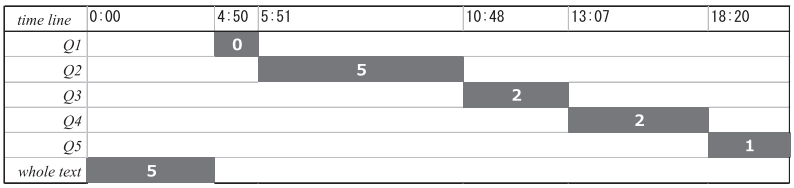



**Table 5.**
*Interest areas of eye movement: Student J*




Tables 4 and 5 show the interest areas of their actual eye movement. These indicated which parts of the text they actually read during lookup. “Whole text” in the tables means that they read the entire text before or after answering each question. The number in each black line in the tables indicates the number they looked up in the tablet dictionary app while reading. Table 3 demonstrates that Student K slightly performed better with fewer lookups than Student J did.

### 5.2. Eye movements while reading with smartphone app

Table 6 shows the same kind of variables as in Table 3. Also, Tables 7 and 8 represent each interest area of their actual eye movements with the smartphone dictionary app.

**Table 6.**
*The comparison of variables of look-up behavior and quiz score with smartphone app*

| | The duration of reading | Number of lookups | Quiz Score (%) |
|---|---|---|---|
| Student K | 26:38 | 6 | 60 |
| Student J | 17:36 | 14 | 20 |

**Table 7.**
*Interest areas of eye movement: Student K*

| time line | 0:00 | 3:21 | 7:47 | 14:17 | 19:00 | 21:55 |
|---|---|---|---|---|---|---|
| *Q1* | 1 | | | | | |
| *Q2* | | 2 | | | | |
| *Q3* | | | 0 | | | |
| *Q4* | | | | 2 | | |
| *Q5* | | | | | 0 | |
| *whole text* | | | | | | 1 |

**Table 8.**
*Interest areas of eye movement: Student J*

| time line | 0:00 | 3:33 | 5:10 | 11:24 | 12:41 | 15:22 |
|---|---|---|---|---|---|---|
| *Q1* | | 1 | | | | |
| *Q2* | | | 3 | | | |
| *Q3* | | | | 2 | | |
| *Q4* | | | | | 2 | |
| *Q5* | | | | | | 1 |
| *whole text* | 5 | | | | | |

In contrast to the use of the tablet app, it is obvious that participants' behavior and learning outcomes were somewhat different when using the smartphone app. Student K who had looked up more on the tablet took considerably longer to complete the task with the smartphone app in particular. In addition, as seen in Tables 7 and 8, Student K whose vocabulary size was larger spent a longer time to comprehend the text with fewer lookups. This was also observed in Figures 3 and 4, in which shows the accumulated data of gaze fixations in their areas of interest (AOI) at the first two minutes in the experiment.

**Figure 3.**
*Gaze fixations in the AOI: Student K*

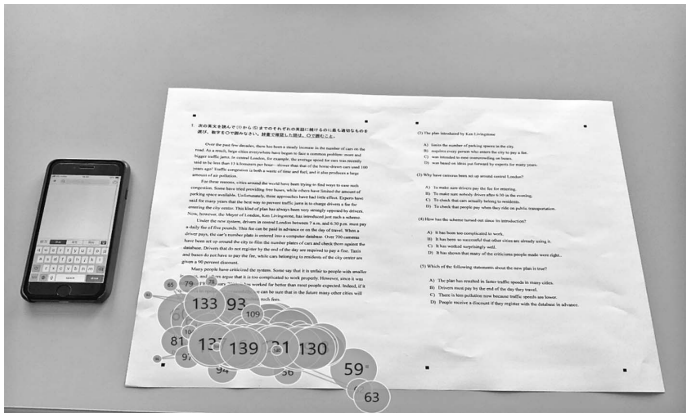
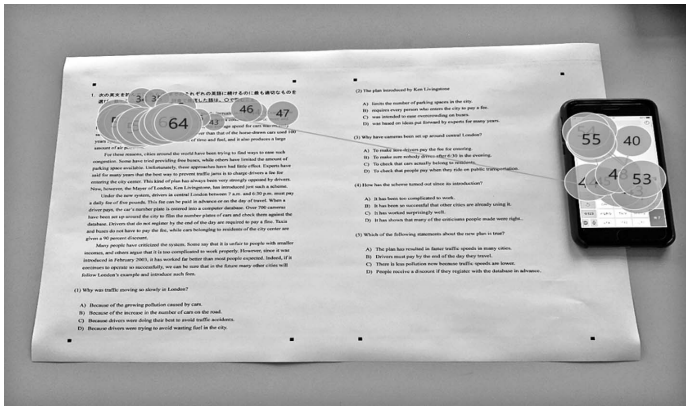


**Figure 4.**
*Gaze fixations in the AOI: Student J*




## 6. Discussion

The current experiment was the first attempt to investigate how the college students' lookup behavior on the dictionary apps was captured by the wearable type of the eye tracker. Although the participants' gaze data while looking up was not clearly recorded, some findings based on the collected data were follows:

1) lookup behavior seemed to be different when using tablet dictionary apps compared to smartphone dictionary apps;
2) this difference was even greater when they were using smartphones;
3) their vocabulary sizes may affect their lookup behavior when using dictionary apps.

The findings seem partially to be consistent with those in Koyama (2023), who found that EFL learners' performance using smartphone apps was better than that using tablet apps. Due to the preliminary experimental situation, however, no decisive data was drawn so far. More detailed experimental research is required.

*This article is a revised version of the poster presented at the EUROCALL Conference held in Iceland from 15 to 18 August in 2023.

**Acknowledgements**
This research is partially supported by the Grant-in-Aid for Scientific Research (C) 22K00695 in the fiscal years from 2022 to 2024. The author would like to express her gratitude to Professor Emeritus, Thomas Robb of Kyoto Sangyo University for their insightful comments on earlier version of this article.

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**Appendix**

Text A

次の英文を読んで**(1)**から**(5)**までのそれぞれの英語に続けるのに最も適切なものを選び、数字を○で囲みなさい。辞書で確認した語は、○で囲むこと。

Overcrowding on highways in the United States has long made driving to and from work a slow and frustrating experience for many Americans. About 30 years ago, government agencies in the United States introduced high-occupancy vehicle (HOV) lands on some highways to try and reduce traffic levels. These lanes were reserved for cars with three or more people. Because fewer cars used HOV lanes, traffic in those lanes moved faster than in the other lanes/ The government's intention was to reduce the amount of gasoline being used by having friends

and co-workers travel together to work.

Soon after HOV lanes were set up on some highways between Washington, D.C., and its suburbs, however, something unexpected began to happen. Single drivers started picking up strangers at bus stops in order to make use of the faster lanes. This practice, which became known as slugging, gradually grew in popularity. These are now a number of different routes with specific pick-up and drop-off points where "slugs" can be seen waiting patiently in line for a ride. Slugging is not actively promoted by the government, but some individuals have set up websites that give details of slug routs and invite more people to get involved.

Over time, a number of rules have developed that are designed to make slugging safer and more pleasant. On arrival at the pick-up point, the driver first calls out his or her destination rather than asking where the slug wants to go. Slugs can refuse a ride if they are suspicious of the driver or if taking the ride would mean leaving a woman waiting alone. In the car, there should be no taking unless the driver begins the conversation, and no money should be exchanged. At the end of the ride, the driver and the slugs all say "thank you."

Everybody benefits from slugging. Drivers who pick up slugs are able to get to work faster. And by not taking their cares into town, slugs save money on fuel and parking. Slugging also reduces the number of cars on the road. So, as many commuters in Washington D.C., now know, taking a slug to work is a great way to help improve the environment.

(1) In the United States about 30 years ago,

A) driving to work not a slow and frustrating experience.
B) lanes were created for cars carrying at least three people.
C) government agencies wanted more cars to use the highways.
D) government agencies built new highways to reduce traffic levels.

(2) What happened soon after HOV lanes were introduced?

A) Drivers began giving rides to people waiting at bus stops.
B) Websites were developed to give information about bus routes.
C) The government set up a number of pick-up points for slugging.
D) More people began commuting to work by bus instead of by car.

(3) According to the rules of slugging,

A) drivers may charge for the ride if the slug does not say "thank you."
B) slugs should first tell the driver where they want to go.
C) slugs should not refuse a ride if the driver is a woman.
D) conversations should only by started by the driver.

(4) The practice of slugging

A) means that drivers now spend less on parking.
B) saves people money and helps the environments
C) allows drivers to travel longer distances to work.
D) has enabled the government to build more bus stops.

(5) Which of the following statements is true?

A) HOV lanes were not actively promoted by the government.
B) HOV lanes were introduced to make highways in the U.S. safer.
C) Drivers who pick up slugs are able to reach their destinations more quickly.
D) Slugging was started by individuals who no longer wanted to work in Washington, D.C.

*From the 2nd Grade test of EIKEN, 2004*

Text B

次の英文を読んで**(1)**から**(5)**までのそれぞれの英語に続けるのに最も適切なものを選び、数字を○で囲みなさい。辞書で確認した語は、○で囲むこと。

Over the past few decades, there has been a steady increase in the number of cars on the road. As a result, large cities everywhere have begun to face a common problem: more and bigger traffic jams. In central London, for example, the average speed for cars was recently said to be less than 13 kilometers per hour—slower than that of the horse-drawn cars used 100 years ago! Traffic congestion is both a waste of time and fuel, and it also produces a large amount of air pollution.

For these reasons, cities around the world have been trying to find ways to ease such congestion. Some have tried providing free buses, while others have limited the amount of parking space available. Unfortunately, these approaches have had little effect. Experts have said for many years that the best way to prevent traffic jams is to charge drivers a fee for entering the city center. This kind of plan has always been very strongly opposed by drivers. Now, however, the Mayer of London, Ken Livingstone, has introduced just such a scheme.

Under the new system, drivers in central London between 7 a.m. and 6:30 p.m. must pay a daily fee of five pounds. This fee can be paid in advance or on the day of travel. When a driver pays, the car's number plate is entered into a computer database. Over 700 cameras have been set up around the city to film the number plates of cars and check them against the database. Drivers that do not register by the end of the day are required to pay a fine. Taxis and buses do not have to pay the fee, while cars belonging to residents of the city center are given a 90 percent discount.

Many people have criticized the system. Some say that it is unfair to people with smaller incomes, and others argue that it is too complicated to work properly. However, since it was introduced in February 2003, it has worked far better than most people expected. Indeed, if it continues to operate so successfully, we can be sure that in the future many other cities will follow London's example and introduce such fees.

(1) Why was traffic moving so slowly in London?
A) Because of the growing pollution caused by cars.
B) Because of the increase in the number of cars on the road.
C) Because drivers were doing their best to avoid traffic accidents.
D) Because drivers were trying to avoid wasting fuel in the city.

(2) The plan introduced by Ken Livingstone
A) limits the number of parking spaces in the city.
B) requires every person who enters the city to pay a fee.

C) was intended to ease overcrowding on buses.
D) was based on ideas put forward by experts for many years.

(3) Why have cameras been set up around central London?
A) To make sure drivers pay the fee for entering.
B) To make sure nobody drives after 6:30 in the evening.
C) To check that cars actually belong to residents.
D) To check that people pay when they ride on public transportation.

(4) How has the scheme turned out since its introduction?
A) It has been too complicated to work.
B) It has been so successful that other cities are already using it.
C) It has worked surprisingly well.
D) It has shown that many of the criticisms people made were right..

(5) Which of the following statements about the new plan is true?
A) The plan has resulted in faster traffic speeds in many cities.
B) Drivers must pay by the end of the day they travel.
C) There is less pollution now because traffic speeds are lower.
D) People receive a discount if they register with the database in advance.

*From the 2nd Grade test of EIKEN, 2004*