Effects of Tablet Devices on Reading to Support Discussion: Comparison of Conversation Processes involving Paper, a Tablet, a Laptop PC

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Abstract

Discussion processes involving the use of paper, tablet devices, and laptop PCs, were experimentally compared from the viewpoint of verbal interaction. In task discussions, 24 participants (12 groups of two people) were asked to plan a one-day sightseeing trip by using guidebooks presented on paper, an iPad2, or a laptop PC. According to the results of the tests, the frequency of essential conversations to attain the goal of the task was the highest when the participants used paper and not significantly different in the cases that iPads and PCs were used. Moreover, the frequency of asking redundant questions such as, "Which one are you talking about?" due to not understanding a partner's intent was higher when iPads and PCs were used than when paper was used. These results suggest that tablet devices should be used with caution in scenarios in which a topic needs to be thoroughly discussed in a short amount of time.

Introduction

Various experiments have quantitatively compared reading performance in the case of performing tasks on paper and tablet devices (hereinafter, tablets) such as reading novels [1,2], finding answers in manuals [3], and finding errors in a document during editing [4]. In general, paper was found to be the superior medium in terms of reading performance.

These researches, however, focused on reading individually, and little quantitative research on the effects that documents on either paper or tablet devices may have on discussions between several people has been performed. In actual applications of business situations, simultaneously reading several copies of the same document by several people in situations such as meetings and conferences occurs quite frequently. According to Adler's analysis, approximately 22% of reading in a workplace is performed during a meeting or discussion [5].

In the meantime, it is expected that tablets will be used in the workplace for meetings and places of discussion. For example, it has been reported that unlike PCs, tablets can be laid flat on a table so that a document can be browsed by several people during a meeting, thereby making it easier to catch expressions of the other participants of the meeting [6]. However, the effect of tablets in such situations has only been investigated qualitatively.

In light of the above-described research, this study quantitatively compares the effects that documents on three media (i.e., paper, tablet, and PC) have on the processes of discussions. Documents are used in discussions in many types of scenes [5,7]. This study focuses on a scenario that often occurs in a working environment; namely, a small number of people informally get together in an office open space for a quick meeting.

Previous studies suggest that it can be difficult to share the work progress in a meeting to which each participant brings their own documents [8,9]. In this paper, work progress is defined as where one is currently focusing on or reading, or what one is currently doing or about to do. In this situation, each person can read their document at their own pace; however, it forces a division of work amongst the participants, which can hinder communication [8]. Pearson observed that in this type of scenario, namely, each participant brings their own document, a significant amount of time is used to explain where a participant wanted the other participants to look at [9]. Both studies suggest that a lot of time is wasted in conversation not related to the topic itself when the work progress is not shared efficiently. It is therefore necessary to analyze what kind of roles different media play in these kinds of situations. Accordingly, in the present study, the conversations that were directly related to the topic and the redundant questions that occurred in order to share the status of their work progress were compared.

Hypothesis

This experiment was based on the following two hypotheses.

Hypothesis 1: The frequency of essential conversations will decrease in the order of paper, tablet, and PC.

As mentioned later, it is hypothesized that the frequency of asking redundant questions will decrease in the order of paper, tablet, and PC. It is therefore also hypothesized that the amount of time used to explain the background of a statement would increase in the order of paper, tablet, and PC. As a result, the amount of time used to exchange relevant ideas will decrease in that order.

Hypothesis 2: The frequency of asking redundant questions will increase in the order of paper, tablet, and PC.

The difficulty of operating a PC force people to concentrate on the screen of the device, making it harder to look at the other party involved in the conversation [7,10]. It has been shown that the cognitive load during reading decreases in the order of paper, tablet, and PC [2]. It is therefore hypothesized that the ability to pay attention to the other party will decrease in the order of paper, tablet, and PC.

Method

Design

The experimental design was a "within-participants design" in which the factors were different types of media (paper, iPad, and PC). Each group member (two people per group) used the same

kind of medium during a given task and did the tasks using all three media. The orders of the media and documents in the series of the subjects' trials were counterbalanced to cancel the overall effects of the trial order.

Subjects

This study had 24 participants (14 male and 10 female), all native Japanese speakers between the ages of 20-39 (avg.: 28.0). Each participant had more than three years of experience using a PC, more than two months of experience using touch-panel devices, and corrective eyesight of more than 14/20. Each group consisted of two people who knew each other before this study. The last condition was added purposefully in order to avoid any effects that may influence the effectiveness of a discussion as participants gradually get to know each other.

Materials

Documents used for this study were based on a published guidebook about three Italian cities: Venice, Milan, and Florence. Each document has 17-23 pages that include maps, sightseeing spots, and restaurant information. The maps were marked with the locations of sightseeing spots and restaurants, and the page number at which the details could be found. The details include entrance fees, meal-price ranges, business hours, and a description of the place. Furthermore, the sightseeing spots were rated with stars ("3" stars means the highest recommendation; "0" means the lowest).

Task

The task was to plan a trip using the guidebook and was designed as a typical ill-posed problem with no correct answer, which is common in a business setting. The start and end point, budget, and time span of the trip were given as preconditions, and each group had to plan a day-trip to which both group members agreed. The details were as follows.

First, the following factors needed to be decided in planning the trip.

- Which sightseeing spots to visit and length of stay there
- Which restaurant to go to for lunch, budget for the meal, and length of stay there
- Which route to take to the sightseeing spots and restaurant
-
- The following restrictions were applied on making the plan.
- Budget limit: 100€ per person
- Return to the start point at a certain time (i.e., leave a designated location at 10am, and return to the same location between 4:45pm and 5:15pm)
- Sightseeing spots or restaurants cannot be visited outside of business hours.
- Travel by foot only (due to difficulty in calculating transportation fees)

To abide by these restrictions, the participants need to refer to the guidebook for information on business hours, fees, etc. and the scale of the map (to make an estimate of transportation time).
At the beginning of the experiment, this information was given to the participants, who were instructed to, "Plan a day trip on the basis on this guidebook. If your interests differ, do not plan the trip on the basis of only one person's interests; instead, make the trip satisfying for both of you." These rules and directions were printed out and given to the participants so they could refer to them during the task. The time limit for each task was 25 minutes, and each task ended either when the time limit came or when the task was completed.

Experimental conditions

The following three types of display media were used:

- Paper: Documents were printed in color on both sides of A5 paper, which was cut in half and stapled together at the two corners of the left side.
- iPad: An Apple iPad2 Wi-Fi 16G was used for the tablet.
- PC: Panasonic Let's Note CF-J10 was used for the PC.

The material for this task was converted to PDF format so that two pages were displayed side by side in "landscape" view. The PDF file was printed out to provide the paper material. For the iPad, Adobe Reader was used to view the PDF document so that the search and annotation functions could be used. For the PC, Windows 7 was used for the OS, and Adobe Acrobat X Pro was used for the same reason as for the iPad. Participants were allowed to zoom in and zoom out of the document when using either the iPad or PC, but the displays were adjusted initially so that the text size was about the same as the paper document.

Procedure

Participants were allowed to read in any posture and to position the media in any way under all media conditions. Moreover, to create a situation similar to real life, no limitations were added to what could be done to the document. For example, notes could be added under all conditions. Furthermore, in the paper condition, documents could be bent, folded, and disassembled, and zooming-in and zooming-out of the documents were allowed in the cases of the iPad and PC. In the experiment, two chairs were initially located on adjacent sides of a corner of a table, as often seen in meetings held in rest areas. Each medium was placed so that it would be in front of the participants when they sat in the chairs. However, participants were allowed to move the medium wherever they wanted after the experiment started.

Pieces of paper and writing utensils for taking notes were placed on the table. Participants were asked to write out their day-trip plan on a piece of paper. One person was pre-selected to explain the trip they had planned after each task. Before the participants started each task with a certain medium, they were given a short practice session to get used to the task and the software used in the experiment.

Results and discussion

Task performance

Before the above-mentioned hypotheses were tested, the "accuracy" and "attainment" of the day-trip plans made by the participants were compared. As for accuracy, the plans were checked for errors such as exceeding the budget or entering a store off business hours. As a result, the number of plans with errors made in the usage cases of paper, iPad, and PC were, respectively, two, three, and three out of 12 plans. As for attainment, the number of groups that could not finish their plans within the time limit were two, four, and four out of 12 plans for paper, iPad, and PC, respectively.

Regarding time to complete a task, more groups using iPads or

PCs than those using paper finished right before the given time (three, six, and six groups for paper, iPad, and PC, respectively). Although this difference is not statistically significant, it suggests that discussions between people using paper are more efficient than those between people using iPads or PCs. To test the hypotheses stated previously, the conversation data were analyzed next.

Essential conversations

To measure the frequency of essential conversations, the conversations of the participants discussing where and how to get to places were analyzed. Such analyzed conversations include ones about entrance fees, suggestions of where to stop by, disagreements about such suggestions, and confirming a partner's preferences. Conversations that were not directly relevant to the task were omitted. For example, opinions concerning the usability of a media or temporary straying from the topic with comments like such as "There's a store with the same name in Japan." were omitted. Redundant conversations that occurred because of not knowing the context of which the partner was talking about were also omitted. Examples include questions such as "Where is that?" and "What are you talking about?" and the answers to these questions. Each conversation was separated into units each time a turn was taken or whenever a pause of more than one second occurred during talking. However, if a participant continued to talk about the same topic after the pause, his or her turn was considered as one segment. This situation was judged by the tester. The counts of essential conversations per minute are plotted as bar graphs in Figure 1.

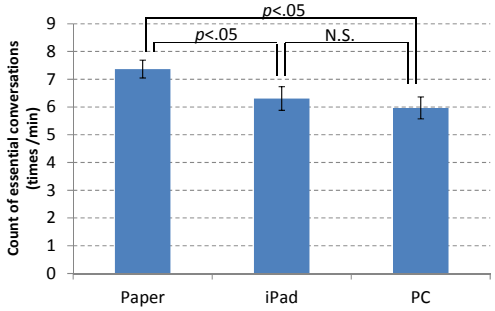

***Figure 1**. Counts of essential conversations per minute*

A one-way within-participants analysis of variance on the counts of essential conversations per minute revealed significant differences among the media used [$F(2, 22)=16.0$, $p<.05$]. According to multiple comparisons by the LSD method, the count of essential conversations was significantly greater in the case of the paper medium than in the other cases [$p<.05$], and there were no significant differences between the iPad and PC [$p>.1$].

Two conclusions can be drawn from the above results. First, there was no significant difference between the frequency of essential conversations in the iPad and PC cases. This result does not support the second hypothesis, namely, the case of using an iPad generates more frequent essential conversations. This is because there was little difference between iPad and PC in terms of the frequency of asking redundant questions. Second, the frequency of essential conversations was high in the paper-usage case. This conclusion supports the first hypothesis (that is, frequency of essential conversations is higher in the paper-usage case than the tablet- and PC-usage cases).

The reason for this result was because the participants did not need to ask questions as frequently when using paper as when they used the other media, so they did not interrupt the flow of conversation. Moreover, we think that the efficiency of collecting information from the trial document was easier on paper. As mentioned later in detail, it was observed that it was easier to go back and forth between the pages in the case of paper than the cases of tablets and PCs. It is thus suggested that paper has a high frequency of essential conversations because the operability of going back and forth between pages was preventing essential conversations when using tablets and PCs, but not paper.

Redundant questions

The count of asking redundant questions per minute, such as "Where?" or "Which one are you talking about?" to a partner is plotted in Figure 2. The error bars represent the standard error of the mean (which is the same for all graphs).

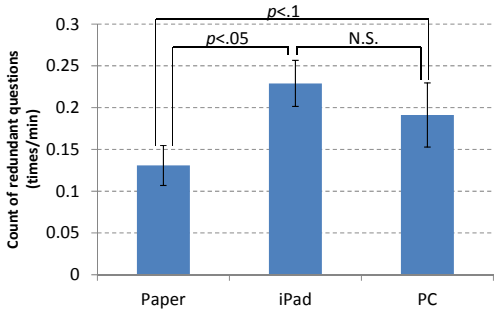

***Figure 2**. Count of asking redundant questions per minute*

A one-way within-subject analysis of variance on the count of asking redundant questions per minute revealed significant differences between the media used [$F(2, 22)=4.9$, $p<.05$]. According to multiple comparisons by the LSD method, the count of asking redundant questions was greater for the iPad usage case than the paper usage case [$p<.05$], and it tends to be greater in the PC usage case than in the paper usage case [$p<.1$]. However, the iPad and PC usage cases show no significant difference [$p>.1$].

The following two conclusions can be drawn from the above results. First, it suggests that the frequency of asking redundant questions is less in the case of paper usage. This conclusion supports the second hypothesis; that is, fewer questions occur when paper, rather than tablets or PCs, is used. The reason behind this result is thought to be that paper is not only easier to handle with a lower cognitive load but also easier to show to another person. Unlike iPads and PCs, frequent moving of the paper document towards a partner was observed during the trials. This observation suggests that it is easier to not only notice another person's state when using paper but also to share work progress.

Second, the frequencies of asking redundant questions in the cases of iPad and PC usage were not significantly different. The hypothesis that redundant questions would be asked more frequently in the case of PCs compared to tablets was not supported. In follow-up interviews after the experiment, the participants gave comments like "I got distracted with handling the iPad or PC and couldn't focus on the conversation with my partner." Just as when they used PCs, participants were frustrated

with the operability of the iPad and were therefore not able to concentrate on the discussion.

In fact, many scenes in which the participants using iPads or PCs seemed to have difficulty going back and forth between map pages and sightseeing pages were observed. When using an iPad, to go back and forth between pages that are apart, a participant either needs to "swipe" the pages or use a slider to go to certain pages. The user had to either repeat swiping until a certain page was reached or use a slider to skip through pages until the intended page was found, an operation that the participants seemed to have difficulty with. Scrolling was mostly used when PCs were used; however, in a similar manner to using the slider of iPads, the participants seemed to have difficulty in finding a certain page. On the contrary, in the case of paper usage, the participants frequently bookmarked pages with their fingers so that they could flip back to those pages immediately. In contrast, the ease of going back and forth between pages on iPads was not much different from that for PCs. The reason for this similarity is thought to be that there was not much difference in how much attention the participants paid to their partners in the two cases.

General discussion

Discussion on the results

Compared to the paper-use case, the iPad- and PC-use cases resulted in more redundant questioning to share context. This redundant questioning is thought to interrupt the flow of the discussion.

Additionally, the results of this experiment suggest the difficulty in going back and forth between pages in the tablet-use case compared to the paper-use case and the difficulty in showing documents to partners prevented sharing of context when tablets were used. The reasons behind the difference in the discussion processes in the case of the different media are discussed in more detail in the following.

First, paper supports various types of page navigation. The difficulty in going back and forth between the pages when iPads and PCs were used was one of the main reasons for interruptions of conversations. In the case of paper usage, however, participants used their fingers to bookmark pages so they could go back to them easily. This behavior has been replicated electronically, but only one place can be bookmarked at one time [11, 12]. In reality, when paper is used, multiple pages can be bookmarked by using multiple fingers, making comparing and discussing information more efficient. Moreover, as shown in Figure 3, people were observed to be holding the pages that are between the 2 pages they were referring to. The movement required to go back and forth between pages was minimal, just a slight shifting of the hand to the left or right, so the process was very fast. The various ways of handling paper improves page navigation and, therefore, did not interrupt the discussion process.

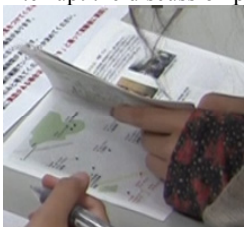

***Figure 3**. Act of supporting page turns by holding the pages in-between*

Second, the act of holding paper documents while reading encouraged people to share their document with their partner. Unlike the cases that iPads and PCs were used, in the case that paper was used, participants tended to read their paper document while holding it, so there was less action required in showing the document to their partner. In the case where participants used paper, they were able to share their document with minimal action, such as rotating their wrist slightly to change the angle of the document they were holding. In previous studies, it was pointed out that the ability to hold a document in one's hand alleviates fatigue [13]; the present study shows that it also improves the sharing of work progress with several people who are reading the same document.

Finally, participants were able to guess what page their partner was reading, even if they didn't actually look at their partner's document. In follow-up interviews after the study, some participants reported that they could tell roughly what page their partner was reading by the look of where it was opened to, such as halfway or a quarter from the front cover, even if they didn't know exactly what page they were looking at. This is a characteristic that cannot be imitated by an iPad or a PC, and it is thought to help with sharing context when paper is used in discussions.

Suggestions from the Study

Two suggestions can be drawn from this study. First, the use of tablets in a discussion should be considered carefully according to each scenario. Compared to using paper, using tablets gives lower frequency of essential conversations. This means that in the same amount of time, a topic cannot be discussed in depth in the case a tablet is used as much as in the case paper is used. To improve the quality of a discussion and make the best decision, active exchanges of ideas and opinions—with all the pros and cons to be discussed—are crucial. With this in mind, the use of paper should be reconsidered in regard to time-sensitive, important meetings.

Second, the results of this study suggest the potential use of electronic paper (hereinafter e-paper) in discussions. They suggest that the ability to easily move documents is one of the factors that make paper a favorable medium for sharing context with other people. E-paper devices are generally lighter and easier to move than tablet devices. It can therefore be assumed that e-paper devices will be shared frequently, just as paper has been. Furthermore, there is less reflection on e-paper compared to an LCD, so its visibility is higher when someone is looking at a document from an angle. These characteristics encourage the sharing of context, so e-paper should be considered a medium that is worth looking into in regard to use in discussions.

When e-paper is used in discussions, however, its usability in terms of page navigation must be improved. It has been pointed out that the page navigation of e-paper devices is inferior to those of paper and tablets [2, 3]. This finding suggests that users will be distracted with operating the device and will not be able to pay attention to other people. Therefore, to allow context to be shared and discussed efficiently, the usability of page navigation on e-paper devices must be improved. For example, exploiting the lightness of e-papers makes it possible to use several e-papers to browse through more pages at once would reduce page navigation.

Concluding remarks

The communication efficiencies of paper, tablets (iPads), and PCs during a discussion were compared. Compared to the trials

using paper, people in trails using tablets had to go through redundant questioning and answering to share their work progress, and the frequency of exchange of essential ideas and opinions was less. Currently, there is a trend where uses of tablets in conversations are being considered in various business fields. However, caution should be taken in using tablets in a situation in which a topic must be discussed thoroughly in a short amount of time. Additionally, going back and forth through pages and showing documents to other people are more difficult on tablets than on paper.

Future work includes categorizing and quantifying various behaviors in discussions, such as writing and flipping pages. From this work, we will devise an approach to determine what kind of usability helps discussions.

Trademarks

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