A Digital Bookmark using Tobii Eye-Tracking

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Video: https://drive.google.com/open?id=1i3p4iOETdqNapWzf8oB-crHGNBBb2Umg

ABSTRACT

Since technologies are constantly changing, the way we read is also constantly changing. This brings science to the important question: How exactly does the way we read change when we use technology? Studies have shown that there are limits with digital reading, such as spatial landmarks, reference points and physicality. As consequences, readers may not comprehend the complexity or length since our brains cannot properly pause and reflect in the same way compared when reading print. Therefore, we created a digital bookmark using eye tracking, with the aim to help the reader navigate in the text when getting distracted. The study consisted of 4 tests and used a participatory design process where participants constantly participated in the development. The results show that this digital bookmark helped readers save time when trying to find where they were, after being distracted, in the middle of a digital text. The digital bookmark was also perceived as a good tool to make digital reading smoother.

1. INTRODUCTION

1.1 Background

The use of e-textbooks is becoming more prevalent due to an increase in access to mobile devices, the acceptance of e-books in general and the high cost of print textbooks [6]. Because technologies, devices and applications are constantly changing, the ways we access information are also constantly changing [10]. Especially when it comes to e-textbooks, which look different, feel different and are known by a variety of names. An e-textbook integrates the familiar features of a textbook, but in a digital form, to be accessed with an app or an Internet connection and to be read on an e-reader, tablet, smartphone, or computer [3]. Studies have shown that it is harder to concentrate and inhibits reading comprehension while reading digitally, because our brains can not properly pause and digest what we are reading [9]. Also, continually moving from one reading situation to the next on the internet, forces readers to mentally adapt[17] in order to construct meaning from the complex system. Since navigating through digital textual landscapes differs from navigating on print, people tend to choose printed versions rather than digital [14].

With this project we further investigate how to achieve the full potential of digital reading. By focusing on improving the reading situation on digital books by letting the reader know where they left off, using eye tracking technology, which can determine the current focus point of the eye precisely while being relatively unobtrusive in their application [10]. This

will be done in order to answer the question: Can eye tracking technology, in form of a bookmark, improve the experience of digital reading?

1.2 Earlier studies

When comparing digital reading to traditional printed reading, habits and attitudes appeared to be important [13]. When it comes to studying, a digital textbook seemed to be the best alternative to a printed version [13]. On the other hand, those who prefered digital reading are originally native paper readers and since there are limits, like spatial landmarks, people will not transfer to only reading digitally [13]. A study made at the University of Maryland showed that readers reading from a digital paper may not comprehend the complexity or length as well when compared to reading from a traditional printed paper [16]. Science has shown that this is because our brains cannot properly pause and digest what we are reading [9]. Based on a survey of 113 participants, San Jose State University concluded that shortcuts seemed to appear a lot while reading on screens, which indicated that people tend to browse, scan and hunt for keywords more often compared to printed papers [7]. According to another study based on students from 5 different countries, 92 percent of all students said they concentrated better when they read in print [2]. Professor Kate Garland came to the conclusion that printed books give us a physical reference point and a part of our recall includes how far along in the book we are, while digital reading can be perceived as limitless and infinite which can be dizzying [9]. Naomi S. Baron, indicated just like Garland that digital reading encourages us to keep going, scrolling and not take time for reflection compared to read print which give us the leeway to pause and think [2]. Additionally, a study on reading behaviour came to the conclusion that eye tracking will become more widespread in the future and that it has great potential in the area of digital reading [10]. It has earlier been shown that eye tracking can help disabled people [11], and we argue that it can improve experiences for all users as well [8].

2. METHOD

To address the question of whether eye tracking technology can improve digital reading, this study is using the participatory design process to develop an eye tracking application that follows the user's eyesight while reading. The application then places a bookmark on the line that was last read and the user can then easily find their way back after being distracted.

The definition of a participatory design process is an "approach towards computer systems design in which people destined to use the systems play a critical role in designing it" [15]. This means that the users should be in the centre of the process, involved in every step and iteration with the goal to create an application that is well-adapted to the user's interaction behaviour [12], which means that the users participating in the design are considered experts guiding the actual developers to build the final result [5]. The ideas of a participatory design process are quite different from other design methods in technology development, but has, when used, resulted in applications with more likelihood of being used and higher user

satisfaction as well as better user experience and increased productivity [4]. This is why the participatory design process was chosen for this project, and also because involving users might hopefully develop experts on how the product is used.

The first test in the process was done through a Google Form to determine which bookmark users find the best (Figure 2). 21 test subjects were shown one text several times, each time with a different bookmark created in the design toolkit Sketch. Then they got to choose the one that they preferred and the one with the best result was used later on in the process.

After this, test 2 was conducted with five test subjects. This was done to confirm the hypothesis that a digital bookmark makes reading more efficient and easier to immediately keep on reading after a distraction has occurred. To do this, two different texts were used, both from the same book and with the same length. They have no paragraphs or subtitles, this to make it harder to remember where in the text the reader was. The actual test was done by five test subjects reading the texts while following the lines with their finger. They were then distracted in the middle of their reading, asked to let go of the paper and then asked to start reading again after a short break. One of the two texts then had an orange arrow pointing at were they left off and the other text had no bookmark whatsoever. The total time it took to read each of the texts was then measured by using a timer, not including the distraction time. Then the test subjects were interviewed in semi-structured interviews to get their personal experiences of the test and how they perceived the reading with versus without the bookmark.

After compiling the results from test 2, the third test was conducted. It was done in a similar way to the previous test but by using Tobii Eye Tracking 4C, the game engine Unity and the plugin Tobii Unity SDK for Desktop. Through these computer programs, an interface with text was implemented, with the bookmark showing up when the user looks away from the screen and a clickable button to switch page in the text (Figure. 1). Four new participants started the test with calibrating their eyes in order to track their eye gaze as precisely as possible. After this, the participants got to read the same texts as in test 2 but in a digital format with two columns, mainly due to research that shows that this might ease reading time [1]. Similar to test 2, the participants were distracted and put to other thoughts, and a digital bookmark was then placed in one of the two texts before the test subjects continued reading. The participant got distracted to simulate reality where one get distracted all the time, for example by ones phone, and look away from the text one is reading. As in test 2, timing was conducted, excluding the time when the subjects got distracted. The participants then got to answer questionnaire with some basic questions about the functionality of the implementation and their perception of the test. The subjects got to answer if they felt that the bookmark helped them get back to the text faster, if they liked the idea of the bookmark and if they would use an implementation like this. They also got to comment on what could be better and what they would have liked to be different about the functionality. Interviews were then conducted with all the test subjects to investigate how they perceived the reading with and without the bookmark in a more semi-structured manner.

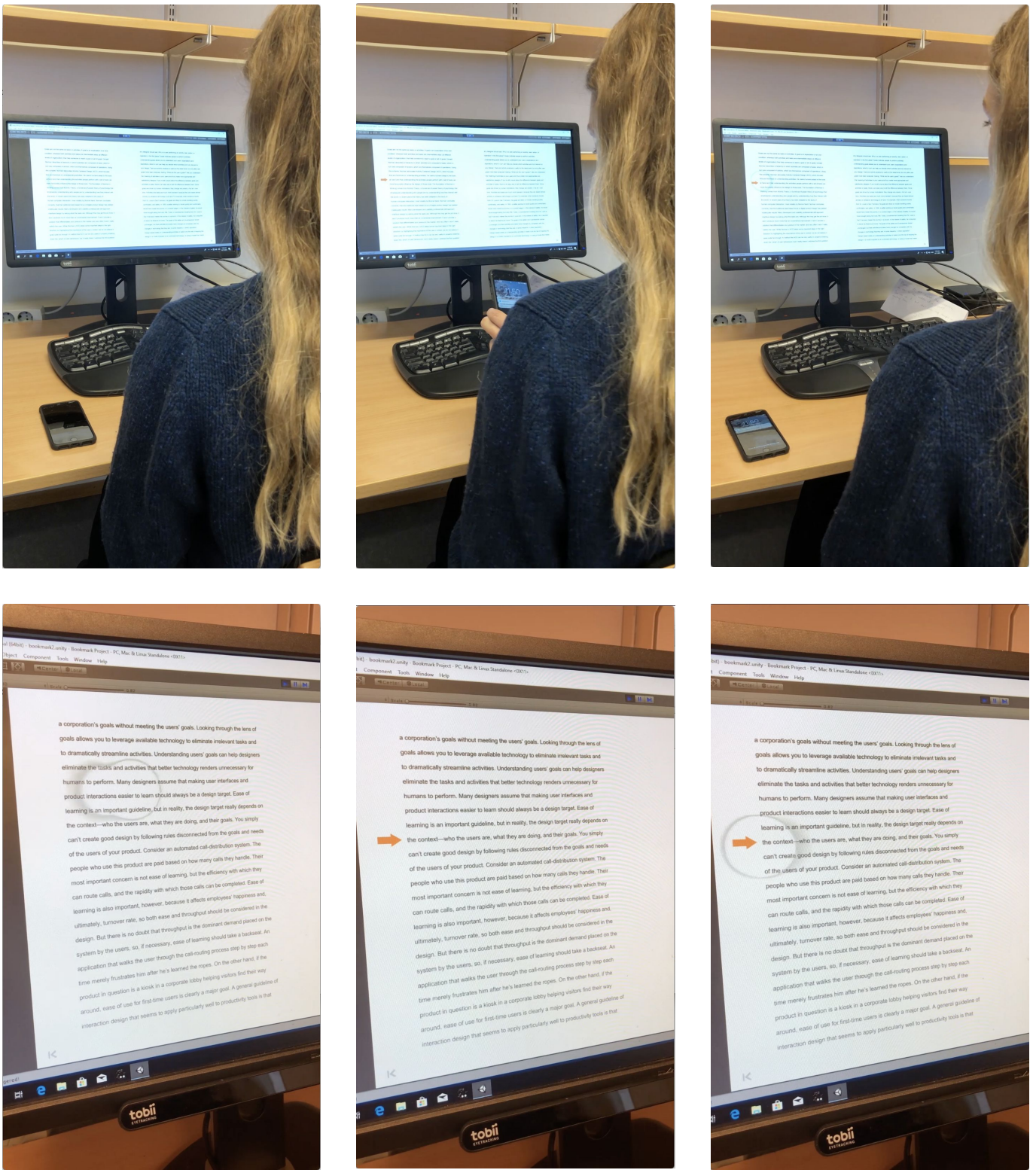

Figure 1. The second row is a close up of the first row. To the left: Testperson is reading on the screen. The bubble shown was not used in the test but is used here to show where the user's gaze is. In the middle: Phone lights up and distracts the reader. When no gaze is detected an arrow shows up where there person last read. To the right: When the person looks back at the screen her sight immediately finds the arrow and can continue reading.

After compiling the results from test 3 and minor changes to the implementation, test 4 was conducted. The execution of test 4 was identical to test 3, except that the participants got distracted for a longer time and the test persons knew before that the bookmark would show up. Also, Tobii eye tracker got covered with a paper instead of making the test persons look away to lose the gaze.

3. RESULTS

3.1 Test 1

The results showed that a strong majority with 15 out of 21 participants (Figure. 2) thought the orange arrow (Bookmark 1) would help the most in a situation of distraction when reading. 3 out of 21 participants chose the orange dot (Bookmark 3) as the most beneficial and 2 out of 17 participants chose the red arrow (Bookmark 4). No participants chose the flowers bookmark (Bookmark 2, Bookmark 5) or the red dot (Bookmark 6).

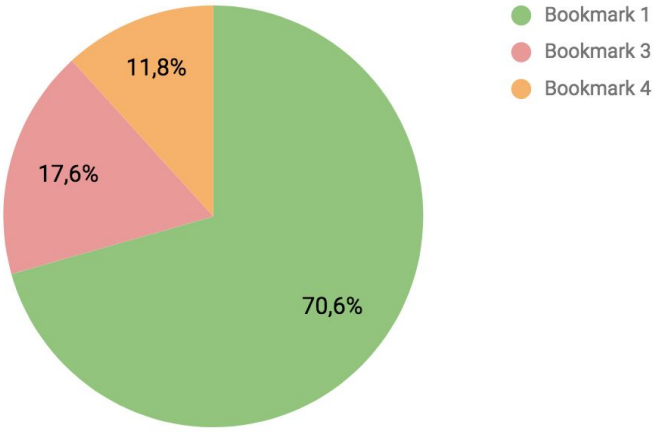

Figure 2.

3.2 Test 2

The results (Table 1) showed no clear difference in terms of time. It is important to pay attention to that the timing was difficult to perform correctly. It was especially difficult for A3 and A4, since they misunderstood that they were to tell us when they begun reading and when they finished. A5 said that "*Without the bookmark, I didn't know exactly where I was in*

the text and therefore I might have skipped some lines" This could have been the case for A3 and A4 as well, that also got a faster time without the bookmark.

Test subject	Time 1	Time 2	Difference (s)	Text started with
A1	04:47:14	04:35:21	00:11:93	text 1 without bookmark
A2	02:18:88	02:38:41	00:19:53	text 1 with bookmark
A3	02:46:47	02:35:94	00:10:53	text 2 with bookmark
A4	02:50:64	03:02:15	00:11:51	text 2 without bookmark
A5	03:26:62	03:29:21	00:02:29	text 1 without bookmark

Table 1.

3.2.1 Interviews

The results of the interviews showed that the subjects perceived it much easier to get back to the text faster and continue reading with the bookmark. All of the participants, 5 out of 5, were positive to use the bookmark while reading. A1 thought it was time efficient to use the bookmark, A1: *"I saw the arrow directly and on what line it pointed at. I did not read one word too much since I ended on a period and remembered that. I got back into the text quickly. Without the arrow, I knew where I was in the text ± 4 rows".* A2 thought it was hard to get back to the text without help, A2: *"It took longer time to find the line of interest without the arrow".* Since there were not any paragraphs in the text many of the participants thought it was extra tough to get back to reading after distraction. A4: *"I felt that the bookmark helped a lot. It was also easier to find where I was last reading since it was no breaks in the text."*

A1, A2 and A3 felt that the texts were similar in difficulty and length, A3: *"The texts felt the same regarding difficulty level. The situation without the arrow, I had to think and try to remember where in the text I last read".* A4 thought that text 2 were slightly simpler to read than text 1 and A5 thought the opposite, A5: *"Text 1 felt a little easier, but I also got more distracted from background noise when reading text 2"*. Therefore, the timing of the readings is hard to get valid facts from that can be evaluated, since there are a lot of different aspects that may have affected the results. Therefore, the experience of the participants became even more important to evaluate as results. The results from test 2 showed that the test persons think it do exists potential in a digital bookmark in order to ease the reading process, this suggests a reason for further development of this tool.

3.3 Test 3

The result from the questionnaire of test 3 showed that half of the participants found the bookmark helpful and would use a similar digital bookmark (Figure 3, 4). The other half did not find the bookmark helpful in the test situation and they did not know whether they would use a digital bookmark like this or not. However, on the semi-structured interview it appeared that it could be of more use in other situations. Since, in a situation like the test, where the participants were fully concentrated on the reading task, they did not forget where in the text they were when being distracted. Whilst in a situation when, for example writing a scientific report, where one might have many tabs and windows open at the same time, all participants believed the bookmark could be useful.

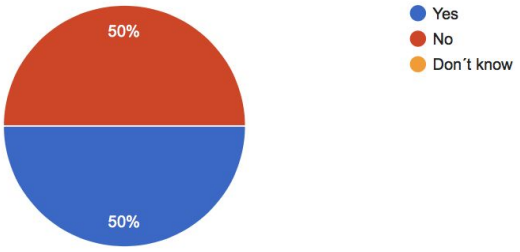

Figure 3. "Did you find the bookmark helpful?"

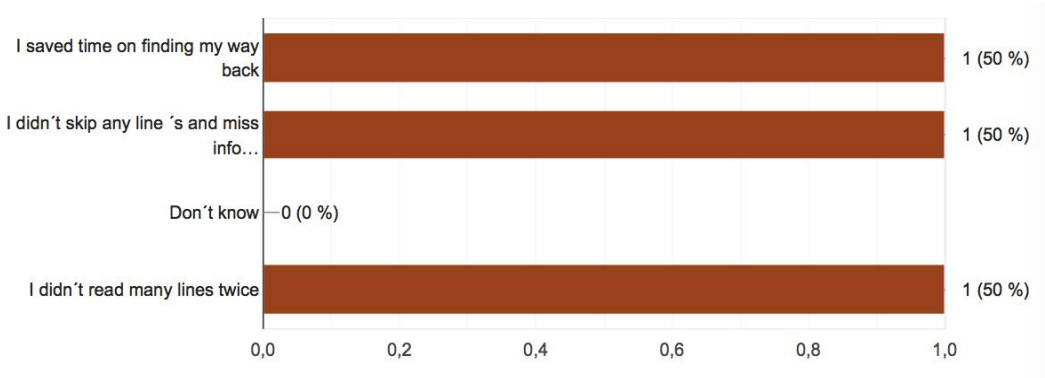

Figure 4. "If Yes, in what way did it help you?"

All participants agreed on the symbol being appropriate. Three participants, B1, B2 and B4, answered it was very good and B3 answered it was good. On the semi-structured interviews one participant, B2, mentioned that when reading on the right side of a row and looking away quickly, the arrow would only appear on the left side. But in that case, according to the participant, it could be more intuitive to have another arrow on the right side as well. The same participant also mentioned that another way could be to highlight the row instead of using the arrows.

Question three in the questionnaire was "How did you find the implementation of the bookmark?" (Figure 5). One participant, B1, answered it was very good, B2 said it was very bad and the others, B3 and B4, answered it was neither good or bad. B2 said that it was bad

because the arrow was always two lines above where the person was reading and that it showed up every time the person blinked more than one time in a short time interval. B1 said the bookmark would be of good use if doing something for a longer time, then being distracted for a couple of seconds or minutes or if reading and writing at the same time.

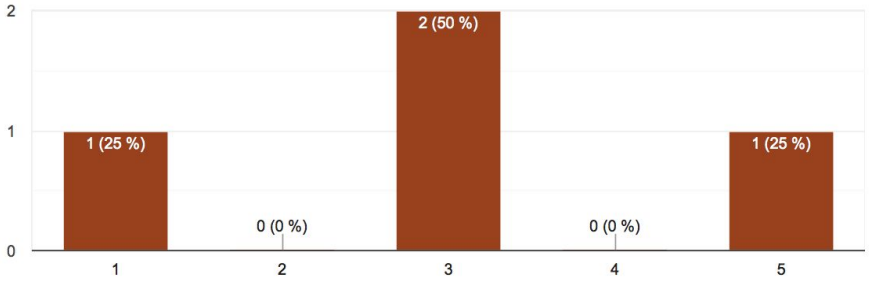

Figure 5. "How did you find the implementation of THIS digital bookmark?"

In the semi-structured interviews asked the participants were asked if they had any suggestions of improvements for us. B1 said it would be nice to have more than one arrow in a large PDF file where you might not read every page. B2 said "*if I want the re-read a paragraph it would be nice to have the arrow staying at the place where I stopped, so that when I go up a couple of lines I know when I am back again."*

B1 said the reading was not affected by the arrow and B2 said the arrow was disturbing the reading since it popped up when blinking. B3 said *"If I would be aware of that the arrow would be there and for what purpose I would have felt more secure in my reading. First I thought it was aimed to disturb me and that was what you were going to measure."*. B4 thought the arrow could affect the reading positively but also mentioned a feeling of being lucky in the test when not using the arrow. So because when being distracted the participant was just finishing a sentence which was easy to distinguish, and mentioned that the time differences between having an arrow or not might not reveal that the arrow actually had helped. The time differences between having an arrow or not did not prove that the arrow helped. In fact B1, B2 and B3 all had up to 4 seconds longer time when using the arrow. B4 was the only participant who received a shorter time when using the arrow. Furthermore, half the participants answered they would use a digital bookmark like this (Figure 6).

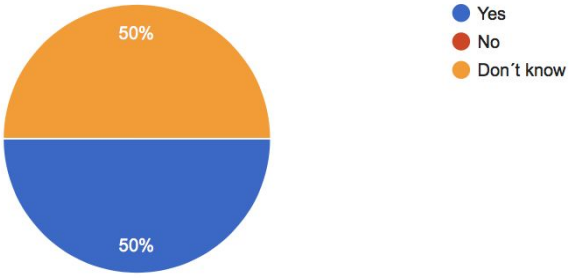

Figure 6. "Would you use a digital bookmark like this?"

3.4 Test 4

In the questionnaire to the 4th test 100 % of the participants answered that they perceived the bookmark as helpful (Figure 7). C1, C2 and C4 said they perceived that they saved time on finding their way back to the text. C3 and C4 were helped to avoid reading lines a second time and also to not accidentally skip any lines. C1, C2 and C4 also said both the implementation of the arrow and the actual symbol (color, shape and size) was very good (Figure 8). C2 said: "*Orange is a visible and sharp color, but still neutral. Sufficient color contrast against the white background".* C3 said both parts were good.

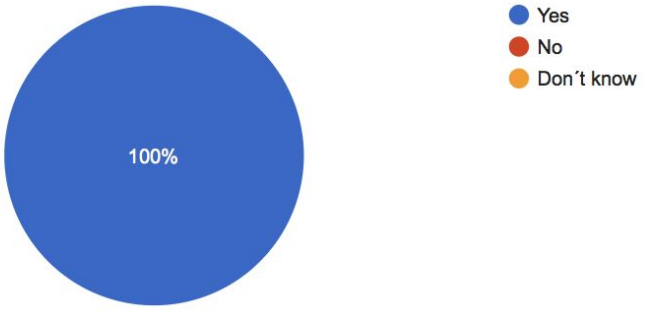

Figure 7. "Did you find the bookmark helpful?"

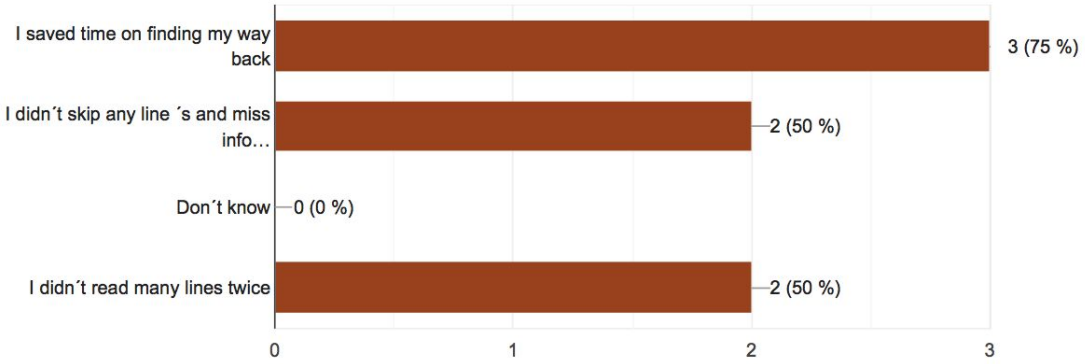

Figure 8. "If Yes, in what way did it help you?"

C3 and C4 thought a digital bookmark could affect the reading very positively, C1 thought it could affect positively and said: "*It was much easier to find where I left the text, before I got distracted with the bookmark".* C2 did not think it would have neither a positive nor a negative effect. However, C2 and C3 thought you can speed up your reading with such a bookmark, and C3 mentioned *"it is good since you don't have to read anything twice or skip anything".* C1 and C4 did not think the actual reading speed would be affected. All four participants agreed on that the understanding of the text would not be affected.

One of the participants C3, mentioned that the bookmark was implemented in a smart way, saying *"It (the bookmark) disappeared before I had time to think 'when will it disappear?'. That was a very good way of implementing it".*

After the changes of the arrow from test 3 and also having the test persons know the bookmarks function, the time differences now showed that the bookmark seems to help (Table 2, Figure 9).

Test subject	**Without** bookmark	**With** bookmark	Time differences	Started with:
C1	02:45:21	02:21:81	00.23:04	With bookmark
C2	02:03:96	01:45:63	00:42:33	Without bookmark
C3	03:04:77	02:41:72	00:37.05	With bookmark
C4	03:31:47	03:08:00	00.23:47	Without bookmark

Table 2.

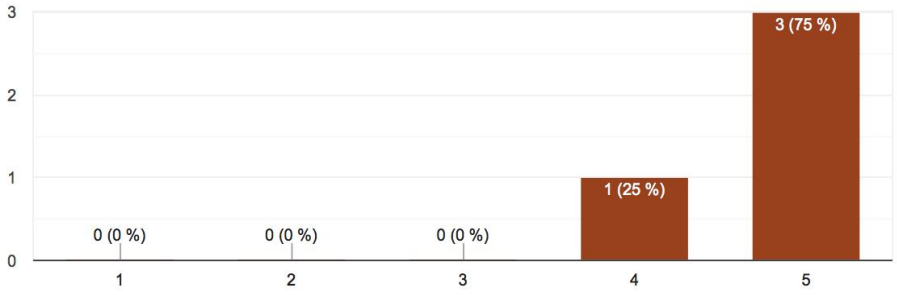

Figure 9. "How did you find the implementation of THIS digital bookmark?"

In the end of the questionnaire the subjects were asked whether they would use a digital bookmark like this (Figure 10). All four participants answers yes to the question and to evaluate their answers they were asked how much they were willing to pay for it in the semi structured interviews. B1 said *"If I would buy it as an app I would be willing to pay around 40-50 SEK or together with an e-book I would pay maximum 100 SEK"*. B2 answered *"I would buy it if it costed between 0 and 20 SEK. I would consider to buy it if it costed 21-50 SEK but I would never pay more than 50 SEK"*. B3's answer was 30-50 SEK and B4 said *"between 30 and 80 SEK depending on if I can only use it on PDF files or on internet web pages as well"*.

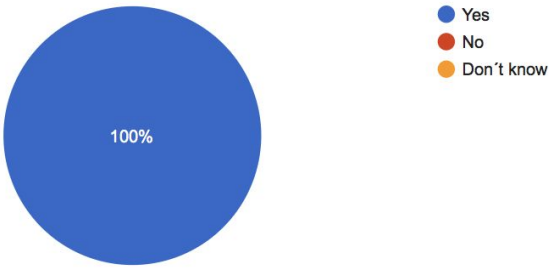

Figure 10. "Would you use a digital bookmark like this?"

4. DISCUSSION

4.1 Implementation

During test 3 the general response to the implementation was not as positive as we had hoped for. We listened to the participants feedback and made improvements before the 4th test. For example B3 in test 3 mentioned that if he/she had been aware of the function of the bookmark it might have helped more because the participant instead thought the aim was to distract. So in test 4 it was made sure that all participants knew the function of the bookmark. It was also made clear that the bookmark appeared when the user was blinking. This was perceived as disturbing. This was fixed by adding a delay to the bookmark in the code so it would not show up directly when no gaze was detected, but after 0.5 seconds instead. This gave good results in test 4, since no participants mentioned the bookmark showing when blinking. It now only appeared when their gaze left the screen. What was noticed in test 3 was that for some participants the gaze position was exact, whilst for others it differed up to two rows in the text. This is unfortunately not anything that can be affected since the coordinates of the gaze point are received from Tobii. The reasons for this problem could have been that Tobii is not exact, the execution of the configuration might have been incorrect or the user might have been sitting too close to the screen whilst reading or other unknown reasons. In test 4 the participants were informed about the risk of the arrow not pointing at the exact row they were last reading on and that it might point to a row above or under their last gaze point. This was not informed to participants in test 3. This information might have affected the results being better in test 4. The response from the test persons of test 4 was much more positive and no one mentioned the possible incorrect position of the bookmark.

4.3 Timing

During the timing process there were many occasions that might have caused timing errors. For example, we might have started the timer a few seconds too early or too late, which affects our results when comparing the reading time between the tests. However, to reduce these possible errors the timing was conducted in the same manner and by the same persons, one timing and one distracting. We therefore believe these timing errors are approximately the same for each test. For each test the timing got improved from us learning how to be more exact and careful, thus making the timing in test 4 more accurate. We do not believe that the difference in how easily read the texts were has a conclusive effect on the results, since the

texts were both excerpts from the same book and it is highly personal what text is perceived as easily read or not.

4.4 Test 4

The results from test 4 show that this digital bookmark is of help for its users and it is indicating that it can be even more helpful in other situations, such as reading multiple texts at the same time. The previous research show that this is the situation where many people find it the hardest to navigate through text, which is the purpose of the digital bookmark in this study. We therefore believe that a similar implementation would ease reading in many kinds of situations and that eye tracking is of great help for such an implementation. Additionally, users were also asked during the test if they would be willing to pay for a similar kind of bookmark, which got a positive result and many users actually would pay a small amount for the bookmark. This indicates that there is a demand for this tool among users.

4.5 Future research

A larger sample size is more representative and would better determine the average values and avoid errors. More users participating in the study would therefore be desirable. In order to improve digital reading, the actual comprehending process of reading should be measured for future work and also include more users. Future research could be how a digital bookmark could also be a tool to help readers understand a text.

As participant B2 mentioned, it could be of interest to highlight the whole row of interest instead of using arrows on the side. This is something we discussed and since it is more similar to using a highlighting pen on a paper it might be appreciated by the user. Though, it could also distract the user when the highlighting disappears after the user has continued reading. This could be interesting to investigate further. One participant also mentioned that he/she would have liked the arrow to be visible all the time to ease the reading. A function to make it possible to choose for oneself to have the bookmark visible all the time or only when gaze is lost could be a future implementation.

5. CONCLUSION

Users found the reading smoother and the bookmark made it easier to get right back to the text after a disturbance. It saves them time not having to re-read lines in order to find where they left the text. The users liked the bookmark symbol and would pay a fixed amount to have a tool like this one to ease their reading. Therefore, eye tracking technology in the form of this digital bookmark is improving the experience of digital reading.

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