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Master Media Technology

The Impact of Visual Overview on Recall Quality in Digital and Print Reading: an Analysis of Narrative Text

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Abstract

This study examined whether the level of visual overview provided by different reading conditions affects the recall quality of a narrative text. Fifty-two participants, aged 30 to 75, were randomly assigned to one of three reading mediums (book, e-reader or tablet) offering varying levels of visual overview and tasked with reading an eleven-page short story. Recall of the story was assessed using a sentence finding test and a timeline reconstruction task. No significant differences were found across the different reading conditions. These findings suggest that the amount of visual overview as afforded by different reading mediums may not significantly impact recall quality for narrative texts. Future research should be directed at exploring the impact of scrollable text and include younger participants to better reflect current digital reading practices.

Introduction

The increasing use of digital devices for reading has sparked discussions on the efficacy of reading on screen versus paper, especially concerning its impact on reading comprehension. Reading comprehension is a broad concept, but in short it determines the degree to which readers understand the meaning of a text. Proficient reading comprehension is a prerequisite for learning from text (Kirby, 2007).

While some studies suggest negative effects of screen reading on comprehension, others report little to no difference compared to reading on paper. A meta-analysis conducted in 2019 comprising 33 studies from 2008 onwards, indicated that screens have an adverse effect on reading performance relative to paper, an effect that was limited to expository texts and was not found in narrative ones. Readers showed greater efficiency when reading from paper, and were more aware of their performance (Clinton, 2019). A meta-analysis by Delgado et al. (2018) observed that both children and adults perform better on reading comprehension tasks when reading expository texts from paper. Again, the effect did not apply for narrative text. Margolin et al. (2013) however found no significant difference in comprehension accuracy between screen and paper reading conditions, regardless of the text type offered to readers.

To explain potential causes of poorer digital reading comprehension, the mechanisms underlying how readers remember and understand what they read must first be discerned. Kintsch's construction-integration model proposes that reading comprehension occurs based on the interaction of two main processes: construction and integration. During construction, the reader forms a mental representation of the text based on propositions, or units of meaning, that are linked together to form a textbase. The textbase is made up of sentence level propositions and the ideas that follow from these propositions. During integration, the textbase is linked to the reader's prior knowledge to form a meaningful representation of the text, also called the situation model. This model is constantly updating with new information during reading, while inconsistencies are filtered out (Kintsch, 1998, 2018).

Following this model, digital reading is expected to have little influence on reading comprehension, as it is predominantly the narrative structure of a text that is used to form the basis of a mental representation of text contents. This might explain why readers of narrative texts perform equally well on comprehension tasks regardless of the reading medium used, as opposed to readers of texts that are not as coherent as narrative texts, such as informational texts.

Payne and Reader (2006) however propose that full understanding of a text is not only dependent on the interpretation of its propositional structure, but also on the reader's ability to form a mental representation of the mapping between the physical structure of the text and its meaningful content. These representations, called 'structure maps', could offer support when readers interact with a text after reading it, for instance when re-reading or looking up information. Payne and Reader focus on readers' ability to recall and locate information after reading a text.

There are indications that readers encounter greater difficulty retracing information from scrollable text compared to paper, as shown in a study by Lauterman and Ackerman (2014). This sparks the question whether the form in which a text is presented influences the quality of readers' mental representation of the text, and consequently, their ability to recall and relate to information from it. Paper as a medium might promote the formation of text structure representation, as there are reference points on the page level and because the text is fixed to the pages, providing readers with spatial orientation, or a sense of location within the text (Payne & Reader, 2006). In contrast, screen reading may be suboptimal for construction of

text structure representations due to shifting reference points while scrolling, lack of fixity and varying navigational features (Kerr & Symons, 2006).

Prior research has mainly focused on how different mediums impact reading comprehension, rather than looking into the underlying reasons why digital reading might affect this cognitive process negatively. A limited number of studies suggest that when text presentations on screens mirrors the fixed format on paper, there may be minimal differences in reading comprehension between the two mediums for adults (Hou et al., 2007; Mangen et al., 2019; Hermena et al., 2017). However, Mangen et al. (2019) attribute variations in comprehension to the lack of tangibility associated with digital devices in comparison to paper conditions. This implies that the physical aspects of paper may aid in the construction of a mental map of text structure during reading.

Printed text may better facilitate the construction of text structure representations for two reasons: paper provides a sense of fixity on the page level, as well as a sense of location in the text due to tangibility: readers can quite literally feel where they are in the story (Mangen & Kuiken, 2014). These explanations seem to point to an underlying mechanism: the importance of having some sense of overview to support the reader's sense of location in the text, both on the page and the full text levels, in constructing text structure representations during reading.

This study aims to build on the idea that the level of overview provided by a reading medium, at both the levels of the page and the whole text, plays an important role in building a proper representation of text structure, thereby influencing reading recall. This perspective shifts the emphasis away from the specific medium used for reading.

A fictional short story was chosen as the focus of this study due to the relative underrepresentation of narrative text in reading research. Previous research found no significant difference in comprehension between participants reading narrative text from paper versus screens (Delgado et al., 2018; Margolin et al., 2013). However, in this study the primary interest is examining recall, as opposed to broad comprehension.

The main objective of this study is to determine whether the degree of visual overview afforded to readers of a narrative text – through the reading conditions of a physical book copy, an e-book on an e-reader, or an altered version of the e-book on a tablet – affects readers' recall quality of the story. Additionally, the study aims to contribute to a broader understanding of the effects of digital reading on information recall and to a basis for recommendations for digital reading practices.

The reading conditions used in this study offer three different levels of visual overview. The paper copy provides an overview at the page level, but not the story level. The e-reader offers overview at the page level, though inconsistently due to the changeable interface. Also, the e-reader page view is inconsistent with the conditions of test 1 as explained further below. It does not provide an overview at the story level. The tablet offers an overview at both the page and story levels, as the e-book display on the tablet shows a full story overview between each page turn.

The first hypothesis (H1) posits that readers from group 1 (book), group 2 (e-reader), and group 3 (tablet) will differ in the amount of time they need to physically locate information within the text. The second hypothesis (H2) suggests that readers from groups 1 (book), 2 (e-reader), and 3 (tablet) will differ in their ability to recall the chronological sequence of the story.

Based on an assumption that greater visual overview might enhance recall, it would be expected that tablet readers, with the highest level of visual overview, would perform better

than book and e-reader readers. However, due a lack of extensive research on this topic, previous studies provide only limited support to firmly predict this outcome. Therefore this study is designed to explore differences in performance across all groups, which allows for the possibility of outcomes in either direction.

Materials and methods

Recall quality was tested in two ways. The first method involved interaction with the text post-reading, where participants were instructed to search the text they had read for specific, literal sentences. The second method involved a content-based memory task, wherein participants were asked to recall and arrange the order of story events, as if reconstructing the story's timeline.

To test the hypotheses, participants were included in three separate study groups based on three reading conditions: book (group 1), e-reader (group 2) and tablet (group 3). They were recruited from the researcher's immediate environment. The cohort consisted of 24 men and 28 women, with a mean age of 53.3 years (SD = 14.3). Prior to participation, all individuals provided informed consent. The study received approval in advance from the Ethics Review Committee of the Faculty of Science.

Three different reading setups were used. The first condition involved participants reading from a paper copy of the book "Alle verhalen" by Roald Dahl, containing the Dutch translation of the short story "The Way Up to Heaven" - "Op weg naar de hemel" – from the 32nd printing (Fig. 1). The second condition utilized a Kobo Libra 2 e-reader, with the e-book version of the same story in Dutch, based on the 26th printing which is identical to the 32nd printing (Fig. 1). For the third condition, participants read the e-book on a Samsung Galaxy Tab S7 FE tablet, which was constructed from pages of the paper edition using Unity 2021.2.1. The e-book on the tablet featured an overview of all eleven pages from the book in overview mode, with zoomable pages (Fig. 2).

The materials for the experiment itself comprised of eleven book pages printed on A1 blowups, arranged in a room to mimic the overview mode on the tablet (Fig. 3). The text was presented on a large scale to emphasize the spatial aspect of recall, requiring participants to literally walk through the text. Additionally, participants were provided with sentence cards, timeline cards, and a questionnaire on paper (as shown in appendices A, B and C).

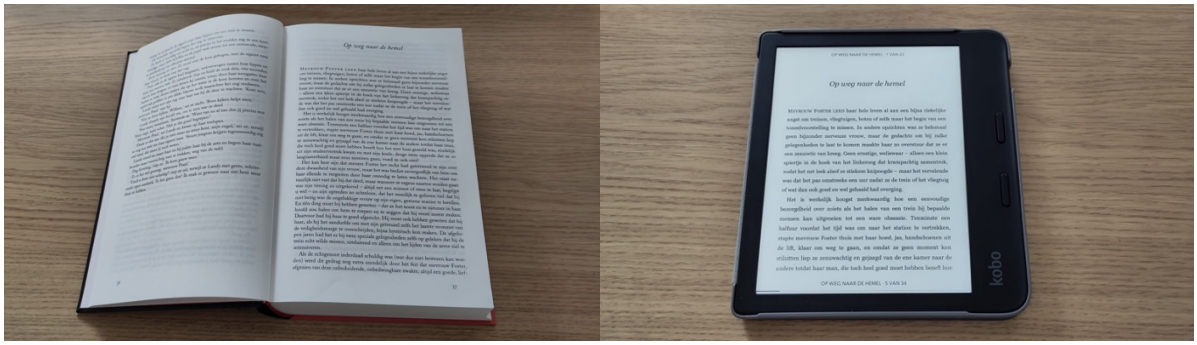


Figure 1. Book and e-reader conditions

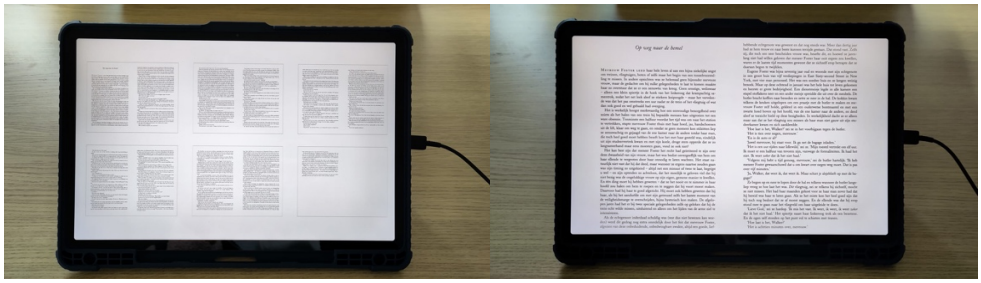


Figure 2. Tablet condition – full story overview vs. double page zoom

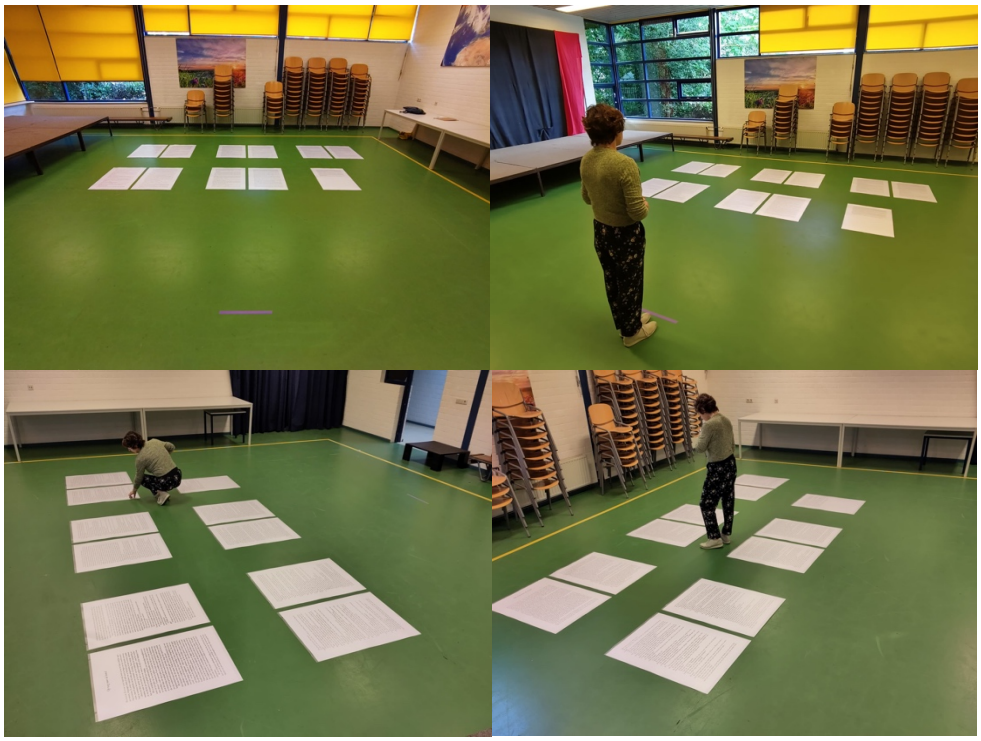


Figure 3. Test 1 Setup and procedure

The data collection procedures followed a structured sequence. First, participants were briefed on the study's objectives and procedures. Next, they were asked to read and sign a consent form indicating their voluntary participation. After that, participants were randomly assigned a reading medium and instructed to read the story at their own pace, without a time constraint. Participants' reading times were recorded, but they were not a focus of the analysis in the context of the formulated hypotheses. Following the reading session, participants completed a sentence-finding test (Test 1), in which they were tasked with locating nine specific sentences within the text, while the researcher recorded the time taken for completion (Figure 3). Participants were allowed to move between the pages to locate these sentences, returning to a designated starting point in the room before being showed the next sentence. Next, participants completed a timeline test (Test 2), arranging timeline cards in the correct order, while the researcher recorded time taken and any errors. Following these tasks, participants filled out a questionnaire with five questions about the story, with the researcher noting the number of correct answers. This questionnaire was added to ensure participants had properly read the story. Participants who made more than two errors, possibly showing a lack of story comprehension or engagement in the experiment, would be excluded from further analysis. To ensure anonymity, participant's data were pseudonymized using a unique identifier on the scoring form. Finally, the results were entered into SPSS and anonymized further by assigning random numbers to participants, with the master file stored on a password-protected drive.

The statistical analysis for the study involved examining two parameters – sentence finding speed and timeline reconstruction errors – both representing continuous data. To summarize the data, means and standard deviations were reported. Differences between groups were assessed using one-way ANOVA and independent two-sided t-tests, allowing for comparisons between groups while accounting for potential confounding variables. The analysis was conducted using IBM SPSS 24. A significance level of $p < 0.05$ was chosen as the cutoff point.

Results

Participant characteristics are described in Table 1.

Descriptive statistics for sentence finding speed across the three conditions (Test 1) are presented in Table 2. A one-way ANOVA revealed no significant differences in sentence finding speed between the book, e-reader and tablet conditions, $F(2,49) = .505$, $p = .606$. Subsequent independent two-sided t-tests failed to detect significant pairwise differences for any comparison: book/e-reader ($t(33) = .076$, $p = .863$), book/tablet ($t(33) = .842$, $p = .252$), and e-reader/tablet ($t(32) = .996$, $p = .097$).

Even though no significant differences were observed between the groups on sentence finding speed, the tablet readers performed better in an absolute sense. The book and e-reader groups were not far apart in their results. In a secondary analysis, these two groups were aggregated to form a single group (readers who did not have full visual overview) and compared to the tablet group (readers who had full visual overview). Descriptive statistics for sentence finding speed across these two conditions are presented in Table 3. The independent two-sided t-test revealed no significant differences between these groups: $t(50) = 1.012$, $p = .122$.

Descriptive statistics for timeline accuracy across the three reading conditions (Test 2) are presented in Table 2. A one-way ANOVA showed no significant differences in timeline accuracy between the book, e-reader, and tablet conditions, $F(2,49) = .305$, $p = .738$. Further independent two-sided t-tests failed to reveal significant pairwise differences for any comparison: book/e-reader ($t(33) = .712$, $p = .989$), book/tablet ($t(33) = .438$, $p = .116$), and e-reader/tablet ($t(32) = .336$, $p = .194$).

Although the original purpose of the questionnaire was to serve as a check on participants' engagement with the story, an exploratory analysis of the mean number of errors between groups was done to find out if comprehension varied significantly between conditions. None of the 52 participants made more than two mistakes. Descriptive statistics for questionnaire answers across the three reading conditions are presented in Table 2. A one-way ANOVA showed no significant differences in the number of correct answers between the book, e-reader, and tablet conditions, $F(2,49) = .163$, $p = .850$. Further independent two-sided t-tests failed to reveal significant pairwise differences for any comparison: book/e-reader ($t(33) = .102$, $p = .588$), book/tablet ($t(33) = .468$, $p = .539$), and e-reader/tablet ($t(32) = .525$, $p = .312$).

Table 1. Participant characteristics

	All	Book	E-reader	Tablet
N (total)	52	18	17	17
Female, n (%)	28 (53,8)	10 (55,6)	9 (52,9)	9 (52,9)
Age, mean (sd)	53,3 (14,3)	52,3 (14,9)	55,2 (13,2)	52,5 (15,4)

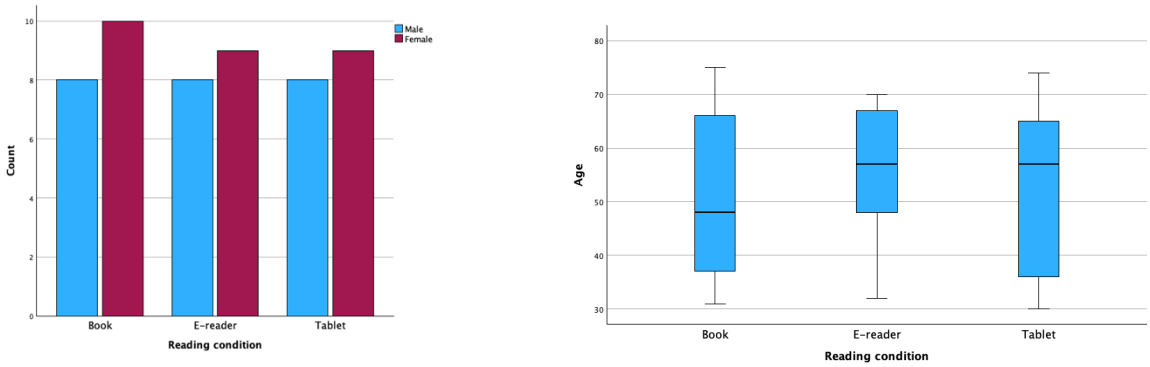


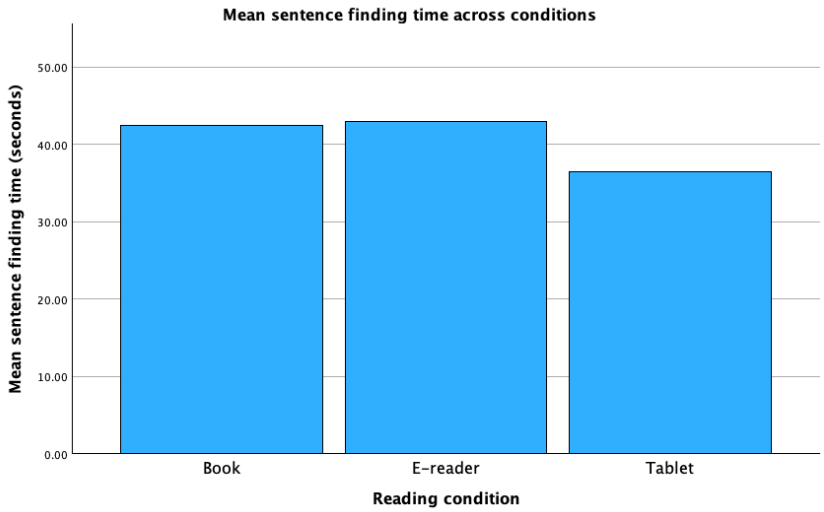
Figure 4. Distributions of gender and age across reading conditions

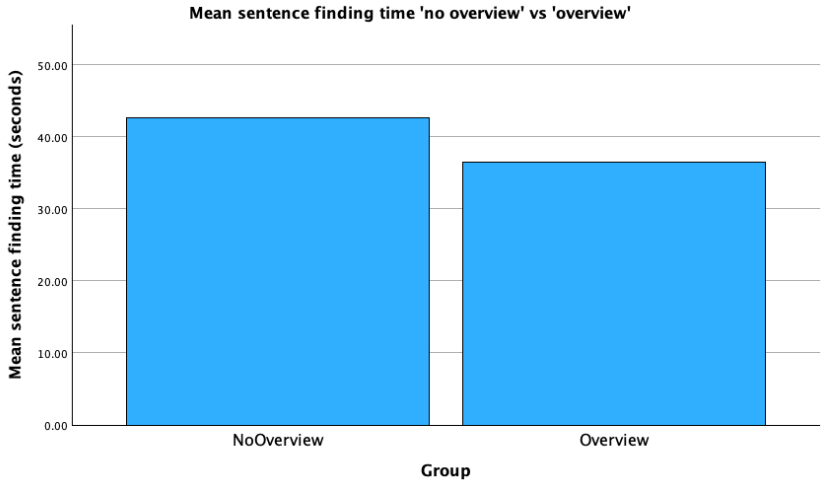
Table 2. Performance across reading conditions

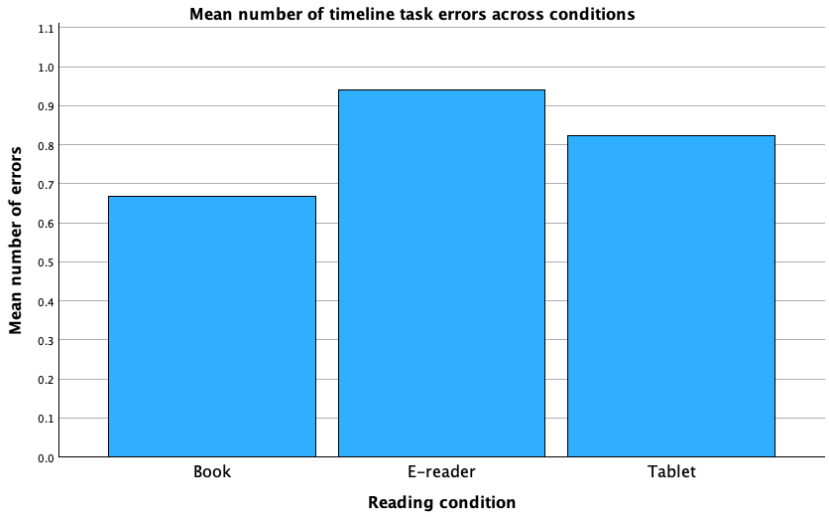
	All	Book (n = 18)	E-reader (n = 17)	Tablet (n = 17)
Sentence finding task, mean (sd) time in seconds	40,6 (21,0)	42,4 (24,4)	43,0 (21,5)	36,4 (16,7)
Timeline task, mean (sd) number of errors	0,8 (0,5)	0,7 (1,1)	0,9 (1,0)	0,8 (0,8)
Questionnaire, mean (sd) number of errors	0,37 (0,6)	0,4 (0,6)	0,4 (0,7)	0,3 (0,6)

Table 3. Performance of group 1 and 2 combined (no full overview) and group 3 (full overview)

	All	No full visual overview (n = 35)	Full visual overview (n = 17)
Sentence finding task, mean (sd) time in seconds	40,6 (21,0)	42,7 (22,7)	36,4 (16,7)


Mean sentence finding time across conditions
Mean sentence finding time (seconds)
50.00
40.00
30.00
20.00
10.00
0.00
Book
E-reader
Tablet
Reading condition


Mean sentence finding time 'no overview' vs 'overview'
Mean sentence finding time (seconds)
50.00
40.00
30.00
20.00
10.00
0.00
NoOverview
Overview
Group


Mean number of timeline task errors across conditions
Mean number of errors
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Book
E-reader
Tablet
Reading condition

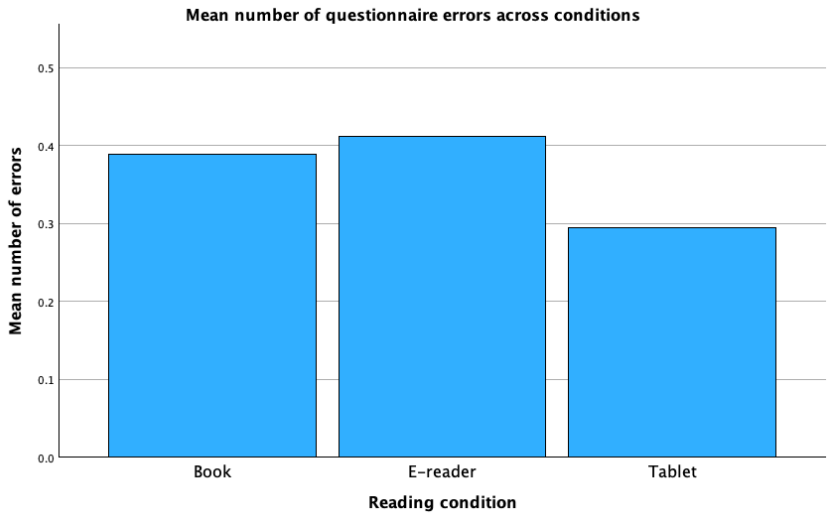


Figure 5. Means of sentence finding time (across conditions and between 'no full overview' and 'full overview'), timeline task errors and questionnaire errors across reading conditions

Discussion

This study was done to examine whether the level of visual overview afforded by different reading conditions affects recall quality of a narrative text. No significant impact was observed: all groups of readers performed equally well on both tasks. Neither hypothesis H1, proposing differences between the reading conditions in sentence finding speed, nor hypothesis H2, suggesting differences between the reading conditions in timeline reproduction accuracy, were supported.

The study was designed to explore whether differences in recall quality existed across the reading conditions. Considering previous research outcomes from a limited number of studies, an initial expectation did exist that one group might outperform the others. Specifically, it was anticipated that tablet readers might perform best on recall tasks due to the visual overview they were offered on both the page and full-text levels. Book readers would perform second best, as they were offered visual overview only on the page level. Participants reading from the e-reader then would come in third due to the least amount of visual overview offered within their reading condition. However, this relationship was not supported by the results of this study.

There are several possible explanations for these findings. Firstly, it is plausible that in digital reading, the presence of scrollable text is to blame for any negative effect on reading recall quality. Previous research has found that scrolling negatively affects comprehension and recall (Mangen et al., 2019; Hou et al., 2007; Kaufman & Flanagan, 2016). However, in this study all reading formats were non-scrollable, which may have minimized potential effects as they all offered a certain amount of fixity. Moreover, the tablet reading condition in this study differed from the reading experience as it would be afforded by regular tablet use. It was specifically designed for this study with the intention of enhanced overview in mind.

Secondly, the age range of participants, all of them 30 and above, who learned to read almost exclusively on paper, may contribute to them being resilient against potential negative effects of digital reading. Studies have shown that older readers who are more used to print may perform better on reading tasks no matter the medium, compared to younger readers who are more familiar with screen reading (Jeong, 2012; Margolin et al.; 2013). Moreover, Stiegler-Balfour et al. (2023) found that readers with weaker reading comprehension strategies showed a lower ability to recall information from digital expository text compared to their performance after reading from paper. This difference was not present in more skilled readers.
This should be kept in mind, especially considering the general decline in reading skill levels in young readers (Meelissen et al., 2023).

Thirdly, drawing from Kintsch's construction-integration model, the quality of text representation in the brain may be more reliant on the propositional content of a story (situation model) rather than visual cues provided by the medium (Kintsch, 1998, 2018). This model emphasized the role of mental representations formed through interaction with the text, which may not be significantly influenced by the medium when text structure is clear and coherent – as was the case with the short story used in this study. This might also explain why in previous research no significant difference in reading comprehension was found between readers of digital or paper narrative text (Delgado et al., 2018; Margolin et al., 2013).

The findings do not support the idea that the specific reading medium has influence on recall quality of a narrative text. However, it is important to note that this study did not control for factors like tactile feedback, or other inherent qualities afforded by each medium. This could mean that the medium's effect on recall may be confounded with the level of visual overview available to the reader. Nevertheless, this tentative conclusion aligns with Hou et al.'s (2017) finding that when text representation on screens replicates the fixed format of paper,

differences in reading comprehension are likely very small. This is encouraging information for those who prefer to read narrative texts digitally, as both comprehension and recall appear unaffected. However, it remains uncertain if this effect is applicable to all readers. For instance, comprehension and recall in children who learn to read on screens might be impacted differently.

There are some limitations to this study that may have influenced its results. First, the participants reflected an older age range than most comparable studies. Second, the sample size was relatively small, which may have limited the statistical power of the study. Even though the results showed no significant differences between groups, there was a discernable trend in the data that suggested a particular direction in the sentence finding task, albeit non-significant. Perhaps with a larger sample size and a more targeted, one-sided approach, these trends may become significant. Therefore, these findings should be interpreted with some caution. Third, the unconventional way of navigating through the text as if it were a maze turned out to be a useful methodological tool for this study but does not reflect typical use of text. Fourth, the absence of scrollable text limits the generalizability of the findings to the digital reading context as a whole. And finally, the study's focus on narrative text might not indicate how different mediums affect recall of other text types.

For future research, it is recommended to involve younger readers and include scrollable narrative text to better simulate realistic digital reading conditions. Also, increasing the sample size would provide the needed statistical power to detect potential effects that may have been missed in this study. Additionally, to better understand the influence of the reading medium on recall, future research might explore how different levels of overview affect recall within each medium separately. Lastly, including non-narrative text in the same fixed manners could offer valuable insights into information recall, especially in educational contexts where students need to remember information from different types of texts (Jeong, 2012; Mangen et al., 2019; Kaufman & Flanagan, 2016).

This study opens the door to numerous new questions on the complex topic of digital reading. Continued research is needed to disentangle the many factors that influence reading comprehension and recall in a fast-evolving reading landscape.

Conclusion

This study examined whether the level of visual overview afforded by different reading mediums (a physical book, e-reader and tablet) affects the recall quality of a narrative text. No significant differences were found in sentence finding speed or timeline reconstruction accuracy among the different reading conditions, suggesting that varying levels of visual overview across reading mediums may not significantly influence recall quality for narrative text. These findings do not provide support for the idea that the level of visual overview, or the specific medium itself, impacts recall. This suggests that digital reading formats may offer similar recall results to paper formats, at least for narrative text. However, the study did not control for affordances of each medium other than the level of overview it provided. Further research is needed to explore the impact of these factors. Limitations such as the smaller sample size, older participant range and unconventional text navigation methods should be considered. Future research might involve younger readers, include scrollable text to reflect more realistic digital reading experiences, and incorporate non-narrative texts to explore any implications for educational settings. A larger sample size and a more directional approach are also recommended to further explore the potential effects of visual overview on recall quality.

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Appendix A. Sentence Cards

Het kan best zijn dat meneer Foster het recht had geïrriteerd te zijn over deze dwaasheid van zijn vrouw, maar het was beslist onvergeeflijk van hem om haar ellende te vergroten door haar onnodig te laten wachten.
Ze zou helemaal in haar eentje naar Parijs gaan om haar dochter op te zoeken, haar enig kind, dat met een Fransman was getrouwd.
Mevrouw Foster sprong zonder een woord te zeggen uit de auto en holde door de hoofdingang het gebouw binnen.
‘En’, zei hij terwijl hij bij de deur van de studeerkamer bleef staan, ‘hoe was het in Parijs?’
Vijf minuten later kwam meneer Foster naar buiten, en toen ze hem langzaam de stoep zag aflopen viel het haar op dat zijn benen in die smalle broekspijpen precies op bokkenpoten leken.
Op dat moment ontwaarde mevrouw Foster plotseling de punt van iets wits in de gleuf van de bank, aan de kant waar haar man had gezeten.
Zoals ze daar stond, met haar hoofd achterover en met dat gespannen lichaam, was het net alsof ze op de herhaling wachtte van een geluid dat ze een ogenblik eerder ergens ver weg in huis had gehoord.
Terwijl mevrouw Foster hem vanaf de achterbank aanvuurde reed de man hard naar het vliegveld, en ze haalde het vliegtuig met een paar minuten speling.
Het zag eruit als een weloverwogen, doelbewuste handeling; ze gedroeg zich als een vrouw die een gerucht gaat onderzoeken of een vermoeden bevestigen.

Appendix B. Timeline Cards

Het personeel is druk in de weer in het huis in New York.
Bij vertrek maakt meneer Foster een opmerking over de mist.
Mevrouw Foster komt onverrichter zake terug van het vliegveld.

Meneer Foster vraagt zijn vrouw om een lift naar zijn club.
Mevrouw Foster luistert aan de voordeur.
Het vliegtuig naar Parijs vertrekt.

Mevrouw Foster belt aan bij haar eigen huis.

Mevrouw Foster bladert door het adresboek van haar man.

Appendix C. Questionnaire

Omcirkel het juiste antwoord

1. Hoeveel kleinkinderen heeft het echtpaar Foster?
    a. 2
    b. 3
    c. 4

2. Hoe heet het vliegveld?
    a. JFK Airport
    b. Lincoln Airport
    c. Idlewild Airport

3. Welk cadeautje wil meneer Foster mee wil geven voor zijn dochter?
    a. Een spiegel
    b. Een kam
    c. Een haarspeld

4. Hoeveel weken is mevrouw Foster in Parijs?
    a. 4
    b. 6
    c. 8

5. Waar belt mevrouw Foster de liftreparateur?
    a. In het kantoor van haar man
    b. In de keuken
    c. In de gang