

An Examination of View-Settings for Long Texts in VR Reading

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ABSTRACT

To reduce the burden from VR reading of long texts, this study finds the view-settings for better readability and less fatigue. As the view-settings, we focus on the font type, the font color, the font size, and the view-distance from the text. Our results show the relation among the view-settings, the readability, and the fatigue for long texts in VR reading.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Empirical studies in HCI**; **User studies**.

KEYWORDS

Virtual reality, Text readability, E-Book

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1 INTRODUCTION

In recent years, e-books, which can be used easily and anywhere, have become popular. With the spread of virtual reality (VR), the contents of e-books have been developing for reading in VR, such as VIVEPAPER provided by HTC Corporation. Most studies on VR reading have focused on the contents associated with photos, videos, and computer graphics. In the near future when head-mounted displays (HMDs) become more accessible to us, we will have more opportunities to read texts in VR environment. There are studies on the presentation of short texts like signboards in VR [Büttner et al. 2020] and on the investigation of VR reading for English texts [Dingler et al. 2018]. However, these studies did not deal with long texts in VR reading, because experiments for reading of long texts are more complicated with the needs of checking the readers' understanding of the texts. It is necessary to investigate the readability and fatigue of VR reading for long texts. Since some users have VR sickness due to experiencing VR for a long time, VR reading for long texts may cause VR sickness for them. Therefore, our aim is to find the view-settings for better readability and less fatigue, in order to reduce the burden from VR reading of long texts.

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In this study, we carry out an experiment to examine the relation among the view-settings, the readability, and the fatigue for long texts in VR reading with an HMD.

2 EXPERIMENT

The goal of this experiment is to find the view-settings for long texts in VR reading in terms of better readability and less fatigue. In this experiment, the participants themselves adjust the view-settings, such as the font type, the font color, the font size, and the view-distance from the text, for reading the long texts presented on the HMD.

2.1 Experiment Design and Tasks

We define the length of a long text as 400 Japanese letters that are approximately 200–250 words in English, as shown in Figure 1. Eight different long texts are extracted from a high school text book. Two are sample texts and the others six are test texts. The difficulty of all eight texts is consistent. We also create three fill-in-the-blank questions for each test text to check the participant's understanding of the text.

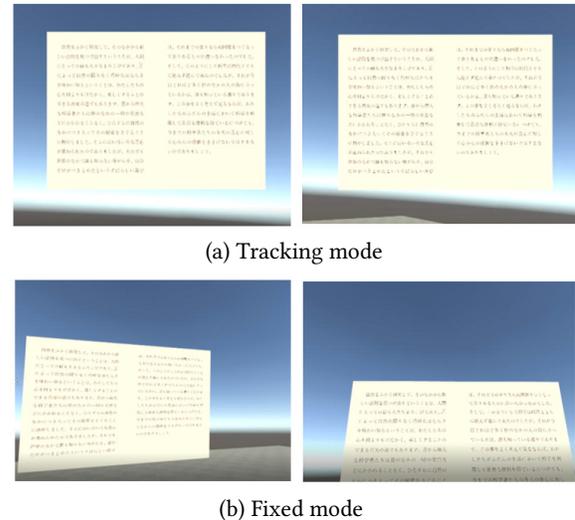


Figure 1: Long text

We focus on the view-settings shown in Table 1. The participant can adjust these view-settings as he/she thinks the easiest to read the long text among the choices in Table 1. We have referred to related studies for these view-settings [Büttner et al. 2020]. As for the font, the participant can choose the type, color, size. The font types of "Yu Mincho" and "Yu Gothic" are representatives of Japanese font types as serif and san-serif typefaces, respectively. For the presentation, the participant can adjust the view-distance from the text area and can choose the mode of the presentation.

We prepare two modes of the presentation; “Tracking mode” and “Fixed mode,” as shown in Figure 1. Tracking mode is a way to always present the text area in front of the participant, which can be achieved in a VR environment. The view-distance in Tracking mode is a constant after adjusting. Fixed mode is a way to present the text area at a fixed position in a VR environment and the view-distance is freely adjusted from 10 cm to 180 cm by the participant.

Table 1: View-settings to be adjusted by the participant

| View settings | Choices | Results |
|-------------------------------------|--|----------------------------------|
| Font type | Yu Mincho (Serif, 叢), Yu Gothic (Sans-serif, 𠄎) | Serif |
| Font size | 10 pt, 11 pt, 12 pt, 13 pt, 14 pt, 15 pt, 16 pt, 17 pt, 18 pt | 18 pt |
| Font color | #ffffff (𐀀, 255), #cccccc (𐀁, 204), #999999 (𐀂, 153), #666666 (𐀃, 102), #333333 (𐀄, 51), #000000 (𐀅, 0) | #cccccc (black background) |
| View-distance from the text area | From 10 cm to 180 cm | 30.5 cm |
| Presentation mode | Tracking, Fixed | Fixed |

We present the long text to the participant in a total of six conditions, consisting of a combination of three background colors (white [#ffffff], sepia [#fcd0da], and black [#000000]) and two writing directions (horizontally from left to right, and vertically from right to left). Writing vertically from right to left is the writing direction that is commonly seen in Japan, starting from the upper right to the lower left.

2.2 Procedure

For each condition, we ask the participant to

1. Adjust the view-settings to make it easier to read a sample long text,
2. With the adjusted view-settings, read silently one of the six long texts for the test,
3. Answer orally the fill-in-the-blank questions about the presented test text,
4. Fill the evaluation sheet regarding the readability and the fatigue on a 7-point scale (very strongly disagree (1)/agree (7), strongly disagree (2)/agree (6), slightly disagree (3)/agree (5), neutral (4)).

Each participant performs all the six conditions. The order of conditions is randomized for each participant. The participant takes breaks for a maximum of five minutes after the adjustment and after the half of the conditions done. The number of the participants is eighteen (eleven male and seven female university students).

3 RESULTS AND DISCUSSION

The number of the data for analysis is 108 points (six conditions × eighteen participants). In the following, in order to find the view-settings for better readability with the understanding of the long

texts, we analyze the data that the evaluation of the readability is positive and the correctness of the fill-in-the-blank questions is more than two-thirds. The number of such data is 96 points. For these 96 points, we examine the relation between the view-settings and the fatigue in the evaluation.

As for the font type, the mean values of the fatigue in the evaluation were 3.10 for Yu Mincho and 3.85 for Yu Gothic, respectively. There was a significant difference between Yu Mincho and Yu Gothic (a *t*-test, $t(94)=2.41$, $p<.05$). We conclude that the font type, Yu Gothic, is less fatiguing in VR reading of long texts. The most chosen font colors were complete black [#000000] for the white or sepia background and white with a slight grayish tint [#cccccc] for the black background. This suggests that the font color should not be too bright compared to the dark background. The mean value of the fatigue in the evaluation was slightly lower in the black background (white: 3.67, sepia: 3.47, black: 3.29). In addition, there was a comment that “the darker in the background, the less tiring for the eyes.” Therefore, we recommend that the font color is white with a slight grayish tint [#cccccc] and the background is black. Figure 2 shows the visual angles while VR reading that were calculated based on the font size and the view-distance (the most frequent value). From Figure 2, the visual angle between 1.1° and 1.2° was the most preferred (31.3%). For this visual angle, the most common combination of the font size and the view-distance was 18 pt and 30.5 cm. As for the presentation mode, all the participants chose Fixed mode. Also, there was no particular difference in the results between the writing directions.

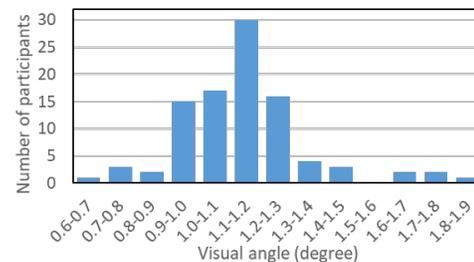


Figure 2: Visual angle while VR reading

We performed a multiple regression analysis with the dependent variable, the fatigue. The independent variables were the font type, the font color, the font size, the view-distance, the writing direction. We excluded the presentation mode and the background color, because the chosen presentation mode was Fixed mode only and the background color was strongly correlated with the font color. As a result, the font type most influenced the fatigue ($\beta=0.20$, $p=0.06$) and the font type, Yu Gothic, increased the fatigue for long texts in VR reading.

In conclusion, the view-settings shown in a “Results” column of Table1 are effective for better readability and less fatigue in VR reading of long texts.

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