Comparing Paper Books and Electronic Media in Reading to Answer Questions

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Abstract

This report describes experiments comparing reading performance such as reading speed and accuracy of tasks in reading to answer questions using different media: paper books, e-readers, and computer displays. As examples of reading of this kind, we considered two scenarios: seeking answers from text manuals and seeking photographs from collections. In two experiments conducted according to the two situations, participants performed tasks most quickly using a paper book or a PC. They had trouble flipping through pages with e-readers. Although the paper book was inferior to the PC in terms of turning over pages continuously with rapidity, participants performed flexible navigation with the paper book such as turning over pages from the end or middle of the book.

Introduction

The rapidly spreading use of e-readers is receiving much attention. Many experiments have been conducted to compare performances of reading when reading from paper books and from e-readers [1–5], generally assessing the reading of single documents, typically novels. Moreover, they assess sequential reading, of which the processes include less scanning back and forth between pages of a document or among documents.

Accepting the possibility of using e-readers in reading in the office, one must evaluate them from different perspectives from the previous studies, which particularly examine reading for leisure [6]. In work situations, only rarely do workers read documents sequentially from beginning to end while turning pages one by one. Readers often refer to the table of contents or references frequently, skim documents, and move back and forth between pages repeatedly while reading [7,8]. In such reading, observations show the importance of operability of handling documents, e.g. moving documents or laying out documents spatially [9,10]. Our previous experiments showed quantitatively that readers are able to read from paper more efficiently than from electronic media as for cross-reference reading among multiple documents [11] and reading with changing places back and forth between pages [12,13]. To discuss the possibility of e-readers in reading in the office, we must analyze how current e-readers affect the process and performance of reading with changing reading places back and forth among multiple pages or multiple documents.

Academic reading is similar to reading in the office in that reading of neither type is performed sequentially. Some studies have discussed the academic potential of e-readers based on their actual use [14,15]. They organized problems of e-readers in the use of academic situations. However, we cannot know if or how these problems affect reading performance because these results are based only on qualitative discussion.

Adler et al. [7] observed various work-related reading tasks in work situations and assigned each instance to one of ten categories. Among them, the most frequently observed task was cross-reference reading using multiple documents. Current generation e-readers do not support cross-reference reading, and do not enable simultaneous viewing of multiple documents. They are too cumbersome to overlap or otherwise move frequently. Therefore, we evaluated these devices for the second-most common task cited in a study by Adler et al.: Reading to Answer Questions.

For reading to answer questions, we consider two examples: seeking for answers from text manuals and seeking photographs from collections. According to these two search scenarios, we conducted two experiments and compared paper books with other electronic devices.

Experiment 1: Seeking answers from text manuals

Method

Design and participants The experimental design was a one-way within-participant design. The factor was the task condition with five levels: reading from paper books (**Paper**), reading from iPad (**iPad**), reading from Kindle (**Kindle**), reading PDF documents from a computer display (**PC**), reading PDF documents with links from table of contents to each page from a computer display (**PC-Link**).

Participants were 24 people (12 men, 12 women). Their ages were 23–37 years (avg. 30.6). Each had three or more years' experience using PCs. The vision of each, after correction, was better than 0.7. They performed four trials in each condition. The task condition order was counterbalanced to cancel effects of the trial order overall.

Materials A text manual dealing with business manners such as instructions for telephone conversations or orders of precedence was used for the experiment. This included a table of contents and an index. The table of contents comprised 9 chapters and 63 sections. The total length of the documents was 84 pages.

The paper book was bound by the experimenters. The document was printed on one side of B5 paper in black and white and stapled on the left side of the paper document.

Apparatus and environments We used two e-readers: iPad (the first version) WiFi model (Apple Computer Inc.) and Kindle DX (Amazon.com Inc.). In the PC and the PC-Link conditions, we used a notebook computer (Let's note CF-T7CW; Panasonic) with an external 23-inch TFT monitor (FlexScan EV2303W-T; Nanao Corp.). The OS was Windows XP (Microsoft Corp.). The three-button mouse (Dell Inc.) had a wheel. All electronic documents were PDF format, displayed using Adobe Reader 9 (Adobe Systems Inc.).

We adjusted the character size of electronic documents to be the same size as that of characters in the paper book. We prohibited changing of the size of displayed characters during the tasks. In all conditions, participants were able to view a single whole page in each medium. In the PC and the PC-Link conditions, we used the "single page" mode of Adobe Reader that enabled to view a single page at a time.

Procedure Before the experiment, participants engaged in 10 min training to familiarize themselves with the operability of each medium. They also adjusted the brightness and positions of the devices according to their preferences. Tasks were to search answers from the text manual to fill in the blanks as shown below.

- In a sleeper train, ( ) is a seat of honor.
- The use of a mobile phone while driving a car is prohibited by ( ).

We required participants to identify where the answer was written even if they were able to answer without referring to the manual. We also required them to report the answer as soon as possible after they found the answer so that they did not search for answers after the declaration of the task.

After all tasks were completed, we administered a questionnaire survey and an interview.

Results and discussion

Figure 1 presents the task completion time in each condition. The error bar shows plus or minus one standard error from the average. A one-way repeated measures analysis of variance was conducted to assess the task completion time. Results show that the main effect of the task condition was significant [$F(4, 76)=15.07$, $p<.001$]. According to multiple comparison using the LSD method, no significant difference was found between the Paper condition and the PC-Link condition, and between the PC condition and the iPad condition [$p>.1$]. However, a significant difference was found between the PC-Link condition and the PC condition, and between the iPad condition and the Kindle condition [$p<.05$]. Furthermore, no significant difference was found among all five conditions related to the percentage of correct answers.

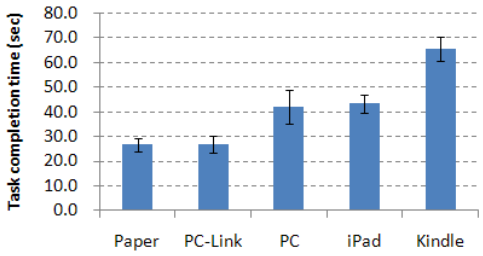

***Figure 1**. Task completion time in each task condition*

In the PC-Link condition, users can quickly access a desired page by clicking a section item in the table of contents because the manual has a rich table of contents. Therefore, we expected that participants would be able to complete the search task fastest in the PC-Link condition. However, the task completion time in the PC-Link condition was similar to that of the Paper condition. In the PC-Link condition, participants found answers quickly if they found an answer on a page that they initially accessed. However, if they were unable to find an answer on the initial page, they needed to return to the table of contents again, which took much time. In the Paper condition, they returned to the table of contents in no time in such a situation because they inserted their fingers in the position of table of contents. We can say that paper books allow flexible navigation depending on the circumstances.

Participants spent more time to find answers in the iPad condition than in the Paper and the PC-Link condition. According to the observation of performing tasks, participants spent much time for navigation. Using iPad, they were able to turn pages easily one by one, but they reported difficulty in flipping through multiple pages successively. They were able to jump to a specified page using a slider, but they were unable to perceive text information during turning multiple pages. In other words, they were unable to obtain peripheral information around target pages. Consequently, they felt difficulty in returning to the table of contents or moving adjacent pages to seek answers.

Kindle takes much time (about one second [3]) to redraw a screen when turning pages and the usability of jumping pages is not user friendly. Although the recent version of Kindle shows improvement of these shortcomings, this was the main reason why Kindle demanded much time for seeking answers.

In the experiment, we did not prohibit the use of search functions provided by the electronic media. However, it was bothersome to select appropriate keywords and to input the keywords. Moreover, when using inappropriate keywords, the procedure was repeated many times. Therefore, we did not recommend using these functions. Although several participants attempted to use search functions, they gave up after several trials. When using longer documents (e.g., more than 500 pages), search functions seem to work effectively in reading to answer questions. However, when using text manuals with fewer than 100 pages and with a rich table of contents as we used in this experiment, users can find answers more quickly by referring to the table of contents than by using search functions.

Experiment 2: Seeking photographs from collections

Method

Design and participants The experimental design was a one-way within-participant design. The factor was the task condition with three levels: reading from paper books (**Paper**), reading from iPad (**iPad**), and reading PDF documents from a computer display (**PC**). Kindle was eliminated because it cannot present color images.

Participants were 24 people (12 men, 12 women). Their ages were 26–39 years (avg. 30.5). Each had three or more years' experience using PCs. The vision of each, after correction, was better than 0.7. The task condition order was counterbalanced to cancel effects of the trial order overall.

Materials The documents were collections of photographs. The photographs were all "landscape" pictures of 640×480 resolution. Their physical size in paper books was 9.7×7.2 cm. Each collection included 48 photographs.

The paper books were bound by the experimenters. The document was printed on one side of B5 paper in full color and stapled on the left side of the paper document.

Apparatus and environments All devices (an iPad, a PC, a display, and a mouse) and all software environments (OS and a PDF reader) are the same as those used in Experiment 1.

Similarly to Experiment 1, we adjusted the physical size of photographs to be the same size as those of the paper books. In the electronic media, we prohibited changing the size of displayed documents during the tasks. In all conditions, participants were able to view a single whole page. In the PC and the PC-Link conditions, we used the "single page" mode of Adobe Reader that enabled to view a single page at a time.

Procedure Before the experiment, participants engaged in 10 min training to get accustomed to the operability of each medium. They also adjusted the brightness or positions of the devices according to their preferences.

The task was to seek specified photographs from collections and to report a page number as quickly and accurately as possible. In each collection, participants performed 18 trials of seeking photographs. We changed collections for every task condition (medium).

We arranged a set of target photographs and 18 search trials as follows. We divided the 48 photographs of each collection into three categories according to the position of the page: head (1–16), mid (17–32), and tail (33–48). In the first six trials (first half trials), we selected two photographs without duplication from each category. In the second six trials (second half trials), we selected two other photographs without duplication from each category. In the final six trials, we selected three photographs from that of the first six trials and three from the second six trials, i.e., participants sought the same photographs as they had already sought in the first six and second six trials.

After the experiment, we conducted a recognition test of photographs, a questionnaire survey, and an interview. The recognition test required participants to respond according to whether the photographs was used in collections, confidence level for their memory (5 levels), rough position of the photograph in a collection (3 levels), and media that they viewed the photographs (3 levels) for 75 photographs. We selected 45 photographs from the three collections and added 30 photographs not used in any collection as distracters. For 15 photographs selected from each collection, 10 of them were those they searched in the experiment and the remaining 5 were those they did not search.

Results and discussion

Figure 2 presents a comparison of the task completion time in the first half and second half trials in each condition. A two-way repeated measures analysis of variance was conducted to assess the task completion time according to the task condition (Paper, PC, and iPad) and the order of searching (first half and second half). Results show that both main effects of the task condition [$F(2, 46)=38.86$, $p<.001$] and the order of searching [$F(1, 23)=21.03$, $p<.001$] were significant. Interaction of the two factors was not significant [$p>.1$]. According to multiple comparison using the LSD method, the task completion time of the PC condition was significantly shorter than that of the Paper condition [$p<.01$] and the task completion time of the Paper condition was significantly shorter than that of the iPad condition [$p<.001$].

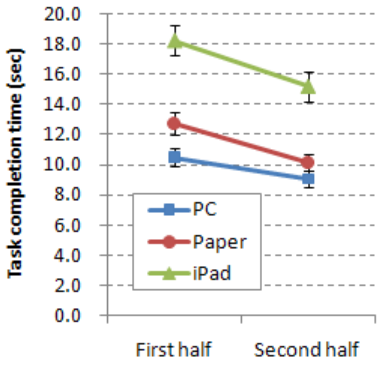

***Figure 2**. Task completion time in the first and second half of searching photographs*

Figure 3 presents a comparison of the task completion time in the re-searching of photographs (final six trials) in each condition. A one-way repeated measures analysis of variance was conducted to assess the task completion time according to the task condition (Paper, PC, and iPad). Results show that the main effect of the task condition was significant [$F(2, 36)=51.63$, $p<.001$]. According to multiple comparison using the LSD method, the task completion time of the Paper condition and the PC condition was significantly shorter than that of the iPad condition [$p<.001$]. Moreover, there was a trend by which the task completion time of the Paper condition was shorter than that of the PC condition [$p<.1$].

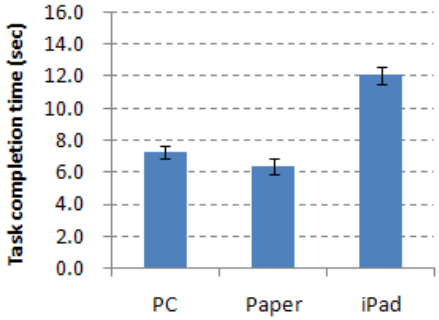

***Figure 3**. Task completion time in retry of searching photos*

Regarding the score of the recognition test, no significant difference was found among media according to the photographs, the position, and media used for viewing (task conditions) [$p>.1$].

We expected that participants would find photographs fastest when using the paper book. However, they found photographs faster in the PC condition than in the Paper condition. When participants flipped through pages using the paper book, multiple pages were sometimes unintentionally turned over simultaneously because of the failure of controlling the thumb pressure. In such a case, the participant returned to the previous page and started turning pages again. During the task of searching for the same photographs, readers must check all photographs exhaustively. Such kinds of tasks need quick and accurate navigation. It was difficult to turn pages one by one quickly without skipping pages with the paper books.

Participants were able to turn pages accurately when using the PC and the iPad. Using the PC, they switched pages successively at short regular time intervals without skipping multiple pages by pressing buttons of a scroll bar continuously. Consequently, the scrolling feature is the best fit to the searching of photographs in this instance. Similarly, participants were able to turn pages one by one accurately using the swiping feature with the iPad. However, turning pages with swiping interaction of the iPad took more time than that of the PC and the paper book. Mainly for this reason, searching among the photographs was slowest with the iPad.

Although the use of the paper books was inferior to the use of the PC in the search of photographs that participants encountered for the first time, a trend was observed by which participants were able to find target photographs in the second search when using the paper books than when using the PC. That is because they frequently opened the position of a target photograph from the beginning when they remembered where the photograph was located in the collection. However, when using the PC or the iPad, they often seek a target photograph by turning pages one by one from the first page (the percentages of times that participants opened a page other than the first page from the beginning were, respectively 28.6%, 22.5%, and 12.5% in the Paper, the iPad, and the PC condition).

Moreover, even if participants open a page other than the first page from the beginning, the mode of accessing pages differed among media. When using the paper books, participants often accessed a target page or its neighborhood from the beginning. However, when using the PC or the iPad, they often jumped to a far front page of the target page and turned pages one by one from that position. Regarding this phenomenon, one participant reported that she adopted a sound strategy to avoid jumping over the target photograph. In other words, although participants navigated pages boldly with the paper books, they navigated pages carefully with the PC and the iPad. People are accustomed to turning pages with paper books from their childhood. They perform the task almost automatically without demanding any cognitive load. We think that this fact enables bold flexible navigation using paper books.

Conclusion

Results show that paper books are superior to e-books in reading to answer questions. Navigation with paper books was flexible both in searching answers from a text manual and in searching for photographs from a collection. This flexibility enables quick searching with paper books. We are now designing an e-book application that supports flexible navigation.

Trademarks

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