Reading Comprehension on Smartphones, A Comparison with Computers*

ANDRÉS COTTON**
PEDRO BENEDETTI***
VALERIA ABUSAMRA****

How to cite this article: Cotton, A. Benedetti, P & Abusamra, V (2023). Reading Comprehension on Smartphones, A Comparison with Computers. *Cuadernos de Lingüística Hispánica*, (41), e16032

....

** Bachelor and Professor in Letters, UBA (Universidad de Buenos Aires), Argentina. andrescotton@gmail.com
https://orcid.org/0000-0002-6398-8365

*** Bachelor in Bioengineering, ITBA (Instituto Tecnológico de Buenos Aires), Argentina. pbenedetti@itba.edu.ar
https://orcid.org/0000-0002-7906-7974

**** PhD in Linguistics, UBA. Affiliated to CIIPME, CONICET, Argentina. vabusamra@gmail.com https://orcid.org/0000-0002-2954-8665

Abstract

This study aims to compare the effects of smartphones and computers on reading comprehension of both narrative and expository texts among adults of different ages and educational levels. To do so, a reading task followed by multiple-choice questions was designed, and 2391 volunteers participated; their educational levels, ages, and reading devices were recorded. Of these, 1510 worked with narrative text and 881 with expository text. Our analyses included descriptive statistics, Mann-Whitney U, Kruskal-Wallis tests, and simple and multiple regressions. Results indicate that while smartphones yield disadvantages with expository texts —especially among younger groups, from whom better performance on smartphones is generally expected— such disadvantages are not observed with narrative texts. Furthermore, educational level showed a significant effect under all reading conditions. In line with existing research, our results reveal a significant disadvantage associated with reading expository texts on smartphones; accordingly, we recommend employing alternative reading media whenever feasible.

Keywords: reading comprehension, smartphones, reading on smartphones, reading on screen, reading media, technology and education.

La comprensión lectora en los teléfonos inteligentes, una comparación con los computadores

Resumen

Este estudio pretende comparar los efectos de los teléfonos inteligentes y los computadores en la comprensión lectora de textos narrativos y expositivos entre adultos de diferentes edades y niveles educativos. Para ello, se diseñó una tarea de lectura seguida de preguntas de opción múltiple y participaron 2391 voluntarios; se registraron sus niveles educativos, edades y dispositivos de lectura. De ellos, 1510 trabajaron con texto narrativo y 881 con texto expositivo. Nuestros análisis incluyeron estadística descriptiva, la prueba U de Mann-Whitney y la prueba de Kruskal-Wallis, así como regresiones simples y múltiples. Los resultados indican que, si bien los teléfonos inteligentes presentan desventajas con los textos expositivos (especialmente entre los grupos más jóvenes, de quienes generalmente se espera un mejor desempeño en estos teléfonos), tales desventajas no se observan con los textos narrativos. Además, el nivel educativo mostró un efecto significativo en todas las condiciones de lectura. En consonancia con investigaciones existentes, nuestros resultados revelan una desventaja significativa asociada a la lectura de textos expositivos en teléfonos inteligentes; en consecuencia, recomendamos emplear medios de lectura alternativos siempre que sea posible.

Palabras clave: comprensión lectora, teléfonos inteligentes, lectura en teléfonos inteligentes, lectura en pantalla, medios de lectura, tecnología y educación.

La Compréhension écrite sur smartphone, une comparaison avec les ordinateurs

Résumé

Cette étude prétend comparer les effets des smartphones et des ordinateurs sur la compréhension lectrice de textes narratifs et expositifs chez des adultes de différents âges et de niveaux d'éducation différents. Pour ce faire, une tâche de lecture a été conçue suivie de questions à choix multiples et 2 391 volontaires y ont participé ; leurs niveaux de scolarisation, leurs âges et leurs appareils de lecture ont été enregistrés. Parmi eux, 1 510 ont travaillé avec un texte narratif et 881 avec un texte expositif. Nos analyses comprenaient des statistiques descriptives, le test U de Mann-Whitney et le test de Kruskal-Wallis, ainsi que des régressions simples et multiples. Les résultats indiquent que même si les smartphones présentent des inconvénients avec les textes expositifs (en particulier parmi les groupes plus jeunes, qui sont généralement censés avoir de meilleurs résultats sur ces téléphones), de tels inconvénients ne sont pas observés avec les textes narratifs. Par ailleurs, le niveau de scolarisation a montré un effet significatif dans toutes les conditions de lecture. Selon les recherches existantes, nos résultats révèlent un inconvénient important associé à la lecture de textes expositifs sur les smartphones ; par conséquent, nous conseillons d'utiliser autant que possible des supports de lecture alternatifs.

Mots-clés: compréhension lectrice, smartphones, lecture sur smartphone, lecture sur écran, lecture sur support, technologie et éducation.

Compreensão de leitura em smartphones, uma comparação com computadores

Resumo

Este estudo tem como objetivo comparar os efeitos de smartphones e computadores na compreensão leitora de textos narrativos e expositivos entre adultos de diferentes idades e níveis de escolaridade. Para isso, foi elaborada uma tarefa de leitura seguida de questões de múltipla escolha e participaram 2.391 voluntários; seus níveis educacionais, idades e dispositivos de leitura foram registrados. Destes, 1.510 trabalharam com texto narrativo e 881 com texto expositivo. Nossas análises incluíram estatística descritiva, teste U de Mann-Whitney e teste de Kruskal-Wallis, além de regressões simples e múltiplas. Os resultados indicam que, embora os smartphones apresentem desvantagens com textos expositivos (especialmente entre os grupos mais jovens, de quem geralmente se espera um melhor desempenho nestes telefones), tais desvantagens não são observadas com textos narrativos. Além disso, a escolaridade apresentou efeito significativo em todas as condições de leitura. Consistentes com a investigação existente, os nossos resultados revelam uma desvantagem significativa associada à leitura de textos expositivos em smartphones; consequentemente, recomendamos o uso de meios de leitura alternativos sempre que possível.

Palavras-chave: compreensão leitora, smartphones, leitura em smartphones, leitura na tela, mídia de leitura, tecnologia e educação.

Introduction

The type of device used for reading can significantly influence reading comprehension (Hou et al., 2017; Kong et al., 2018). Smartphones, in particular, have been increasingly used for reading on a daily basis, both within and beyond the educational context (García, 2020). However, the influence of smartphones on reading comprehension remains an open topic of investigation.

Several researchers (e.g., Delgado et al., 2018; Lauterman & Ackerman, 2014) have pointed out that increasing exposure to technology, with its emphasis on speed and multitasking, may encourage a shallower kind of cognitive processing that leads to a decrease in deep comprehension in digital environments. This "Shallowing Hypothesis" suggests that challenging tasks that require sustained attention or reflective thought, such as reading comprehension, are more difficult for individuals who are highly accustomed to the use of digital media that primarily relies on quick interactions driven by immediate rewards (Annisette & Lafreniere, 2017).

The time spent per day using smartphones for leisure or personal reasons, as opposed to using them for studies or work, varies significantly across generations (Etcoff, 2018). When comparing younger generations, such as Gen Z and Millennials (ages 18 to 40), with older ones, such as Gen Xers and Baby Boomers (ages over 40), it was found that the younger groups spend 41% more time per day using smartphones for leisure or personal reasons than the older groups. According to the "Shallowing Hypothesis", as younger groups use smartphones more frequently for quick or shallow interactions, they may encounter greater difficulty in effectively utilizing these devices for demanding and sustained cognitive tasks, such as reading comprehension.

Reading Comprehension from a Cognitive Perspective

To investigate the complex process of reading comprehension, a multicomponential approach has proven to be very useful. This theoretical model considers 11 components (e.g., lexical semantics, inferences, metacognition, text hierarchy, etc.) targeted throughout the comprehension questions to address the way these cognitive processes contribute to sound reading comprehension (Abusamra et al., 2010, 2011, 2014; De Beni et al., 2007). The development and execution of these cognitive processes can be influenced by various factors controlled in this study, such as age (De Beni et al., 2007), reading medium (Delgado & Salmerón, 2021; Hou et al., 2017), and educational level (Abusamra et al., 2010).

Understanding a text is an essential cognitive ability for the social and educational development of human beings. For this reason, it represents one of the fundamental skills that all education systems aspire to cultivate (Abusamra et al., 2014; Abusamra & Joanette, 2012). The relationship between reading comprehension and education has been extensively studied by various researchers, including Shanahan and Shanahan (2008, 2012), who recognize three levels of literacy: basic, intermediate, and disciplinary. Literacy and comprehension skills are developed

throughout the educational system and not solely in its early stages (Abusamra et al., 2022). Therefore, when studying reading comprehension in adults, it is important to consider their educational level to gain a better understanding of their performance.

Reading on Screens

Most of the research we are aware of is focused on comparing reading on screens versus reading on paper (Delgado et al., 2018; Kong et al., 2018). However, little attention has been devoted to exploring the differential influence that different digital devices may have on reading comprehension. Recent research in this area has mainly investigated the use of e-readers and computers (e.g., Hou et al., 2017; Margolin et al., 2013), while the impact of smartphones on reading comprehension remains a novel topic. A meta-analysis conducted by Schwabe et al. (2022) specifically emphasizes the need for further research on the effect of smartphones on reading comprehension.

When studying reading on screens, it is important to consider the following factors according to previous investigations:

Text genre can be a variable that moderates the effects of the reading medium. Delgado et al. (2018) conducted a meta-analysis where they found that a paper-based reading advantage was consistent across studies using expository texts, or a mix of expository and narrative texts, but not on those using only narrative texts. Schwabe et al. meta-analysis (2022) also found no negative effects of screens when reading narrative texts. Expository texts usually comprise more specific vocabulary, more complex syntactic structures and they also tend to imply a higher level of abstraction, which makes them harder to understand deeply (Graesser & McNamara, 2011) Therefore, if reading media enhances or hinders comprehension, such differences may arise in expository texts rather than in narratives, since the first ones are often more challenging.

Clear spatial references must be provided in all cases to prevent the reader from becoming disoriented, for this hinders the formation of an orderly and coherent mental representation (Hou et al., 2017). Therefore, the disposal of the information on the screen must allow the length of the lines to remain unchanged during reading or browsing, in all study conditions. Also, several authors point out the importance of using the same font in all experimental conditions (Mohamad Ali et al., 2013; Nafiseh & Balakrishnan, 2014)

Readers establish different relationships with technologies across generations (Etcoff, 2018). Therefore, many researchers consider that age could strongly influence the reading processes mediated by different technological devices. The meta-analysis conducted by Delgado et al. (2018), which examined studies carried out between 2000 and 2017, revealed that the hypothesis of "digital natives", that holds that new generations would read better on screens because they are more familiar with digital culture does not seem to have any support. In general, a superiority of the printed text

was found, although with variability of the size of the effect. The study indicated that having more experience in using digital devices or an earlier exposure to them does not necessarily lead to an improvement in reading comprehension when compared to reading on paper.

When the reading task is carried out under time pressure, differences in reading comprehension between reading media may appear. However, without time limitations these differences may not arise (Ackerman & Lauterman, 2012; Delgado & Salmerón, 2021).

Finally, it is important to consider the distinction between traditional text and hyperlinked or "digital text." Traditional text continues to be very similar to the one found in books. Reading traditional text typically involves a linear progression with a clearly defined beginning and end. In contrast, hyperlinked text is fragmented into multiple pages or links that readers navigate as they read and from which they select, hierarchize and integrate information (Burin, 2020). In this paper we studied linear (traditional) texts.

Considering all of the above, this study aims to compare the effects of smartphones and computers on reading comprehension of narrative and expository text in a sample of adults with different ages and educational levels.

Our first hypothesis (H1) is that there will be a negative effect of the smartphone on reading comprehension compared to the effect of the computer. Furthermore, due to Gen Z and Millennials' more frequent habit of using smartphones for tasks involving shallow cognitive processing, (H2) we predict that the negative impact of reading on smartphones will be greater for Gen Z and Millennials than for Gen Xers and Baby Boomers. Additionally, (H3) we hypothesize that the difference in comprehension scores between reading devices will be more significant with the expository text than with the narrative text. Finally, (H4) we expect that readers with a higher educational level will outperform less educated readers in all reading conditions.

Method and Participants

Materials

Two screening tests were designed to measure reading comprehension: one from a narrative text and the other from an expository one. Each test consists of answering questions about the content of the text. The subject must select a single correct answer among the four possible options (multiple-choice format). The questions were developed following the perspective of the multicomponential reading comprehension model, which recognizes 11 components that facilitate evaluation and intervention (Abusamra et al., 2010, 2011, 2014; De Beni et al., 2007).

The narrative text was 1117 words long and was about a love triangle between a woman and one of her husband's friends. It was followed by 13 questions that addressed the components of the multicomponential reading comprehension model.

The expository text was 1113 words long and its topic was children's brain development and its relationship with mathematical abilities. The topic was approached in a way that was accessible to non-specialized readers. The test comprised 15 questions that addressed the components of the multicomponential reading comprehension model.

The screenings were embedded in two twin web pages. One page contained the narrative screening test and the other the expository one. In both pages, three forms were incorporated. The first form requested demographic data on the participants (age, gender, educational level); the second form asked for information about the device from which the exercise was going to be completed (smartphone, tablet or computer); the third form, which was presented after the participants had read the text, contained the comprehension questions.

Web pages were accessible both from smartphones and computers. In all cases, the layout of the text on the screen was clear and navigation was simple. To avoid difficulties that could hinder comprehension throughout the development of the test, clear spatial references were always provided, both in the smartphone and computer versions of the web pages.

Procedure

The objective of the task was explained to the informants and informed consent was requested from those who decided to participate. This research was conducted following the ethical regulation 5344/99 by the National Scientific and Technical Research Council of Argentina (CONICET) and was approved and supervised by CONICET committee. All procedures were in accordance with the 1975 Helsinki Declaration and its later amendments. The mechanism of multiple-choice response was also explained, and the participants were informed that they would have the possibility of consulting the text as many times as they wished while answering the questions. This aimed to assure that this experiment would measure reading comprehension and not memory. Participants were also informed that although there would be no time limit to complete the task, the time spent reading the text and answering the questions would be recorded. Registering the time spent during the task was important to prevent participants from taking breaks when solving it and allowed us to identify those who rushed to finish the task without dedicating a reasonable amount of time to read and respond the best they could. How the time spent on completing the reading task influences reading comprehension on screens, especially without the presence of the evaluator while the task is completed, is still unclear (Delgado & Salmerón, 2021). Therefore, we decided to focus our analyses on the comprehension scores rather than on time.

Both web pages were distributed on social networks (Twitter, Facebook, Instagram and WhatsApp). All participants completed the task between April 14 and April 30, 2020. Participants were not allowed to choose which text to read. The first week the narrative screening was available; the second week, the informative one.

None of the participants were aware of the existence of a different test than the one they were completing.

Participants

A total of 2,479 people voluntarily participated in the experiment, of which 1,571 answered questions about a narrative text and 908 about an expository one.

Exclusions

In both tests, participants who had not completed high school and those who performed the task from a tablet were very few to establish reliable comparisons with other groups, therefore they were excluded. Those participants who took less than 8 minutes or more than an hour to complete the task and those who scored less than 3 points (could not answer at least 3 questions correctly) were excluded as outliers. After the aforementioned exclusion, 1510 participants remained for narrative text and 881 for the expository one.

Data Analysis

The analyses described were repeated for each type of text. Firstly, descriptive and distribution statistics of the different variables were obtained, including the calculation of the mean and standard deviation of the participants' age and scores. Next, the Mann-Whitney U test was employed to compare the reading scores among the categories of "device used." Additionally, the Kruskal-Wallis test was used to compare the reading scores among different categories of "educational level" due to the significant deviation from normal distribution of the dependent variables in each subgroup. In cases where the Kruskal-Wallis test yielded significant results, Dunn's test with Bonferroni adjustment was performed as a post-hoc analysis.

Then, to corroborate whether the effect of the device on the reading score was the same for both younger (18 to 39 years old) and older (40 to 70 years old) subjects, the bivariate analysis was performed separately within each group.

Finally, in order to determine the effect of the devices on the reading score, controlling for the other variables (age and educational level), a multiple linear regression was performed. For the various analyses, the data was grouped in several ways. In each case, the outliers of each group were previously excluded.

Results

Descriptive Analysis

First, descriptive statistics were obtained for each of the variables. In the case of numerical variables, the mean and standard deviation were calculated. For the narrative text, the mean score in comprehension was 7.91 (SD = 2.30) and the mean

age of the participants was 33.82 (SD=10). For the expository one, the mean score was 9.09 (SD=2.52) and the mean age was 34.29 (SD=11.43).

1510 participants completed the narrative text task (212 did so on a computer and 1298 on a smartphone). Tables 1 and 2 show the distribution of participants according to the categorical variables analyzed for each device.

Table 1. Frequency and values of categorical variables for participants that completed the narrative text task on a computer

Variables	Values	Frequenc	%
Age	18-39	152	71.7
	40-70	60	28.3
Educational leve	Completed high school	13	6.1
	Uncompleted tertiary or university	81	38.2
	Completed tertiary or university	118	55.7

Table 2. Frequency and values of categorical variables for participants that completed the Narrative text task on a smartphone

Variables	Values	Frequency	%
Age	18-39	951	73.3
	40-70	347	26.7
Educational level	Completed high school	83	6.4
	Uncompleted tertiary or university	540	41.6
	Completed tertiary or university	675	52.0

881 participants completed the informative text task (263 did so on a computer and 618 on a smartphone). Tables 3 and 4 show the distribution of participants according to the categorical variables analyzed for each device.

Table 3. Frequency and values of categorical variables for participants that completed the Expository text task on a computer

Variables	Values	Frequency	%
Age	18-39	172	65.4
	40-70	91	34.6
Educational level	Completed high school	16	6.1
	Uncompleted tertiary or university	125	47.5
	Completed tertiary or university	122	46.4

Table 4. Frequency and values of categorical variables for participants that completed the Expository text task on a smartphone

| Variables	Values	Frequency	%
Age	18-39	445	72.0
	40-70	173	28.0
Educational level	Completed high school	51	8.3
	Uncompleted tertiary or university	281	45.5
	Completed tertiary or university	286	46.

Bivariate Analysis

The association of each of the variables with the reading score was studied, selecting the tests to be used according to their characteristics. In most cases, the distribution of the variables both independently and within each group is significantly different from normal, so nonparametric statistics were used.

Mann-Whitney U tests were performed to analyze the existence of differences in the reading score according to the device used (Figure 1A). No significant differences were found in the score (U=149778.5, p = 0.59) for the narrative text.

For the expository text task, Mann-Whitney U tests were performed to analyze the existence of differences in the score obtained according to the device used (Figure 1B). Significant differences were found in favor of the computer (U=92942.5, p <0.01).

Figure 1. Reading score for each device (A. Narrative text; B. Expository text)

Narrative Text

A

Expository Text

B
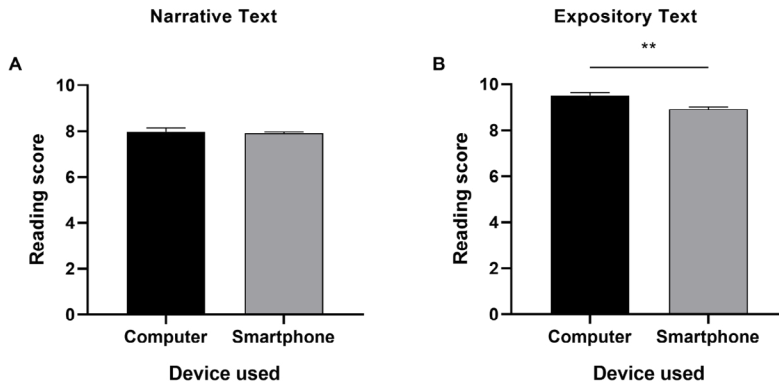
To detect differences related to the educational level in the narrative text performance, the Kruskal Wallis test was used and significant differences were detected between the groups (H(2) = 29.56, p<0.01). The Dunn test with Bonferroni correction was used as post hoc analysis and it was found that scores improve with educational level (Figure 2A).

Also, to detect differences related to the educational level for the expository text, the Kruskal Wallis test was used. Significant differences were detected between the groups (H(2) = 30.56, p<0.01). The Dunn test with Bonferroni correction was used as a post hoc analysis and it was found that the score of participants who only finished secondary school is worse than of those who also started or finished tertiary or university studies (Figure 2B).

Figure 2. Reading score for educational level (A. Narrative text; B. Expository text)

Narrative Text

A

Expository Text

B
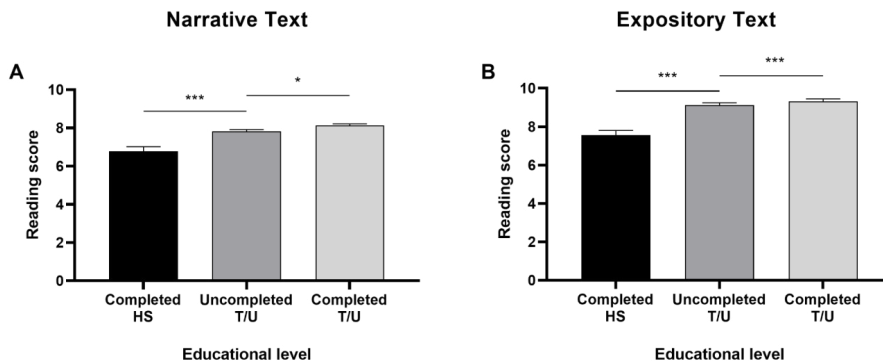
Age-grouped Comparisons

In section 2.2 the effects of the device on comprehension scores were for all the participants. However, it was unclear whether these effects were replicated within each age group. To analyze that, we performed four Mann-Whitney U tests.

For the narrative text task (Figure 3A) no significant differences were found in the score among the younger (U=70369, p = 0.5978) or older (U=9782, p=0.4524) participants.

For the expository text task (Figure 3B) no significant differences were found in the score among the older (U=7400, p=0.4201) participants but significant differences were found among younger readers (U=30597, p<0.0001)

Figure 3. Reading scores grouped by Age group and device used. (A. Narrative text; B. Expository text)
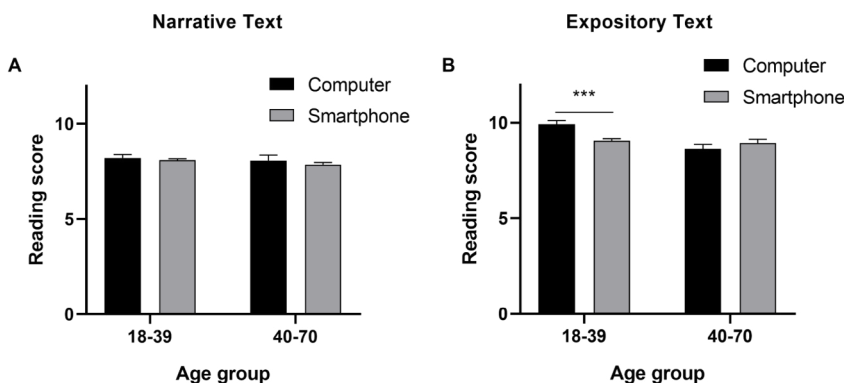
Multiple Linear Regressions

To study the effect of the device on comprehension scores, controlling for the other variables, we conducted two multiple linear regressions. We included device, educational level and age as predictors. Because of the Shapiro-Wilk test's sensitivity to sample size, we use qq-plots to analyze if the model's residuals followed a normal distribution, and scatterplots of standardized residuals against fitted values to assess homoscedasticity. Multicollinearity was evaluated through the variance inflation factor. We excluded observations with residuals larger than 2.5 or smaller than -2.5. To assess the relative contribution of each predictor, we report the partial R2.

For reading scores of the narrative text, the model was significant (F (4, 1505) = 8.48, p<0.001). There was a significant effect of age (β= -0.02, t = -3.47, p<.001), where older participants showed lower scores, but not of device (β = -0.13, t = -0.81, p = .42). Regarding education level, the analysis showed significant differences between COMPLETED TERTIARY OR UNIVERSITY and COMPLETED HIGHSCHOOL (β

= 1.14, t = 4.88, p<.001) and between UNCOMPLETED TERTIARY OR UNIVERSITY and COMPLETED HIGHSCHOOL (β = 0.71, t = 3.07, p<.001), where higher educational levels showed higher mean scores.

We excluded 40 outliers (3%) and repeated the analysis. The model was significant (F (4, 1465) = 13.65, p< 0.001) and the coefficients varied slightly with no changes in the interpretation (age: β = -0.02, t = -4.27, p<.001; device: β = -0.12, t = -0.82, p = .41; COMPLETED TERTIARY OR UNIVERSITY: β = 1.32, t = 5.93, p<.001; UNCOMPLETED TERTIARY OR UNIVERSITY: β = 1.71, t = 3.21, p =.001). Partial R2 shows that the larger contribution comes from the educational level (0.03), followed by age (0.01) and device (0.0004).

For the reading scores of the expository text, the model was significant (F (4, 876) = 11.41, p<0.001). There was a significant effect of age where older participants showed lower scores (β = -0.03, t = -3.56, p<.001), an of device where participants that solved the task with the smartphone got lower scores (β = -0.48, t = -2.76, p = .005). Regarding the education level, the analysis showed significant differences between COMPLETED TERTIARY OR UNIVERSITY and COMPLETED HIGHSCHOOL (β = 1.71, t = 5.43, p<.001) and between UNCOMPLETED TERTIARY OR UNIVERSITY and COMPLETED HIGHSCHOOL (β = 1.31, t = 4.17, p< .001), where higher educational levels showed larger mean scores.

We excluded 25 outliers (3%) and repeated the analysis. The model was significant (F (4, 851) = 15.48, p< 0.001) and the coefficients varied slightly with no changes in the interpretation (age: β = -0.03, t = -4.64, p<.001; device: β = -0.52, t = -3.09, p = .002; COMPLETED TERTIARY OR UNIVERSITY: β= 1.80, t = 6.07, p< .001; UNCOMPLETED TERTIARY OR UNIVERSITY: β = 1.25, t = 4.24, p< .001). Partial R2 shows that the larger contribution comes from the educational level (0.04), followed by age (0.03) and device (0.01). Residuals were normally distributed and homoscedastic. No multicollinearity was detected. As with the previous analysis, the visual analysis of the residuals suggested a slight deviation from a normal distribution, but with relatively similar skewness and kurtosis (-0.02, -1.15 each). For these reasons, we consider the regression to be adequate.

Discussion

This paper compares the influence of smartphones and computers on reading comprehension. To do so, the effect of these reading media is studied in relation to other factors that can have an influence on comprehension. These factors are: the level of education of the participants, the relationship of the different generations to technology, the distribution of the information on the screen, and the time required to complete the task. The first three are central to our study, while the last two are simply controlled to assure the correct development of the task.

Our first hypothesis (H1) "there will be a negative effect of the smartphone on reading comprehension compared to the effect of the computer" is supported by our

data. No significant advantage of the smartphone over the computer was found in any group or reading condition. Additionally, it is important to highlight that age and text genre appear to play a key role in moderating the effect of the device.

On that matter, it is notable that our second hypothesis (H2) "the negative impact of reading on smartphones will be greater for Gen Z and Millennials than for Gen Xers and Baby Boomers" is partially supported. Younger readers show a significant disadvantage in comprehension scores only when reading the expository text on smartphones but not when reading the narrative one. These findings are consistent with the *Shallowing hypothesis*, which posits that individuals who are highly accustomed to using digital media for leisure will perform worse on tasks that require deep reflective thinking, such as the expository test (Annisette & Lafreniere, 2017).

Besides the *Shallowing hypothesis,* other explanations could be held to justify these differences between smartphones and computers as reading media. On the one hand, it could be argued that the smaller screens force the reader to maintain a greater amount of active information in his/her working memory during the task, since there are fewer fragments of text in front of him or her at any one time. Previous research shows that an overload in working memory negatively impacts reading comprehension (Cartoceti, 2012). However, Margolin et al. (2013) found no differences in comprehension when using screens of different sizes, so that might not be the main factor conditioning reading tasks on smartphones. Another possible explanation for the smartphone disadvantage when reading highly demanding texts is related to the distractions that smartphones can foster. However, this does not explain the difference between age groups as consistently as the *Shallowing hypothesis.*

In line with previous findings (Schwabe et al., 2022), the third hypothesis (H3) "the difference in comprehension scores between reading devices will be more significant with the expository text than with the narrative text" is supported by our results. The expository text highlighted the difference between reading devices, but no difference was found when reading the narrative text.

Lastly, our fourth hypothesis (H4) "readers with a higher educational level will outperform less educated readers in all reading conditions" is also confirmed, which is consistent with earlier research (Shanahan and Shanahan, 2008, 2012; Abusamra et al., 2022). Our results support the idea that higher levels of education continue to play an important role in the development of reading comprehension. The erroneous belief that literacy and comprehension skills are developed only during the early stages of school leads to much less effort often being devoted to teaching and consolidating literacy in the higher stages (Abusamra et al., 2022). We hope that this practice is revised in the years to come.

This experiment was conducted during the SARS-CoV-2 pandemic (COVID-19), which made it impossible for researchers and readers to be in the same room. We decided to distribute the tests through social networks; this decision has both

advantages and limitations. On the one hand, in our daily lives reading takes place in different situations where distractions can occur; the conditions in which this test was conducted are more ecological than hyper-controlled reading conditions inside a laboratory. In addition, this method allowed us to evaluate a large number of people with different backgrounds, rather than focusing only on a small sample of undergraduate students as many other experiments chose to do. On the other hand, these decisions imply limitations: the conformation of the groups and the conditions under which the test was performed are less controlled, so some factors not considered (such as distractions while reading) may affect the results. Therefore, it would be interesting to replicate this study in a more controlled setting, if possible, to compare both reading conditions and complement the findings of this study.

In future research, it would be desirable to explore some points that have not been specifically studied in our work. It is possible that when performing the reading task under time pressure, new differences appear between devices (even with narrative texts) that are otherwise not observable or are attenuated (Delgado & Salmerón, 2021; Lauterman & Ackerman, 2014). Also, it would be desirable to study how different devices influence the reading of hyperlinked texts.

Conclusion

This study assesses the impact of smartphones and computers on reading comprehension, considering the educational level, generational differences in technology use, and the type of text. Our key finding is that smartphones exhibit a neutral or negative influence on reading comprehension compared to computers, with no observed advantages for any demographic in using smartphones. Crucially, younger generations show more pronounced comprehension challenges on smartphones when reading expository texts, consistent with the *Shallowing hypothesis*. The differences found were particularly significant for the expository texts, but not for the narrative texts, while education level remained a consistent determinant of comprehension proficiency across conditions.

A deeper understanding of the influence of smartphones on reading comprehension is essential for making informed educational decisions. We should not lose sight of the fact that the cost and access differences between computers and smartphones are very large. The smartphone is currently much more accessible, and its use is notably more widespread (García, 2020), so being able to rely on this tool in the educational context could be considered a form of inclusion. However, the use of smartphones for reading tasks is just beginning to be studied. For now, giving that this article shows a significant disadvantage to reading expository text on such devices, we recommend that educators encourage the use of other reading media whenever possible, especially if the activities they are conducting focus on reading expository text.

Supplementary Materials

The narrative and expository screenings used in this research are available online for those who wish to consult them.

References

Abusamra, V., Cartoceti, R., Ferreres, A., Raiter, A., De Beni, R. & Cornoldi, C. (2014). *Leer para comprender II (TLCII). Evaluación de la comprensión de textos*. Paidós.

Abusamra, V., Casajús, A., Ferreres, A., Raiter, A., De Beni, A. & Cornoldi, C. (2011). *Leer para comprender. Desarrollo de la comprensión de textos. Libro de actividades*. Paidós.

Abusamra, V., Difalcis, M., Martínez, G., Low, D. M., & Formoso, J. (2020). Cognitive Skills Involved in Reading Comprehension of Adolescents with Low Educational Opportunities. *Languages*, *5*(3), 1-20. https://doi.org/10.3390/languages5030034

Abusamra, V. Ferreres, A., Difalcis, M. & Piacente, T. (2022). *Leer y comprender: tejidos con hilos de palabras.* AZ Editora.

Abusamra, Ferreres, A., Raiter, A., De Beni, R. & Cornoldi, C. (2010). *Leer para comprender (TLC). Evaluación de la comprensión de textos.* Paidós.

Abusamra, V. & Joanette, Y. (2012). Lectura, escritura y comprensión de textos: aspectos cognitivos de una habilidad cultural. *Revista Neuropsicología Latinoamericana*, *4*(1), i-iv.

Ackerman, R., & Lauterman, T. (2012). Taking Reading Comprehension Exams on Screen or on Paper? A Metacognitive Analysis of Learning Texts Under Time Pressure. *Computers in Human Behavior*, *28*(5), 1816-1828. https://doi.org/10.1016/j.chb.2012.04.023

Annisette, L. E., & Lafreniere, K. D. (2017). Social Media, Texting, and Personality: A Test of the Shallowing Hypothesis. *Personality and Individual Differences*, *115*, 154-158. https://doi.org/10.1016/j.paid.2016.02.043

Burin, D. (2020). *La competencia lectora a principios del siglo XXI*. Teseo.

Cartoceti, R. (2012). Inhibitory Control and Reading Comprehension: Evidences from Specific Verbal Domain. *Neuropsicologia Latinoamericana*, *4*, 65-85. https://doi.org/10.5579/rnl.2012.0085

De Beni, R., Borella, E., & Carretti, B. (2007). Reading Comprehension in Aging: The Role of Working Memory and Metacomprehension. *Aging, Neuropsychology, and Cognition*, *14*(2), 189-212. https://doi.org/10.1080/13825580500229213

Delgado, P., & Salmerón, L. (2021). The Inattentive On-screen Reading: Reading Medium Affects Attention and Reading Comprehension Under Time Pressure. *Learning and Instruction*, *7*. https://doi.org/10.1016/j.learninstruc.2020.101396

Delgado, P., Vargas, C., Ackerman, R., & Salmerón, L. (2018). Don't Throw Away your Printed Books: A Meta-analysis on the Effects of Reading Media on Reading Comprehension. *Educational Research Review*, *25*, 23-38. https://doi.org/10.1016/j.edurev.2018.09.003

Etcoff, N. (2018). *Motorola Phone-Life Balance Study Data Report by Generations*. IPSOS. https://www.ipsos.com/sites/default/files/ct/news/documents/2018-02/motorola- phone-life-balance-study-topline-2018-02-21.pdf

García, S. (2020). COVID-19 y educación primaria y secundaria: repercusiones de la crisis e implicaciones de política pública para América Latina y el Caribe. *Serie de Documentos de Política Pública* (20). https://www.unicef.org/lac/informes/covid-19-y-educacion-primaria-y-secundaria

Graesser, A. C., & McNamara, D. S. (2011). Computational Analyses of Multilevel Discourse Comprehension. *Topics in Cognitive Science*, *3*(2), 371-398. https://doi.org/10.1111/j.1756-8765.2010.01081.x

Hou, J., Rashid, J., & Lee, K. M. (2017). Cognitive Map or Medium Materiality? Reading on Paper and Screen. *Computers in Human Behavior*, *67*, 84-94. https://doi.org/10.1016/j.chb.2016.10.014

Kong, Y., Seo, Y. S., & Zhai, L. (2018). Comparison of Reading Performance on Screen and on Paper: A Meta-analysis. *Computers and Education*, *123*, 138-149. https://doi.org/10.1016/j.compedu.2018.05.005

Lauterman, T., & Ackerman, R. (2014). Overcoming Screen Inferiority in Learning and Calibration. *Computers in Human Behavior*, *35*, 455-463. https://doi.org/10.1016/j.chb.2014.02.046

Margolin, S. J., Driscoll, C., Toland, M. J., & Kegler, J. L. (2013). E-readers, Computer Screens, or Paper: Does Reading Comprehension Change Across Media Platforms? *Applied Cognitive Psychology*, *27*(4), 512-519. https://doi.org/10.1002/acp.2930

Mohamad Ali, A. Z., Wahid, R., Samsudin, K., & Zaffwan Idris, M. (2013). Reading on the Computer Screen: Does Font Type Has Effects on Web Text Readability? *International Education Studies*, *6*(3), 26-35. https://doi.org/10.5539/ies.v6n3p26

Nafiseh, H., & Balakrishnan, M. (2014). The Effects of font Type and Spacing of Text for Online Readability and Performance. *Cotemporary Educational Technology*, *5*(2), 161-174. http://www.cedtech.net/articles/52/525.pdf

Schwabe, A., Lind, F., Kosch, L., & Boomgaarden, H. G. (2022). No Negative Effects of Reading on Screen on Comprehension of Narrative Texts Compared to Print: A Meta-analysis. *Media Psychology*, *25*(6), 779-796. https://doi.org/10.1080/15 213269.2022.2070216

Shanahan, T., & Shanahan, C. (2008). Teaching Disciplinary Literacy to Adolescents: Rethinking Content-area Literacy. *Harvard Educational Review, 78*(1), 40-59. https://doi.org/10.17763/haer.78.1.v62444321p602101

Shanahan, T., & Shanahan, C. (2012). What is Disciplinary Literacy and Why Does it Matter? *Topics in Language Disorders, 32*(1), 7-18. https://doi.org/10.1097/TLD.0b013e318244557a