

Did screen reading steal children's focus? Longitudinal associations between reading habits, selective  
attention and text comprehension

Ladislao Salmerón <sup>1</sup>, Lidia Altamura <sup>1</sup>, Mari Carmen Blanco-Gandía <sup>2</sup>, Amelia Mañá <sup>1</sup>, Sandra  
Montagud <sup>1</sup>, Mario Romero <sup>1</sup>, Cristina Vargas <sup>1</sup>, Laura Gil <sup>1</sup>

<sup>1</sup> University of Valencia, <sup>2</sup> University of Zaragoza

[ladislao.salmeron@valencia.edu](mailto:ladislao.salmeron@valencia.edu)

Manuscript accepted for publication 17/03/2025 at Journal of Reading Research. Please check the  
original reference at <https://doi.org/10.1111/1467-9817.70003>

- data availability statement

Anonymized data will be available from the authors upon request. Data will be made available through the open repository OSF upon completion of the project (expected 2025).

- funding statement

Funding for this research was provided by Grant PID2020-118512GB-I00 funded by MCIN/AEI/10.13039/501100011033, financed by the Ministry of Economy and Competitiveness of the Spanish Government.

- conflict of interest disclosure

The authors report there are no competing interests to declare.

- ethics approval statement

The project was approved by the Research Ethics Commission of the University of Valencia (reference # 1894095). APA ethical standards and the guidelines of the Helsinki Protocol were followed in conducting the study. Parents or legal guardians signed an informed consent form for each of the two measurement times.

- permission to reproduce material from other sources

We didn't use material from other sources.

- Acknowledgements

We would like to thank Deborah Angoli, Vivian Sánchez, Antra Angena, and Irene García for their support on data collection, Pablo Delgado, Luís Ramos, Victoria García and Johannes Naumann for their fruitful discussions about the results, and the participating schools and students for their time and effort.

### **Abstract**

**Background:** The idea that screens “stole children’s focus” and that reading books, in contrast, stimulates selective attention, is theoretically complex and has largely been ignored in empirical tests. Research has identified positive associations between reading habits and various dimensions of attention in children, but most research is restricted to book or print reading habits, with limited evidence for digital habits.

**Methods:** We tested the assumption that selective attention (students’ ability to focus on relevant information and to ignore distractors) may mediate the relation between print and digital reading habits and comprehension in a longitudinal study that analyzed 654 4th and 635 5th grade students at the end of their school year (T1), and one year later (T2).

**Results:** Overall, and contrary to our expectations, the longitudinal associations for reading habits in T1 to selective attention and reading comprehension in T2 were mostly null. Digital reading habits for academic purposes in T1 were negatively associated with reading comprehension in T2, for students assessed from 4th to 5th grade, but not those from 5th to 6th grade. In addition, students’ selective attention was positively associated with reading comprehension.

**Conclusions:** To conclude, we discuss the need to search for mediators other than selective attention on the associations between reading habits and comprehension, and highlight the need to identify key developmental milestones during Primary school that may be accomplished to be ready to take full advantage of digital reading practices.

**Keywords:** reading habits; digital reading; comprehension; selective attention; Primary school

### **Implications for practice**

#### **What is already known about this topic**

- Children's print reading habits improve their reading comprehension skills.
- Children's digital reading habits do not pay off in terms of reading comprehension.
- Children's selective attention are positively associated to their reading comprehension.

#### **What this paper adds**

- The study evaluates the long-term effects of children's reading habits on their selective attention and comprehension.
- The results indicate that children's reading habits do not predict changes in selective attention one year later.
- Children's academic digital reading habits in 4<sup>th</sup> grade negatively predict reading comprehension skills in 5<sup>th</sup> grade.

#### **Implications for theory, policy or practice**

- In Primary education, academic digital reading activities must be introduced with caution.
- It is important to develop school programs that help students maximize their focus on relevant information and ignore distractors while reading.

The last decade has seen rapid digitisation at all levels of our daily lives, including reading. Such change has come with relevant educational implications. Recent meta-analyses evidence a small effect favoring print over screen reading comprehension (Clinton, 2019; Delgado et al., 2018; Salmerón et al., 2024). The exact conditions and causes to explain when

and why this effect occurs are not yet clearly identified. A common assumption is the shallowing hypothesis, the idea that as readers interact with digital media they develop a mindset favoring rapid, short, and immediate gratification consumption of information (Annisette & Lafreniere, 2017). Such mindset, developed through extensive practice with digital devices, may prevent readers from engaging in the kind of deeper processing associated with advanced reading comprehension processes (Baron, 2015). In this study we test the digital chain hypothesis (Wolf, 2018), that considers that selective attention (students' ability to focus on relevant information and to ignore distractors) mediates the association between digital reading habits and comprehension in children.

The digital chain hypothesis by Wolf (2018) describes the multiple steps that link digitalization with readers' decreases in focus and comprehension. This hypothesis considers that in order to cope with the current unprecedented increase of information from the Internet, people have reacted by reshaping their reading habits that have become “rarely continuous, sustained, or concentrated” (p. 73). Such habits do not support focus anymore, as readers must cope with “attention-dividing bombardment by multiple sources of information” (p. 82) and may lack an “ability to give sufficient time to unpacking the multiple layers of meaning in words” (p. 82), as this would interfere with the need to process large amounts of sources. In turn, digital publishers react to this changing scenario by creating new short and simplified texts to accommodate the needs of such reader, “whose typical skimming style is ill suited to long, densely worded texts, to complex thoughts not easily (or quickly) grasped, or to words deemed less than necessary” (p. 84). According to this hypothesis, such change would then prevent young readers exposed to digital materials to fully develop their ability to focus during reading, as current digital texts may not require to selectively pay attention to relevant information for long periods of time.

The idea that screens “stole children’s focus” and that reading books, in contrast, stimulates selective attention, is theoretically complex and has largely been ignored in empirical tests. Accordingly, we need to articulate the reciprocal associations between reading habits, selective attention and reading comprehension skills. In the next sections we delineate such proposal, referring to previous literature on each of those associations. We will then test some of the predictions outlined in a longitudinal study that analyzed 4th and 5th grade students’ digital and print reading habits, selective attention and reading comprehension as measured by a traditional paper and pencil task.

### **Reading habits and reading comprehension skills**

A large body of literature has looked at the association between reading habits and reading comprehension skills. Reading habits, usually conceived as the frequency of reading for leisure or academic purposes, are positively associated with the development of reading comprehension skills across the lifespan (Mol & Bus, 2011; Stanovich, 1986). Of note is that most studies linking reading habits and comprehension have used traditional paper and pencil measures for measuring reading comprehension. Accordingly, in the remaining sections we will use the term reading comprehension to refer to the skills assessed with paper and pencil tasks.

By engaging in book reading, children are exposed and learn new vocabulary and other relevant linguistic aspects. They also learn world knowledge about different disciplines. Those factors contribute to the development of advanced reading comprehension skills, such as making sense of text by identifying its relevant ideas and connecting them with other ideas from the text or prior knowledge (Kintsch, 1998). In turn, children who are good readers tend to engage in more frequent book reading than poor readers, which contributes to their faster development of reading comprehension skills (Pfoest et al., 2014; Stanovich, 1986).

Most of our knowledge about the reciprocal relationship between reading habits and the development of reading comprehension skills comes from studies that have analyzed exposure to printed texts (Altamura et al., 2025b). The irruption of digital reading devices and practices raises the question if such positive association between print and comprehension would hold in the digital domain. In principle, there is no reason to believe that digital reading habits would exert a different influence on reading comprehension skills as that of printed texts, as in the end readers would be exposed to texts, regardless of the medium. Alternatively, from the lenses of the shallowing hypothesis (Annisette & Lafreniere, 2017), we can expect that readers' exposure to digital texts would result in more shallow reading episodes. Consequently, it is plausible that the association between digital reading habits and reading comprehension skills would be lower than that observed for printed texts. As digital tools encourage quick and short interactions with information, readers often adopt a rather shallow processing that allows them to maximize their coverage of information, to the expense of a deep understanding (Baron, 2015). Recent metaanalytical evidence supports that idea. Altamura et al. (2025b) analyzed 25 studies (39 effect sizes) which had measured leisure digital reading habits (in terms of frequency) and reading comprehension skills. The overall association was significant and of small-size ( $r = .055$ ), and it turned null in Primary school children. It should be noted that only 2 studies analyzed the association between digital reading habits and reading comprehension skills in Elementary/Primary school (1st-5th grade).

The digital revolution has introduced changes not only on the devices and reading practices, but also in the different reading practices, such as reading social media. Thus, one could argue that the small association between digital reading habits and comprehension could be just one of current digital leisure reading habits, which do not favor a more linguistically rich long-form reading (Hakemulder & Mangen, 2024). A stronger test for the

shallowing hypothesis could include other reading practices less prone to societal changes, such as academic reading. Following this rationale, Vargas et al. (2024) recently analyzed the combined association of print and digital reading habits, and reading comprehension skills in a large sample of Primary school students (grades 4th to 6th grade), following a correlational design. While academic digital reading habits (e.g. time reading digital textbooks, or searching the Web to understand better a topic) were negatively associated with reading comprehension skills ( $r = -.116$ ), leisure print reading habits (e.g. time reading fiction books on paper) were positively related ( $r = .079$ ) (see Torppa et al., 2021, for a similar pattern of results). In sum, evidence suggests that, across a variety of practices, including leisure and academic reading, print habits tend to be more positively related to reading comprehension skills than digital habits.

According to the digital chain hypothesis (Wolf, 2018), a possible causal mechanism for the null or negative influence of digital reading habits on students' ability to comprehend texts is selective attention. As we have anticipated, such relations could be reciprocal, from reading habits to selective attention, as well as from selective attention to reading comprehension. In the following we analyze current evidence for both possibilities, considering the critical role of reading media (print vs. digital).

### **The role of reading habits on the development of selective attention**

Inherent to the critique that digital reading habits interfere with children's development of selective attention is the idea that print reading habits support its development. Despite there being no single definition that fully captures the conceptual scope of attention, it is generally agreed that attention is a multidimensional construct that serves several subfunctions related to information processing. The Attention Networks model, an influential model by Posner (Posner & Petersen, 1990; Posner & Rothbart, 2007), identifies



the following subfunctions: alert and vigilance (state of high sensitivity to stimuli), selective orientation of attention (selection of relevant information among competing irrelevant stimuli), and executive attention (functions for monitoring and resolving conflicts among thoughts). The tripartite executive functions (EF) model by Miyake et al. (2000) further extends executive attention into three subfunctions: inhibition (ability to override dominant responses), shifting (ability to shift attention between stimuli), and updating (ability to update information on working memory). More recent models make a distinction between two types of inhibition: interference control and response inhibition (Diamond, 2013).

Research on the development of attention and EFs reveal that this tends to be a gradual and multistage process. Attention tend to see quick and gradual developments beginning in infancy until approximately age 10, with subsequent slower improvements until adolescence (Betts et al., 2006; Klenberg et al, 2001; Korkman et al., 2001, 2013). EFs follow a different pattern, with inhibition reaching a maturity level early at infancy, while other more complex EFs develop at least until adolescence (Klenberg et al, 2001; Korkman et al., 2013; Theodoraki et al., 2020).

In her description of the digital chain hypothesis, Wolf (2018) emphasizes the negative impact of digitalization on students' ability to focus while reading. From the Attention Networks model (Posner & Petersen, 1990; Posner & Rothbart, 2007), focus can be conceived as a high-order cognitive process that involves both the alert and orienting networks (Fischer, 2019). This is because focus requires that readers selectively attend to relevant information from a text for a prolonged period of time. Those functions have been referred to in the scientific literature using different terms, such as focused attention, sustained attention, and selective sustained attention (Fischer, 2019).

Different research lines have explored the associations between reading habits and attention networks, with a disproportionate number of studies focusing on the impact of print reading habits (but not digital reading habits). Within this research line, studies tend to measure either inhibition, assessed as the ability to inhibit a response to an infrequent stimulus in the context of a long, monotonous task, or selective orientation of attention, as the ability to focus on relevant information and to ignore distractors (McAvinue et al., 2012).

Extensive and frequent print reading has the potential to positively influence the development of children's attention, as they can be trained by concentrating on reading or listening to adults reading stories. Few studies have analyzed the association between print reading habits and attention in children (Davidse et al., 2011; Koolstra & van der Voort, 1996; Rosenqvist et al., 2016). Rosenqvist et al. (2016) analyzed habits and attention of 381 typically developing 5 to 12-year-old children. Parents reported their child's media consumption habits. Of particular interest is the indicator of print reading habits ("How many hours per week does the child read at home?") Attention were measured with the standardized battery NEPSY-II (Korkman et al., 2017), which included several subtests such as animal sorting, auditory attention, and inhibition. Bivariate correlations showed a significant and small association between attention and print exposure ( $r = .16$ ), which was only significant in the younger students, supporting the critical role of attention in developing readers. Davidse et al. (2011) studied 228 4-year-old children. Reading habits were assessed by a storybook-cover recognition task, and attention was evaluated with the Amsterdam Neuropsychological Tests (De Sonneville, 2005), a computerized test that presented animals one by one. Children were told to click only when a cat appeared. The number of correct responses (corrected for false alarms and missing) was used as a key indicator of inhibition. The bivariate correlation between both variables was significant but small ( $r = .13$ ). Koolstra and van der Voort (1996) followed 1050 children from 2th-4th grade for a period of three

years. Print reading habits were measured with a self-reported book reading frequency questionnaire (e.g. “When you are on vacation, do you often, sometimes, or never read books?”). Attention was measured using a questionnaire about children’s perceived concentration during reading (e.g. “When I start to read a new book, I’m totally involved after reading a few pages”). Results showed small positive longitudinal associations ( $r_s = .14$ ) between print reading habits in one year, and perceived attention one year later. In sum, studies point to a small positive association between print reading habits and attention networks in young children. This association may be stronger than that found for older students, as beginning readers may need to selectively focus on relevant words of the text to properly decode its meaning. As reading development progresses, selective focus on decoding can be automatized (Walczyk, 2000).

To the best of our knowledge, no prior study has looked at the association between digital reading habits and selective attention in children. Contrasting with such absence, an extensive body of research in media studies has analyzed the associations between media exposure and attention networks. Digital reading habits include not only static texts that mirror print-based reading, but they also involve dynamic and interactive reading activities that go beyond what is possible in print. These activities, such as navigating the internet and engaging in social communication, are inherent to digital devices. To fully understand contemporary reading habits, researchers must consider this spectrum, acknowledging that digital reading is shaped by technological affordances and the socio-cultural contexts in which it occurs (McKenna et al., 2012). In this study, we specifically address digital reading habits, considering the similarities and differences with print reading habits.

Although the differences between digital reading habits and media consumption are huge, there are similarities in the rationale used to analyze its potential effects on attention

networks. From this body of research, the fast-paced presentation of media such as TV or videogames, characterized by the use of cuts and edits, might prevent the development of selective attention at the expense of promoting a discontinuous scan-and-shift style. Nikkelen et al. (2014) meta-analyzed results from 45 empirical studies to test an association between media consumption (TV or videogames) and ADHD-related behaviours. The original studies focused either on clinical populations of ADHD or that measured continuous measures of ADHD-related behaviours, such as attention difficulties. Authors found a small negative association ( $r = -.12$ ) between media consumption and ADHD-related behaviours. This small-size association has been largely replicated in more recent reviews (Beyens, et al., 2018; Kostyrka-Allchorne et al., 2017; Vedeckina & Borgonovi, 2021). Similarly, such effect has been reported with longitudinal designs that allow to identify the potential causal role of media consumption on attention difficulties (Baumgartner et al., 2018; Boer et al., 2020; Gueron-Sela & Gordon-Hacker, 2020; Tamana et al., 2019; Ra et al., 2018; Thorell et al., 2022). In sum, the absence of research on the effects of digital reading habits and selective attention prevents us from making strong claims about their association. Looking at media consumption research, evidence supports a small negative association between digital media exposure and selective attention (Nikkelen et al., 2014). Some characteristics of digital media identified as responsible for attention difficulties, such as quick interactions, constant information shifts, and fast pace of information, can be present in several digital reading scenarios, such as when reading a news report in an online newspaper. Accordingly, one could argue that the negative associations with selective attention observed in media consumption studies could be present in digital reading habits as well. We will test this hypothesis in our study. Before that, in completing the anticipated review, in the following we discuss the association between selective attention and reading comprehension.

### **The role of selective attention on reading comprehension**

Selective attention is necessary to comprehend texts because, while reading, children need to selectively focus on main ideas from the text while updating their ongoing representation by making connections with information previously presented in the text (Anderson, 1982; Kintsch, 1998; van den Broek et al., 1999). In addition, readers must inhibit irrelevant information, which prior work has shown to be important for successful reading comprehension (Gernsbacher, 1993).

Recent metaanalyses suggest that attention networks, measured both as skills (Follmer, 2018) and as a process during reading (Bonifacci et al., 2023), and reading comprehension are significantly associated. Follmer (2018) meta-analyzed the association between students' attention networks and reading comprehension in a large set of primary studies, which added to 96 correlations and 6673 participants. Average effect resulted in a moderate positive association between attention and comprehension ( $r = .36$ ), which did not vary as a function of age range or type of measure used to assess participants. Recent follow-up studies have identified that the positive association between attention and reading comprehension is independent of participants' disability (Segal, 2023) or socio-economic status (Gallen et al., 2023). Bonifacci et al. (2023) synthesized primary studies that analyzed the association between mind wandering, defined as a shift in attention away from an ongoing task, and reading comprehension. Data from 73 correlations and 3926 participants yielded a small negative pooled correlation ( $r = -0.21$ ), indicating that higher mind wandering during reading is related to lower comprehension. These studies highlight the importance of selective attention on reading comprehension, our study will delve into the longitudinal associations between these two cognitive skills.

### **The current study**

As we have reviewed so far, the different associations between reading habits, selective attention and reading comprehension, as a function of reading media (print vs. digital), have attracted different degrees of research interest. Meta-analytical evidence supports a positive relationship between print reading habits and reading comprehension among children and adolescents (Mol & Bus, 2011). Such association is weaker, or even negative, when it comes to digital reading habits (Altamura et al., 2025b; Salmerón et al., 2023; Torppa et al., 2021). Central to our study, we propose that students' skill to selectively attend to relevant information while ignoring irrelevant ones may mediate those relationships. The positive association between reading habits and selective attention in children is supported by several studies (Davidse et al., 2011; Koolstra & van der Voort, 1996; Rosenqvist et al., 2016), although research has only explored this link for print reading habits. Related research on the association between media consumption and attentional difficulties (Beyens, et al., 2018; Kostyrka-Allchorne et al., 2017; Nikkelen et al., 2014; Vedeckina & Borgonovi, 2021) may suggest a potential negative association between digital reading habits and selective attention, that nevertheless, still needs to be tested empirically. Finally, research has identified a robust positive association between attentional networks and text comprehension skills (Bonifacci et al., 2023; Gallen et al., 2023; Follmer, 2018; Segal, 2023).

Critically, to our knowledge no previous research has explored all those relationships in combination. To this end, we conducted a longitudinal study where a large sample of 4th and 5th grade students were assessed twice, one year apart. We assessed their leisure and academic reading habits in print and on digital in the first year and used these scores to predict their selective attention and reading comprehension one year later. Specifically, we expected a positive longitudinal relation between leisure and academic print reading habits in year 1 (T1) and comprehension skills in year 2 (T1) (hypothesis 1) (Mol & Bus, 2011) and a negative longitudinal association between digital reading habits in T1 and comprehension

skills in year T2 (hypothesis 2) (Torppa et al., 2021). In addition, we expected that the above relations would be mediated by selective attention in T2 (hypotheses 3 & 4, for print and digital habits, respectively).

Of note is that in an attempt to generalize students' reading habits we measured both leisure and academic reading habits. Nevertheless, we did not have different expectations based on the specific purpose of the reading habits.

Finally, in our study we aimed to control for relevant factors that may play important roles in the model, including comprehension and attentional skills in T1, students' socio-economic and disability status, as well as classroom effects.

## **Method**

### *Participants*

Our sample consisted of 1289 Primary school students from 4th ( $n = 654$ , *Age range at T1*: 9-10, 51.8% girls) and 5th grade ( $n = 635$ , *Age range at T1*: 10-11, 51.0% girls). 15 schools from Valencia (Spain) collaborated, of which 5 were public schools, 7 private schools that receive public funds, and 3 fully private schools. Schools varied widely in terms of families' socio-economic status (SES): while private schools usually accommodate students from medium-high SES families, public schools receive students from low-medium SES families. 6 schools were located in large cities of the region ( $> 50.000$  inhabitants), 5 in medium size cities (20.000-50.000 inhabitants), and 5 in small villages ( $< 20.000$  inhabitants). The Spanish education system requires a comprehensive approach, which includes accommodating students with special education needs (SEN) in all schools. In addition, one of the participating public schools specialized in providing specific support to students with SEN, particularly those from socio-economically disadvantaged backgrounds. In our sample, schools varied greatly in the degree to which they introduced technology in the classroom.

Some schools provided one-to-one tablets to students from early Primary school years, while others avoided introducing technology at all during Primary school. Such policies regarding technology were idiosyncratic to each school. According to the recent ICILS 2023 report (Fraillon, 2024) Spanish adolescents, compared to international average, use technology for schoolwork within schools at average levels, and outside schools at significantly higher levels.

Students were measured twice, at the end of their school year. The first measurement (T1) took place between March and June 2022, and the second (T2) approximately 12 months later. Initially, 1533 students participated in T1. Data from 244 participants in T2 could not be retrieved. Dropout could be due to students' change of school, not being present during T2, or being held back a grade at T2. In addition, 11.3% of the final sample had a diagnosed or duly reported SEN (e.g. learning disabilities, curricular adaptations, foreign language...). They were included in the analyses, and disability status (yes/no) was included as a covariate in the models.

The project was approved by the Research Ethics Commission of the University of Valencia (reference # 1894095). APA ethical standards and the guidelines of the Helsinki Protocol were followed in conducting the study. Parents or legal guardians signed an informed consent form for each of the two measurement times.

#### *Reading comprehension test*

The ACL tests (Català et al., 2001) were used to measure reading comprehension. The corresponding version was used for each grade. This paper and pencil test includes texts of different genres, including narrative, expository, and discontinuous texts. Questions are meant to tap different comprehension aspects: literal, inferences and evaluation. Literal questions requested the identification of ideas and facts explicitly mentioned in the text, including main ideas, a sequence of events or the cause and effect of a phenomenon.



Inferential questions asked students to integrate pieces of text information or to combine information in the text with prior knowledge, or to make predictions based on text content. Finally, evaluative questions required critical judgments of information, including identifying facts from opinions, or judging the authors' intentions. Each test consists of 8 texts, with 3 to 5 multiple-choice questions with 5 alternatives for each text. The assigned score corresponds to the sum of the total number of correct answers. The maximum score that can be obtained in each test is 28 (4th grade), 35 (5th grade), and 36 (6th grade). High ordinal omega scores for our sample indicated very good reliability ( $\omega$  ACL 4th =.92,  $\omega$  ACL 5th =.90,  $\omega$  ACL 6th =.91). Additionally, anchoring items were used in the second measurement point: 6 items for the 5th grade test version and 7 items for the 6th grade test version were selected based on their discrimination capacity in the first measurement point.

#### *Selective attention test*

Students' selective attention was measured using the Perception of Differences Test - Revised (Thurstone & Yela, 2014). This paper and pencil test assesses the ability to quickly and correctly perceive and select relevant stimuli, while filtering distracting information. It consists of 60 graphic items, representing schematic drawings of faces with very elementary outlines (mouth, eyes, eyebrows and hair). The task is to determine which of the three faces is different and cross it out. Participants have 3 minutes to point out as many different faces as possible. The final score consisted of correct hits minus errors, with 60 being the maximum score. The test has been validated on a sample of 12,190 students, yielding high internal consistency ( $\alpha = 0.91$ ) (Thurstone & Yela, 2014).

We selected this test because it represented a good compromise between the adjustments to our theoretical approach, as selective attention is critical in identifying relevant ideas in the text and to avoid irrelevant ones, and the constraints of our data

collection approach in schools, as we needed a test that could be used simultaneously to assess small groups of students.

### *Reading habits questionnaire*

Reading habits were measured by assessing the frequency of two types of practices: leisure reading habits, which refer to activities students engage in voluntarily, without being told to do so; and academic reading habits, which involve out-of-school reading tasks prompted by teachers' requests or undertaken to study or complete homework at home. We employed the Multidimensional Reading Habits Instrument for primary school students (MRHI, Altamura et al., 2025a). This instrument contains two questionnaires, one per reading purpose: leisure and academic. Each questionnaire involves 8 items, half of them refer to print reading activities and half refer to digital reading activities (Table 1). Students answer on a 4-point scale: "Never or almost never", "Once or twice a month", "Once or twice a week", "Every or almost every day". The MRHI is a validated instrument with good internal consistency indices for both questionnaires, each distinguishing a print and digital factor (Leisure:  $RMSEA = .052$ , 90%  $CI [.043, .061]$ ;  $CFI = .900$ ;  $SRMR = .042$ ; Academic:  $RMSEA = .023$ , 90%  $CI [.013, .033]$ ;  $CFI = .986$ ;  $SRMR = .026$ ).

Table 1

Items for the leisure and academic reading habits questionnaire, for the dimensions in print and on digital devices.

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#### Leisure print habits

- Paper books on topics that interest me
- Fiction books on paper
- Comic books on paper
- Magazines on paper

Leisure digital habits

Books on tablet or e-book

On the Internet, to look for things that interest me

On the Internet, to communicate with other people

On the Internet, to receive and send emails (e-mails) to relatives or friends

Academic print habits

Fiction books on paper

School textbooks on paper

Worksheets that we have done in class

Exercises from my notebook

Leisure digital habits

School textbooks on Tablet or E-book

On the Internet, to look for information to do homework

On the Internet, to look for information to understand better an issue

On the Internet, to receive and send emails (e-mails) to teachers or classmates

*Procedure*

The assessment took place in the students' classroom in a session of approximately 90 minutes. All tests were completed individually as paper and pencil tasks. At least one researcher was present in each assessment. Pupils in each grade received the corresponding version of the reading comprehension test. Afterwards, participants received the selective attention test and the leisure reading habits questionnaire. This procedure was repeated in each of the two measurement times.

**Data Analyses**

Analyses were performed in R Statistical Software (v4.3.0; R Core Team, 2021), SPSS 28, and Mplus 8.10. To operationalize the reading comprehension performance, we carried out a Raasch model with the anchoring items to control for item difficulty in the reading comprehension assessment. As for selective attention, we used the direct scores, correct hits minus errors. We created composite scores of the two dimensions of leisure reading habits (the mean across items), which were included in the subsequent analysis to calculate descriptive statistics, and to check outliers (threshold of Z-score of 3 or -3). Mplus was used to address our hypotheses regarding whether selective attention at T2 functions as a mediator between reading habits at T1 and reading comprehension at T2. We employed Structural Equation Model (SEM) with a robust maximum likelihood estimation with robust standard errors (MLR). We used this estimator to account for non-normal distributions of observed variables (Muthén & Muthén, 1998, 2017). Selective attention at T1, socio-economic status at T1 (SES), SEN status at T1 and reading comprehension at T1 were included as control variables in the SEMs. The fit statistics used to evaluate the models were the Comparative Fit Index (CFI > .9), the Root Mean Squared Error of Approximation (RMSEA < .08), and the Standardized Root Mean Square Residual (SRMR < .08) (Bentler & Bonett, 1980; Hu & Bentler, 1999). The full information maximum likelihood (FIML) was used to handle missing data. In addition, because the students are nested within classrooms, we applied the *complex* option in Mplus to account for the possible dependencies (for instance, some classrooms could be more digitized than others). The cluster-robust standard errors allowed us to adjust for potential bias in standard errors. This modeling approach was found to be a more parsimonious way to account for the clustering than multilevel models in practical situations such as when the clustered data structure is not particularly interesting per se (McNeish, Stapleton, & Silverman, 2017).

## Results

## **Preliminary analyses**

Descriptive statistics are shown in Tables 2 (sample tested at 4th and 5th grade) and 3 (sample tested at 5th and 6th grade). Overall, students reported rather low levels of reading frequency for leisure purposes, particularly for print reading. Average scores corresponded to "Once or twice a month" for print reading, and in between "Once or twice a month" and "Once or twice a week" for digital reading. In both samples, print leisure reading significantly decreased from T1 and T2, while leisure digital reading increased (in all cases medium effect sizes). As for reading for academic purposes, frequency was also modest, and higher for paper than digital reading. Average scores corresponded to "Once or twice a week" for print reading, and in between "Once or twice a month" and "Once or twice a week" for digital reading. As for their evolution, digital academic reading significantly increased from T1 to T2 in both samples (medium and high effect sizes). Print academic reading also increased from T1 to T2 from 4<sup>th</sup> to 5<sup>th</sup> grade (medium effect size), but no significant changes were observed from 5<sup>th</sup> to 6<sup>th</sup> grade. Finally, average scores for the reading comprehension and selective attention tests fell within the normal range in both samples, with rather large variation among students. While selective attention scores increased substantially between T1 and T2, reading comprehension scores decreased from T1 to T2 (large effect sizes).

### **Table 2**

Descriptive statistics for the study variables, for students that were enrolled in 4th grade in T1 and in 5th grade in T2.

	T1		T2		<i>t</i>	<i>p</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Print leisure <sup>1</sup>	1.15	0.55	1.05	0.59	4.43	.001	.58
Digital leisure <sup>1</sup>	1.33	0.74	1.50	0.71	-5.71	.001	.74
Print academic <sup>1</sup>	1.99	0.59	2.11	0.54	-3.70	.001	.74
Digital academic <sup>1</sup>	1.14	0.71	1.36	0.72	-6.14	.001	.81
Reading comprehension <sup>2</sup>	5.84	1.90	4.78	2.15	14.80	.001	1.82
Selective attention	35.61	9.13	42.13	9.40	-19.77	.001	8.30

Note. <sup>1</sup>Reading habits scale: 0) "Never or almost never", 1) "Once or twice a month", 2) "Once or twice a week", 3) "Every or almost every day". <sup>2</sup>10-level standardized scale

Table 3

Descriptive statistics for the study variables, for students that were enrolled in 5th grade in T1 and in 6th grade in T2.

	T1		T2		<i>t</i>	<i>p</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Print leisure <sup>1</sup>	1.06	0.57	0.96	0.59	3.85	.001	.62
Digital leisure <sup>1</sup>	1.58	0.72	1.75	0.62	-5.25	.001	.72
Print academic <sup>1</sup>	2.06	0.56	2.05	0.57	.58	.28	.68
Digital academic <sup>1</sup>	1.37	0.71	1.59	0.72	-6.96	.001	.76
Reading comprehension <sup>2</sup>	5.37	2.17	4.82	2.29	6.98	.001	1.87
Selective attention	40.79	9.68	46.03	9.23	-16.95	.001	7.73

Note. <sup>1</sup>Reading habits scale: 0) "Never or almost never", 1) "Once or twice a month", 2) "Once or twice a week", 3) "Every or almost every day". <sup>2</sup>10-level standardized scale

Bivariate correlations between the study variables at T1 are shown in Table 4, for both samples. Of particular interest for our hypotheses was a significant positive and small association between selective attention and leisure and academic reading habits in print at T1, only for 4<sup>th</sup> grade students. No other significant associations between selective attention and

reading habits were found at T1. In addition, there were positive significant associations (small and medium) between selective attention and reading comprehension skills at T1, in both samples of 4<sup>th</sup> to 5<sup>th</sup> grade students.

Table 4

Bivariate correlations across study variables in T1 (4<sup>th</sup> and 5<sup>th</sup> grade)

*Note.* The lower triangle represents correlations for the first cohort (4<sup>th</sup> graders in T1), the upper triangle represents correlations for the second cohort (5<sup>th</sup> graders in T1). <sup>1</sup> Reading comprehension scores are WLEs from a Rasch model applied to the ACL test data from T1. \* $p < .05$ . \*\* $p < .01$ .

	SEN	SES	Selective attention	Reading Compreh.	Leisure print	Leisure digital	Academic print	Academic digital
SEN	--	-.03	-.13**	-.24**	.01	-.01	-.03	.07
SES	-.12**	--	.09*	.18**	.25**	-.11**	.03	-.08*
Selective attention	-.09*	.12**	--	.31**	.00	-.05	.01	-.01
Reading Compreh. <sup>1</sup>	-.31**	.26**	.25**	--	.08	-.10*	.06	-.14**
Leisure print	-.03	.21**	.13**	.12**	--	-.076	.17**	-.02
Leisure digital	.14**	-.07	.05	-.05	.04	--	.07	.48**
Academic print	-.14**	.04	.08*	.07	.24**	.09*	--	.14**
Academic digital	.05	-.06	.01	-.09*	.12**	.52**	.24**	--

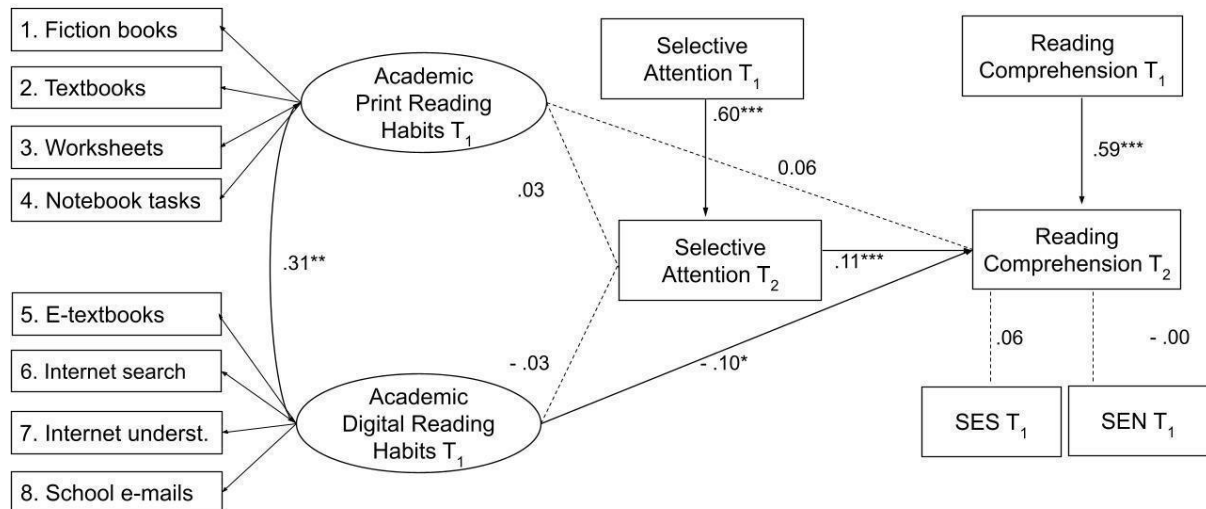
### Main analyses

In order to investigate the hypotheses, four SEMs were applied. The first two models were used to evaluate whether selective attention at T2 mediates the effect of print or digital

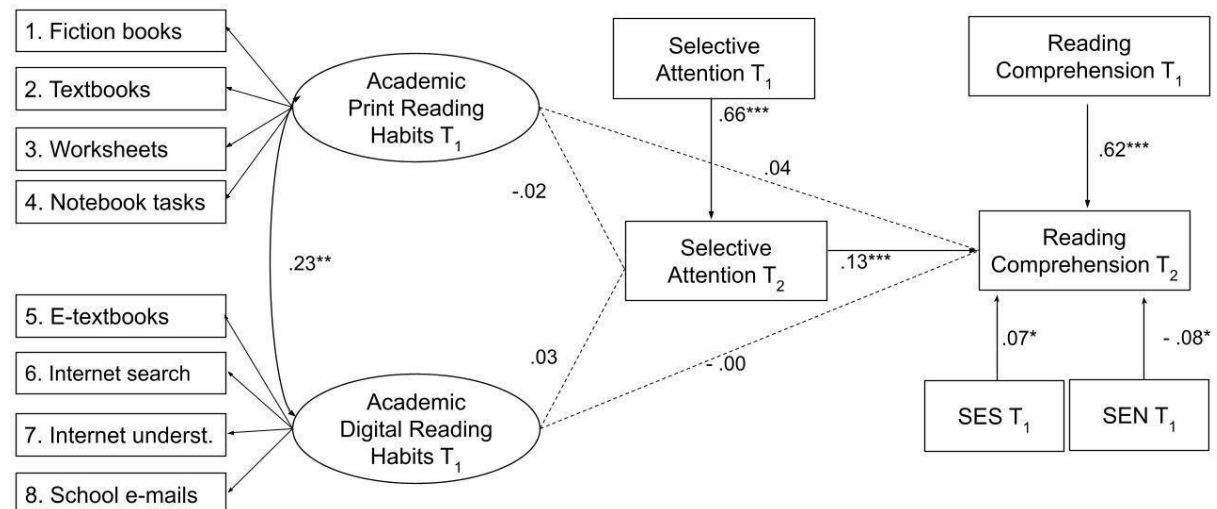


reading habits for academic purposes at T1 on reading comprehension at T2 in students from 4th to 5th grade (Model 1) and 5th to 6th grade (Model 2). Both models showed good fit indices to the actual data: a) Model 1 ( $CFI = .926$ ,  $RMSEA = .039$ ,  $SRMR = .054$ ); b) Model 2 ( $CFI = .934$ ,  $RMSEA = .044$ ,  $SRMR = .058$ ). Figures 1 and 2 give standardized structural parameter estimates for the models. Regarding Model 1, neither academic print nor digital reading habits were significant predictors of selective attention ( $\beta = .03$ ,  $p = .545$ ;  $\beta = .03$ ,  $p = .396$ , respectively). On the other hand, selective attention was a significant predictor of reading comprehension ( $\beta = .11$ ,  $p < .001$ ). Additionally, the indirect coefficient also was not significant for print ( $\beta = .00$ ,  $p = .547$ ) or digital reading habits ( $\beta = -.00$ ,  $p = .414$ ) for academic purposes. Finally, while print reading habits for academic purposes was not a significant predictor of reading comprehension ( $\beta = .06$ ,  $p = .205$ ), digital reading habits for academic purposes negatively predicted comprehension ( $\beta = -.10$ ,  $p = .029$ ). In regards to Model 2, that tested students from 5th to 6th grade, the overall pattern of results remained the same as in Model 1, that assessed students from 4th to 5th grade (see Figure 2). The one difference observed was that digital reading habits for academic purposes was not a significant predictor of reading comprehension ( $\beta = -.00$ ,  $p = .987$ ).

**Figure 1.** Standardized estimates of the effect of reading habits for academic purposes on reading comprehension, mediated by selective attention from 4th to 5th grade (Model 1).

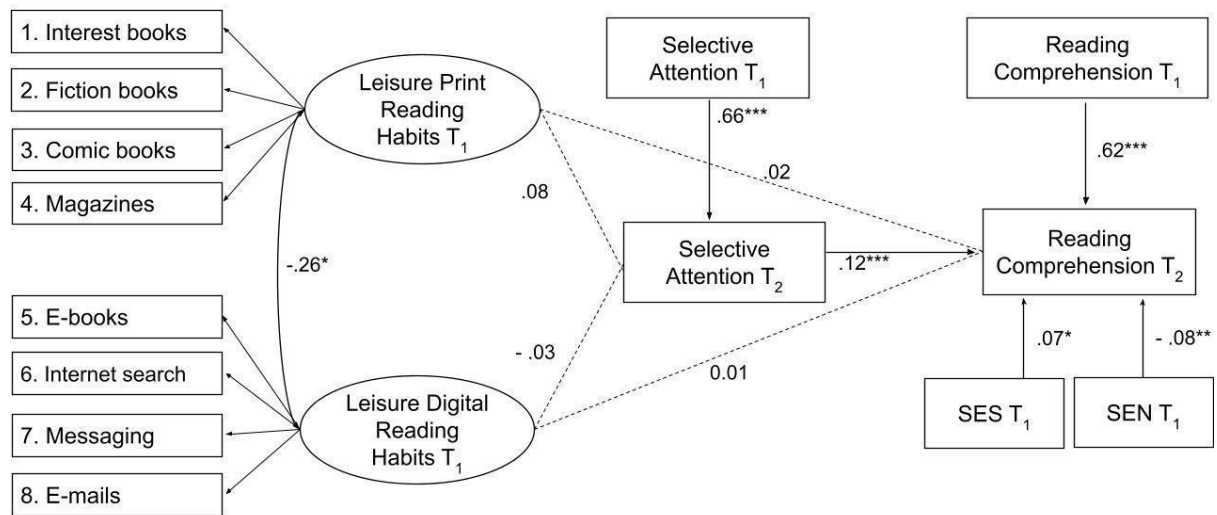


**Figure 2.** Standardized estimates of the effect of reading habits for academic purposes on reading comprehension, mediated by selective attention from 5th to 6th grade (Model 2).



Next, in addressing leisure reading habits, the other two models evaluated the mediating role of the selective attention between print or digital reading habits on reading comprehension in students from 4th to 5th grade (Model 3) and 5th to 6th grade (Model 4). Unfortunately, Model 3 did not show an acceptable model fit ( $CFI = .850$ ). For this reason, and in accordance with ethical reporting standards in structural equation modeling (Kline, 2023), which emphasize the importance of presenting only well-fitting models to ensure valid and reliable conclusions, we refrain from reporting any further results from this model. By contrast, Model 4 exhibited SEM fit indices suggesting a reasonable fit ( $CFI = .915$ ,  $RMSEA = .047$ ,  $SRMR = .057$ ). Figure 3 presents the standardized estimates for the Model 4. Overall, results from Model 4 were similar to those from Model 2, which only differed on the purpose of reading habits (academic vs. leisure). Specifically, leisure print and digital reading habits were not associated with selective attention ( $\beta = .08$ ,  $p = .187$ ;  $\beta = -.03$ ,  $p = .613$ , respectively). A positive association also was found between selective attention and reading comprehension ( $\beta = .12$ ,  $p < .001$ ). The direct effects of print ( $\beta = .02$ ,  $p = .778$ ) or digital reading habits for leisure ( $\beta = .01$ ,  $p = .811$ ) on reading comprehension were not significant. Like Model 2, the indirect effects for print ( $\beta = .01$ ,  $p = .209$ ) or digital reading habits for leisure ( $\beta = -.00$ ,  $p = .617$ ) on reading comprehension through the mediating effect of selective attention were not significant.

**Figure 3.** Standardized estimates of the effect of leisure reading habits on reading comprehension, mediated by selective attention from 5th to 6th grade (Model 4).



In sum, against our expectations, our SEM analyses did not evidence the expected relation between academic print reading habits at T1 and comprehension at T2 (T1) (hypothesis 1). We found partial support for hypothesis 2 only for students from 4th to 5th grade since the model revealed a negative longitudinal association between digital reading habits for academic purposes in T1 and comprehension skills at T2 (hypothesis 2). No such difference was observed for the models including students from 5th to 6th grade. Finally, although selective attention predicted comprehension in all models, it did not mediate the association between print and digital reading habits and comprehension (hypotheses 3 & 4).

## Discussion

To our knowledge, this is the first empirical test for the prediction based on the digital chain hypothesis (Wolf, 2018), concerning the mediating role of selective attention on the longitudinal association between print and digital reading habits and reading comprehension skills of Primary school students. Cross sectional analyses revealed positive associations between academic and leisure print reading habits and selective attention for 4th grade

students. But contrary to our expectations, the longitudinal associations for reading habits in T1 to selective attention and reading comprehension in T2 were mostly null. In the following, we discuss these results in light of the assumption that selective attention is relevant for the association between reading habits and comprehension in Primary school children.

### **Did reading on screen steal students' focus?**

Overall, our data do not support the assumption that young students are losing focus, at least as measured by a selective attention test. Longitudinal analyses indicate substantial improvements on selective attention across 4th to 6th grade, even though reading comprehension scores for this sample declined during the same years. From this pattern of results it is difficult to argue that changes in students' focus may be responsible for the decline in reading comprehension. A central expectation of the digital chain hypothesis (Wolf, 2018) is the association between reading habits and the development of selective attention, which may ultimately mediate the association between reading habits and comprehension. Overall, our data is mixed when it comes to the associations between reading habits and selective attention. Correlational analyses reveal positive and small associations between selective attention and print reading habits, but not for digital habits, for 4<sup>th</sup> grade students. This pattern of results is consistent with previous correlational evidence studying print reading habits in young students (Davidse et al., 2011; Rosenqvist et al., 2016). The lack of significant correlations between digital reading habits and selective attention in our samples can be interpreted as a limitation of those habits in promoting focus. Nevertheless, any explanation regarding causality is best addressed by looking at the longitudinal analyses. Analyses from those analyses in our samples indicate that all of the associations between reading habits on changes on selective attention one year later were null. This pattern of results contrasts with those from the study by Koolstra and van der Voort (1996), who found

positive longitudinal associations between print reading habits and perceived concentration in young students. As that study followed a sample of children from 2th to 4th grade, as compared to our samples of 4th to 6th grade, it could be argued that print reading habits play a particular role on the development of selective attention specifically in developing readers (Rosenqvist et al., 2016). Potentially, print reading may serve as frequent practice in focusing attention on relevant parts of the text while filtering out irrelevant information, especially as students learn to read—at least until decoding becomes automatic around 4th grade (Walczyk, 2000).

The null longitudinal associations between leisure and academic digital reading habits and selective attention one year later do not support the claim that screens are loosening students' attention (Wolf, 2018). Similarly, we cannot just extrapolate the negative associations reported between media exposure and attention (Beyens et al., 2018; Kostyrka-Allchorne et al., 2017; Nikkelen et al., 2014; Vedeckina & Borgonovi, 2021) to the field of digital reading. The null or negative associations identified in the literature between digital reading habits and comprehension in children (Altamura et al., 2025b) must be mediated by other factors. For example, in analyzing the negative effects of TV viewing on comprehension skills in children, Koolstra and van der Voort (1996) proposed as potential causes motivational factors (i.e. TV viewing may decrease children motivation towards reading) and displacement of productive activities (i.e. TV viewing may compete for time devoted to more productive literacy activities). Future research could explore the extent to which those factors explain the associations between digital reading habits and comprehension. Finally, congruent with previous research (Bonifacci et al., 2023; Gallen et al., 2023; Follmer, 2018; Segal, 2023), our models highlight the importance of selective attention on reading comprehension in children. Even after controlling for previous skills levels, SES and SEN status, we found small positive associations between selective attention

and comprehension. Selective attention may help children to select main ideas from the text while ignoring irrelevant information, which may be critical in developing an integrated representation of the text (Anderson, 1982).

In interpreting our analyses on the role of selective attention on comprehension it should be considered that in our study we measured reading comprehension skills using a paper and pencil task. Recent research has aimed to test if selective attention and reading comprehension is moderated by reading media (print or digital) (Delgado & Salmerón, 2021; Ruffini et al., 2023). Some characteristics of digital texts that are not present in printed texts, such as interactive features or the presence of distracting elements such as notifications, may require further selective attention to efficiently comprehend digital information. Ruffini et al. (2023) analyzed text comprehension in print and digital of a large group of 3-5<sup>th</sup> grade students. Executive functions (response inhibition, interference control and switching, and updating in working memory) explained a substantial part of the variance in text comprehension scores. The contribution of executive functions was similar in both media (9.3 and 9.1%, for paper and digital, respectively). This suggests that their role in supporting comprehension does not change substantially in response to medium demands, at least with plain PDF-like documents such as the ones used in the study (see Stern & Shalev, 2013, for a similar conclusion in a study with adolescent students). Delgado and Salmerón (2021) evaluated the attention of undergraduate students devoted to reading a long text in print or on-screen, using the "probe-caught technique" to capture mind wandering while reading. When asked to read under time pressure, students reading on paper indicated lower levels of mind wandering than when reading without such pressure. Students who read on screen did not change their mind wandering levels between media. This pattern of results suggests that students are better able to adapt their focus when reading in print than on screen. In sum, the evidence is limited and does not allow us to draw strong conclusions about the mediating role

of digital media on the association between selective attention and reading comprehension.

Future research is needed to test this possibility.

### **Effects of reading habits on the development of reading comprehension skills**

Our results indicate that the longitudinal associations between reading habits and reading comprehension skills vary depending on the reading media (i.e. print or digital habits) as well as on students' grade (4th or 5th). Contrary to previous research (Mol & Bus, 2011), we found no evidence that print reading habits, in either 4th or 5th grade, for leisure or academic purposes, exerted any influence on reading comprehension skills one year later. Three potential mechanisms may explain such lack of effects. First, reading frequency of printed texts was relatively low in our sample. This was particularly true for leisure print reading habits, for which, on average, students engaged only once or twice a month. Such pattern is in line with current world-wide trends indicating a sharp decline in leisure print reading and increased digital reading (OECD, 2019). Increased availability of digital devices could be displacing the traditional habit of reading printed books (Merga & Roni, 2017). In any case, more frequent print reading than that observed in our sample may be required to observe any influence on the development of reading comprehension skills. Second, only one year lapsed in between measurements. Potentially, the effects of habits may only be evident after years of frequent practice. For example, van Bergen et al. (2020) followed a sample of Finnish students from age 5 to 15. The longitudinal associations from print reading habits to comprehension skills, controlling for autoregressive effects, were not significant when using short temporal windows, such as from 2nd to 3rd grade, but they turned significant and positive when looking at long-term ones, such as from 3rd grade to 9th grade. Finally, it should be considered that we measured habits using a questionnaire, rather than with the author recognition test (ART) used in previous research (Mol & Bus, 2011). A limitation of



ART is that it does not differentiate between print and digital habits, and therefore was not well suited to answer our research questions. As new versions of ART attempt to differentiate exposure to print and digital texts (Strømsø, 2024), future research could use those to further analyze the effects of habits on comprehension.

Potentially, the expected effects of reading habits on selective attention may be moderated by the quality of the reading experience. In a recent study, Romero et al. (2025) found that adolescent and undergraduate students reported that, while reading for leisure or study, they engaged more often in additional activities (i.e. multitasking) when reading on digital than in print. More frequent multitasking habits were, in turn, associated with impaired text comprehension. Accordingly, we could expect that multitasking habits while reading, and not necessarily the reading media, would be responsible for a decreased development of focus and comprehension in children. Future research should address this possibility.

Finally, our models contribute to the scarce literature on the effects of digital reading habits in Primary school students. Congruent with previous correlational findings (Salmerón et al., 2023), the longitudinal effect of academic digital reading habits in 4th grade on reading comprehension skills in 5th grade was small and negative. This effect is consistent with the shallowing hypothesis (Annisette & Lafreniere, 2017), as frequent digital reading may support the development of a shallow mindset which may prevent students from fully engaging with texts (Baron, 2015). By contrast, this association was not observed for the longitudinal model from 5th to 6th grade, where we did not find any influence of digital reading habits on comprehension. One could argue that the negative effects of digital reading on comprehension can be more pronounced in 4th grade, a sensible developmental period when students start reading for the purposes of learning. But our pattern of results is at odds with previous findings. For example, analyzing a sample of Finnish students, Torppa et al.

(2021) found a negative longitudinal association between academic digital reading habits in 6th grade and comprehension skills in 7th grade. Potentially, the nature of the digital reading practices may vary across adolescence. As children grow older, they spend more time on social media (Rideout & Robb, 2019), which may further reinforce a shallow processing of digital information. This makes it difficult to compare the effects of digital reading habits across different ages.

### **Limitations and future research**

Our study comes with certain limitations. First, in interpreting our results, it should be considered that our sample was limited to students from 10 to 12 years old. As selective attention develops at fast rates during infancy (Betts et al., 2006; Klenberg et al, 2001; Korkman et al., 2001, 2013), we can not rule out the possibility that selective attention mediate the longitudinal association between reading habits and reading comprehension at younger ages. This possibility is open for future research. Second, as a measure of selective attention we used a paper and pencil test (Thurstone & Yela, 2014). While this test is adequate for group testing, as was done in our study, it does not provide other more fine-grained measures such as reaction times, needed to measure other dimensions such as sustained attention (McAvinue et al., 2012). Although previous research has demonstrated that the effect of attention on reading comprehension is independent of the measure used to assess participants' attention (Follmer, 2018), we can not rule out the possibility that digital reading habits may influence other attentional dimensions. Third, our conclusions are limited to the domain of print reading comprehension, as measured by a traditional paper and pencil test with only multiple-choice questions. Digital reading comprehension emphasizes some processes that are not as salient when comprehending printed texts, such as navigating within and between pages, integrating multimodal information, and critically evaluating information

(Hahnel et al., 2016). Accordingly, the associations between reading habits and selective attention may be different for this type of comprehension assessment. For example, digital reading habits may provide the necessary training to master digital reading comprehension tasks. Similarly, open ended responses may shed further light on the comprehension processes potentially moderated by selective attention (Ruffini et al., 2023). Future research should address these issues.

### **Conclusions**

Our study provides insights regarding the complex association between reading habits, selective attention and reading comprehension in children. The importance of selective attention on comprehension supports the need to further develop school programs aimed at maximizing students' focus on relevant information while ignoring irrelevant one during reading (Dion et al., 2011). In addition, our study highlights the need to exert caution in introducing digital reading devices for academic purposes before 5th grade, and spurs the need to identify key developmental milestones that may be accomplished to be ready to take full advantage of digital reading practices.

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