Comparison of Alternative Representational Formats for Hyperlinks: Pictogram, Labeled-pictogram, and Text

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Abstract: This paper reports an eye-tracking experiment conducted to compare alternative representations of directories typically shown on web pages. The experiment simulated a directory-based information search task to understand how it is performed when directories are represented in text, labeled pictograms, or unlabeled pictograms. Twenty-one hard-of-hearing and 21 hearing participants were asked to select one of 27 directories represented in one of the three alternative formats for each of 38 queries. The result demonstrated that only in the labeled-pictogram condition, the hearing group and the hard-of-hearing group performed equally well in terms of the number of fixations and the fixation times.

Introduction

Directory-based information search is a widely used method to access information buried in an information structure. This paper compares three alternative representations of hyper-links, *i.e.*, text, labeled pictograms, and unlabeled pictograms, in terms of their utility for supporting directory-based information search tasks. A pictogram is a symbol representing a concept, object, activity, place or event by illustration. Examples of pictogram are shown in Figure 1. Pictograms have been used at public spaces such as airports and train stations as a means for transmitting messages directly and instantly to passengers. Pictograms are intuitive visual representations of meanings and would have advantage over textual representations in those situations. The advantage of pictograms may hold in directory selection tasks performed in web sites where quick navigability would be preferred.

This paper specifically focuses on the level of multimedia literacy of users concerning text and pictograms. The level of multimedia literacy might be defined in various ways. However, this paper exclusively focuses on text and images. Hard-of-hearing persons use different cognitive processes than hearing persons when examining visual information (Wilson and Emmorey, 1998), and they rely more heavily on visual representation than textual representation when examining the contents on web pages (Namatame et al., 2006; Namatame and Kitajima, 2006, 2005; Namatame et al., 2007). This paper considers hard-of-hearing persons as the representative visitor group that uses visual information more heavily than textual information and hearing persons as the hard-of-hearing persons' counterparts along the multimedia literacy spectrum characterized by text and image usage.

This paper reports the result of an eye-tracking experiment that investigated the effect of alternative representations of directories on the users' performance of a directory-based information search task from the viewpoint of speed of directory selection, the variability of the selected directories for given queries, and the eye movement measures such as the number of eye fixations and the duration of eye fixations. We hypothesize that an ideal representation should be equally good for the hearing group who are good at processing textual information and the hard-of-hearing group who are good at processing graphical information, and better than the rest of the representations as well.

(a) Departures (b) Arrivals

Fig. 1. Examples of pictogram defined by JIS Z8210 (Japanese Industrial Standard).

EXPERIMENT

Twenty-one hard-of-hearing persons and 21 hearing persons participated in the experiment. All the participants were regular internet users and had an adequate performance level for using the Japanese language. The participants were asked to select a directory that best matched a query such as "Want to buy a used computer" from the 27 directories displayed on an LCD monitor in one of three forms: 1) labeled pictogram (Fig.1 (a)), 2) unlabeled pictogram (Fig.1 (b)), or 3) text (Fig.1 (c)). Participants' eye movements and mouse events were recorded with a Tobii 1750 eye tracker.

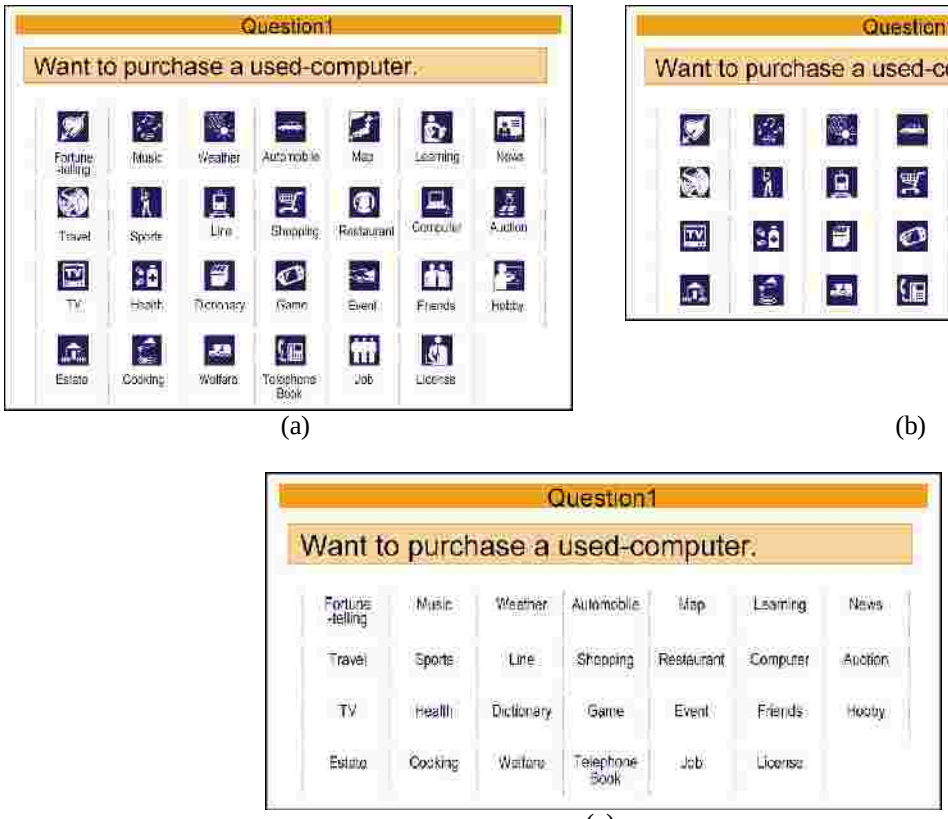


Fig. 2. Alternative representations of directories. (a) Labeled pictogram, (b) Unlabeled pictogram, and (c) Text.

RESULTS

Task Completion Time

The average time necessary for a participant to complete the task measures the speed of task performance. Fig. 3 (a) plots the average time necessary for completing a query in terms of characteristics of participants, hard-of-hearing vs. hearing. Task completion time for the unlabeled-pictogram condition was significantly greater than the other two conditions. There were no significant differences between the task completion times of the hearing group and the had-of-hearing group. This result suggests that the unlabeled-pictogram representation should not be a good one for directory search in terms of speed of task performance.

The Degree of Consistency of Selections

The distribution of the frequencies of selected directories for a query that a group of participants selected using one of the three representations measures the degree of consistency with which the group understands the meaning of the query with reference to the specific representations of the directories in the respective formats. A group selecting a single, unique directory for a query understands the query consistently using the representation format. In contrast, a group selecting a variety of directories for a query perceives the meaning of the query less consistently, *i.e.*, more ambiguously. We calculated the information theoretic entropy for measuring the degree of consistency. As the smaller the information theoretic entropy becomes, the more consistently the participant-group understands the query.

The procedure to derive entropy is as follows. Let $X_{r,g,k}(i)$ be the frequency of selecting the directory i ($1 \le i \le 27$) for the query k ($1 \le k \le 38$) in the representation form $r \in$ {unlabeled-pictogram, labeled-pictogram,

text} by the participant-group $g \in$ {hard-of-hearing group, hearing group}, then the probability of selecting directory i for query k by group g in representation format r is given by the following formula:

$$P_{r,g,k}(i) = \frac{X_{r,g,k}(i)}{\sum_{i=j}^{27} X_{r,g,k}(j)}$$

By using this probability, information theoretic entropy of query k for participant-group g in representation form r, $H_{r,g,k}$, is given as follows:

$$H_{r,g,k} = -\sum_{i=1}^{27} P_{r,g,k}(i) \log_2 P_{r,g,k}(i) \text{, where } 0 \le H_{r,g,k} \le 4.75 = \log_2 27$$

$H_{r,g,k}$ becomes smaller as the participant-group's responses become more consistent. It takes the minimum value, 0, when all the participants of the group g selected a common directory for the query k in representation form r. On the other hand, when the responses to the query k from the participant-group g distributed evenly to all the directories, it takes the maximum value, 4.75. Finally, we can obtain the average information theoretic entropy for queries in each representation form by averaging over the corresponding values of information theoretic entropy.

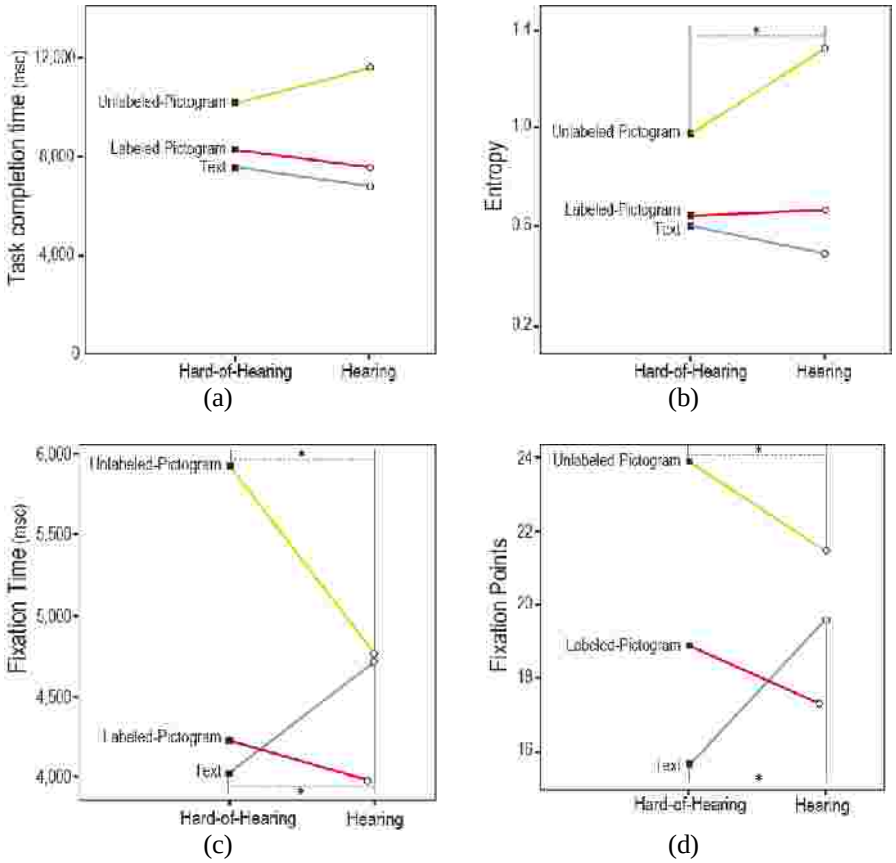


Figure 3. Results of the eye-tracking experiment.
(a) Task completion time, (b) Entropy, (c) Fixation Time, and (d) Fixation Points.

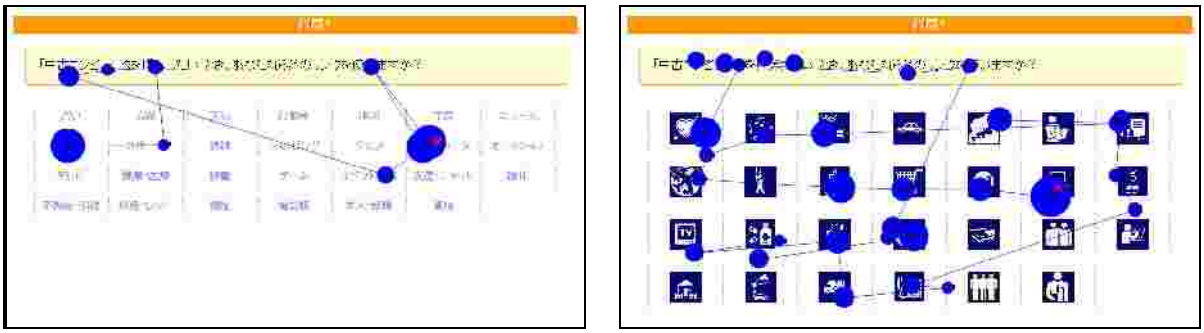
Fig. 3 (b) demonstrates that the average entropy for the unlabeled-pictogram condition was significantly greater than those for the other conditions. In addition, the average entropy value of the unlabeled pictogram condition for the hearing group was significantly greater than that for the hard-of-hearing group. This result suggests that the directories that the participants selected for the queries were more diverse for the unlabeled-pictogram condition than the other conditions and the disadvantage of the unlabeled-pictogram representation.

Eye Movement Measures

So far, disadvantage of unlabeled-pictogram has been suggested but the goodness of the other two conditions, labeled-pictogram and text, has not been investigated by the task completion time and the entropy measures. However, as is shown below, eye movement measures were able to disentangle this issue. Fig. 4 shows typical gaze plots of the hard-of-hearing participants for the text representation (Fig. 4 (a)) and for the unlabeled-pictogram (Fig. 4 (b)) who searched for the directory for the task "want to purchase a used-computer." The directory located at the second column from the right on the second row is the right one "computer."

Fixation Time and Fixation Points

Fig. 3 (c) and (d) demonstrate that in the unlabeled-pictogram condition and the text condition the fixation times and the number of fixation points from the hard-of-hearing group were significantly different from those from the hearing group. On the other hand, in the labeled-pictogram condition, there was no significant difference between the groups.



(a) (b)

Figure 4. Gaze plots from the hard-of-hearing participants: (a) Text and (b) Unlabeled-pictogram

CONCLUSION

This study showed that labeled-pictogram representation has advantage over text representation. It required least fixation times and least number of fixations. This implies that the participants gathered information necessary to select a directory most efficiently when the directories were represented by text and pictograms. We conjecture that this is because pictogram is useful when quickly recognizing what is represented with limited preciseness and text can add information to make the meaning of the pictogram clearer.

The spectrum of media literacy is wide and affects the degree of utility of hyperlinks used in web sites. We will continue on this direction of research to seek optimal multimedia representations for individual visitor groups with specific multimedia literacy.

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