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Visual Behavior and Cognitive Load on E-book Vocabulary Learning

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Abstract: This pilot study examined learning English vocabulary by an E-book from cognitive load aspect, and adopted eye-tracking data as a reference to investigate participants' attention distribution among learning targets, pictures and background graphics. An ASL Mobile Eye-XG eye-tracking system was used to record participants' visual behaviors in this study. A Wilcoxon test was conducted to compare the performance before and after the learning process. Correlation tests were conducted to examine the relationships among posttests, visual behaviors and cognitive loads. Also an ANOVA analysis was conducted to compare the total reading time spent on texts, pictures and background graphics. The preliminary results indicated that participants demonstrated a significant progression through reading the E-book. Besides, it was found that the participants spent more time on reading texts than pictures and background graphics. More details of the results will be discussed in the conference.

Keywords: E-book, cognitive load, eye-tracking, English vocabulary learning, visual behavior.

1. Introduction

Owing to the convenience and motility, the rapid growth of mobile devices generated. Accompany with this state, it springs up varied kinds of products that fit into the mobility mobile devices. E-Book is one of them, and plays an important role in it. Moreover, it pushes the relative studies forward. Mayer's Multimedia Learning Theory became a reference for multimedia learning materials design and examining in many studies. Mayer's (2009) Spatial Contiguity Principle and Temporal Contiguity Principle (2009) claimed that to present integrated texts and graphics on the same page at the same time will be a support during cognitive processing. Furthermore, it may lead to a better learning performance since learners have distributed their cognitive resource to deal with connecting the relation between texts and graphics rather than searching the position of target texts and the corresponding graphics. In addition, the Segmenting Principle, which was also proposed by Mayer, noticed that the key point to carry out this principle is to design a self-paced learning material. On the other side, the cognitive load theory proposed by Sweller, van Merrienboer, and Pass (1998) distinguished cognitive load into intrinsic cognitive load, extraneous cognitive load, and Germance cognitive load (Sweller, et al., 1998; Paas, Tuovinen, Tabbers, and Van Gerven, 2003). Further, van Gog & Scheiter (2010) hold the view that eye tracking could be a direct measurement to help explain the cognitive load during learning process. According to the reviewed paper of Lai et al (2013), studies were prompt in adopting eye tracking from 2009, and also mentioned that many studies suggested using eye-tracking measure as index to combine with interpreting cognitive or meta-cognitive concerned learning. Overall, this study aims to inquire into the relation between eye -tracking measure and cognitive load throughout learning English vocabulary by E-book and also examine the interaction among texts, pictures, and background graphics (hereinafter referred to as background) while reading an English vocabulary E-book.

2. Method

2.1 Participants

Six participants (three males and three females, aged twenty and over) from an university of north Taiwan got involved in this study. Their English ability was under the standardized test – GETP intermediate level (equal to CEFR B1 threshold).

2.2 Instrument

An eighteen English stationary and kitchenware vocabularies E-book is the leaning material of this study. All the participants read the same eighteen vocabularies, yet these vocabulary cards' orders were randomized for individuals. In addition, this study adopted ASL Mobile Eye-XG eye-tracking system, with a sapling rate of 60 Hz, which recorded sixty eye movements information per second. It allowed participants to read the E-book comfortable that close to real reading state without limiting their movement. Meanwhile, the difficulty of each vocabulary that the participants perceived when they were answering the pretest sheet was also asked following by the meaning of each vocabulary. And participants rated a self-reported number lines cognitive load questionnaire after the experiment. The cognitive questionnaire consisting of nine questions, participants rated from one to ten, which indicated that, the vocabulary difficulty from very easy to very difficult, and the degree of assistance and interference about pictures and backgrounds from very low to very high. Finally, the pretest sheet contains all the vocabularies of E-book. Participants were asked to fill in the blank with corresponding words of vocabulary in Chinese and rated the difficulty of each vocabulary at the same time. For the posttest, they were also asked to fill in the blank with corresponding Chinese words, but the order was different from the pretest sheet by randomizing.

2.3 Data Collection and Analyses

Participants were asked to fill in pretest sheet at first. Then, they went through on 5-point eye calibration. After calibration, they began to read the English vocabulary E-book with a time limit of ten minutes. Last, they were asked to fill out a posttest sheet and a cognitive load questionnaire. As for the data analyses, this study conducted Wilcoxon test to compare the pretest and posttest. Besides, correlation analysis was used to examine the relationship between visual behavior and cognitive load, and visual behavior and posttest. In addition, an ANOVA analysis was conducted to compare the total reading time and total entered count of background, pictures, and texts. Besides, recording videos of vocabularies learning behavior were analyzed using Interact 9 software. Statistics of total reading time, entered count and duration of backgrounds, texts, and pictures were coded.

3. Result

3.1 Wilcoxon test of pretest and posttest

As shown in Table 1, through a Wilcoxon test, pretest (M=50.50, SD= 10.436) has significant different from posttest (M=97.71, SD= 2.704) ($z=-2.207$，$p=0.027$, $p<0.05$) , and further comparing the mean score of each, we can learn that the posttest is higher than pretest. That is, it has enhanced the English vocabulary learning performance through the designed E-book in this study.

Table 1: Wilcoxon test of pretest and posttest

	N	Mean difference	SD	z	p
pretest-posttest	6	-47.208	9.592	-2.207	0.027

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.2 Correlation between Posttest, Visual behavior, and Cognitive load.

As shown in Table 2, Background Assistance had significantly negative correlations with Posttest (r=-.939，p=.005，p< .05). This finding reveals that participants who had better performance on learning English vocabulary perceived less assistance from backgrounds. On the contrary, participants who had worse performance perceived more assistance from backgrounds.

Table 2: Correlation between Posttest and Cognitive load

	PiA	PrA	BA	D	PiI	PrI	BI
Posttest	-0.485	-0.127	-0.939**	0.000	-0.211	0.018	-0.949**

* p < 0.1, ** p < 0.05

Note: PiA=Picture Assistance, PrA= Pronunciations Assistance, BA=Background Assistance, D=Difficulty of vocabularies, PiI= Pictures Interference, PrI= Pronunciation Interference, BI=Background Interference

3.3 Correlation between Visual behavior and Cognitive load

As shown in Table 3, Total Entered Count of Background had significantly negative correlations with Pronunciation Interference (r=-.845，p=.034，p< .05). This finding reveals that during the reading process, with paying more attention to backgrounds, participants perceived less pronunciation interference, and with paying less attention to backgrounds, participants perceived more pronunciation interference relatively.

Table 3: Correlation between Visual behavior and Cognitive load

	PiA	PrA	BA	D	PiI	PrI	BI
TEC of Background	0.696	-0.441	-0.232	0.696	-0.683	-0.845**	0.098
TET of Background	-0.116	0.383	-0.348	-0.058	-0.293	-0.845**	0.098
TEC of Text	-0.116	0.647	0.145	-0.493	-0.488	-0.507	0.293
TET of Text	-0.319	0.765*	-0.029	-0.493	-0.293	-0.676	0.293
TEC of Picture	-0.162	0.493	-0.338	-0.441	-0.396	-0.429	-0.198
TET of Picture	0.145	0.088	-0.464	-0.029	-0.488	-0.507	-0.293

* p < 0.1, ** p < 0.05

Note: PiA= Pictures Assistance, PrA= Pronunciations Assistance, BA=Background Assistance, D=Difficulty, PiI= Pictures Interference, PrI= Pronunciations Interference, BI=Background Interference

TEC of Background= Total Entered Count of Background, TET of Background= Total Entered Time of Background, TEC of Text= Total Entered Count of text, TET of Text= Total Entered Time of Text, TEC of Picture= Total Entered Count of Picture, TET of Picture= Total Entered Time of Picture

3.4 Correlation between Visual behavior and posttest

As shown in Table 4, there are no significant correlation among posttest and eye-tracking measures.

Table 4: Correlation between Visual behavior and posttest

	TRT	TRP	TEC of Background	TET of Background	TEC of Text	TET of Text	TEC of Picture	TET of Picture
Posttest	.031	.309	-.062	.123	-.370	-.185	.172	.278

* p < 0.1, ** p < 0.05

TRT= Total Reading Time, TRP= Total Reading Pages, TEC of Background= Total Entered Count of Background, TET of Background= Total Entered Time of Background, TEC of Text= Total Entered Count of text, TET of Text= Total Entered Time of Text, TEC of Picture= Total Entered Count of Picture, TET of Picture= Total Entered Time of Picture

3.5 ANOVA results

In order to compare the total reading time and total entered count on backgrounds, texts, graphics, a factorial ANOVA was conducted. The results indicate that the all participants spent longer reading texts than looking at backgrounds. On the other hand, the frequency of reading texts and looking at graphics are both more than looking at backgrounds.

Table 5: Total Reading Time and Total Entered Count on background, text and graphic

	(1)Background		(2)Text		(3)Graphic		F	Scheffe
index	Mean	SD	Mean	SD	Mean	SD		
TRT	22.512	9.347	81.870	55.067	66.845	37.566	3.784**	(2)>(1)
TEC	47.000	17.251	120.167	46.154	121.167	54.024	5.734**	(2)>(1),(3)>(1)

* $p < 0.1$, ** $p < 0.05$

Note: TRT= Total Reading Time, TEC= Total Entered Count

4. Conclusion and discussion

This study aims to investigate the correlation among visual behavior, cognitive load, and performance during the process of reading an English vocabulary E-book. In sum, according to the results, it is an effective English vocabulary E-book to help learners to learn English vocabulary by themselves. As for cognitive of background shows negative correlation with posttest, which means that to some extent, it seems that background has interaction with learners' cognitive load of background and performance. The further study can probe the interaction between the background design and the performance and relative reading behavior.

In another aspect, the significant negative correlation among frequency and duration looking at backgrounds with the cognitive load of pronunciation interference and the total reading time of texts shows significant positive correlation with pronunciation assistance that the participants perceived. For this result, we speculate that participants thought that pronunciation function was helpful while they integrated elements, which are more relative to each other (texts and pronunciations). However, while integrated elements that are less relative to each other (backgrounds and pronunciations) they would take it as interference. Last, with the result of total reading time and total entered count on reading texts and looking at pictures and backgrounds, we can know that learners would primly focus on texts and pictures, while background plays a subordinate role.

Further study can be conducted to involve more participants to infer to larger population. On the other hand, the collected eye-tracking data can be further interpreted by deeper analysis. More details of results will be presented and discussed in the conference if the paper is accepted by the conference.

References

Lai, M. L., Tsai, M.-J., Yang, F. Y., Hsu, C. Y., Liu, T. C., Lee, S. W. Y., ... & Tsai, C. C. (2013). A review of using eye-tracking technology in exploring learning from 2000 to 2012. *Educational Research Review*, 10, 90-115.

Mayer, R. E. (2009). Multimedia learning (2ed ed.). New York: Cambridge University Press. *Journal of Computer Assisted Learning*, 20 (4), 257-268.

Paas, F., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. W. M. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, 38, 63-72.

Sweller, J., van Merrienboer, J. J. G., & Paas, F.(1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10(3), 251-296.

van Gog, T., & Scheiter, K. (2010). Eye tracking as a tool to study and enhance multimedia learning. *Learning and Instruction*, 20(2), 95-99.