Communication Support for the Deaf and Hard of Hearing using Head Mounted Display: Toward Its Use in Museums

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Abstract: The purpose of this study was to clarify the issues of using Optical See-Through Head Mounted Displays (HMD) to provide communication support for the disabled in museums. The study also examined how to present closed captions in the HMD that would be suitable for the deaf and hard of hearing. The presentation of closed captions for the deaf and hard of hearing person adopts different methods, depending on the situation, such as presenting a few lines (akin to closed captions used in television programs and movies) or presenting several dozen lines in an entire screen, as seen in university classes and lectures. There are many items that need to be examined in order to use HMD in museums, including the ideal HMD presentation method for the deaf and hard of hearing person and the comprehension levels and safety when closed captions are presented. This paper detailed the results of a simulation experiment of presenting closed captions using HMD for the deaf and hard of hearing.

1 INTRODUCTION

In recent years, museums have played an important role as a place for science education in local community (Gilbert, 2012). For the deaf and hard of hearing to have an efficiency experience in a museum, some kind of support is needed to supplement auditory information, such as creating learning content (Constantinou, 2016) and preparing guided tours for the deaf and hard of hearing (Namatame, 2019).

Advances in augmented reality (AR) technology that adds information to the real world (Azuma, 2001, Kruijff, 2010), particularly with regard to advances in resolution improvement of Head Mounted Displays (HMD) and speech recognition technologies, have led to research on the presentation of closed captions using HMD (Kurahashi, 2018). However, research on the cognitive load and comprehension levels of users when various information is presented to the deaf and hard of hearing, or users' safety when they move about while wearing one, has not yet been sufficiently conducted.

There is a guideline that limits the number of Japanese characters to 240 per minute to be displayed when audience members read text while watching films. Meanwhile, an average of 300-400 characters are spoken in a minute when talking in Japanese at a regular speed. Therefore, when transposing the content spoken to written words, as they are, it will require displaying many more characters, thereby surpassing the character count limit used in films. For this reason, when presenting the same amount of information provided through auditory means in real-time into characters or text for the deaf and hard of hearing at museums and similar locations, it is necessary to examine whether or not the deaf or hard of hearing person can simultaneously view the exhibits while processing the textual data. It is also necessary to determine whether or not the deaf or hard of hearing person can understand the content from the presented closed caption while viewing the exhibits. Because there is a trade-off between real-time performance and the amount of information, it is important to find an appropriate balance (Figure 1).

This research presumed a scene for providing information support at a museum by using an optical see-through HMD for the disabled in the museum. The aim was to clarify issues related to HMD use and to examine the presentation method of closed captions in HMDs that are most suitable for the deaf and hard of hearing.

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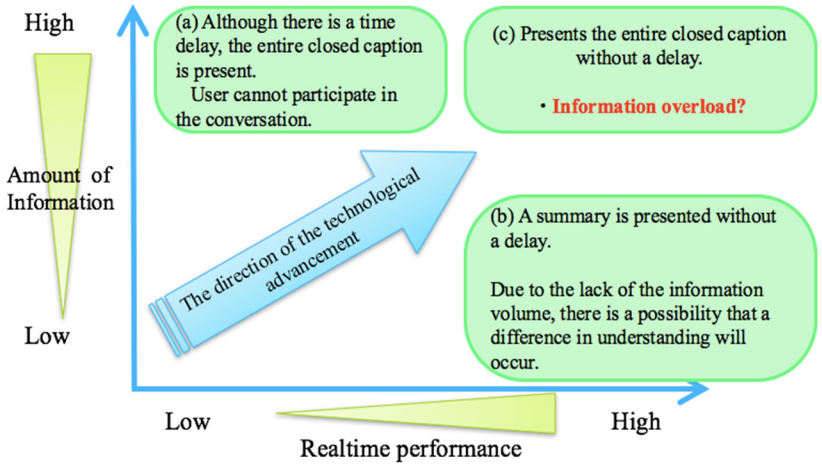


Figure 1: Issue of communication support using closed caption in Japanese.

2 EXPERIMENTS USING HMD

2.1 Examination of HMD Suitable for Presenting Closed Captions in Japanese

When closed captions are presented to an HMD, the line count as well as the presentation position need to be determined. A comparative review was conducted between Sony's optical see-through eyeglass device, SmartEyeglass SED-E1, Epson's SmartGlass MOVERIO BT -200, and BT -300 (Table 1). As a result of a display trial, the BT-300 was selected as the device to be used for the experiment since a high-resolution is required to display several lines of Japanese text, including Kanji characters.

2.2 Line Count and Presentation Position

Table 1: Comparison of optical see-through HMDs.

Model Name	Resolution	Number of colors	Angle of view (opposite angle)
SED-E1	419 x 138	256(Green)	20 degrees
BT-200	960 x 504	Approx. 1.677M	Approx. 23 degrees
BT-300	1280 x 720	Approx. 1.677M	23 degrees

Table 2: The rank sum of the comparison experiment.

Positions and line count	Rank sum
Upper 1 line	25
Lower 1 line	21
Upper 3 lines	17
Lower 3 lines	17

2.2.1 Comparison Experiment

In order to compare the presentation position and line count of closed captions, a total of four types of closed captions were prepared, namely closed captions in the 1) upper or 2) lower positions of the screen, with the line count set as 3) one or 4) three. The four types were presented on HMDs in a random order, with the eight experiment participants ranking them in order of 1st to 4th in terms of ease of viewing.

2.2.2 Result of Experiment

The rank sum of the eight participants' experiences with the four types of closed captions (i.e., upper 1 line, upper 3 lines, lower 1 line, and lower 3 lines, in a random order) is presented in Table 2. The results showed that the rank sum of the upper 3 and lower 3 lines (rank: 17) were high, with the upper 1 line (rank: 25) and lower 1 line (rank: 21) being low.

The free writing sections in the post-experiment survey indicated:

- 3 lines were easy to see.
- Closed captions with many, rather than a few, characters can be read with more ease.

- Three lines were easier to navigate as they allowed for participants to read the lines back.

Between closed captions with one line and three lines, those with three lines tended to gain a high evaluation; however, there was no difference between the upper three lines and the lower three lines. The difference in the preference between the upper and lower positions is believed to be largely attributed to the individual differences in how the closed captions were seen, dependent on such factors as where the HMD nose pads were positioned.

2.3 Closed Caption Presentation Experiment using HMD

2.3.1 Method of Closed Caption Presentation Experiment

As a simulation of a viewing experience at a museum, an experiment was conducted in which participants viewed, in order, four images simulating an exhibition in a room while reading the closed captions presented to the HMD. The following two types of closed captions of explanatory notes of the exhibition were presented:

- Closed captions that presented the original text as they were.
- Closed captions that presented the simplified text.

Here, the simplified text refers to a structured and simplified version of the original text. The number of characters was set at around 80% of the original text, and structuring included aspects such as adding a heading that indicated the content being explained.

The experiment participants were eight deaf or hard of hearing students in their 20s. The experiment was performed twice, with each participant experiencing the original and simplified texts in random order. One experiment session took about 3 minutes. A comprehension test was given before and after each experiment, and a survey was conducted after the experiment. The closed captions presented on HMDs during the experiment displayed three lines.

After conducting a test to enable the participants to become acquainted with the closed caption presentation on the HMDs, each participant was asked to select the presentation position they preferred (i.e. upper or lower). Their chosen selection was used in the individual experiments.

2.3.2 Comprehension Test Results Related to the Closed Captions Presentation

Participants' comprehension test results from the aforementioned experiment are presented in Figure 2. Each comprehension test was scored out of 20.

The difference in comprehension test scores before and after the test was 4.5 points on average for the original text, and 5.6 points on average for the simplified text. There was no significant difference between the mean scores of the original and simplified texts.

2.3.3 Survey Results

The results of the survey conducted after the experiment are presented in Figures 3 and 4. The mean evaluation score for the question "Do you think explanations using closed captions is useful?" (responses were given on a 7-point scale of 1: Strongly disagree, and 7: Strongly agree) was 5.4 for the original text and 5.8 for the simplified text presentations ($p<0.05$).

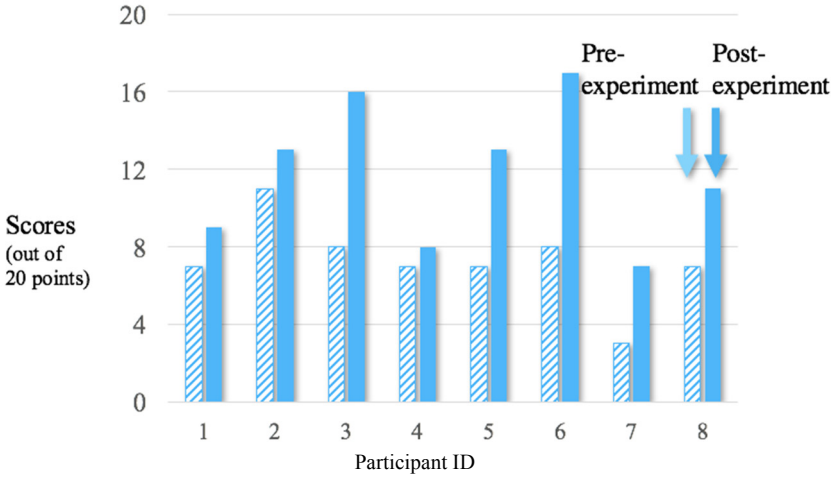
The mean evaluation score for the question "Would you like to use such closed captions again?" (responses were given on a 7-point scale of 1: Strongly disagree, and 7: Strongly agree) was 4.8 for the original text and 5.1 for the simplified text ($p<0.05$).

2.3.4 Free-writing Section

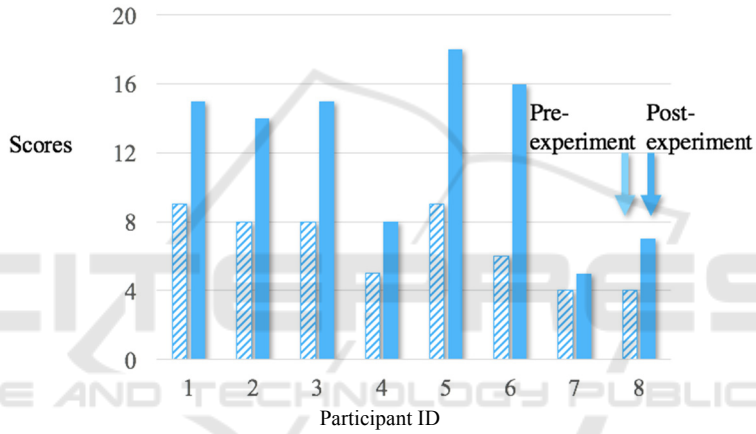
Surveys, which were conducted after the participants experienced closed captions presentations using HMD, included the following comments:

Descriptions related to reading the closed captions while viewing the exhibits:

- Because I was focused on the closed captions, my attention did not go much toward the images.
- Although I wanted to see both the images and the closed captions, I was only able to see one, making it difficult to deepen my understanding.
- I personally wanted time to view the object (image).
- The closed caption kept being presented; there was no break.
- It was difficult to read the presented closed captions while moving.
- I thought that it bugged me a little that I wasn't able to rewind the closed caption when I wanted to see it again.



(a) Original text



(b) Simplified text

Figure 2: The comprehension test result before and after the experiment.

Descriptions related to viewing the simplified text:

- It was easy to understand because the features (of the exhibit) were separated by brackets at the beginning of the sentence.
- It was easy to understand as there were sections that were classified with headings like [history].

The results related to participants' preference for using a Smartphone or HMD when moving, are presented in Figure 5.

3 DISUCUSSION

3.1 The Line Count and Presentation Position of the Closed Captions

Concerning the line count of closed captions, three lines tended to receive a high evaluation, even in the comments presented in the free-writing section of the survey. Previous studies related to television screens also showed that three lines of closed captions received a high evaluation in Japanese (Monma, 2000). When asked about the best subtitle change-over method, participants in such studies also preferred three lines of closed captions completely switching over, as opposed to captions scrolling (Monma, 2000). Similar results were found with HMD in this study.

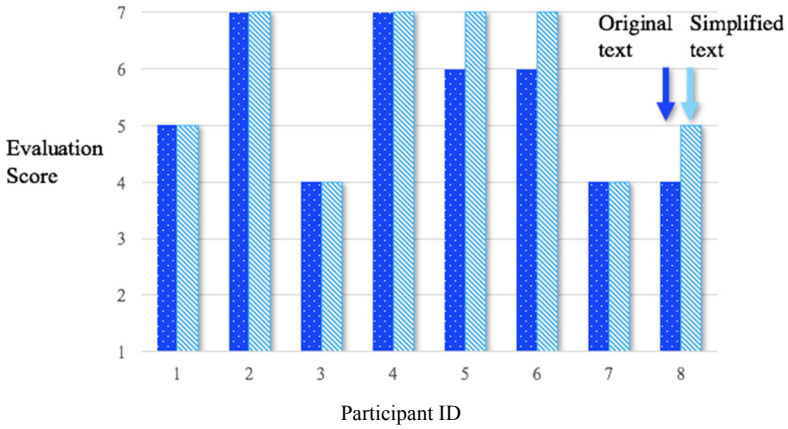


Figure 3: Survey (1) result: “Do you think explanations using such closed captions is useful?”.

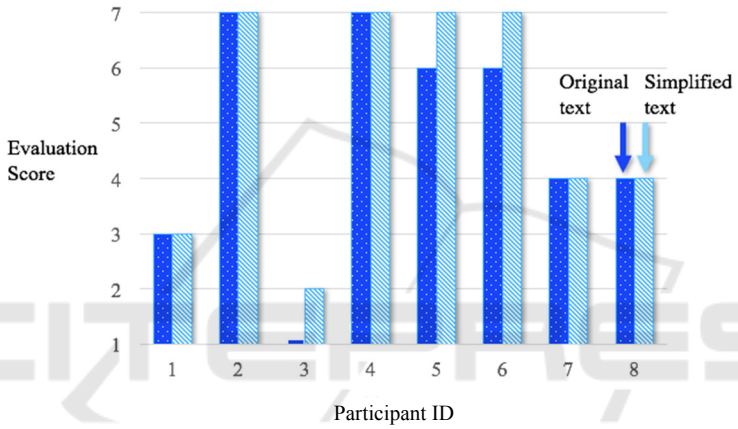


Figure 4: Survey (2) result: “Would you like to use such closed captions again?”.

3.2 Relationship between Closed Captions Presentations and Comprehension Levels

As a result of the experiment that used both original and simplified texts for closed captions presentations, the free-writing section of the survey indicated that participants had difficulties in viewing both the closed captions and the images simulating a museum exhibit. Although providing closed captions near the exhibit is believed to reduce the gaze movement, the results indicated that this practice does not eliminate the difficulties.

A comparison of the original and simplified texts answered the questions "Do you think explanations using such closed captions are useful?" and "Would you like to use such closed captions again?". These answers tended to more highly evaluate the reading of the simplified texts. The results could possibly be attributed to how the time necessary to view the exhibits was secured by reducing the amount of time necessary to read the closed captions.

Conversely, no significant differences were found in the comprehension tests. Thus, it can be concluded that a certain level of content comprehension can be obtained even if texts are properly simplified. The free-writing section also indicated the efficacy of structuring texts using such means as adding headings.

Survey answers related to the question of whether Smartphones or HMDs are easier to use when moving indicated differing opinions. Three participants chose Smartphones while five preferred HMDs. In particular, those the deaf and hard of hearing who tended to rely more heavily on closed captions than audio during daily television watching tended to choose Smartphones.

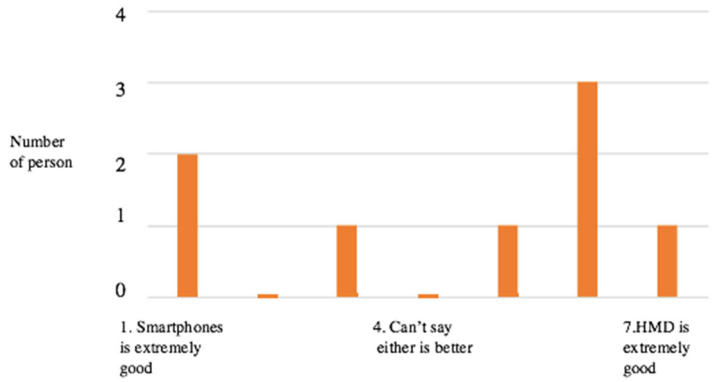


Figure 5: Survey result regarding the ease of viewing while moving.

4 CONCLUSIONS

In this study, a basic examination of a method of presenting explanatory content as closed captions on HMDs when viewing museum exhibits was conducted. It was found that three lines of closed captions tended to receive a higher evaluation than one line in terms of presenting text to the deaf and hard of hearing.

Furthermore, in an experiment that simulated museum exhibits viewing, it was found that participants had difficulties with viewing both the target object and the closed captions. In addition, as a result of the comparison that used both original and simplified texts for closed captions presentations for the deaf and hard of hearing, it was found that there was no significant difference in the level of comprehension, and that the simplified text had higher evaluation. In order to see the exhibition and the closed captions while moving in the room, it is important to make a suitable time interval when the closed captions are not displayed.

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REFERENCES

Gilbert, J.K., Stocklmayer, S.M., 2012. *Communication and Engagement with Science and Technology: Issues and Dilemmas* A Reader in Science Communication, Routledge, UK.

Constantinou V., Loizides F., Ioannou A. (2016) A *Personal Tour of Cultural Heritage for Deaf Museum Visitors.* In: Ioannides M. et al. (eds) Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection. EuroMed 2016. Lecture Notes in Computer Science, vol 10059. Springer, Cham, 214-221.

Namatame M., et.al, 2019, *Can Exhibit-Explanations in Sign Language Contribute to the Accessibility of Aquariums?* , Proceedings of HCI International 2019 Posters, 289-294.

R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, B. MacIntyre, 2001, *Recent advances in augmented reality,* IEEE Comput. Graphics Appl., 21 (2001), pp. 34-47

Kruijff, E., Swan, J. E., S. Feiner, 2010, *Perceptual issues in augmented reality revisited*, Proceedings of IEEE International Symposium on Mixed Augmented Reality, 3-12.

Kurahashi,T., Sakuma, R., Zempo, K., et.al., 2018, *Retrospective Speech Balloons on Speech-Visible AR via Head-Mounted Display*, IEEE International Symposium on Mixed and Augmented Reality, 423-424.

Monma,T., et al. , 2000, *Subjective Evaluation on Closed Caption Presentation Methods of News for the Deaf and Hard of Hearing*, The Journal of the Institute of Image Information and Television Engineers, 54,9,1288-1297.