**Tablets and Adolescent Readers: Does Digital Medium Affect Processing, Comprehension, and Calibration?**

**Abstract**

Recent meta-analyses of studies mainly involving higher education students show that reading comprehension is higher on paper than on screen for informational texts. Only few studies are available on younger students, which are increasingly involved with digital texts in learning context. This study aims to investigate the effect of reading medium (paper vs. tablet) on processing time, text comprehension and calibration of performance in lower secondary school students. In addition, the interaction between medium and different levels of reading comprehension ability is considered. Eight graders (N = 150) read two informational texts, one on paper and the other on a tablet screen. Reading time was recorded and text comprehension was assessed through open-ended questions. At the end, participants were asked to self-evaluate their comprehension performance. Calibration bias was the difference between their evaluation and the actual performance. Results showed that young adolescents performed better in the comprehension task and their calibration bias was lower when they read the text on paper rather than on a tablet. There was no difference between mediums in processing time. Interestingly, no significant interaction effect between medium and reading comprehension ability emerged. Therefore, the screen inferiority affected likewise all participants, regardless of their level of reading comprehension ability.

**Summary**

**Theoretical Framework**

Over the last two decades, printed texts are increasingly been complemented or replaced by digital texts at all educational levels. The actual Covid-19 pandemic situation and the resulting shift toward distance learning have only accelerated the process. Therefore, it is urgent to gain research-based knowledge about how the processes and outcomes of reading comprehension may vary across the two mediums, especially in younger students.

Three recent meta-analyses on the effects of reading medium showed how reading on paper determined a greater comprehension of text contents compared to reading on screen, especially when expository or informative texts were involved (Clinton, 2019; Delgado et al., 2018; Kong et al., 2018). Delgado et al. (2018) highlighted as screen inferiority effect increased in the past years rather than decreased. No difference related to reading medium was found for reading time (Clinton, 2019; Kong et al., 2018). Theoretically, a plausible explanation for the screen inferiority effect is the shallowing hypothesis (Annisette & Lafreniere, 2017). It assumes that students engage in a more superficial information processing when reading on screen because they are used to quick and immediately rewarding interactions with digital devices. Therefore, difficulties emerge when they engage in task requiring sustain attention, such as text comprehension tasks.

Clinton (2019) found that digital medium negatively affected metacomprehension accuracy, considered in terms of calibration, that is, the correspondence between readers’ ability to self-evaluate their own performance and their actual performance on a reading task (Schraw et al., 1993). This might be related to increased mind wandering during reading on screen, which means that thoughts unrelated to the task at hand (Smallwood, 2003) occurs more frequently and makes it more difficult to maintain a focus on metacomprehension (Delgado & Salmerón, 2021).

The general aim of this study was to extend current knowledge focusing on lower secondary students, which are mostly overlooked by studies in this field but daily use digital texts for learning. Only few studies are available on the effect of reading medium among secondary school students (Eyre et al., 2017; Goodwin et al., 2020; Simian et al., 2016), while most of the studies reviewed in the meta-analyses above mainly involved undergraduate students. We also aimed to shed light on the potentially interesting interaction effect between reading medium and different levels of reading comprehension ability. To the best of our knowledge, only Støle et al. (2020) investigated the effect of medium on the performance while considering different levels of reading skills in children, showing that the negative effect of digital medium was more pronounced in students with higher comprehension skills.

Four research questions guided this study: does reading medium affect (1) reading time, (2) text comprehension, and (3) calibration of comprehension performance in lower secondary school students? (4) Does the level of comprehension ability moderate the effect of reading medium on the outcome variables? Based on the literature, we could expect longer reading times when using tablet than for paper-based reading (Simian et al., 2016). On the other hand, based on the Clinton’s meta-analysis (2019), we could expect no significant difference in reading time between the two mediums. We hypothesized a negative effect of digital reading medium on text comprehension and calibration. Therefore, we could expect lower comprehension score, associated with an increased tendency to overestimate their one’ performance, when reading on screen rather than on paper. In addition, we hypothesized that poorer readers would be more disadvantaged that their peers with higher reading skills when reading on screen.

**Method**

Participants were 150 eight-grade students (F = 89, M = 13.50), involved in a within-subjects design. Each student read two different informational texts (length range: 381- 467 words), one on paper and the other on a tablet screen. Each text was presented on a single page, to avoid the need to turn page or scroll down to read the entire text. Reading time was recorded and comprehension assessed with open-ended questions (mean inter-judge agreement: *r* =.96). Calibration was computed as the difference between post-diction metacognitive judgment and actual performance. Topic knowledge and reading comprehension ability were assessed as control variables. Based on students’ performance in the standardized Italian test (MT) (*ω* = .77), we considered three different levels (low, medium, high) of reading comprehension ability.

**Results**

Descriptive analyses are presented in Table 1. To answer the research questions, we run a series of linear mixed models (LMMs). The fixed part of model included medium (print vs. digital), levels of reading comprehension ability and their interaction. Gender and topic knowledge were included as control variables. Class and school were added as random effects. Conditional R2 and marginal R2 ranged from .58 to .67 and from .06 to .18, respectively.

The LMMs are presented in Table 2. For reading time, no main effects or interaction medium x levels of reading comprehension ability emerged. For comprehension, the main effects of medium and levels of reading comprehension ability, but not the interaction, emerged. There was a statistically significant decrease in the score for comprehension of 0.66 points when reading digitally. In addition, participants with a medium and high level of ability scored 0.17 and 0.12 points more, respectively, compared to those with lower skills, regardless of reading medium.

For calibration, only the main effect of different level of comprehension ability emerged: the calibration bias of students with medium or high comprehension skills was statistically significantly lower than those with lower skills, regardless of reading medium.

**Discussion**

Findings partially confirm our hypotheses and are aligned with results of research involving older students. Lower secondary school students achieved better comprehension when reading on paper than when reading on screen. Moreover, participants were better calibrated when self-evaluating their comprehension after reading on paper than after reading on tablet. No differences emerged for reading time. The absence of significant interactions between medium and reading comprehension skill highlight as, regardless of the level of reading comprehension ability, young adolescents better comprehend and evaluate their performance when reading on paper rather than on screen.

The observed inferiority of digital reading could be explained by the shallowing hypothesis: students with different levels of comprehension skills perform less well on a demanding reading task on screen than on paper because they tend to adopt the same relaxed and superficial interaction approach with digital devices even in school tasks that require deeper comprehension (Annisette & Lafreniere, 2017).

Table 1

*Descriptive Statistics for All Variables for the Entire Sample and by Medium (N = 150)*

|  |  |  |  |
| --- | --- | --- | --- |
| Control variables | | | |
|  | *M (SD)* | *Skewness (SE)* | *Kurtosis (SE)* |
| Reading comprehension ability | 14.52 (4.28) | -0.73 (0.20) | 0.25 (0.39) |
| Topic knowledge | 1.16 (0.54) | 0.37 (0.20) | -0.47 (0.39) |
| Print | | | |
|  | *M (SD)* | *Skewness (SE)* | *Kurtosis (SE)* |
| Reading time | 556.47 (216.14) | 0.81 (0.20) | 0.12 (0.39) |
| Comprehension | 4.62 (2.70) | 0.24 (0.20) | -0.63 (0.39) |
| Calibration bias | 3.89 (1.89) | -.12 (0.20) | 0.35 (0.39) |
| Digital | | | |
|  | *M (SD)* | *Skewness (SE)* | *Kurtosis (SE)* |
| Reading time | 550.34 (259.92) | 0.59 (0.20) | -0.18 (0.39) |
| Comprehension | 4.07 (2.58) | 0.44 (0.20) | -0.50 (0.39) |
| Calibration bias | 4.32 (1.74) | -0.53 (0.20) | -0.08 (0.39) |

Table2

*Effects of Reading Medium and Control Variables on Reading Time, Comprehension, and Calibration of Performance (with Interaction Effect between Medium and Reading Comprehension Ability)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Model 1: Reading Time** | | |  | **Model 2: Comprehension** | | |  | **Model 3: Calibration** | | | | | |
|  | ***B*** | ***CI*** | ***p*** |  | ***B*** | ***CI*** | ***p*** |  | ***B*** | | ***CI*** | | ***p*** | |
| **Fixed Effects** |  |  |  |  |  |  |  |  |  | |  | |  | |
| (Intercept) | 444.84 | 324.01 – 565.66 | **<.001** |  | 2.01 | 0.88 – 3.13 | **.001** |  | 4.40 | | 3.65 – 5.15 | | **<.001** | |
| Medium [D] | -34.15 | -98.22 – 29.92 | .295 |  | -0.66 | -1.30 – -0.02 | **.044** |  | 0.25 | | -0.25 – 0.75 | | .321 | |
| Gender [F] | 87.87 | 31.85 – 143.90 | **.002** |  | 1.18 | 0.50 – 1.85 | **.001** |  | -0.63 | | -1.14 – -0.11 | | **.017** | |
| Topic knowledge | 58.03 | 1.11 – 114.94 | **.046** |  | 0.82 | 0.14 – 1.50 | **.018** |  | 0.47 | | -0.02 – 0.97 | | 0.62 | |
| Reading comprehension ability [Medium] | -14.54 | -90.16 – 61.07 | .705 |  | 1.19 | 0.32 – 2.06 | **.007** |  | -0.86 | | - 1.52 – -0.20 | | **.011** | |
| Reading comprehension ability [High] | -41.38 | -142.98 – 60.23 | .424 |  | 1.70 | 0.53 –2.87 | **.005** |  | -1.27 | -2.16 – -0.38 | | **.005** | |
| Medium [D] x Reading comprehension ability [Medium] | 36.56 | -43.39 – 116.51 | .369 |  | 0.17 | -0.63 – 0.97 | .672 |  | 0.26 | | -0.36 – 0.89 | | .407 | |
| Medium [D] x Reading comprehension ability [High] | 48.67 | -55.23 – 152.57 | .357 |  | 0.12 | -0.92 – 1.16 | .817 |  | 0.21 | | -0.60 – 1.02 | | .614 | |
|  |  |  |  |  |  |  |  |  |  | |  | |  | |
| **Random Effects** |  |  |  |  |  |  |  |  |  | |  | |  | |
| σ2 | 23313.77 |  |  |  | 2.33 |  |  |  | 1.42 | |  | |  | |
| τ00 ID | 15450.72 |  |  |  | 2.83 |  |  |  | 1.68 | |  | |  | |
| τ00 Class | 15835.76 |  |  |  | 0.62 |  |  |  | 0.01 | |  | |  | |
| ICC | 0.57 |  |  |  | 0.60 |  |  |  | 0.54 | |  | |  | |
| Marg. *R2* /Cond. *R2* = 0.056 / 0.597 | | |  |  | Marg. *R2* /Cond. *R2* = 0.183 / 0.671 | | |  | Marg. *R2* /Cond. *R2* = 0.087 / 0.584 | | | | | |