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Dynamic text presentation in print interpreting – An eye movement study of reading behaviour ☆

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ABSTRACT

Print interpreting supports people with a hearing disability by giving them access to spoken language. In print interpreting, the interpreter types the spoken text in real time for the hard-of-hearing client to read. This results in dynamic text presentation. An eye movement study was conducted to compare two types of dynamic text presentation formats in print interpreting: letter-by-letter and word-by-word. Gaze path analysis with 20 hearing participants showed different types of reading behaviour during reading of two pieces of text in these two presentation formats. Our analysis revealed that the text presentation format has a significant effect on reading behaviour. Rereading and regressions occurred significantly more often with the word-by-word format than with the letter-by-letter format. We also found a significant difference between the number of regressions starting at the words that end a sentence and that of regressions starting at all other words. The frequency of rereading was significantly higher for incorrectly typed or abbreviated words than for the other words. Analysis of the post-test questionnaire found almost equal acceptance of the word-by-word and letter-by-letter formats by the participants. A follow-up study with 18 hard-of-hearing participants showed a similar trend in results. The findings of this study highlight the importance of developing print interpreting tools that allow the interpreter and the client to choose the options that best facilitate the communication. They also bring up the need to develop new eye movement metrics for analysing the reading of dynamic text, and provide first results on a new dynamic presentation context.

1. Introduction

Print interpreting is a method for making spoken language available for people with a hearing disability. In print interpreting, the spoken utterances and other significant audible information are translated into print in real time simultaneously with the speech. The process is also called typing/writing interpreting, captioning, and real-time writing (Tiittula, 2009). The deaf can use other communication methods, such as sign language or lip-reading, but these are rarely used among the hard-of-hearing and those with late deafness (Tiittula, 2009): they have acquired the language from hearing society and usually can speak. Therefore, sign language is not a suitable option for them; rather, they need interpretation that is as close as possible to the original speech.

Print interpreting is widely used in seminars and meetings for the deaf and hard-of-hearing group of people. In print interpreting, spoken language is typed on a computer and the text is displayed either on another computer screen or on a projected bigger screen for a larger audience. The most common presentation format for the text on the display screen is the letter-by-letter format, where letters appear at the rate the text is written. In this dynamic text presentation system, the lines scroll up from the bottom. As soon as the screen is full, the top lines disappear and the new text appears from the bottom of the screen. Similarly, when a word is typed towards the right edge of the screen, if the screen width is exceeded before the word is complete, the characters already typed disappear from the current line and reappear on the next line. Thus the reader sees the text dynamically in real time.

The letter-by-letter rendering of the text is the de facto standard used by professional print interpreters. However, reading text that appears letter-by-letter can be very different from the usual reading of static text where full sentences and paragraphs are in view. The print interpretation process demands that the text appears as soon as possible after the spoken utterance, so that those reading it can understand the mimicry of the speaker and the reactions of the hearing audience. Nevertheless, buffering the text slightly so that it is rendered word-by-word, not letter-by-letter, would probably not have a significant effect on the real time requirement, and reading text presented in such manner would be somewhat closer to the normal reading experience. In addition, although errors in the final interpretation remain visible independently of the rendering method

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and may create distractions in the reading, the word-by-word presentation format has the advantage that it hides those typing errors that the print interpreter corrects on the fly before completing a word.

This motivated us to create a tool, Sprintanium (Špakov, 2011), for studying the process of producing the interpretation and reading the resulting text. Of the many novel features included in Sprintanium, of particular relevance to this study is its ability to optionally produce the text letter-by-letter (the most common format) or one word at a time. Furthermore, it takes as input the real time keypress sequence of the print interpreter and can later render the text in either format at the original rate, allowing a comparative study involving several participants and different experimental conditions.

How does one study the effect of the text and its presentation format on the reading process? Reading requires the visual processing of words, and therefore eye movements provide a window to the cognitive process of perception and comprehension that take place during reading. Eye movements reflect difficulties in understanding the document being read and can also be used to automatically recognise the quality of the text by integrating gaze data from several readers (Biedert et al., 2012).

Reading on-screen electronic text is one of the most widespread interactions between humans and computers. A large number of previous studies have carefully analysed gaze behaviour in reading (Rayner, 1998). In reading, eyes make brief jumps along the line of the text. Rapid movement of eyes are called saccades. Stops in between the saccades are called fixations. Standard metrics in gaze data analysis are average number of fixations and average duration of fixations (Jacob and Karn, 2003). However, eyes do not move forward to read all the time. Often they also move backward for rereading. Saccades that move backward in the text that has previously been encountered by the reader are called regressions. Previous research has documented that regressions are an indicator of comprehension difficulties when reading static text (Rayner, 1998). In the context of print interpreting, where text is rendered dynamically and it appears at a rate that depends on the typing speed of the interpreter, this need not be the case anymore: the reader has time to review past text just to confirm the existing mental model, instead of resolving comprehension difficulties or ambiguities. Thus, the pauses introduced by word-by-word rendering may provide an additional advantage.

Several studies have been conducted focusing on using dynamic text on small display screens of devices like wrist watches, mobile phones, pagers, and desktop phones (Chien and Chen, 2007; Laarni, 2002; Brewster and Murray, 2000). Many studies were conducted mostly to evaluate users' comprehension rate with different text presentation formats; we give more details in Section 2. However, no formal study has compared different presentation formats in print interpreting, where the text appears dynamically, at the rate of spoken speech, on a computer screen or projected on the wall.

Hence, we carried out an eye movement study where we compared eye movements in reading print interpreted text using two dynamic text presentation formats, word-by-word and letter-by-letter. Our study consists of two experiments. In the first experiment, presented in Section 3, we analysed eye movement data from 20 normal-hearing participants in reading two pieces of print interpreted dynamic text. The texts were presented on a computer screen with two presentation formats: word-by-word and letter-by-letter. The goal of that experiment was to investigate the effect of text presentation format on eye movements and reading behaviour. Specifically, the interest was in finding out whether there are any differences in eye movements during reading that are due to differences in text presentation format. In addition to standard metrics, we examined rereading of the preceding words or sentences, and regressive eye movements during the pauses, during editing, or when an incorrect word is typed. For reasons discussed in Section 4, regressions proved to be a more useful metric than the traditional fixation and saccade related metrics. After the first experiment we carried out a follow-up experiment where 18 hard-of-hearing participants took part. In addition to the stimuli used in the earlier experiment, here we showed the video of the speakers without any sound. The follow-up experiment is described in Section 5.

What did we expect to find in the study? Our main motivation was to compare the two presentation formats, word-by-word and letter-by-letter, in terms of regressions. The characteristic feature of dynamic text is that the pacing is not controlled by the reader. In print interpreting, in particular, there are many reasons why text does not appear at a regular pace, and it can be assumed that the pauses introduced between words that appear on the screen can have an effect on reading behaviour. In particular, with the word-by-word presentation format the pauses are longer, so it can be expected that this shows up in the regression data: it is not natural for the eyes to remain focused at the same spot if nothing happens there. Instead, the time waiting for the next word to appear could be used to review text that has been read already. This yields our two main hypotheses:

Hypothesis 1. The word-by-word format causes more rereading than the letter-by-letter format.

Hypothesis 2. The length of the pause before a word appears affects the number of regressions starting from the preceding word.

In addition to reading behaviour that is specific to print interpreting, we expected some known facts of reading to carry over to the print interpreting context. First, it is well known that people have different styles of reading static text (e.g., Wotschack, 2009), and there was no reason to assume otherwise for dynamic text. Similarly, it is known that end of sentence is a frequent trigger of rereading with static text (Hyönä, 1995), and we expected this to be the case with dynamic text as well. Moreover, because regressions are used to improve comprehension, we expected that incorrectly typed or abbreviated words would be reread more often than the other words. These considerations gave us three more hypotheses:

Hypothesis 3. The number of regressions varies considerably between the readers when reading dynamic text.

Hypothesis 4. More regressions start from the last words of sentences than from the other words.

Hypothesis 5. Regressions land more often on incorrectly typed or abbreviated words than on the other words.

In general, all hypotheses were confirmed by our analysis. We will discuss the implications of the findings in Section 6. Results from the post-test questionnaire suggested almost equal preference for both presentation formats. The follow-up experiment showed a similar trend for the hard-of-hearing participants. Taken together, the results indicate that the word-by-word presentation format is a viable alternative to be used by print interpreters and should be supported by the tools available for them. For eye movement research the study pinpoints problems with the usual analysis methods (fixation duration and number of fixations), suggests an alternative (number of regressions), and provides the first results concerning reading the specific type of dynamic text that is encountered in print interpreting.