



Does students' exposure to websites moderate the positive relationship between print exposure and text comprehension?

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Abstract

In this study, I investigated the print exposure and website exposure of undergraduates in relation to their scores on a text comprehension test. Print exposure was measured with a national version of the author recognition test, whereas a new website recognition test was developed to measure students' exposure to texts on the internet. The participants' reading attitudes and number of years in higher education were included as control variables. Exploratory factor analysis suggested that three factors are measured by the website recognition test: (1) lifestyle topics; (2) news and culture; and (3) social activity. The results showed that only print exposure predicted text comprehension significantly and positively, but not for students with a high score on the website recognition test. Moderation analyses indicated that the pattern was clearest for the social activity factor of the website recognition measure. Hence, high activity on social media seems to diminish or remove the positive relationship between print exposure and text comprehension. The results confirm that print exposure relates positively to important aspects of students' literacy, while further studies should be carried out to investigate the potential negative relationship between website exposure and literacy.

Keywords Text comprehension · Print exposure · Website exposure · Undergraduates

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Introduction

Teaching children to read is considered a key task for educators all over the world. Reading outside educational contexts also seems to be essential, as time spent reading facilitates the development of reading skills. The results from numerous studies show that students' reading habits, extracurricular and self-initiated reading, are significantly related to their reading achievement (Allington & McGill-Franzen, 2021). However, it should be noted that the positive influence of students' leisure time reading on a number of language- and reading-related skills has been demonstrated in studies on students' reading of printed texts. Less is known about how students' leisure time reading of digital texts affects their reading skills. During the last decade, there has been a considerable decrease in students' self-reported reading of printed texts and a substantial increase in their online reading (e.g., OECD, 2021; Twenge et al., 2019). Hence, the increase in online reading seems to take place at the expense of students' reading of printed texts. A number of studies indicate that printed texts favor students' reading performance compared to digital texts (Delgado et al., 2018; Kong et al., 2018). However, our knowledge about the relationship between students' reading skills and their new reading habits is still limited. In the present study, I set out to investigate the relationships between print and digital exposure on the one hand and text comprehension on the other.

Print exposure

Some of the strongest arguments supporting book reading come from research on how book reading facilitates individuals' development of important linguistic skills, such as vocabulary, spelling, and text comprehension. One common explanation of the positive relationships between book reading and linguistic skills is the fact that written language is normally characterized by more precision, complexity, and a more sophisticated vocabulary than oral language (Nation et al., 2022; Stanovich, 2000). In analyses of word frequency in different sources of spoken and written language, Hayes and Ahrens (1988) showed that moderate- to low-frequency words appear much more often in common texts than in common speech. For example, children's books included nearly twice as many "rare" words as transcripts of conversations between college graduates. Thus, people seem to learn more new words from book reading than from exposure to oral communication. In addition, printed texts are also important sources of knowledge, and print exposure seems to increase people's level of general knowledge more than exposure to other channels of information, such as TV (Stanovich, 2000).

Print exposure has been measured in a number of ways (Zhang et al., 2018), mainly by different kinds of self-reports, such as reading diaries (e.g., Duncan et al., 2016), questionnaires and interviews (e.g., Huang et al., 2014), and the number of books in students' home library (e.g., Sikora et al., 2019). One type of measure frequently used is recognition tests, with the author recognition test (ART) developed by Stanovich and West (1989) being probably the most used. Stanovich and West argued that self-reports of print exposure had a tendency to be confounded by social desirability. Many students would probably consider reading to be a "good thing"

and might thus exaggerate to some extent how much they read. An instrument was developed to prevent social desirability from affecting students' responses. The ART consists of a list of popular authors, and students are asked to put a check mark next to names with which they are familiar. Nonexistent authors (foils) are added to the list to correct for guessing. Familiarity with author names is assumed to indicate engagement in literacy-based activities. To capture leisure time reading, ART basically included popular authors of fiction. In a comprehensive research program, Stanovich and his colleagues demonstrated that print exposure positively predicted a number of cognitive outcomes, including orthographic processing, vocabulary, verbal fluency, spelling, and text comprehension, and that print exposure was a positive predictor in populations from primary school to groups of retired people (Stanovich, 2000).

The positive association between print exposure and linguistic abilities was confirmed in a meta-analysis conducted by Mol and Bus (2011) including studies on samples from preschool to university. In the 30 studies including college and university students, the meta-analysis showed a strong correlation between print exposure (ART) and oral language skills and moderate correlations between print exposure (ART) and text comprehension and spelling. Interestingly, the results also showed a moderate correlation between ART and the participants' SAT and GPA scores. The results from the meta-analysis conducted by Mol and Bus (2011) have been confirmed by more recent studies including adolescents and young adults. For example, Martin-Chang and colleagues (2020) showed that ART positively predicted adolescents' word level reading, spelling, and reading time, whereas Mar and Rain (2015) demonstrated that ART predicted a number of different linguistic abilities, including text comprehension, among undergraduates. Finally, the results from a study by Spear-Swerling et al. (2020) indicated a positive relationship between ART and SAT reading and writing test scores. That study also showed results confirming that students' leisure time reading tends to be increasingly dominated by digital media, with the participants reporting a considerably higher frequency of reading digital media than book reading. Thus, students in the 21st century still read, although their reading of printed texts has decreased considerably (Twenge et al., 2019).

Digital texts and leisure time reading

Three recent meta-analyses indicate that readers profit somewhat more in terms of text comprehension from reading on paper than from reading on screens (Clinton, 2019; Delgado et al., 2018; Kong et al., 2018). However, the digital text material in those studies is mainly digital versions of printed texts, and we know less about leisure time reading of the myriad of websites presented on the internet and social media texts. Whereas printed books are edited, and the language is considered more precise and includes a more sophisticated vocabulary than oral language, an editor is not required when publishing on the internet, and language characteristics seem to vary greatly. As mentioned above, Hayes and Ahrens (1988) demonstrated that moderate- to low-frequency words appear much more often in common scripted and edited texts than in oral language. Studies on corpora based on social media (e.g., Twitter, Facebook) indicate that such texts more closely reflect peoples' oral language practices than corpora based on printed texts (Gimenes & New, 2016; Herdağdelen &

Marelli, 2017). Hence, while reading social media texts, students will not be exposed to unfamiliar words to the same extent as when they read printed texts. Additionally, social media texts seem to include more words related to personal matters than other texts (Herdağdelen & Marelli, 2017).

For other texts on the internet, there is a tremendous variation in the written language to which people are exposed. Many printed texts have simply been transformed to a digital format and published on the internet. Other online texts are professionally edited and will not necessarily differ from printed texts in terms of linguistic sophistication, whereas numerous web texts are not edited by a gatekeeper. There also seems to be a trend among professional publishers to simplify the language when publishing on the web. For example, in a textbook for journalism students, the language of social media for writing on the web is emphasized, as follows: “However, writing for the web is different in some very important ways. Among other things, you’ll need to speak the language of social media as well as tabloid and broadsheet editorial” (Allen, 2021, p. 52). Moreover, algorithms integrated in social media and search engines increasingly affect publishing on the internet (Cherubini & Nielsen, 2016). An example is the use of search engine optimization (SEO) among both amateur bloggers and professional publishing houses, implying that authors strive to use the same words and phrases that they anticipate their readers to use. In summary, it seems plausible that students’ leisure time reading of printed books generally represents exposure to a more sophisticated language and varied vocabulary than their reading on the web.

Large international studies among younger students, such as PIRLS (4th grade) and PISA (15 years old), indicate that leisure time use of information and communication technology (ICT) might be related to participants’ text comprehension. For example, an analysis of PISA data from 44 countries indicates a positive relationship between participants’ leisure time ICT use and text comprehension (Hu et al., 2018). In a Dutch sample from the PISA 2015 study, Gubbels et al. (2020) found that such a positive relationship only occurred for students reporting a moderate use of ICT in their leisure time, whereas the relationship turned negative for students reporting an excessive use of ICT. Thus, students following a “golden mean” of time spent on the internet seem to obtain the best results on the text comprehension test. One should note that ICT use in those studies is measured by composite scores based on students’ self-reported ICT use related to diverse activities (e.g., chatting, browsing, gaming, messaging). The results from other studies indicate that high scores on the use of e-mail/messages and social media (Facebook, forums) negatively predict text comprehension (Pfost et al., 2013; Torppa et al., 2020). In a comprehensive longitudinal study, Torppa and her colleagues (2020) found that six-graders’ self-reported digital reading related to social media negatively predicted text comprehension in Grade 7. For fourth-graders taking part in the PIRLS study, the results from the Irish sample showed that internet browsing time did not relate to text comprehension but that such browsing related positively to a measure of digital reading (Gilleece & Eivers, 2018). That study also showed that the number of books in the home, indicating print exposure, positively predicted results on both a printed and a digital reading test. The positive relationship between the number of books in the home and reading was also demonstrated in a study by Sikora et al. (2019) based on data from 28 countries tak-

ing part in the Programme for the International Assessment of Adult Competencies (PIAAC). The participants were asked to estimate the size of their home library when they were 16 years old. The results demonstrate that adolescent exposure to books is positively related to the participants' digital literacy later in life. Thus, print exposure seems to relate positively to text comprehension whether the text material is printed or digital. The results are more mixed for the relationship between ICT use and text comprehension, although there are indications that at least the exposure to social media is negatively related to text comprehension.

One challenge in the above studies is that digital leisure time reading primarily has been measured with different kinds of self-reports. Thus, as argued by Stanovich and West (1989) in relation to self-reports of print exposure, self-reports of exposure to digital texts might also be confounded by social desirability and/or recall limitations. In a recent meta-analysis Parry et al. (2021) showed that peoples self-reported problematic digital media use was weakly associated with usage logs, and that self-reported digital media use in general was only moderately correlated with logged measurements. The use of log data seems to be a more valid measure of peoples' digital media use. However, collecting log data indicating digital text exposure over time requires substantial resources. Hence, a recognition test of digital text exposure could be a less resource demanding measure than collecting log data, and a more valid measure than self-reports. In the present study, a website recognition test was developed based on the procedure described by Stanovich and West (1989) for the development of the author recognition test.

Reading attitudes

Leisure time reading, or recreational reading, is self-initiated by individuals. Readers who engage in this kind of reading will potentially be motivated to spend time on a text of their own choosing, and there are results showing a positive relationship between such intrinsic motivation and reading amount (Schiefele et al., 2012). Measures of reading attitudes have frequently been used to capture readers' feelings related to reading or favorable/unfavorable predispositions to aspects of reading (McKenna et al., 2012). In a meta-analysis, Petscher (2010) showed a moderate relationship between reading attitudes and reading achievement among students in elementary and middle school. However, that relationship became weaker over time, and students' positive attitudes toward reading tended to decline. These results were also confirmed in the literature review of Schiefele and colleagues (2012), with studies showing a stronger relationship between reading attitudes and reading achievement for elementary school students than for middle school students.

In several studies, reading attitudes have been classified into four categories according to purpose and context (e.g., Jang et al., 2021; McKenna et al., 2012). Hence, attitudes can be directed toward reading printed or digital texts for recreational purposes or printed or digital texts for academic purposes. The results from a study by Lupo and colleagues (2017) showed a moderate association between reading achievement and recreational print reading attitudes, whereas there was no relationship between reading achievement and recreational digital reading attitudes. There were, however, small and positive correlations between reading achievement and

both academic print and digital reading attitudes (Lupo et al., 2017). In the current study, reading attitudes are measured by the adult version of the “*I like reading*” scale from the PIRLS study (IEA, 2015). The items included in this measure do not specifically distinguish between printed and digital texts but refer to recreational reading in general. The results over a period of 15 years show a decline in the participants’ (parents’) reading attitudes (Hooper, 2020). Since recreational reading attitudes tend to correlate with text comprehension, I will include this variable in the present study as a control.

The present study

A number of studies have convincingly demonstrated a positive relationship between students’ leisure time reading and language skills such as vocabulary, reading fluency, text comprehension, and spelling (Allington & McGill-Franzen, 2021). The author recognition test (ART) developed by Stanovich and West (1989) has shown good validity as a measure of the leisure time reading of printed books, and it has proven to relate more strongly to text comprehension than other recognition tests related to other kinds of printed material (e.g., magazines, newspapers) (Mol & Bus, 2011). However, young people’s reading of printed material has decreased substantially in recent decades (NBA & NPA, 2022; Twenge et al., 2019). Hence, it seems worthwhile to investigate whether print exposure (i.e., ART) is still positively related to text comprehension at a significant and moderate level among young adults who have grown up in a digitalized society. Thus, in my first research question, I ask if the results of the many studies demonstrating a positive relationship between university students’ leisure time reading of printed texts and text comprehension will be replicated in a digitalized society (European commission, 2022). Based on results from prior studies (e.g., Mol and Bus, 2011), I expect a positive relationship, although the steep increase in students’ exposure to digital texts could have modified this relationship.

In the second research question, I ask whether students’ leisure time exposure to website texts is related to text comprehension when print exposure (i.e., ART) is controlled for. The results from PISA studies indicate a positive relationship between leisure time ICT use and text comprehension (Hu et al., 2018) but perhaps only for students reporting moderate leisure time ICT use (Gubbels et al., 2020). Other studies report that the frequent use of social media negatively predicts text comprehension (Pfof et al., 2013; Torppa et al., 2020), whereas there is more uncertainty about how exposure to other web-based sources relates to text comprehension (Pfof et al., 2013). Given the multitude of different sources on the internet, representing numerous, often blurred, genres (Belcher, 2023), more knowledge is needed about how exposure to different types of digital texts is related to students’ text comprehension. Thus, in the present study, I will also attempt to identify different categories of common website texts and explore the relationship between students’ exposure to these categories of website texts and text comprehension. The studies above have investigated relationships between leisure time reading of digital texts and text comprehension among younger students, whereas I include participants at the university level in the present study. I expect there would be a less clear relationship between website exposure and text comprehension than what I expect to find between leisure

time print exposure and text comprehension, and that exposure to social media in particular would be negatively related to text comprehension, in accordance with prior findings among younger students (Pfof et al., 2013; Torppa et al., 2020).

In the last research question, I ask whether there will be a moderating effect of students' website exposure on the relationship between print exposure and text comprehension. In accordance with Gubbels et al. (2020), one might expect that excessive website exposure could negatively affect the relationship between print exposure and text comprehension. However, students low in print exposure might profit somewhat from being exposed to digital texts on the web, depending of the nature of those texts. In turn, students high on both print and website exposure could potentially score somewhat lower on text comprehension measures than those only high on print exposure, also depending on the nature of the digital texts they have been exposed to. According to corpora studies on social media, such texts seem to be closer to everyday oral language than printed texts (Gimenes & New, 2016; Herdağdelen & Marelli, 2017). Hence, students with a high exposure to both printed text and to social media will potentially be exposed to a mix of digital texts characterized by everyday oral language and printed texts characterized by more precision, complexity, and a more sophisticated vocabulary (Nation et al., 2022). That mixture of text exposure might not be as positively associated to text comprehension as print exposure (i.e., book reading) has been demonstrated to be (Mol & Bus, 2011). Regarding other categories of web-based texts that students are exposed to in their leisure time, the nature of such texts will vary immensely, and whether website exposure moderates the relation between print exposure and text comprehension will potentially depend on the kinds of digital texts students access.

Finally, students' self-reported reading attitudes and number of years in higher education were used as control variables in regression analyses. Reading attitudes have been shown to moderately relate to text comprehension (Schiefele et al., 2012), whereas the number of years in higher education might affect students' reading habits.

Methods

Participants

The participants were 93 undergraduate students ($M_{\text{age}} = 21.9$, $SD = 4.06$; 81.3% females) from a large Norwegian university. The majority (88) of the students were taking an introductory sociology course, whereas five were enrolled in an introductory education course. All of the participants were fluent in Norwegian, and 19.4% of them stated that they were bilingual. Together, 41.9% of the participants had entered a university program for the first time, whereas 32.3% had 2 years or more experience at other higher education programs. The participants were informed that it was voluntary to take part in the study and that they could withdraw at any point in time. Procedures for collecting and handling data followed the General Data Protection Regulation and were approved by the Norwegian Social Science Data Services. After the data collection, all of the participants received a gift card worth approximately USD 20.

Materials and procedure

Data were collected in groups of 15–20 students in sessions lasting for approximately 25 min. The participants first completed a brief questionnaire containing questions on age, gender, and the number of years they had studied in higher education (Study experience). Next, the participants completed a questionnaire on reading attitudes, an author recognition test, a website recognition test, and a text comprehension test – in that order.

Reading attitudes

Reading attitudes were measured with a scale adapted from the parents' section of the PIRLS (IEA, 2015). The measure, originally referred to as “parents like reading”, contained eight items concerning attitudes toward reading assessed on a five-point Likert scale, ranging from 1 = “Agree a lot” to 5 = “Disagree a lot”. Two items, not consistent with positive attitudes, were reversed before calculating the index score as the mean of the items. Sample items are “I like to spend my spare time reading”, “Reading is an important activity in my home”, and “I enjoy reading”. One of the reversed items had a low correlation with the other items and was removed from further analyses. Cronbach's alpha for the remaining seven items was 0.85.

Author recognition test (ART)

A Norwegian version of the author recognition test (ART) (Stanovich & West, 1989) was constructed based on procedures used in developing the original Stanovich and West (1989) ART and more recent versions (Acheson et al., 2008; Spear-Swerling et al., 2020). The author recognition test is assumed to measure exposure to print based on voluntary reading, not on required academic reading. Thus, authors included in the list should primarily represent books that students might be exposed to outside an academic setting. Accordingly, the selection of authors in the present ART was mainly based on the top twenty authors on the best-selling lists from the Norwegian *Booksellers Association* during the last five years (2016–2020). Additionally, popular authors from loan lists of the city's public library for the same five-year period were included to create a selection of fairly well-known writers in the list. A couple of authors of more classic works were added (George Orwell, Sigrid Undset), although I attempted to avoid classic works typically included in school syllabi. The authors represented a range of fiction genres, such as crime, romance, realistic fiction, humor, and historical fiction, and there was a mix of Norwegian and international authors. In total, 65 authors were included in the first version of the measure. The selected authors were mixed with 65 foils, that is, names of people who are not popular authors. International foils were mainly selected from English ART versions (Acheson et al., 2008; Stanovich & West, 1989), whereas Norwegian foils were fictional names constructed for another Norwegian study (Bråten et al., 2016). The number of international and Norwegian foils matched the number of authors.

In accordance with the prior use of ART measures (e.g., Acheson et al., 2008; Stanovich and West, 1989), the participants were given the following instruction when

the measure was introduced: "Below you will see a list of names. Some of the people on the list are writers of books, and some are not. You are to read the names and put a check mark next to the names of those individuals whom you know to be writers. Do not guess, but only check those whom you know to be writers. Remember, some of the names are people who are not writers, so guessing can easily be detected. Thus, you should only check names when you are certain they are writers". A derived score was calculated from the number of real authors correctly checked off minus the number of false alarms to foils. Based on preliminary analyses, authors with extremely high identification rates (higher than 90%) and an identical number of foils were removed from further analyses. Hence, the final version of the instrument included 55 authors and 55 foils. Cronbach's alpha of the correct items checked was 0.92. The participants checked a mean number of 0.4 ($SD=0.93$) foils, thus indicating that they followed the instruction to not guess.

Website recognition test (WRT)

A website recognition test (WRT) was designed by primarily following the design principles of the ART. Thus, URLs from Norwegian lists of popular websites published during the last five years were considered for inclusion in the WRT. In addition, specific lists of popular bloggers for the same period were reviewed, as well as lists of popular browsers (e.g. duckduckgo.com; mozilla.org). In accordance with the selection of items for the ART, I aimed to select reasonably popular websites for the WRT that the participants may have potentially accessed in their leisure time. The WRT included 61 websites and 59 foils. All the fictional web addresses (foils) were checked at domene.no (registration of domain names) to confirm their status as foils.

The WRT shares some features with prior versions of the MRT, the Magazine recognition test (Acheson et al., 2008; Stanovich and West, 1989), as both the WRT and the MRT include information sources on a number of different topics for which people might potentially search in their leisure time. However, an important difference is the digital nature of sources listed in the WRT, as well as a much wider mixture of genres and opportunities for interaction. The WRT included both Norwegian and international websites containing information related to news, entertainment, and shopping, as well as websites offering possibilities for gaming or interaction on social forums.

Following the procedures for completing the ART, the participants were instructed: "Below you will see a list of websites. Some of them are real, and some are not. You are to read the list and put a check mark next to the websites of those that you know to be real. Do not guess, but only check those that you know to be real. Remember, some of the websites are not real, so guessing can easily be detected. Thus, you should only check websites when you are certain they exist". Websites with extremely high identification rates (higher than 90%) and an identical number of foils were removed from further analyses. Again, a derived score was calculated from the number of real websites correctly checked off minus the number of false alarms to foils. The final version of the WRT included 51 websites and 49 foils. Cronbach's alpha of the correct items checked was 0.84. The mean number of checked foils was 0.4 ($SD=0.83$), indicating that guessing was not a common strategy.

Compared to the ART, the WRT represented a more diverse selection of information sources, and one could presume that the WRT represented several factors. Hence, an exploratory factor analysis with categorical variables was performed by using the Categorical Principal Components Analysis (CATPCA) module in SPSS.28 (Meulman et al., 2004). Preliminary inspection of correlations between items indicated three factors. After first testing a two- and a four-factor solution, the three-factor solution was considered the best solution. Eigenvalues ranged from 3.1 to 6.6, and the three factors together accounted for 27.56% of the variance. Items loading lower than 0.80 or with cross loading higher than 0.40 were omitted from the final factor solution. The first factor, WRT-lifestyle (WRT-LS; 11 items, $\alpha=0.77$), included mainly websites on fashion and shopping – all Norwegian websites. Four of the websites are blogs representing different kinds of influencers, while the other websites more or less offer online shopping. The second factor, WRT-news and culture (WRT-N&C; 10 items, $\alpha=0.76$), included websites related to news, culture, and entertainment. The majority of the websites were international (e.g., theguardian.com; huffpost.com; rottentomatoes.com). The third factor, WRT-social (8 items, $\alpha=0.68$), included websites related to communication/social activities. The items represent a mix of national and international websites. Examples of items are websites representing instant messaging applications such as snapchat.com and whatsapp.com, as well as image sharing (e.g., vsco.co) and social media services (e.g., pinterest.com).

Text comprehension

Text comprehension was assessed with a cloze comprehension test for adults and young adults (Gellert & Elbro, 2013). The test consisted of five narrative and five expository texts, including 41 word gaps in all. The Norwegian version of the test comprised 1.340 words in total, with a range of 41 to 330 words across the ten texts. There were four alternative words provided for each gap, and the participants were instructed to read the texts and refill as many gaps as possible. Correct refilling of the gaps required bridging inferences, and the number of correct refilled gaps constituted the text comprehension score. Participants were instructed to refill as many word gaps as possible within 10 min. Gellert and Elbro (2013) concluded that the test was both valid and reliable after correlating it with standardized tests of reading comprehension. Reliability was satisfactory (Cronbach's $\alpha=0.85$) in a prior study including Norwegian secondary students (Bråten et al., 2019), and in two studies including Norwegian university students with $\alpha=0.89$ in Haverkamp et al. (2022) (BA/MA students) and $\alpha=0.83$ in Latini et al. (2019) (BA students). In the two studies including university students, analyses of correlation showed a statistical significantly relationships between the cloze comprehension test and text integration measures. In the present study reliability of the cloze comprehension test was $\alpha=0.75$.

Results

Descriptive measures and zero-order correlations among the measures are presented in Table 1. Initial examination of the data showed that three participants scored more than three standard deviations from the mean on the text comprehension measure. Data from those three participants were removed from any further analyses.

The mean study experience score indicates that the participants generally had less than a year's experience as students in higher education. The descriptive data also show that students checked a mean of 25.64% of the authors included in the ART and 40.20% of the websites in the WRT. Study experience correlated weakly but significantly and positively with ART and the WRT-N&C, whereas there was a weak, statistically significant, and negative correlation between the participants' study experience and the WRT-social measure. Reading attitudes were moderately and positively related to ART and WRT-N&C and weakly related to text comprehension. The ART measure was more strongly related to text comprehension than any of the other measures, and there was a moderate and positive correlation between ART and WRT. The full WRT measure correlates strongly with the WRT-LS and the WRT-N&C and moderately with the WRT-social. However, except for a weak and positive relationship between WRT-LS and WRT-N&C, there are no statistically significant relationships between the subscales.

To address the three research questions, I performed four hierarchical multiple regression analyses. Text comprehension was entered as dependent variable in all four analyses. Study experience and reading attitudes were entered into the equations in step one, whereas ART was entered into step two in all analyses. In the first analysis, the full WRT measure was added in step two together with the cross-product multiplicative term between ART and WRT. In the next three analyses, WRT was replaced by one of the three factors (i.e. WRT-lifestyle; WRT-news and culture;

Table 1 Skewness, means, standard deviations and zero-order correlations (r) among variables ($N=90$)

Variables	1.	2.	3.	4.	5.	6.	7.	8.
1. Study exp	-							
2. Reading att	0.11	-						
3. ART	0.30**	0.46***	-					
4. WRT	0.13	0.16	0.40***	-				
5. WRT-LS	0.19	-0.06	0.36***	0.70***	-			
6. WRT-N&C	0.21*	0.40***	0.39***	0.68***	0.21*	-		
7. WRT-social	-0.22*	-0.08	-0.11	0.44***	0.18	-0.02	-	
8. Text comp	0.12	0.27**	0.46***	0.21*	0.11	0.28**	-0.02	-
Mean (SD)	1.66 (1.64)	3.07 (0.68)	14.1 (9.50)	20.5 (6.85)	3.16 (2.68)	5.19 (2.48)	5.53 (1.90)	33.89 (3.54)
Skewness	0.32	-0.56	0.81	-0.15	0.79	-0.44	-0.45	-0.73
Kurtosis	-1.5	-0.41	0.23	-0.27	-0.34	-0.52	-0.69	0.42

* $p < .05$, ** $p < .01$, *** $p < .001$

Note. Study exp=Study experience, Reading att=Reading attitudes, ART=Author recognition test, WRT=Website recognition test, WRT-LS=Website recognition test – lifestyle, WRT-N&C=Website recognition test – news and culture, WRT-social=Website recognition test – social, Text comp=Text comprehension

WRT-social) identified in the exploratory factor analysis with categorical variables performed on the full WRT. To avoid potentially problematic high multicollinearity with the interaction term, ART and the WRT measures were mean centered prior to the analyses. The interactions were probed by testing the conditional effects of ART at text comprehension at three levels of the WRT measures, the 16th, 50th, and 84th percentiles of the distribution, by performing simple slopes analyses in the PROCESS macro for SPSS (Hayes, 2022).

The results for the analysis predicting text comprehension with the ART and WRT in the equation are shown in Table 2. When study experience and reading attitudes were entered in step one of the analysis, 8% of the variance was explained, $F_{\text{change}}(2, 87)=3.89, p=.024$. In this step, reading attitudes was a unique predictor of text comprehension, indicating that participants holding positive attitudes towards reading were more likely to comprehend the texts than participants holding neutral or negative attitudes towards reading. The addition of ART, WRT and the interaction term in step two resulted in a statistically significant increase in explained variance, $R^2=0.19, F_{\text{change}}(3, 84)=7.47, p<.001$, after step two. In this step, only ART ($\beta=0.44, p<.001$) and the interaction between ART and WRT ($\beta=-0.25, p=.009$) were statistically significant predictors of text comprehension. Thus, print exposure was positively associated to text comprehension whereas there was no statistically significant association between website exposure and text comprehension. Following Aiken and West (1991) and Hayes (2022), the interaction between ART and WRT was graphed. As illustrated in Fig. 1, the moderation analysis indicates that the positive relationship between ART and Text comprehension is negatively affected by students' website exposure. Simple slopes analysis showed that when students score low (16th percentile) on the WRT measure, there is a positive and statistically significant relationship between ART and Text comprehension, $b=0.25, t=4.41, p<.001$. For scores at the medium (50th percentiles) level on the WRT measure, there is a somewhat lower positive but still statistically significant relationship between ART and Text comprehension, $b=0.16, t=3.65, p<.001$. For scores at a high level (84th percentiles) on the WRT measure, there is a low nonsignificant relationship between ART and Text comprehension, $b=0.09, t=1.77, p=.081$.

In the next analysis, the WRT-lifestyle measure replaced the full WRT in the hierarchical multiple regression analyses. Results from step one in the analysis are the same as in the first analysis (Table 2). The addition of ART, WRT-lifestyle and the interaction term in step two resulted in a statistically significant 14% increase in

Table 2 Results of hierarchical regression analysis with Text comprehension as the dependent variable and ART x WRT as an interaction term

	ΔR^2	β
<i>Step 1</i>	0.08*	
Study experience		0.09
Reading attitudes		0.26*
<i>Step 2</i>	0.19***	
Study experience		-0.02
Reading attitudes		0.10
ART		0.44***
WRT		0.03
Interaction (ART x WRT)		-0.25**

* $p<.05$, ** $p<.01$, *** $p<.001$

Note. ART=Author recognition test, WRT=Website recognition test

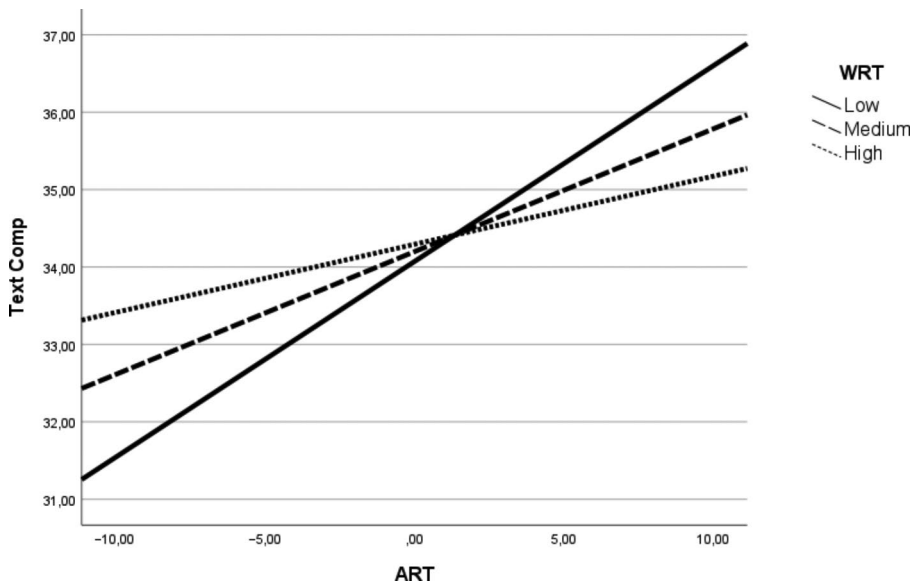


Fig. 1 Graphical representation of the moderation effect of WRT on the association between ART, represented on the horizontal axis, and Text comprehension, represented on the vertical axis. *Note.* ART=Author recognition test, WRT=Website recognition test, Text Comp=Text comprehension

explained variance, $F_{\text{change}}(3, 84)=4.92, p=.003$. In this step, only ART was a statistically significant predictor of Text comprehension, whereas results did not indicate a significant relationships between WRT-lifestyle or the interaction term and Text comprehension. The results for all predictors in the model are reported in Table 3.

Next, the WRT-news and culture measure replaced the full WRT in the hierarchical multiple regression analysis. Results from step one in the analysis are reported above. The addition of ART, WRT-news and culture and the interaction term in step two resulted in a statistically significant 17% increase in explained variance, $F_{\text{change}}(3, 84)=6.36, p<.001$. Again, only ART was a statistically significant predictor of text comprehension in this step, whereas exposure to news and culture websites did not predict text comprehension at a statistically significant level. Neither did the interaction term. The results for all predictors are reported in Table 3.

Finally, WRT-social replaced the full WRT in the hierarchical multiple regression analysis. Again, results from step one in the analysis replicated results reported in the first regression analysis (see above). When ART, WRT-social and the interaction term were added to the equation in step two, there was a statistically significant 17% increase in explained variance, $F_{\text{change}}(3, 84)=6.47, p<.001$. Results show that ART and the interaction between ART and WRT-social were significant predictors of text comprehension, whereas there were no statistically significant association between WRT-social and text comprehension. The results for all predictors in the model are reported in Table 3.

Interpretation of simple slopes indicates a positive and statistically significant relationship between ART and Text comprehension for low scores on the WRT-social, $b=0.24, t=4.26, p<.001$. This relationship is also statistically significant for

Table 3 Results of hierarchical regression analyses with Text comprehension as the dependent variable and three models including either WRT-LS, WRT-N&C, or WRT-SO in the second step

	ΔR^2	β
<i>Step 1</i>	0.08*	
Study experience		0.09
Reading attitudes		0.26*
<i>Step 2 (Model 1)</i>	0.14**	
Study experience		-0.01
Reading attitudes		0.07
ART		0.46***
WRT-LS		0.03
Interaction (ART x WRT-LS)		-0.07
<i>Step 2 (Model 2)</i>	0.17***	
Study experience		-0.03
Reading attitudes		0.05
ART		0.43***
WRT-N&C		0.11
Interaction (ART x WRT-N&C)		-0.17
<i>Step 2 (Model 3)</i>	0.17***	
Study experience		-0.03
Reading attitudes		0.11
ART		0.39***
WRT-social		-0.01
Interaction (ART x WRT-social)		-0.21*

* $p < .05$, ** $p < .01$, *** $p < .001$

Note. ART=Author recognition test, WRT-LS=Website recognition test – lifestyle, WRT-N&C=Website recognition test – news and culture, WRT-social=Website recognition test - social

medium scores on the WRT-social measure, $b=0.12$, $t=2.50$, $p=.015$, although the moderation effect is somewhat weaker than for low WRT-social scores. For high scores on the WRT-social measure, there was no statistically significant moderation effect, $b=0.03$, $t=0.41$, $p=.686$. The moderation analysis is illustrated in Fig. 2. For low scores on the WRT-social measure, there is a clear positive relationship between ART and Text comprehension, with an increase in the ART measure score positively associated with increased scores on the Text comprehension.

The same tendency, although not as salient, is illustrated for medium scores on the WRT-social, whereas Fig. 2 indicates no relationship between ART and Text comprehension for high scores on the WRT-social measure.

Discussion

The present study confirms the positive relationship between print exposure and text comprehension demonstrated among students in higher education in previous studies (e.g., Mar and Rain, 2015; Mol and Bus, 2011; Spear-Swerling et al., 2020). Students' website exposure does not predict text comprehension when print exposure is entered into the equation, and a high degree of website exposure seems to diminish the positive relationship between print exposure and text comprehension. Hence, the current study contributes to our understanding of how students' website exposure might be associated to the positive relationship between print exposure and text comprehension.

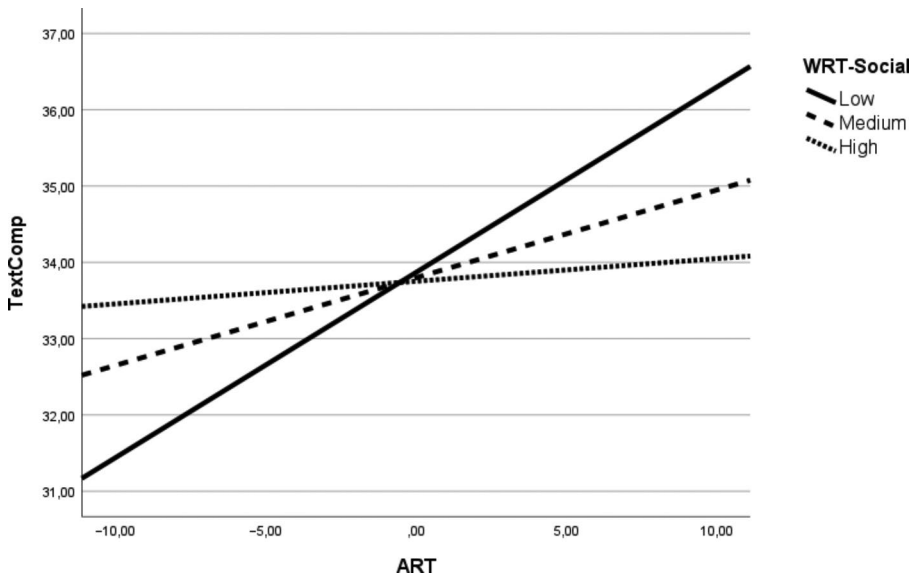


Fig. 2 Graphical representation of the moderation effect of WRT-social on the association between ART, represented on the horizontal axis, and Text comprehension, represented on the vertical axis. *Note.* ART=Author recognition test, WRT-social=Website recognition test - social, Text Comp=Text comprehension

In the first research question, I aimed to investigate whether the positive relationship between print exposure and text comprehension demonstrated in numerous studies would be confirmed in a sample of undergraduates in a digitalized society. We know there is a decrease in young people's reading of printed books and an increase in their reading of digital texts (Gran et al., 2019; Twenge et al., 2019), but we know less about whether that trend has affected the relationship between print exposure and text comprehension. The results in the present study show a moderate and positive relationship between print exposure and comprehension at approximately the same level as reported in the meta-analysis by Mol and Bus (2011). That relationship also remains when students' study experience, reading attitudes, and website exposure are controlled for in the regression analysis.

The second research question concerns whether students' leisure time exposure to website texts is related to text comprehension. The analysis of correlations among the variables indicates a small but significant and positive relationship between the website recognition test and students' text comprehension. Furthermore, this analysis also indicates that the positive relationship relies primarily on students' recognition of news and culture websites. Additionally, the analysis shows a medium correlation between the author and the website recognition tests, indicating some shared variance. Hence, when the author recognition test is entered first into the equation in multiple regression analyses, it is the only variable predicting text comprehension significantly. This result indicates that reading habits associated with texts on the internet do not relate to text comprehension when print exposure is included in the analysis. That result also resembles findings from prior studies including mea-

asures on author recognition related to both fiction and nonfiction, where only ART fiction predicts text comprehension (Mar & Rain, 2015) and vocabulary (Wimmer & Ferguson, 2022) when both fiction and nonfiction print exposure measures are entered as predictors. Websites might have elements of fiction, but the greater part of websites contain nonfiction texts. Although other studies show somewhat mixed results (Acheson et al., 2008; Mol & Bus, 2011; Spear-Swerling et al., 2020), fiction print exposure seems to be a better predictor of students' text comprehension than print exposure measures related to other genres (e.g., nonfiction books, magazines, newspapers). Mar and Rain (2015) suggest that differences in structure and content between genres might explain why exposure to fiction is more positively associated with a number of measures of linguistic abilities than exposure to nonfiction texts. In a meta-analysis, Mar and colleagues (2021) showed that narrative fiction texts were more easily comprehended and better recalled than nonfiction texts. The authors suggested that one reason could be that narrative texts more closely resemble our everyday experience, whereas nonfiction texts require more topic-specific knowledge to make inferences (Mar et al., 2021). This suggests that it could be easier to learn novel words from reading narratives than from nonfiction texts.

In the present study, the website recognition test included content representing a number of different genres, for example, news sites, blogs, and different forums. The myriad of genres represented on the internet might also represent a challenge in students' development of language outcomes such as text comprehension and vocabulary. Genre structures might guide students' text comprehension (Goldman & Bisanz, 2002) but only when they have sufficient experience with the relevant genre. Finally, the huge variation in the quality control of content on websites could also explain why website exposure does not predict text comprehension in the current study.

In the third research question, I asked whether students' website exposure would modify the relationship between print exposure and text comprehension. The results indicate that this is the case when print exposure is measured with ART fiction. For students with low or medium scores on the website recognition test, there is a positive relationship between print exposure and text comprehension, whereas for students with high website exposure, there is no statistically significant relationship between print exposure and text comprehension. Thus, website exposure seems to eliminate the potentially positive effect of print exposure on text comprehension for students high in website exposure, specifically with high exposure to social media of different kinds. The more informal, oral style, in which authors strive to mirror the everyday language of people, as well as to relate more to personal matters (Gimenes & New, 2016; Herdağdelen & Marelli, 2017), might be more dominating on the web, and specifically on social networks sites, than in the language of printed material. The tendency for social media to stand out as a potentially negative predictor of text comprehension is in line with results from studies involving younger students (Pfost et al., 2013; Torppa et al., 2020) and studies on the relationship between social media use and undergraduates' GPA (e.g., Tafesse, 2020). However, one should note that a potential negative relationship between exposure to social network sites and readers' text comprehension might not necessarily be due to the nature of the language of those websites. Another explanation is the tendency people have to become distracted by social media while they are reading other texts (Tafesse, 2020).

The results from the moderation analyses also indicate that when students score low on ART, they seem to profit somewhat in terms of text comprehension by scoring high on WRT. Thus, high website exposure seems to compensate somewhat when students lack exposure to printed material. This tendency is weak, but it might indicate that high website exposure is not necessarily negatively associated to text comprehension. In addition, the results from studies on adolescents' and young adults' text messaging have shown that the use of digital text messaging (writing and reading) does not necessarily relate negatively to a number of literacy skills (e.g., Coe and Oakhill, 2011; Grace et al., 2014; Verheijen et al., 2020). However, none of these studies focused specifically on whether text messaging relates to text comprehension, whereas the results from the present study indicate that high exposure to social network sites is negatively associated to the relationship between print exposure and text comprehension. Print exposure stands out as the only significant variable positively predicting text comprehension. One could argue that students' website exposure is more relevant when digital reading skills are the outcome variables. However, the results on the relationship between students' ICT use and digital reading performance are inconclusive and more often negative than positive (Gubbels et al., 2020; Nauman & Sälzer, 2017).

Limitations and future research

The present study has several limitations. Although the text comprehension test has been demonstrated to have acceptable reliability and validity in several studies (e.g. Gellert and Elbro, 2013; Haverkamp et al., 2022), a cloze test will normally be restricted to measuring comprehension at sentence and passage level (Trace, 2020). Hence, the text comprehension measure could be accompanied by a measure of multiple text or digital text comprehension, potentially measuring the challenges readers often are confronted with in evaluating and integrating information across different sources (Bråten et al., 2018).

In the present study print exposure was measured by ART fiction. Results from other studies have indicated mixed results regarding the association between non-fiction measures of print exposure and text comprehension (e.g. Mar and Rain, 2015; Mol and Bus, 2011). Hence, future studies on the relationships between print exposure, website exposure, and text comprehension, should consider including measures of both fiction and non-fiction print exposure.

There are a number of studies including measures of self-reported accessibility to and use of ICT as predictors of both offline and online comprehension. However, such measures tend to include all activity related to the use of computers, whereas more refined grained measures would probably produce more informative results. Other issues concerning self-reports of digital reading, are the tendency of social desirability to confound peoples' responses and the relatively weak relationship demonstrated between self-reports and log data. Thus, website recognition tests could be an alternative option, but that approach would need to be further explored regarding both reliability and validity. Future studies should attempt to investigate the relationship of print and website exposure to both offline and online comprehension.

Vocabulary is another dependent variable on interest as this variable has been demonstrated to relate significantly to both print exposure and text comprehension (Stanovich, 2000). An important argument in favor of print exposure has been that printed material normally includes more low-frequency words than TV/video and oral language. Hence, it could be of interest to investigate whether print exposure predicts vocabulary better than website exposure.

Future studies should also aim to include a more balanced distribution across gender among participants and to include larger groups of participants. Finally, given the correlational nature of the present analysis, we cannot assume a causal relationship between the exposure variables and text comprehension. Both print exposure and website exposure develops over time, and longitudinal studies of how such exposure might affect text comprehension in the long run needs to be conducted.

Despite the limitations, the results from the study represent a unique contribution to the field in indicating potential dimensions of website exposure and relationships between such exposure and text comprehension. This study confirms that print exposure is an important predictor of text comprehension, whereas the results indicate that website exposure might be negatively related to text comprehension. More research is needed on that relationship. However, the recommendation for students of all ages to read books seems to be well justified.

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