Improving Usability of Web Pages for Hard-of-Hearing Persons: An Investigation of the Utility of Pictograms

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Abstract. This paper reports two experiments conducted to investigate the utility of pictograms for improving usability of web pages for hard-of-hearing persons. The first experiment simulated a directory-based information search task, typically carried out at portal sites, to understand how the task is performed when directories are represented in text form. Sixteen hard-of-hearing and sixteen hearing participants were asked to select one or more directories out of twenty-seven directories for each of the thirty-eight queries. The result demonstrated that the hard-of-hearing participants performed less efficiently than the hearing participants probably due to less elaborated understanding of the meaning of directories represented in text form. The second experiment examined whether hard-of-hearing persons could derive intended meanings of pictograms better than hearing persons by having the participants perform a directory–pictogram name-paring task. The result indicated that the hard-of-hearing participants answered more correctly than the hearing participants, suggesting the possibility of using pictograms as alternatives for text for improving web usability for hard-of-hearing persons.

Keywords: Web usability, hard-of-hearing persons, pictogram, directory-based information search.

1 Introduction

This paper concerns web usability for hard-of-hearing persons. As Wilson and Emmorey [1] pointed out, hard-of-hearing persons use different cognitive processes than hearing persons when comprehending visual information. This has an important implication for web usability for hard-of-hearing persons because the certificate that a web page does not have usability problems for hearing persons does not necessarily guarantee that the page is usability-problem-free for hard-of-hearing persons.

Our previous studies [2–5] support this claim by showing that hard-of-hearing persons utilize visual information on web pages differently than hearing persons when performing information search tasks. We ran a series of eye-tracking experiments and found several differences in performance between hard-of-hearing persons and hearing persons in terms of eye-scanning patterns, selected links (image, text, etc.), the number of errors, and the time to complete tasks. We suggested that these differences would reflect processing characteristics of hard-of-hearing persons, *i.e.*,

relying more heavily on visual representation than textual representation when comprehending the contents on web pages.

This paper follows up our previous studies by reporting a study that investigated the utility of pictograms, a visual alternative of textual representation, for improving usability of web pages for hard-of-hearing persons. The study specifically focuses on the situation where a user searches for information at a portal site by selecting an appropriate directory that matches the information sought. The directories can be represented by text or pictogram.

The study consists of two experiments. The first experiment investigated differences in performing a *text-only* directory-based information search task from the viewpoint of variability of the selected directories for given queries. The specific question here is "How consistently are the directory names represented in text comprehended by hard-of-hearing persons?" If a textual representation of a directory is comprehended in various ways, or ambiguous, it would not be useful as a representation of the link for digging into the web site. The second experiment examined the utility of pictograms as alternatives for textual representations of directories for hard-of-hearing persons by having the participants carry out a pictogram–directory name-pairing task. The question here is "Are hard-of-hearing persons superior to hearing persons in deriving intended meanings of pictograms?"

2 Experiments

Sixteen hard-of-hearing persons and sixteen hearing persons participated in both experiments, Experiment 1 and Experiment 2. All the participants were regular internet users and had adequate performance level for using Japanese language. Each participant was asked to perform the directory-based information search task, Experiment 1, and then the pictogram–directory name-pairing task, Experiment 2.

2.1 Experiment 1: Directory-based Information Search Task

Task. The participants were asked to select one or more directories that best matched a query such as "Want to buy a used computer." There were thirty-eight queries. Table 1 lists the examples of queries and the correct directories to select. The directories and the queries were printed on a paper. The time limit was set to 5min.

Table 1. Examples of queries and the correct directories

Query	*Directories to select*
Want to know tomorrow's weather	Weather
Want to know the schedule of exhibition	Events; Hobby
Want to serve as a volunteer	Welfare

Results. The number of queries that the participants could answer in five minutes measures the speed of task performance. On average, the hearing group could answer significantly more queries, 30.19 (SD=8.01), than the hard-of-hearing group could, 19.87 (SD=9.43), $t(29)=3.29$, $p<.01$. However, there was no significant difference in the accuracy of the selected directories.

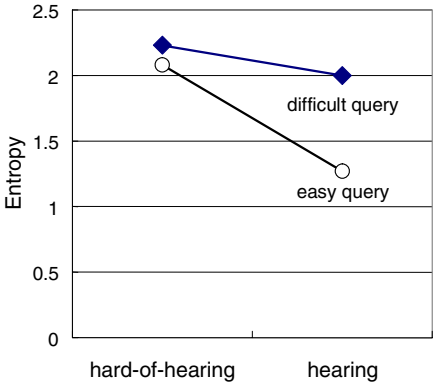

Fig. 1. The results of a directory-based information search task are shown as the degree of variability of selected directories for queries by the two participating groups, hard-of-hearing participants and hearing participants, calculated by averaging information theoretic entropies for difficult queries and easy queries.

The number of directories that the participants selected for a query measures the degree of perceived ambiguity of the query. The more directories the participants selected, the more ambiguous they perceived the query. On average, the hearing group selected significantly fewer directories, 1.53 (SD=0.36), than the hard-of-hearing group, 2.30 (SD=1.01), $t(29)=2.86$, $p<.01$.

The distribution of the frequencies of selected directories for a query that a group of participants selected measures the degree of consistency that the group understands the meaning of the query. A group selecting a single and unique directory for a query understands the query consistently. In contrast, a group selecting a variety of directories for a query perceives the meaning of the query less consistently and more ambiguously.

We calculated the information theoretic entropy for each query to measure the degree of ambiguity of the query for each group. Before conducting this analysis, we divided the queries into three conditions, difficult, easy, and moderate, by conducting a survey on the difficulty of the queries using a five-point subjective rating scale (5, most difficult; 1, easiest) with a separate set of hearing participants. We identified eleven difficult queries and eleven easy queries.

A two-way ANOVA, with group (hard-of-hearing vs. hearing) and query difficulty (difficult vs. easy), demonstrated that there was a significant main effect of group, $F(1,20)=25.19$, $p<.001$, and a significant main effect of query, $F(1,20)=7.37$, $p<.01$. The interaction between group and query difficulty, $F(1,20)=10.70$, $p<.001$, was significant. Post-hoc analyses further probed the interaction between group and query difficulty. These indicated that the entropy values for easy queries of the hard-of hearing-group were significantly greater than those of the hearing-group ($p<.01$).

In summary, the hard-of-hearing participants performed the directory-based information search task less efficiently than the hearing participants in terms of speed and the degree of consistency of the selected directories.

Fig. 2. Pictograms and directory names used in the study

2.2 Experiment 2: Pictogram–Directory Name-Pairing Task

Task. The participants were given a list of twenty-seven pictograms and a list of twenty-seven directory names separately and asked to establish one-to-one connection between the pictograms and the directory names. See Fig. 2 for details. The participants carried out the task at their pace.

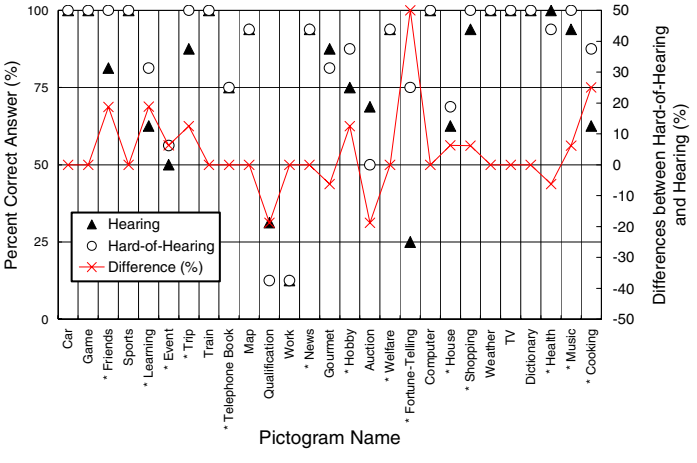

Fig. 3. Percent correct answers of hard-of-hearing and hearing and their differences

Results. Figure 3 presents the percent correct answers of the hard-of-hearing group and the hearing group. In order to further examine the differences in utilization of pictograms between the two groups, we excluded the directories that satisfy either of the following conditions: 1) those directories that the hard-of-hearing participants had difficulty understanding, *i.e.*, they failed to select those directories for the queries they should have selected in Experiment 1 (Gourmet, Auction, and Map), 2) poorly designed pictograms that had low correct answer rates of around 25% (Qualification

and Work), 3) those directories that both groups answered perfectly (Car, Game, Sports, Train, Computer, Weather, TV, and Dictionary). For the remaining fourteen directories, the hard-of-hearing group did a better job in pairing pictograms and directories than the hearing group, 86.61% vs. 75.45% ($p<.1$, t.s.). The largest difference was observed in Fortune-Telling, 75% vs. 25%.

3 Conclusion

The superiority of the hard-of-hearing participants' utilization of pictograms over the hearing participants could be ascribed to the role visual information plays in their daily life: Hard-of-hearing persons depend more heavily on visual information than hearing persons because they communicate by sign-language or non-verbal language, and they would thus develop superior ability in visual information processing. The result reported in this paper suggests that the use of visual information such as pictograms would be highly effective in improving usability of web pages for hard-of-hearing persons.

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