The development of adolescents' comprehension-based Internet reading skills

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Abstract

Internet-based reading involves integration and evaluation of information from different sources and different formats, but also requires fluent navigation skills for adequate comprehension. The effects of linguistic (word decoding and comprehension-based print reading) and non-cognitive factors (reading frequency and self-efficacy) have extensively been studied for print reading; we know very little about their role in Internet reading, which is our focus in this study. 558 students from grades 7 to 10 performed a set of comprehension-based Internet reading tasks on a computer, while their navigation and comprehension scores were recorded. They were also assessed on print reading literacy, word decoding, Internet reading frequency and self-efficacy. Multiple regression analyses suggest that navigation skills increase proportionally with grade level and that print reading literacy and comprehension-based Internet reading share common processes. Moreover, the positive effect of navigation efficiency on Internet comprehension increases in higher grade levels. Finally, reading frequency of the Internet for informational purposes predicts Internet comprehension scores, and self-efficacy predicts more persistent and quicker navigation.

Key words: Internet reading, comprehension, navigation, self-efficacy, language skills

1. Introduction

The Internet has become an essential platform for reading. Reading on the Internet encompasses a wide range of activities, including different reading goals and genres (from social interaction to purposeful reading), which take place in scenarios with complex, idiosyncratic structures (from hypertext documents to lists of results). Our focus in this paper is Internet tasks in which comprehension processes are important, such as integrating information from hypertexts, searching for information in web portals or critically reading web forums.

Few conceptualizations have been proposed to more precisely define the behaviors that characterize reading hypertext documents and reading on the Internet in general (for a review see Salmerón, Strømsø, Kammerer, Stadtler, & van den Broek, 2017). Most definitions agree on that navigation skills necessary to access and retrieve information are an essential competency of this construct. There is less of a consensus about to what extent two other competences, the integration of different sources of information (e.g. connecting information from different webpages) and the evaluation of information (e.g. evaluating the credibility of a recommendation in a webpage), are unique to Internet reading (for a discussion see e.g. Afflerbach & Cho, 2010). Indeed, integration and evaluation of information are central reading skills, both in print and on the Internet. On the Internet, readers must be able to integrate information from different webpages, as well as from different formats (including those not written in a coherent manner, as is the case with printed texts). In addition, Internet readers must critically evaluate information due to the lack of editorial gatekeeping, making it so that the quality of information that can be obtained on the Internet varies a lot. Furthermore, low quality information is often provided in interfaces that appear credible (for a review see Bråten, Stadtler & Salmerón, 2017).

While we have advanced in our knowledge about what it means to be a proficient Internet reader, we still don't fully understand how students become proficient. The goal of our study is to shed light on this issue by investigating the concurrent predictors of high school students' comprehension-based Internet reading.

Recently, different authors have highlighted the need to expand our view of Internet reading by exploring the impact of non-cognitive aspects of those constructs (Naumann, 2015; Zylka et al, 2015). Specifically, they call for studying non-cognitive factors, such Internet frequency of use and self-efficacy. Following these suggestions, we examined the predictive role of linguistic (word decoding, print reading comprehension) and non-cognitive factors (Internet frequency of use and self-efficacy) on the development of comprehension-based Internet reading. Prior to revising the literature on linguistic and non-cognitive predictors on Internet reading, we want to delimit the scenarios we have designed to assess comprehension-based Internet reading skills, inspired by the digital reading assessment developed by PISA (OECD, 2009).

1.1. Assessment of comprehension-based Internet reading

Current models of digital reading concur in that a major skillset for fluent Internet readers to master is the ability to move within and across different complex structures of Internet documents (Salmerón, et al., 2017). This aspect is most obvious in hypertexts that require navigation using hyperlinks to move across pages (e.g., Wikipedia and web portals). In other scenarios, such as search engine results pages (SERPs) or web forums, although navigation may not always be necessary, readers need to know the underlying structure of the documents to be able to move within them (e.g. while in SERPs webpages are usually listed in order of thematic relevance to the user's search query, in discussion forums information is organized in reversed temporal order).

Thus, when performing a comprehension task in each of the scenarios mentioned above (e.g., comparing two posts on a forum, evaluating the credibility of information, or connecting two pieces of information) the reader needs to activate specific website knowledge structures depending on the different features of each scenario (Coiro & Dobler, 2007). Moreover, with certain formats, answering specific questions requires navigating through hyperlinks (e.g., Wikipedia or web portal scenarios), and consequently using forward inferential reasoning (Coiro & Dobler, 2007; Salmerón, Fajardo, Cañas, & Kintsch, 2005), whereas others may simply require understanding the structure of the website and scrolling through it (e.g., forums or SERPs). In sum, the assessment of comprehension-based Internet reading should include some of the scenarios discussed above, as they represent different navigation challenges that must be mastered by readers (OECD, 2009).

1.2. Language predictors of comprehension-based Internet reading

Previous works have substantially explored the relationship between print reading comprehension and comprehension-based Internet reading. As Internet texts have to be ultimately comprehended, it seems rather obvious that print reading skills are necessary to understand texts on the Internet. Indeed, there is ample evidence demonstrating that adolescents' and undergraduates' print reading comprehension facilitates comprehension in different Internet tasks, including reading to comprehend (Coiro, 2011; Naumann et al., 2008; Salmerón & García, 2011; Sung et al., 2015), and question-answering tasks (Naumann & Salmerón, 2016; Salmerón, Cerdán & Naumann, 2015; Salmerón et al., 2017; Sung et al., 2015).

Less obvious is the relationship between print reading comprehension and navigation, which is an essential component of Internet reading, as mentioned above. Efficient navigation is usually defined as the selective selection of hyperlinks relevant to students' goals (Naumann & Salmerón, 2016). An explanation for a potential relationship between navigation and comprehension skills is that students with good reading comprehension skills may have stronger inferential reasoning skills, which allows them to make more efficient navigation decisions (Coiro & Dobler, 2007). While some studies have reported a positive relationship between print reading comprehension and efficient navigation of adolescents and undergraduates (Naumann, Richter, Christmann, & Groeben, 2008; Naumann & Salmerón, 2016; Salmerón & García, 2011; Salmerón et al., 2015), others have reported a non-significant association (Leu et al., 2004; Sullivan et al., 2011; Sullivan, & Puntambekar, 2015).

The development of comprehension-based Internet reading and navigation across adolescence remains largely unexplored. In one of the few studies using samples of middle and high school students, Keil and Kominsky (2013) used a simulated pencil and paper SERP to explore students' ability to match a search query with more or less relevant results. Students in the 6th grade reached adult level performance on tasks that could be solved by matching the word query with the words in the results' title and summary. It was only for tasks in which there was no potential word match, and therefore had to be solved by inferring the semantic relationship between query and results, that a clear development trend emerged. Students improved from 6th grade on, reaching adult performance at 10th grade. Naumann and Salmerón (2016) studied the effects of efficient navigation on performance in a question-answering task using hypertext in a sample of high school students (from 7th to 10th grade). They found that the benefits of an efficient navigation increased as a function of students' print reading comprehension skills. To explain this pattern, they proposed a threshold model: high school students may need to reach a critical level of comprehension skills before they can benefit from their navigation. Less skilled students could still be proficient in their navigation by using simple relevance cues such as word matching (Cerdán, Gilabert & Vidal-Abarca, 2011; Salmerón et al., 2015) or links' typography (Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011); nevertheless they may ultimately have to make sense of the hypertext information to fulfill their assignment.

Based on this preliminary evidence, we expect that comprehension-based Internet reading and navigation will improve throughout the high school years. The positive effects of navigation on performance, however, may be more pronounced in higher grades, once students have reached a critical level of comprehension skills.

There is less known about the effect of other linguistic variables on comprehension-based Internet reading tasks. It is well-known, however, that word-related skill is an important variable in predicting print reading comprehension (Perfetti, 2007). To the best of our knowledge, only one previous study has looked at the relationship between word decoding and comprehension-based Internet reading (Fesel, Segers, & Verhoeven, 2017). The authors found that word decoding skills were a strong predictor in a hypertext study task performed by 6th grade students. Their impact in older students, and their interaction with other linguistic and non-cognitive predictors, remains unexplored.

1.3. Internet frequency of use and self-efficacy and comprehension-based Internet reading

Research on print reading has found that frequency of reading of printed fiction books predicted adolescents' print reading comprehension beyond the influence of other linguistic factors (Duncan, McGeown, Griffiths, Stothard, & Dobai, 2015). Regarding Internet reading, some studies have examined the relationship between the frequency of use of information and communication technologies (ICT) and comprehension-based Internet reading skills. Evidence suggests that this relationship is not straightforward.

One could argue that frequent Internet reading is necessary for students to acquire knowledge about specific Internet website structures. However, not all Internet tasks may be challenging enough to boost the comprehension mechanisms (e.g., inference making) needed to successfully accomplish comprehension-based Internet reading tasks. Using data from the PISA 2009 assessment, Naumann (2015) found that, in 15-16 year old students, the effect of ICT frequency of use on comprehension-based Internet reading tasks varied depending on the type of use. While a high frequency of use of ICT for information tasks (e.g. 'Search the Internet for a particular topic') was related to more adaptive navigation and better performance, the opposite was found for a high frequency of use of social tasks (e.g. 'Use e-mail', 'Chat on-line') (see also Borgonovi, 2016; Lee & Wu, 2013; Pfost, Dörfler, & Artelt, 2013). Naumann (2015) suggests that, contrary to what happens in information tasks, in social interactions, students do not engage in cognitively challenging tasks (e.g., inferring the content of hyperlinks), which ultimately would improve students' comprehension skills. In the same line, Salmerón, Kintsch, & Kintsch (2010, exp. 1) found that a group of undergraduates engaged in more efficient navigation (i.e. selecting links based on their semantic relevance) when they were instructed to follow a high learning goal (i.e. 'read to summarize the hypertext') compared to those instructed to set a low learning goal (i.e. 'read for entertainment').

A critical factor related to students' frequency of use is their self-efficacy with computers and the Internet, described as the confidence in using computers to achieve certain goals, which in turn is directly related to successful performance (Bandura & Locke, 2003). Research using Internet reading tasks has shown that students with high computer self-efficacy tend to use more often and for longer times computers and develop higher performance expectations (Bates & Khasawneh, 2007) and they actually obtain higher performance in question-answering tasks (Joo, Bong, & Choi, 2000). These effects may be partially due to the fact that students with high computer self-efficacy develop more efficient navigation strategies. Specifically, research showed that students with high computer self-efficacy tend to report lower problems in searching for and evaluating information for class assignments (Strømsø, & Bråten, 2010), and use more procedural and metacognitive strategies on learning tasks (Tsai & Tsai, 2003).

Thus, we may expect that as self-efficacy increases, so will students' persistence to navigate to answer comprehension questions, as well the ability to efficiently navigate and perform comprehension-based Internet reading tasks.

1.4. The present study

The present study has two main goals: 1) to analyze the predictive role of linguistic (word decoding, comprehension-based print reading) and non-cognitive factors (Internet frequency of use for social and informational purposes, Internet self-efficacy) on comprehension-based Internet reading, and 2) to characterize the development of comprehension-based Internet reading skills across adolescence.

Our first three hypotheses address the role of linguistic and non-cognitive predictors on Internet comprehension-based skills (including navigation and actual performance). According to our Hypothesis 1 language components will contribute to explaining navigation and performance on comprehension-based Internet reading tasks and navigation. The positive roles of comprehension-based print reading and word decoding are explained by their importance in tasks that require understanding and using complex information from written texts. According to our Hypothesis 2 the role of Internet frequency of use on comprehension-based Internet reading will vary according to use. On the one hand, frequency of information tasks will allow students to practice with complex scenarios and to engage in inferential processing, thus their relation will be positive (Hypothesis 2a). On the other hand, frequency of social tasks will prevent students from practicing other challenging cognitive processes, thus their effect will be negative (Hypothesis 2b). Finally, our Hypothesis 3 predicts a positive role of self-efficacy on comprehension-based Internet reading, which could be explained by the fact that higher confidence will result in higher number of attempts to navigate to answer comprehension questions, and on higher navigation efficiency.

Our second set of hypotheses address the development of comprehension-based Internet reading skills across high-school years. Specifically, hypothesis 4 predicts that navigation efficiency and comprehension-based Internet reading skills will gradually improve across high-school years, as it is the case with other language factors such as print comprehension skills. Finally, hypothesis 5 predicts that high school students may need to reach a critical level of comprehension skills before they can benefit from their navigation. Thus, we expect a stronger effect of navigation on Internet comprehension-based tasks in higher grade levels.

To sum up, our hypothesis were the following:

#1: linguistic skills predict navigation efficiency and performance on comprehension-based Internet reading tasks.

#2: Frequency of use of Internet information tasks positively predicts comprehension-based Internet reading (2a), whereas frequency of use of Internet social tasks negatively predicts performance (2b).

#3: ICT self-efficacy positively predicts comprehension-based Internet reading and navigation efficiency.

#4: navigation efficiency and performance in comprehension-based Internet reading tasks gradually improve across high-school years.

#5: High school students need to reach a critical level of comprehension skills before their navigation efficiency improves their comprehension-based Internet reading.

2. Method

2.1. Participants

A sample of 558 high school students, 258 of them girls, belonging to six different schools located in a big Spanish city and its surrounding suburban area participated in the study. All students were enrolled in grades 7 to 10 (see Table 1 for descriptive statistics for each grade). Students came from both public and private schools, located in both city and rural areas. We only included data from the students who completed all tasks. Data from 23 students who didn't navigate in any of the questions were excluded from the analyses, yielding a final sample of 535 students.

Participation was approved by the School's boards, who planned the sessions as part of the instructional activities in the school aimed at improving pupils' digital reading skills. The study was approved by the Research Ethics committee of the University of Valencia, and followed the guidelines of the Declaration of Helsinki.

2.2. Materials and measures

Our language measures were comprehension-based reading skills (both on the Internet and in print) and decoding skills. Our non-cognitive measures were Internet frequency of use and students' Internet self-efficacy. We considered the grade level as an independent variable as it played a relevant role in this study. We also considered gender since it has been found to be relevant in some large-scale studies (e.g., PISA or PIRLS), although it was not a specific measure of this study. We used materials developed for this study (explained below) and a standardized test for comprehension-based print reading (CompLEC).

2.2.1 WebReading-S. We developed a set of materials called WebReading-S (a simulation of reading on the web) to measure comprehension-based Internet reading skills. WebReading-S includes four web scenarios and 36 questions. The four Internet reading scenarios are Google, Forum, Wikipedia and a Web portal.

Each scenario had specific structural features (see Figure 1). In the two Google scenarios used, students first had to write a query to find information for a complex topic (‘solutions to combat climate change’; ‘benefits and problems of genetically modified food’). Then they were presented with a list of five pages in a simulated Google SERP. For the remaining questions, they had to use only the information in the SERP to select a particular page, and accessed and read two pages to answer a question that required integrating information from both pages. In the two Forum scenarios used, a fictitious user posted a question (‘I am leaving to go on vacation, what should I do with my pet?’, ‘Planting a Christmas tree in my garden’), and three recommendations were provided in reverse chronological order. Items included comparison of recommendations and questions about who answered first. In the Wikipedia scenario, students were presented with a main document on the topic of the French Revolution that included 10 subsections and 24 embedded hyperlinks to additional Wikipedia pages. Questions required that participants clicked on at least one (maximum two) embedded hyperlink(s) to access relevant information to answer the question. Finally, the Web portal was a page dedicated to young people, and was divided into five categories (sports, courses, technology, nature and health), with three subcategories each. Questions required that participants clicked on at least two (maximum seven) links to access relevant information to answer the question, and involved both textual and graphic information, such as tables or maps.

-Insert Figure 1 about here-

WebReading-S contains 36 questions pertaining to three categories, inspired by PISA guidelines (OECD, 2009). The first category, access and retrieval, consists of 12 questions assessing location and information selection skills. For instance, in one of the Forum scenario students are asked “What does Naxian recommend?”, where the right response is “Professionals must take care of her pet”, which is a paraphrase of the actual recommendation (“You must take her to a veterinary center because long trips are stressful to cats”). Please note that most questions in this category required some sort of inferential activity on the part of the reader. The second category, interpretation and integration, consists of 13 questions assessing the ability to combine information from different documents or paragraphs. An example of this is the following. In one of the Google scenarios, a question asked is “Read the websites of "WHO: benefits transgenic foods ..." and "Ministry alert about ..." and then answer the following question. Which of the following statements contains the essential information on the two pages?” and the correct answer was “Transgenic foods may have high nutritional value, but could be harmful to human health.” which summarizes the main idea of the two pages. The last category, reflection and evaluation of information, consists of 11 questions assessing the ability to interpret the text’s information and reliability. For instance, in the scenario Web Portal, students were asked “At the school garden you are cultivating some endangered plants. Do you think you could succeed in planting the Water Clover?” where the correct answer was “Yes, as long as I could use the spores that have been discovered”. To answer this question, the student must navigate and read a report on the recent discovery of spores for a plant, the Water Clover, which was thought to be extinct.

Item types were equally distributed among the different scenarios, except for the questions on reflection and evaluation of information, which were included mostly in the Google and Forum scenarios. As a measure of comprehension-based Internet reading we considered the total score obtained in WebReading-S. We computed different indexes to analyze students' navigation, following the current trend in the literature to compute both time and sequence data (Mañá, Vidal-Abarca, & Salmerón, 2017; Naumann, & Goldhammer, 2017). (#1) First, we computed students' decisions to whether or not search for information in each particular question (cf. Mañá et al., 2017). Because questions were provided before the content in an independent window, in which no content information was provided, students could opt to navigate or not the webpages to obtain relevant information for their question (the system only forced them to navigate on the first question for each of the seven scenarios). Our index considered how many questions students' decided to search. (#2) Second, we coded the amount of time students devoted to read and navigate the contents. We discarded the time devoted to read or reread the question or to answer it. Our index consisted on the average time per question. (#3) Third, we computed a measure of navigation efficiency, as the number of visits to relevant pages divided by the number of total visits, in the Wikipedia and Web portal scenarios, averaged by question. Note that indexes #2 and #3 are averaged on questions for which the students actually attempted to navigate.

2.2.2. CompLEC. CompLEC is a comprehension-based print reading skills test structurally similar to PISA (OECD, 2009), a paper-and-pencil reading literacy test (Llorens et al., 2011). It includes five different texts, three continuous and two non-continuous, and a total of 20 questions: three open questions and 17 multiple-choice questions with four alternatives where only one is correct. Of the 20 questions, five belong to the category "access and retrieval," 10 to "interpretation and integration" and five to “reflection and evaluation of information.” The maximum score on this test is 20 points. Cronbach's alpha for the entire scale is .795 (Llorens et al., 2011). It should be noted that the questions from CompLEC and WebReading-S were structurally parallel, both of them inspired by PISA (OECD, 2009), and that they require the use of information from an available text.

2.2.3. Word decoding skills. As a measure of decoding skill, we used an orthographic separation task designed to assess the ability to recognize whole Spanish words rapidly. The task was designed following the original version in Norwegian (Bråten, Lie, Andreassen, & Olaussen, 1999). This task consisted of 168 nouns and adjectives presented in groups of three. In total there are 14 rows containing four chains of words, with each chain containing three words written without any space between the individual words. The students’ task was to separate as many words as possible in 90 seconds. Students’ scores were calculated by adding up the number of correctly identified words. The orthographic separation task was validated in a sample of 789 Spanish students from 7th to 10th grade (Llorens, 2013). Scores increased along the different grades. Data from a subsample of 90 students revealed a significant correlation with a reading speed task from a standardized test in Spanish (Ramos & Cuetos, 1999). Students with higher scores in the orthographic separation task read quicker both words and pseudo words.

2.2.4. Internet frequency of use. Two questionnaires were developed to measure students’ Internet frequency of use: one for social uses (nine items) (e.g. “How often do you use your computer at home to surf the Internet for fun (e.g. Youtube)”), and one for informational uses (14 items) (e.g. “How often do you use your computer at home to surf the Internet to search for information?”). Questions were answered following a 5-point Likert scale (coded as 4 “almost every day”, 3 “once or twice a week”, 2 “a few times a month”, 1 “once or twice a month”, to 0 “never”). Cronbach’s alpha reliability coefficient for each variable was .688 and .704 respectively.

2.2.5. Internet self-efficacy. To measure the students’ self-efficacy, we used a questionnaire with a set of items focusing on self-efficacy with computers (eight items, e.g. “Do you think you can create a spreadsheet (e.g. Excel)?”) and a second set addressing self-efficacy with the Internet (eight items, e.g. “Do you think you can read and write on Internet forums?”). These questions were answered following a 4-point Likert scale (coded as 4 “I can do this on my own,” to 1 “I don’t know what this is”). Self-efficacy was calculated using the average responses on the whole set of items (α = .973).

2.3. Procedure

Students were assessed in two sessions of approximately 50 minutes each. In the first session, they completed the print reading literacy test CompLEC and the word segmentation task and then responded to the Internet frequency of use and self-efficacy questionnaires in their regular classroom. In the second session, they completed the reading assessment test WebReading-S in a computer-lab classroom. The general instruction was to surf through the different scenarios in order to respond to each question. There was no time limit to perform the task.

3. Results

3.1. Descriptive Statistics

An initial group of analyses was computed to obtain the descriptive statistics for the main variables tested by grade level (Table 1). These variables include scores for the individual differences tests (comprehension-based Internet and paper reading, word decoding skills, social and informational use of the Internet, self-efficacy) and for the navigation indexes (search decisions, reading time and percentage of relevant visits during the task).

It seems that language predictors improved across grade levels, as well as the comprehension-based Internet reading skills. Overall, students were quite efficient in their navigation. The non-cognitive predictors didn't appear to change across grade levels. On average, students used the Internet for informational activities 'a few times a month', and for social activities 'once-or-twice a week'. As for their Internet self-efficacy, students perceived that they could perform different tasks on the Internet in between 'I can do this with some help' and 'I can do this alone'.

-Insert table 1 about here-

Next, we computed Pearson and Spearman correlations between the main variables (see Table 2). Supporting hypothesis 1, Pearson correlations show a positive relationship between the two linguistic factors (print reading comprehension skills and word decoding skills) and navigation efficiency and comprehension-based Internet reading skills.

As for Hypotheses 2a and 2b, Internet frequency of use tended to be unrelated to both navigation indexes and comprehension-based Internet reading scores. In line with our expectations, there was a small but significant correlation between Informational use and comprehension-based Internet reading scores. Furthermore, self-efficacy was positively related to the navigation indexes as well as to comprehension-based Internet reading scores. Such pattern of results constituted an initial support for our hypothesis 3. Finally, navigation indices also correlated with comprehension-based Internet scores: while higher percentage of questions searched and relevant pages accessed were related positively, reading times were negatively related.

As an initial test of Hypothesis 4, we computed a series of ANOVAs with grade as independent variable, and Internet comprehension-based reading and navigation indexes as dependent variables. There was main effect of grade on comprehension-based Internet task, $F(3, 531) = 9.78$, $p < .001$, $\eta^2_p = .05$, which reflected a linear progression grade by grade, as indicated by post-hoc comparisons between grades with Bonferroni corrections (all *p*s <.01). This progression was also evident in the navigation indexes. Specifically, search decisions increased in higher grades (8th to 10th) as compared to lower grades (7th grade, all three *p*s < .01), $F(3, 531) = 13.84$, $p < .001$, $\eta^2_p = .07$. Similarly, reading times decreased in higher grades (Ninth and Tenth) as compared to lower grades (7th grade, both *p*s < .01), $F(3, 531) = 12.64$, $p < .001$, $\eta^2_p = .06$. Finally, navigation efficiency increased in higher grades (9th and 10th) as compared to lower grades (7th grade, both *p*s < .01), $F(3, 531) = 9.78$, $p < .001$, $\eta^2_p = .05$. None of the other comparisons reached significance levels (all p*s* > .10).

-Insert table 2 about here-

3.2. Mixed models with navigation indexes as dependent variable

In the following section we used mixed effects models as a more robust test for our hypotheses 1-4 on the effects of linguistic and non-cognitive factors on both navigation and comprehension-based Internet reading, as well as its development across high-school years. In addition, such models allowed us to test our hypothesis 5 on the different effect of navigation and scores on comprehension-based Internet tasks across grade levels.

Three initial models were performed on the navigation indexes as dependent variables (Table 3). Specifically, we ran mixed effect models with the following predictors as fixed factors: print reading comprehension skills, word segmentation skills, use of Internet for social and informational purposes, self-efficacy, gender and grade. We added school as a random effect to control for variation between educational centers. Gender and grade were coded as dummy variables, while the other factors were transformed to z-standardized values.

The results of the three regression models (Table 3) indicated that language factors predicted navigation, supporting hypothesis 1. Specifically, print reading comprehension skills was related to more search decisions, lower reading time and higher navigation efficiency. In addition, word segmentation was related to more search decisions and lower reading time, but it had no relationship on navigation efficiency. As for the non-cognitive predictors (Hypotheses 2 and 3), in most cases Internet use and self-efficacy didn't contribute to a significant increase in explained variance. There was only a significant negative relationship between self-efficacy and reading times. This pattern of results didn't support our Hypotheses 2-3. In addition, the effect of grade was not evident in all navigation indexes, providing only partial support for our Hypothesis 4. There was significant a progression in navigation efficiency between 7th and 9th grade and between 7th and 10th grade. Such progression was also evident in search decisions, although it only reached significance for the contrast 7th vs. 9th grade. There was no grade difference in terms of reading times.

Finally, gender contributed significantly to the explanation of the models. While girls decided to search in more questions (B = .19, SE B = .05), boys navigated more efficiently than girls (B = -.19, SE B = .08).

-Insert table 3 about here-

3.3. Mixed models with comprehension-based Internet reading as dependent variable

We performed a fourth mixed effect model with comprehension-based Internet reading scores as dependent variable (Table 4). We used the same predictors as in the previous mixed models, and added three additional predictors corresponding to the three navigation indexes used.

-Insert table 4 about here-

Regarding the two language predictors (Hypothesis 1), there was a significant effect of print reading comprehension. Scores on the print reading comprehension test were positively related to scores on the comprehension-based Internet reading test. On the contrary, the effect of word decoding skills didn’t reach significance levels.

As for the non-cognitive predictors (Hypotheses 3-4), only frequency of use of the Internet for informational purposes showed a positive effect, as expected. None of the other factors resulted were significant predictors.

Regarding the development of skills across grades (Hypothesis 4), once we controlled for navigation, linguistic and non-cognitive factors, the only difference for grade was found between 7th and 10th grade. In this line, results of the navigation indices indicated that search decisions and navigation efficiency were positively related to comprehension-based Internet reading, while reading time was negatively related. The impact of these navigation indexes was similar (betas between .09 to .10).

Finally, we tested Hypothesis 5 on the potential differential effects of navigation in comprehension-based Internet scores across grade levels. For each navigation index used in the fourth mixed model, we added three interaction terms, which resulted from multiplying each of the three grade contrasts and the particular navigation index.

First, for search decisions significant differences were found in the slopes of 8th (B = .19, SEB= .07, p = .01) and 9th grades (B = 31, SEB= .08, p < .001), but not for 10th grade (B = .08, SEB= .06, p = .20). Second, for the reading time index no differences were found for the slope of 8th (B = -.06, SEB= .06, p = .32) grade, but significant effects were found for 9th grade (B = -.16, SEB= .06, p = .01) and 10th grade (B = -.13, SEB= .06, p = .05). Finally, for navigation efficiency no significant differences were found for the slopes of 8th (B = .09, SEB= .06, p = .11) and 9th grades (B = .03, SEB= .07, p = .68), but significant differences were found for 10th grade (B = .23, SEB= .07, p = .001).

Finally, gender contributed significantly to the model. Girls scored higher in the comprehension-based Internet reading tasks than boys.

4. Discussion

The results of our study reveal important and new insights on how linguistic and non-cognitive factors predict navigation and comprehension in Internet tasks, and on how navigation and Internet reading skills develop across high-school years. In the following sections we discuss how our results aid in understanding Internet reading skills, its predictors and its development. We also discuss certain limitations of the study, and conclude with relevant educational implications of the results.

4.1. The role of language predictors on Internet reading

Our first hypothesis predicts that language components contribute to explaining navigation efficiency and performance on comprehension-based Internet reading tasks . As for comprehension-based Internet reading, our results are coherent with the hypothesis. Both comprehension reading tasks, on the Internet and in print, require common processes included in reading comprehension theories and models (Kintsch, 1998), such as activating prior background knowledge, forming ideas, and making inferences (Coiro & Dobler, 2007; Salmerón et al., 2005). The processes that take place on print reading comprehension are transferable from paper to the Internet. Regarding word decoding, it has no effect on comprehension-based Internet reading when we controlled for the effects of other variables. Thus, its role on Internet reading may be restricted to primary and middle school (Fesel, et al., 2017), when there is still large variation on this variable across students.

Regarding navigation, both word decoding and higher comprehension-based print reading comprehension skills predict more decisions to search, and quicker reading times, but only print reading comprehension skills predict a higher percentage or relevant pages visited. Making appropriate navigation decisions, such as selecting relevant information to answer questions, implies knowing which topics or ideas are semantically related, which requires making inferences, a central process in comprehension (Kintsch, 1988). In this line, Coiro and Dobler (2007) found that inferential reasoning strategies are processes common to print reading and Internet reading. Vidal-Abarca and colleagues have also shown how inferential reasoning is crucial for making appropriate decisions about what information must be used in order to answer a question, which improves performance on reading comprehension tasks (Vidal-Abarca, Mañá & Gil, 2010; Gil, Martínez & Vidal-Abarca, 2015).

4.2. Effects of Internet frequency of use and self-regulation on navigation and Internet reading

Contrary to our hypothesis 2, Internet frequency of use for informational and social tasks are not predictive of navigation efficiency, but the former predict comprehension-based Internet reading. The more students use the Internet for informational purposes, the higher their performance on comprehension-based Internet tasks, even after controlling for other linguistic and navigation-related factors. The result extends previous findings by Naumann (2015) to younger populations. It also emphasizes the importance to foster the use of the Internet for informational purposes to expose students to good academic language models, which are not so present in the pages students encounter while using the Internet for social activities (Snow, 2010).

Regarding the effect of self-efficacy, as predicted in Hypothesis 3 results evidence that students that are more confident with their ICT skills show a more persistent (higher number of questions attempted) and quicker navigation. These data support the findings of previous studies using self-reports (Strømsø, & Bråten, 2010) or think aloud protocols (Tsai, & Tsai, 2003) as measures of navigation. No effects of self-efficacy have been found for navigation efficiency, which measures the ability to identify and to stay in pages relevant for the students' goal. Persistence in navigation supports students' attempts to continue exploring the navigation space, but don't provide the inferential skills needed to identify topically relevant pages (Coiro & Dobler, 2007).

As for performance, self-efficacy has no direct effect on comprehension scores on Internet reading tasks, once we control for the effects of other factors such as navigation and print reading comprehension skills. This pattern suggests that the positive effect of self-efficacy is already accounted for in our print reading comprehension test (Llorens et al., 2011). In such test, students also must decide if they want to persist on reading to obtain relevant information for each question. The positive relation between self-efficacy and scores on the print reading comprehension test also supports this argument.

4.3. Development of navigation and Internet reading across high-school grades

Hypothesis 4 predicts a progression of navigation and Internet reading across high-school grade levels. Our data provide ample evidence for the development hypothesis. There is a clear progression from lower ($7\text{-}8^{th}$) to higher ($9\text{-}10^{th}$) grades in different navigation indexes, with older students increasing their number of search decisions and navigation efficiency, and decreasing their reading times. Our results are in line with the work by Keil and Kominszky (2013) concerning how adolescents evaluate hyperlinks in Google, and extend them to the ability to navigate on comprehension-based Internet tasks. Navigation differences between grades remain only for navigation efficiency once we control for other linguistic and non-cognitive factors. This means that the development of efficient navigation across high-school years can't be just accounted for the increase in print reading comprehension skills. In other words, the development of navigation efficiency goes beyond the development of inferential skills (cf. Coiro & Dobler, 2007). In the absence of other evidence, we can only speculate about the additional factors implicated in such development. A potential factor is students' knowledge and understanding of the organization of web pages (metatextual knowledge). Text organizers include local organizers, such as headings and introductions, and global organizers, such as tables of contents and page headers (Rouet & Le Bigot 2007). Previous research has only focused on the effects of metatextual knowledge of printed documents, but webpages present important structural differences, such as their organization by means of hyperlinks. Future studies could analyze the development of young students' knowledge of web page structures, and its implication in the development of a more efficient navigation.

Regarding the expected progression of Internet reading scores, our analyses reveal a clear linear progression across grades during high-school. Once we account for navigation, linguistic and non-cognitive factors, most of those differences vanish.

Interestingly, 10th grade students still show better Internet reading scores than 7th graders, after controlling for relevant navigation and linguistic factors. Again, we can only speculate about the factors responsible for such difference. A potential candidate, not explored in our study, is students' background knowledge. As students progress in high-school, their growing knowledge base on different domains could be used to support their navigation. For example, prior topic knowledge supports students' inhibition of hyperlinks irrelevant for the task (Rouet et al., 2011; Salmerón, Kammerer, & García-Carrión, 2013). The exact role of prior knowledge on the development of Internet reading skills is open for future research.

Finally, our hypothesis 5 predicts that the positive effect of navigation on comprehension-based Internet reading is increased in higher grade levels. Although positive effects of navigation on Internet reading are observed for all students, the magnitude of such effects varied across grades. As compared to 7th grade students, the effects on comprehension-based Internet reading are increased in higher grades for the negative relation of reading times (8th and 10th grades) and the positive relation of navigation efficiency (10th grade) and search decisions (8th and 9th grades). The increased effects of navigation on higher grades are in line with the threshold model (Naumann & Salmerón, 2016). Potentially, older students could have reached a critical level of word decoding and comprehension skills that allow them to benefit from quicker reading and efficient navigation.

4.4. Limitations of the study

Our study also comes with certain limitations. First, we have chosen a determined age (high school) of participants as the sample for our investigation. As this is rather unique in the literature, it also covers a limited scope of relevant grade levels. In this way, the effect of some of our predictors may change in other populations (cf.

Fasel et al., 2017). Secondly, a critical test of our study is the development of an ad-hoc but still reliable test for comprehension-based Internet reading, because there is currently no such test available in Spanish, which was the mother tongue of our participants. We have chosen four web scenarios which are representative of Internet reading at the middle and high school level, but of course, they are not the only ones available on the World Wide Web as there are other relevant interfaces such as email inbox or webpages to buy products online. Thirdly, we must acknowledge that our test includes a majority of questions targeting the navigation components. Other typical abilities necessary for Internet use, such as document integration and critical evaluation of sources, are represented to a lower degree in our assessment.

4.5. Educational implications

We also want to emphasize some important educational implications of our study. First, it can be clearly stated that comprehension-based skills from print reading can be transferred to master Internet reading tasks. Schools should continue investing efforts on building strong comprehension skills by working with print media. Second, our data show that navigation indexes such as decisions to search, reading time, and navigation efficiency, have a positive effect on Internet reading that goes beyond the effect of print reading comprehension skills. Thus, navigation should be learned and practiced in Internet instructional settings specifically, as students may not get the necessary proficiency just by practicing comprehension with print media. In sum, schools should find a correct balance between comprehension instruction in print and on the Internet.

Finally, parents and teachers must be aware of the importance of recommending frequent Internet reading at home for informational purposes, as a way to improve competences on comprehension-based Internet reading. Supporting other uses, such as social interactions, won't have a positive impact on the students' skills.

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Table 1

Descriptive statistics for the variables used in the study, by grade level

	Scale	7th Grade *M (SD)*	8th Grade *M (SD)*	9th Grade *M (SD)*	10th Grade *M (SD)*
C-b Internet Reading	0-1	0.45 *(0.13)*	0.51 *(0.14)*	0.56 *(0.14)*	0.62 *(0.14)*
C-b Print Reading	0-1	0.45 *(0.21)*	0.59 *(0.21)*	0.68 (*0.18)*	0.70 *(0.18)*
Word Segmentation	# words	69.03 *(16.84)*	79.04 *(18.82)*	81.24 *(16.04)*	84.20 *(20.02)*
Social Internet	0-4	2.92 *(0.89)*	2.65 *(0.88)*	2.77 *(0.75)*	2.74 *(0.70)*
Informational Internet	0-4	1.93 *(1.28)*	2.04 *(1.29)*	2.01 (*1.31*)	2.13 *(1.22)*
Self-efficacy	1-4	2.43 *(0.43)*	2.60 *(0.33)*	2.68 (*0.24*)	2.67 (*0.28)*
Search decisions	0-100	73.95 *(14.92*)	79.95 (*14.20)*	82.72 *(11.51)*	81.49 *(14.37)*
Reading time	seconds	33.76 *(35.72)*	26.33 *(7.78)*	23.52 *(12.92)*	26.24 *(12.91)*
Percent Relevant Visits	0-100	80.75 *(10.85)*	83.68 *(12.12)*	86.15 *(9.76)*	86.63 *(9.39)*
N		154	141	143	137

Table 2

Correlations between the variables used in the study

	1	2	3	4	5	6	7
C-b Internet Reading (r)							
C-b Print Reading (r)	.649**						
Word Segmentation (r)	.337**	.326**					
Social Internet (r_s)	.057	.068	-.004				
Informational Internet (r_s)	.113**	.112**	.097*	.289**			
Self-efficacy (r_s)	.176**	.239**	.185**	.396**	.134**		
Search decisions (r_s)	.349**	.305**	.403**	.007	-.029	.113**	
Reading time (r)	-.226**	-.170**	-.218**	-.178**	-.134**	-.231**	
Percent Relevant Visits (r)	.279**	.286**	.125**	.033	-.048	.125**	-.152**

Note: Internet reading literacy was measured with WebReading-S; Reading literacy was measured with CompLEC,
* $p < .05$; ** $p > .001$.

Table 3

Summary of the mixed-effects models for the effects of linguistic and non-cognitive variables on each of the three navigation indexes used

Variables	***B(SE B)***	***B(SE B)***	***B(SE B)***
	Search decisions	*Reading time (log transformed)*	*Percentage of relevant navigation*
Intercept (B_0)	-.34 (.13)	-.05 (.15)	-.19 (.15)
C-b Print Reading	.18 (.05) **	-.10 (.05) *	.19 (.05)**
Word Segmentation	.26 (.05) **	-.24 (.06) **	.05 (.06)
Social Internet	.03 (.05)	.08 (.05)	-.02 (.05)
Informational Internet	-.06 (.04)	.08 (.05)	.02 (.05)
Self-efficacy	.08 (.04)*	-.14 (.05) **	.04 (.05)
Gender	.19 (.05)*	.09 (.09)	-.19 (.08)*
D_Grade 8	.16 (.11)	.14 (.12)	.18 (.12)
D_Grade 9	.25 (.11)*	-.20 (.13)	.33 (.13)*
D_Grade 10	.15 (.11)	-.04 (.15)	.32 (.13)*
	R^2 = .21	R^2 = .14	R^2 = .11
	F(10, 525) = 14.08, p < .001	F(10, 525) = 8.75, p < .001	F(10, 525) = 6.70, p < .001

Note: All variables were transformed to z-standardized values, except for gender and grade. Gender is a dummy variable where male is 0 and female 1. D_Grade 8 is a dummy variable with value 1 for 8th graders and zero in all other grades. D_Grade 9 is a dummy variable with value 1 for 9th graders and zero in all other grades. D_Grade 10 is a dummy variable with value 1 for 10th graders and zero in all other grades.
* p < .05; ** p < .01

Table 4

Summary of multiple regression analysis for the effects of language, non-cognitive and navigation on Comprehension-based Internet Reading skills.

Variables	B (SE B)
Intercept (B_0)	-.25 (.11)
C-b Print Reading	.48 (.04) **
Word Segmentation	.08 (.05)
Social Internet	-.01 (.04)
Informational Internet	.08 (.04) *
Self-efficacy	.05 (.04)
Search decisions	.09 (.04) *
Search time (log)	-.09 (.03) *
Percentage Rel. Visits.	.10 (.03) **
Gender	.27 (.06) **
D_Grade 8	-.07 (.09)
D_Grade 9	-.04 (.09)
D_Grade 10	.38 (.10) **
R^2= .52 $F(10, 525) = 42.83$, $p <$ .001.	

Note: The dependent variable is WebReading-S. Gender is a dummy variable where male is 0 and female 1. D_Grade 8 is a dummy variable with value 1 for 8th graders and zero in all other grades. D_Grade 9 is a dummy variable with value 1 for 9th graders and zero in all other grades. D_Grade 10 is a dummy variable with value 1 for 10th graders and zero in all other grades.

* $p < .05$; ** $p < .01$

Figure 1. Screen captations of the WebReading-S scenarios used in this study.