

RUNNING HEAD: Reading skills and navigation strategies

Reading skills and children's navigation strategies in hypertext

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Prior research has identified two important navigation strategies that have a clear impact on hypertext comprehension: link selection and overview processing strategies. The first relate to the order in which students select hyperlinks while trying to comprehend a hypertext, whereas the second relate to when and for how long students process navigation overviews, a text device that conveys the text structure by displaying sections, titles and their relations. Most prior research in navigation strategies has been conducted with undergraduate students. We extend prior research by exploring the navigation strategies used by sixth-graders while reading a hypermedia system. We also investigate how reading skills relate to the use of navigation strategies, and how both shape students' comprehension in hypertext. Results from an electronic reading study replicated in sixth-graders the results on navigation strategies previously found in undergraduate samples. In addition, the results revealed that reading skills predicted the use of link selection but not of overview processing strategies. We discuss our results in light of new models of electronic reading proficiency, and propose some instructional guidelines to improve children' electronic reading proficiency.

Keywords: navigation strategies; reading skills; hypertext comprehension; graphical overviews.

As the influence of the Internet grows and more schools get connected to the Internet, the use of hypertext and hypermedia documents for children learning is becoming a common practice in primary schools (Karchmer, 2008). For example, 79.9% of Spanish primary schools students used the Internet for school assignments during the academic year 2008-2009 (MEC, 2010). The flexible access to information provided by hypertext and hypermedia systems offers great opportunities for learning to young students, because they can take control of their learning by selecting the contents in a way that fits their learning goals (Jonassen, 1993). This flexibility also comes with a cost, because not all young students are able to regulate their study tactics to take advantage of the control offered by these systems. Thus, using efficient strategies to study and navigate through hypertext systems is necessary to warrant optimal comprehension and learning (Salmerón, Kintsch, & Cañas, 2006). Most prior research in navigation strategies has been conducted with undergraduate students, as we will extensively review in the next section. Unfortunately, we can't just assume that younger students use the same kind of strategies as adult do. Indeed, a recent research using analogous hypermedia comprehension studies with college and high school students revealed that younger pupils usually employ less number and less effective self-regulation processes than older readers (Green & Azevedo, 2007).

In this paper we extended prior research by exploring the navigation strategies used by sixth-graders when reading hypermedia systems. We also investigated how reading skills relate to the use of navigation strategies, and how both shape students' comprehension in electronic environments.

Navigation strategies and hypertext comprehension

Two important navigation strategies have been identified in previous studies of hypertext and hypermedia comprehension: link selection (Amadiou, Tricot & Mariné, 2009; Foltz, 1996; Madrid, van Oostendorp & Puerta Melguizo, 2009; Salmerón, Cañas, Kintsch, Fajardo, 2005; Salmerón, Kintsch & Cañas, 2006; Salmerón, W. Kintsch & E. Kintsch, 2010) and overview processing strategies (Salmerón, Baccino, Cañas, Madrid & Fajardo, 2009). The first refers to the order in which students access hyperlinks while reading a hypertext, whereas the second relates to when and for how

long students process navigation overviews, a text device that conveys the text structure by displaying sections, titles and their relations.

Regarding link selection, prior studies have repeatedly found that students who select hypertext sections semantically related to the previously read score higher in inferential comprehension measures than students who follow less cohesive hyperlink routes (Amadiou, Tricot & Mariné, 2009; Foltz, 1996; Madrid, van Oostendorp & Puerta Melguizo, 2009; Salmerón, et al., 2005; Salmerón, Kintsch & Cañas, 2006; Salmerón, W. Kintsch & E. Kintsch, 2010). This effect has been reported with undergraduate students with low prior background knowledge, and has been replicated in topics from different disciplines such as biology, atmospheric science, economics, history and psychology, and in different languages such as Spanish, English, and French. A common interpretation for the effect is based on the Construction-Integration (C-I) model of text comprehension (Kintsch, 1998). For this model comprehension is a process of relating the ideas of a text into a coherent mental representation. Textual information is processed in cycles, so that in each cycle main ideas that are still active from the previous cycle can be interconnected with the new information. The model differentiates between two of the mental representations that a reader forms from the text: the textbase, a hierarchical propositional representation of the information within the text; and the situation model, which integrates that information with reader's prior knowledge. By following a cohesive hyperlink route students can read subsections in a highly cohesive order, which in turn facilitates the integration of related ideas available in the different hypertext sections. Following other hyperlink routes, by contrast, results in cohesion gaps in the hypertext sequence (e.g. two related ideas could be accessed in further apart sections). Cohesion gaps might interfere with students' process of integrating ideas, especially for those lacking the necessary background knowledge to fill these gaps (cf. McNamara, Kintsch, Songer & Kintsch, 1996).

A major drawback of prior research is that it only evaluated undergraduate students. At this point, we don't know much about children hyperlink strategies. In one of the few studies exploring this issue, Coiro and Dobler (2007) discuss the strategies reported by highly proficient sixth-graders in searching tasks. Their qualitative study concludes that these readers self-regulate the relevance of their navigation path and anticipate the content of the hyperlinks while searching for information on the

Internet. This strategic pattern during search resembles the cohesive hyperlinking strategy.

Nevertheless, the use of hyperlinking strategies by young readers in reading to study tasks is still an open question. In this line, Lawless, Mills & Brown (2002) recorded the navigation path followed by fourth to sixth-graders competent readers while reading a multimedia system with the purpose of understanding the topic. The authors identified three main hyperlinking strategies: knowledge seekers, feature explorers and apathetic hypertext users. Knowledge seekers spend most of the reading time on content related documents, whereas feature explorers do that on the special features of the hypertext (as images, videos, maps). Finally, apathetic users spend short intervals of time on content related documents, and seem to follow a random reading order. Although the authors do not report results for comprehension scores, these data suggest that young students, as adult undergraduates, use different strategies to select hyperlinks. In sum, current evidence don't allow to know if younger readers use the cohesion strategy to select links while reading to study, or even if they are capable of using it. Previous developmental studies on narrative text comprehension suggest that younger students possess indeed the necessary skills to follow a cohesive route in hypertext. The ability to reflect on the relationships between text events develops during early adolescence. At around the age of 11 years, students can identify the causal relations between episodes in text narratives. Some years later, at around 14 years, they can grasp the theme that links all episodes together (for a revision, see van den Broek, 1997). From this evidence, we could expect that children as young as 11 years old would be able to follow a cohesive route while navigating hypertext.

Regarding the second important navigation strategy, overview processing, recent studies revealed that the time in which undergraduate students process navigational overviews is critical in shaping their comprehension (Salmerón, Baccino, Cañas, Madrid & Fajardo, 2009). The authors conducted two eye-tracking studies to capture students' visual processing strategies. They found that the longer time low knowledge students devoted to process hierarchical overviews at the beginning of the reading session, the higher their scores were on comprehension questions. The reversed effect was found when considering overview processing times at the end of the reading session, although only for highly cohesive hypertexts. This pattern of results was interpreted from the lens of the Assimilation Theory (Mayer, 1979), that states that graphical overviews provide an organizational

framework prior to reading. Overviews could facilitate reading of rather difficult texts, because low knowledge students will not be overloaded by the need to build a macrostructure in which to integrate the main ideas of the text (Lorch & Lorch, 1996). A major assumption of the model is that overviews may facilitate comprehension only if students process them before attempting to process text information, because overviews act at the time of information encoding, not afterwards (Mayer & Bromage, 1980).

Few studies have explored the role of overview processing with regards to children's comprehension. Developmental studies have shown that students starting at around 10 years can use efficiently a table of contents to search for information (Rouet & Coutelet, 2008). Indeed, in one of the few studies exploring overviews in young students' comprehension, Puntambekar and Goldstein (2007) proved that navigable overviews can be effective for sixth graders. The authors provided a group of young students with two versions of real class materials during a period of a few weeks. These included either a navigation overview or a list of concepts for navigation. Participants first studied the lessons, and afterwards were tested on their comprehension using several measures. The navigational overview had no effect on factual comprehension, but they improved children's inferential understanding. In addition, data revealed that students using the overview navigated better the system, i.e. visited more relevant sections for the students' objectives. This evidence suggests that overall the use of navigation overviews might boost comprehension of younger students. Nevertheless, Puntambekar and Goldstein (2007) did not evaluate the use of the overview (i.e. for how long and when students read it), and therefore we can't conclude that young students indeed behave strategically to take advantage of the overview, as previously reported in undergraduate students (Salmerón et al., 2009).

These previous works focused mostly on one of the important roles played by graphical overviews, as an explicit representation of the text macrostructure. But graphical overviews are also intended to guide students' navigation through the hypertext link structure, as the results by Puntambekar and Goldstein (2007) evidence. Thus, we need to clarify the interplay between these two aspects promoted by overviews. For example, reading an overview at the beginning of the reading may induce students to follow the structure drawn in the overview, which will result in a cohesive

hyperlink route. If that were the case, the effect of overview initial processing might be due just to the beneficial effect obtained by following a more cohesive navigation path.

In sum, previous studies have identified two important navigation strategies essential for acquiring a good comprehension level in hypertext systems: the cohesive hyperlinking and the early processing of overviews. Our review suggests that young students, starting at around 11 years, possess the necessary skills to implement these strategies. Nevertheless, the extent to which young students indeed use these strategies, and how the strategies relate to each other, is still an open question. When studying comprehension processes in young population is necessary to take into consideration their reading skills, as a key variable in children comprehension (e.g. Perfetti, 1994). In the next section we discuss possible models to explain the relationship between reading skills and the use of children navigation strategies.

Reading skills and children navigation strategies

Why some students use some navigation strategies and not others? Adult research considers that emotion-related factors are essential to explain strategy decision making (e.g. Hede, 2010). In the context of children research, before exploring potential causes for strategy decision making it is first necessary to clarify to what extent children basic reading skills are a prerequisite to implement more advanced navigation strategies. Unfortunately, the extent to which the navigation strategies in hypertext discussed above are related to reading skills has not received much attention in the literature. We know that skilled readers can implement basic reading procedures that had been practiced extensively, such as decoding, identifying statements and integrating ideas without explicit attention (Perfetti, 1994). Strategies, by contrast, are conscious and intentional processing procedures, and thus can be differentiated from basic skills (Alexander, Graham, & Harris, 1998). The study of the interplay between reading skills and navigation strategies is especially relevant for its practical implications. If reading skills enable students to use particular strategies in hypertext (e.g. Cataldo & Oakhill, 2000, for search strategies in paper format), instruction should focus on improving skills before attempting to improve students' navigation strategies. On the other hand, if skills and strategies are isomorphic constructs, instruction may target both independently.

In the last decade two research teams have proposed conflicting models to explain the interrelationships between reading skills, navigation strategies and comprehension (Leu, Kinzer, Coiro, & Cammack, 2004; Leu et al., 2005; Naumann, Richter, Flender, Christmann & Groeben, 2007; Naumann, Richter, Christmann & Groeben, 2008; Naumann, Goldhammer & Jude, 2010; Naumann, 2010). On the one hand, Dr. Donald J. Leu and his colleagues have proposed the independent model: reading skills and navigation strategies are not related, and both have an independent impact on comprehension. On the other hand, Dr. Johannes Naumann and his colleagues have developed the mediation model: reading skills benefit comprehension directly and through its impact on navigation strategies. Following we will discuss the existing evidence supporting these models, together with a third alternative, the side effect model, that serves as a control model for the other two: navigation strategies do not have an independent impact on comprehension, because they are just a side effect of reading skills (Figure 1).

INSERT FIGURE 1 HERE

First, the independent model suggests that reading skills and navigation strategies are isomorphic constructs, and thus both independently impact comprehension. This model has been proposed by proponents of the New Literacies framework, which considers that reading on the Internet demands for a different set of skills than those traditionally used to read printed texts (Leu et al., 2004). For example, Leu et al. (2005) studied the relationship between seventh-grade students' reading skills, as measured by a standardized comprehension test, and a test of on-line reading proficiency (ORCA-Blog). This test requested students to use a blog site to locate, evaluate, and synthesize relevant information on the web. Three groups of students undertook a seven or twelve week instruction on Internet science inquiry strategies, such as encouraging students to follow unique hyperlink routes when using hypertext, rather than using common linear path more typical of printed text. Although there was a positive correlation between scores on the paper reading skills test and the on-line test for a control group of students that did not receive any strategy instruction, this relationship dropped to around 0 for the three instruction groups. This result suggests that fluency on

using Internet reading strategies for young students might not be totally related to reading skills, once students get some training on navigation strategies.

In sum, from the point of view of this model, students will use the cohesive hyperlinking and the early processing of overviews strategies independently of their reading skills. In addition, both skills and strategies could have an independent impact on hypertext comprehension scores.

Second, the mediation model considers that reading skills improve students' use of navigation strategies. Thus, reading skills may have a direct effect on comprehension, and an indirect effect through their influence on navigation strategies. Major support for this model comes from the work of Naumann and colleagues (Naumann et al., 2008; Naumann, Goldhammer & Jude, 2010). Naumann et al. (2008) conducted a lab study in which they instructed a group of undergraduate students in several cognitive and metacognitive strategies for hypertext reading. They were also tested on their reading skills with a standardized test. Finally, they read the hypertext, and afterwards wrote an essay from which their amount of learning was derived through content-analysis. The authors found that the effect of reading skills on learning was mediated by students' navigation during hypertext reading (i.e. number of relevant pages accessed). Whereas low skilled readers performed a less efficient navigation, which in turn had a negative impact on comprehension outcomes, high skilled students accessed more relevant pages, which boosted their comprehension scores. Thus, reading skills allowed students to use efficient navigation path strategies, and both had an impact on comprehension scores. In this same line, Naumann (2010) performed a field study involving a large sample of eight to tenth-graders. The authors used students' scores on a reading skills and a computer knowledge skill test to predict students' performance in an electronic reading test. This test included several scenarios typical of Internet reading, such as accessing commercial pages to compare prices, or reading a multimedia scenario to learn about philosophy. On the student level, both reading skills and computer skills significantly predicted different parts of the variance for the electronic reading scores. Again, reading skills and navigation had an effect on comprehension scores. On the level of individual tasks, comprehension was predicted by navigation, and navigation was predicted by reading skill, especially in tasks requiring many navigation steps to solve the task.

In conclusion, for the mediation model students' reading skills will influence their use of the cohesive hyperlinking and the early processing of overviews strategies. In regards to the first case, skilled readers would be better at identifying the semantic relationships between the current hypertext subsection and the existing hyperlinks (Foltz, 1996), which would allow them to use a more cohesive navigation path. In regards to the second strategy, it is not clear to what extent high skilled readers are better equipped to strategically process the overview at the beginning of the text. Indeed, the relationship between skills and overview processing could be the opposite. For example, Naumann, Richter, Flender, Christmann & Groeben (2007) found that providing low skilled readers with a hypertext system including different text-signals such as graphical overviews boosted their navigation and comprehension, as compared to linear versions of the materials.

Finally, the side effect model predicts that reading skills are the only significant predictor for comprehension in electronic environments. Skilled readers use efficient navigation strategies in hypertext, but these strategies per se do not have a direct effect on comprehension. In sum, navigation strategies are just a side effect of reading skills. For this model, the previously reported effects linking comprehension and navigation strategies could be explained by the fact that most prior studies didn't control for students' reading skills. Although to the best of our knowledge no author supports this model, we discussed it to consider the potential confounding between reading skills and navigation strategies when predicting hypertext comprehension.

In sum, previous studies have identified two important navigation strategies essential for acquiring a good comprehension level in hypertext systems: the cohesive hyperlinking and the early processing of overviews. As we discussed, both strategies boost comprehension: the cohesive hyperlinking strategy because it improves text cohesion of hypertext sections, and the early processing of overviews because it provides a framework of the text structure in which to integrate text ideas. A first goal of the current study will be to extend these findings, mostly obtained with undergraduate population, to younger students (sixth-graders). We will explore how these strategies relate to each other, and how they shape children's comprehension in electronic reading. As discussed above, previous research suggests that at least young students possess the skills to implement both

types of strategies. Finally, a second major goal of the study will be to clarify the role of reading skills on the use of navigation strategies, and their interplay in impacting comprehension in hypertext. We will test three possible views of this interplay: the independent model (reading skills and navigation strategies are not related), the mediation model (reading skills predict navigation strategies, and both independently impact comprehension), and the side-effect model (navigation strategies are just a reflection of reading skills). To answer these questions, we conducted an experiment in which a group of sixth-graders performed a reading task in a hypermedia environment provided with a navigable overview. Log-files allowed us to identify the navigation strategies used by students. In addition, students' scores on a standardized reading comprehension test were related to their navigation behaviour to predict scores on a set of comprehension questions about the hypermedia.

Method

Participants

Thirty-three sixth-grade students (11 years old) from a midsize Spanish public primary school participated in the study during the academic year 2008-2009. The sample included 51.6% of female students, and most students were Caucasian. The school is located in a neighborhood with medium-high socioeconomic status families. None of the students were classified as learning disabled by the school therapists. Their average grades for sixth-grade was 3.2 ($SD = 1.2$) (5 being the highest and 1, denoting failure, the lowest).

The school was equipped with two computer labs. Students received two sessions each month on how to use computers for school assignments. On average, students reported that they had been using computers for 3.6 years ($SD = 1.2$), and the Internet for 2.8 years ($SD = 1.5$). All of them had computers with internet access at home.

Materials

Hypermedia. We constructed a hypermedia document based on a chapter on "Ancient Rome daily life" from a text-book used in the participating school. The hypermedia included 2332 words and 8 pictures. It was divided into 20 sections, and included a navigable hierarchical overview, which signaled the structure of the sections (see Figure 2). Students had to click on the nodes in order to read

the sections. The color of the hyperlinks changed after students visited the corresponding section. The higher node of the hierarchy was a main introductory section, “The origins of Rome”. The hierarchy included five second-level sections, eleven third-level sections, and three fourth-level sections. Second level nodes introduced the information with rhetorical questions such as “How was the Roman society?” or “How did the Romans dress?” Sections in levels third and fourth further developed the topics of each subsection. The topic of Ancient Rome is introduced in the Spanish curricula in the seventh grade, thus most students had not much prior knowledge.

INSERT FIGURE 2 HERE

Questions. We constructed twelve questions (6 true-false and 6 multiple-choice). Six questions evaluated text-base comprehension by requesting information that was stated in a single section. An example of a text-base question is the following: “Slaves in Ancient Rome were born and died being slaves, so they could not change their social status. True or false?” The answer to this question was included in the section “Slaves”. Another six questions evaluated inferential comprehension by requesting students to integrate information that appeared in at least two different sections (e.g. “The social status of women in Ancient Rome was similar to that of slaves, because they could not vote nor have a job as politician. True or false?” To answer this question, students had to refer to information included in the “Roman women” and “Slaves” sections). Used as a scale, the questions were moderately reliable (Cronbach’s $\alpha = .52$ and $.49$ for text-base and inferential questions respectively).

Reading skills test. We used the Test of Comprehension Strategies (TEC; Vidal-Abarca, et al., 2007), a standardized paper and pencil test in Spanish, composed of two expository texts and ten multiple-choice questions per text. Questions targeted different comprehension processes as proposed by Kintsch (1998).

Procedure

Students were assessed on their reading skills in their regular classroom. One day later they performed the experimental session in a computer classroom. Students were first instructed on how to

navigate with a sample hypermedia system. Once they declared to be confident with the system, they were instructed to read all the sections of the hypermedia with the aim of answering several questions about the contents. They were explicitly told to check thoroughly the graphical overview provided with the hypermedia, because it could boost their comprehension, and they had to use it to navigate through the system. After reading the hypermedia, they were provided with the comprehension questions. Students could go back to the hypermedia if needed.

Results

Question 1. Children's navigation strategies and their effect on comprehension.

We analyzed log-files to identify the navigation strategies used by our participants. First, we analyzed student's use of the cohesive hyperlinking strategy by means of the mathematic technique of Latent Semantic Analysis (LSA), using a Spanish general corpus. The corpus was composed by the contents of about 600 web pages that included a vast range of topics, but mainly social and natural sciences, and literary issues. The corpus was composed of 2,059,234 documents (paragraphs) and 1,661,954 terms. The resulting matrix after applying the singular value decomposition had 330 dimensions. LSA cosines provided a measure of the degree of argument overlap between texts, which is assumed to reflect the level of cohesion between them (Foltz, Kintsch & Landauer, 1998). The rationale for this approach is that when two propositions are actually related semantically, there frequently exists a shared argument between them (Kintsch, 1992). For each participant, we computed LSA cosines between transited pages. We used the mean LSA cosine of all the transitions as a measure of the cohesion of the participants' navigation path. For example, the node titled 'Work in the Ancient Rome' had a LSA cosine of .69 with the node 'Labor in the cities', and a cosine of .15 with the node 'Feminine Roman dress'. Thus, a participant will have a more cohesive navigation path if she went from the first-mentioned page to the second one than if she moved from the first to the third one.

Second, we computed reading times when the students accessed the graphical overview to analyze the use of the initial overview processing strategy. We separated the time that students devoted to process the overview the first time they access it (i.e. overview initial reading), from the time they spend on the overview afterwards (i.e. overview subsequent reading), to disentangle two

different overview reading processes as suggested by prior research (Salmerón et al., 2009). To correct for a positive asymmetry of the first measure, we used the log values in the analyses. Finally, as a control measure we computed the reading times for the text content.

To respond our first question regarding the use of navigation strategies by young students, we conducted a series of Pearson correlations between the navigation measures (path cohesion, overview initial reading, overview subsequent reading, text reading times), and the comprehension scores (percentage of correct answers for the text-base and inference questions) (Table 1). The results show that path cohesion and overview initial reading were positively correlated to scores on inferential questions. This pattern clearly revealed that young students use similar navigation strategies as those previously reported by undergraduate students, and that these strategies were positively associated with comprehension. In addition, the correlations between overview subsequent reading time and comprehension measures were not significant, which ruled out the alternative of a main effect of using overviews, and stressed the finding that overviews might only be beneficial if processed early on the reading phase (Mayer & Bromage, 1980; Salmerón et al., 2009). Finally, the correlation between path cohesion and overview initial reading times was close to zero. This result suggested that students used both strategies independently, and it ruled out the possibility that the early overview processing strategy improved students' comprehension by just inducing students to follow a more cohesive navigation path.

Question 2. Relationship between reading skills, navigation strategies and comprehension

Our second goal was to explore the relationship between reading skills, navigation strategies and comprehension outcomes. Specifically, we tested three possible models for each strategy: the independent model (reading skills and navigation strategies are not related), the mediation model (reading skills benefit comprehension directly and through its impact on navigation strategies), and the side-effect model (navigation strategies are just a side effect of reading skills).

To test the three models, we first included scores on the reading skill test in the previous set of correlations (Table 1, initial row). Results showed that reading skills positively correlate with both measures of comprehension (inference and text-base questions). Critically for our test, correlations

showed a significant positive relationship between reading skills and path cohesion, but not with overview initial processing. This pattern of results suggested that both strategies related to reading skills following different models. To further explore this relationship, we performed two multiple regression analyses to predict the two comprehension measures, including as predictors reading skills in a first step, and path cohesion and overview initial processing in a second step (Table 2 summarizes these analyses). The first model for scores on inference questions including only reading skills as predictor was significant, $B=.47$, $F(1, 32) = 8.81$, $p < .01$, $R^2 = .22$, $R^2_{corr} = .20$. The second model including also path cohesion and overview initial reading as predictors resulted in a significant change, $F_{change}(2, 29) = 5.52$, $p < .01$, $R^2_{change} = .22$, $R^2_{corr\ change} = .18$. The full model showed that all three predictors, reading skill, path cohesion and overview initial reading had a positive influence on inference comprehension scores.

Considering that reading skill only correlated with path cohesion, we tested for possible mediation effects for this strategy, following the procedure proposed by Preacher and Hayes (2008). The procedure used computed the standard errors through a bootstrapping procedure rather than by relying on distributional assumptions that could be met only in large samples. We specifically tested for the indirect effect of reading skills on inference comprehension scores through path cohesion, after controlling for the effect of overview initial reading on comprehension scores. The results revealed a significant positive indirect effect of reading skill (estimate: 0.03; $CI_{95\%}$: 0.01 to 0.12) (Figure 3).

INSERT FIGURE 3 HERE

In addition, a second set of regression models were performed on text-base questions scores. The first model with only reading skills as predictor was close to significant, $B=.31$, $F(1, 32) = 3.37$, $p = .08$, $R^2 = .10$, $R^2_{corr} = .07$. The second model including also the navigation measures did not explained additional variance, $F_{change}(2, 29) = 1.12$, $p = .36$, $R^2_{change} = 0$.

In sum, the regression models clearly revealed that the relationship between reading skills and navigation strategies followed two different models, depending on the strategy. First, the data for the cohesive hyperlinking strategy supported a mediation model (Naumann et al., 2008). Reading skills

not only produced a positive direct influence on comprehension, but also improved comprehension indirectly through its positive impact on the use of the cohesive hyperlinking strategy. Second, the use and effects of the initial overview processing strategy was best explained by an independent model (Leu et al., 2005). Reading skills were not related to the use of this strategy, which nevertheless had a positive direct effect on comprehension.

Discussion

The results from the study allow identifying the navigation strategies used by young students in a reading to study task, and shed light on how these strategies relate to reading skills to shape students' comprehension in hypertext reading. Next, we discuss the results in light of current theories, and propose some instructional guidelines to improve children' electronic reading proficiency. We conclude by discussing possible future research efforts on the field.

Use of navigation strategies by young students

Electronic reading demands young students to implement a set of strategies not present in traditional text reading. Our study extends prior research by identifying two navigation strategies used by young students similar to those reported previously with undergraduate population: the cohesive hyperlinking (Foltz, 1996) and the initial overview processing (Salmerón et al., 2009) strategies.

First, the cohesive hyperlinking strategy consists of selecting the links trying to maximize the semantic relationship between the section just read section and the next one. Data from our 11-year old students reveal that in reading to study tasks they are able to implement this strategy, which requires linking text episodes together, an ability that develops at this age (van den Broek, 1997). Thus, young students can strategically adapt their navigation route not only when they have a clear objective in mind (information search tasks, Coiro & Dobler, 2007), but also in a more general reading to study task. Also, our results show that the use of this strategy is positively correlated with comprehension scores, which replicates previous results found with undergraduate students with low background knowledge (Amadiou et al., 2009; Madrid, et al., 2009; Salmerón, et al., 2005, 2006, 2010). A classical interpretation for this effect considers that following cohesive hyperlink routes

maximizes the probability to read related ideas in near comprehension cycles (Kintsch, 1998), which facilitates their integration in the students' text representation.

Second, the initial overview processing strategy consists on a paused reading of the hypertext overview depicting the sections and its organization before proceeding to read the text contents. Our results clearly show that young students can efficiently use this strategy. Indeed, students of this age are knowledgeable about the importance of table of contents to search for information (Rouet & Coutelet, 2008). This strategy exerts a positive effect on comprehension, which replicates prior effects found in undergraduate students (Salmerón et al., 2009) in a younger sample. Also, this result concurs with prior studies that identify a global effect of overviews over navigational lists on sixth-graders comprehension (Puntambekar & Goldstein, 2007), and suggest that overview effects might also depend on how students use them. Students who read initially the overview for a longer time could develop a sense of the information structure, and afterwards this representation might act as a schema to help them to integrate the main ideas of the hypertext (Lorch & Lorch, 1996; Mayer, 1979). Finally, the results show that the initial reading of overviews is not related to higher cohesive hyperlinking navigation, which partially contradicts the results reported by Puntambekar and Goldstein (2007). This suggests that at least in the medium size hypertext used in our study the effect of overviews on comprehension is limited to its use as a schema in which to integrate the text ideas. In bigger hypertexts, as those used by Puntambekar and Goldstein (2007), the probability that students navigation departs from their learning objectives might be much higher. In this context, navigable overviews can play a more important role helping students to navigate back to relevant sections.

Navigation strategies and proficiency in electronic reading

In the previous section we have discussed the results regarding the use of navigation strategies by young students and their effects on comprehension. This arises the question about what makes a young reader proficient in electronic reading, and to what extent this proficiency may be just reduced to traditional reading skills. Our results clearly reveal that the relationship between reading skills and proficiency in electronic reading varies in between navigation strategies: reading skills correlate

positively with the use of the cohesive hyperlinking strategy, but not with the strategic processing of graphical overviews.

In regards to the cohesive hyperlinking strategy, the pattern of results obtained suggests that the relationship between this strategy, reading skills and comprehension is better explained by a mediation model (Naumann et al., 2008, 2010). Our study shows that, not surprisingly, reading skills have a direct effect on comprehension. In addition to that, reading skills positively affects comprehension by its impact on the cohesive hyperlinking strategy. In other words, good readers navigate better in terms of link cohesiveness, and because of this they can understand the hypertext better. This effect is in line with prior results conducted with young and undergraduate students (Naumann et al., 2008, 2010), which reveal that good readers navigate more often on sections relevant to their study goals. Basic reading skills may facilitate students' identification of important ideas in hypertext sections. As this, good readers could compare the semantic relationship between the current section main theme and the available hyperlinks, which may lead to a more cohesive route. By contrast, poor readers may base their hyperlink selection on superficial cues, such as mere word overlap, which may lead to a less efficient selection of hyperlinks (cf. Rouet et al., 2010). Our current research efforts aim to clarify the exact mechanisms by which reading skills mediate the selection of hyperlinks in reading tasks.

In regards to the relationship between initial overview processing strategy and reading skills, our results fit better with the interpretation provided by the independent model (Leu et al., 2004, 2005). Contrary to what we find for the cohesive hyperlinking strategy, the data reveal that reading skills are not related to the use of the graphical overview. Indeed, low skilled readers do not take advantage of reading the overview at the beginning of the study session, which could have boosted their comprehension (Naumann et al., 2007). This pattern of results suggest that the initial reading of navigation overviews is a strategy highly specific of electronic reading, and thus should be interpreted as part of the strategic repertoire of electronic proficiency (Leu et al., 2004, 2005).

Implications for instruction and future research

In sum, our results point to the idea that proficiency in electronic reading by young students is partially related to traditional reading skills, but it also has its own particularities that can't just be accounted by basic abilities. Extreme views sustaining that electronic reading either involves a completely different set of reading process than traditional reading or that they can be easily accounted by traditional reading skills would fail to address the complexity of the issue. In this line, Leu et al. (2005) claims that instruction focusing on traditional reading skills is failing to reduce the gap between low and high skilled students in Internet reading tasks, and proposes that instruction should emphasize the skills needed in electronic environments. Our results support this view in that instruction should target specific electronic reading strategies (i.e. use of graphical overviews to construct the structure of the hypertext). But our study also suggests that instruction should be combined with training in traditional reading skills, because this would also reflect in better use of electronic reading skills (i.e. following a cohesive hyperlinking route).

Indeed, the idea that electronic reading involves several skills, some of which can be related to traditional reading skills, has inspired current world-wide assessments of electronic reading, such as such PIRLS' Web-based reading initiative (PIRLS, 2009) or PISA's Electronic Reading Assessment (OECD, 2009). This general view on electronic reading proficiency reveals the importance of focusing instruction of young students on both traditional reading skills and specific Internet strategies.

Although our study provides important insights on the relationship between reading skills and two important navigation strategies, it goes without saying that it did not cover all relevant strategies of electronic reading (e.g. Coiro & Dobler, 2007). Future research should explore the interrelationships between reading skills and other strategies involved in electronic reading, such as how (and if) students' evaluate web source trustworthiness (Mason, Boldrin & Ariasi, 2010), how students integrate ideas from different web pages of a particular topic into a coherent mental representation (Salmerón, Gil, Bråten, & Strømsø, 2010), or how they activate their prior knowledge about hypertext structures (Coiro & Dobler, 2007). In addition, future studies need to relate electronic reading proficiency to specific tasks characteristics. For example, recent studies suggest that the effect of a more efficient hyperlink selection on comprehension is mediated by students learning goals

(Salmerón et al., 2010) and task difficulty (Naumann, 2010), so that navigation improves performance mostly when students set a high learning goal, or when tasks are rather difficult in terms of navigation. Further research will be required to fully understand these issues.

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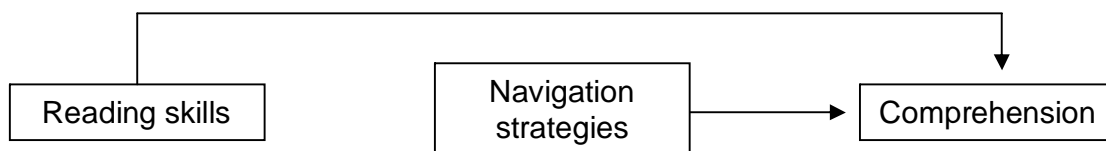
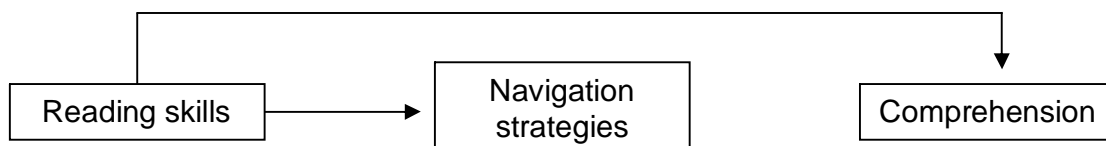
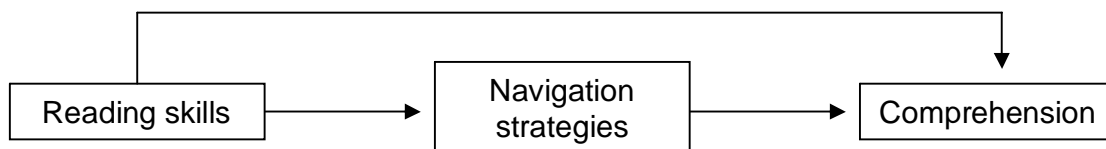
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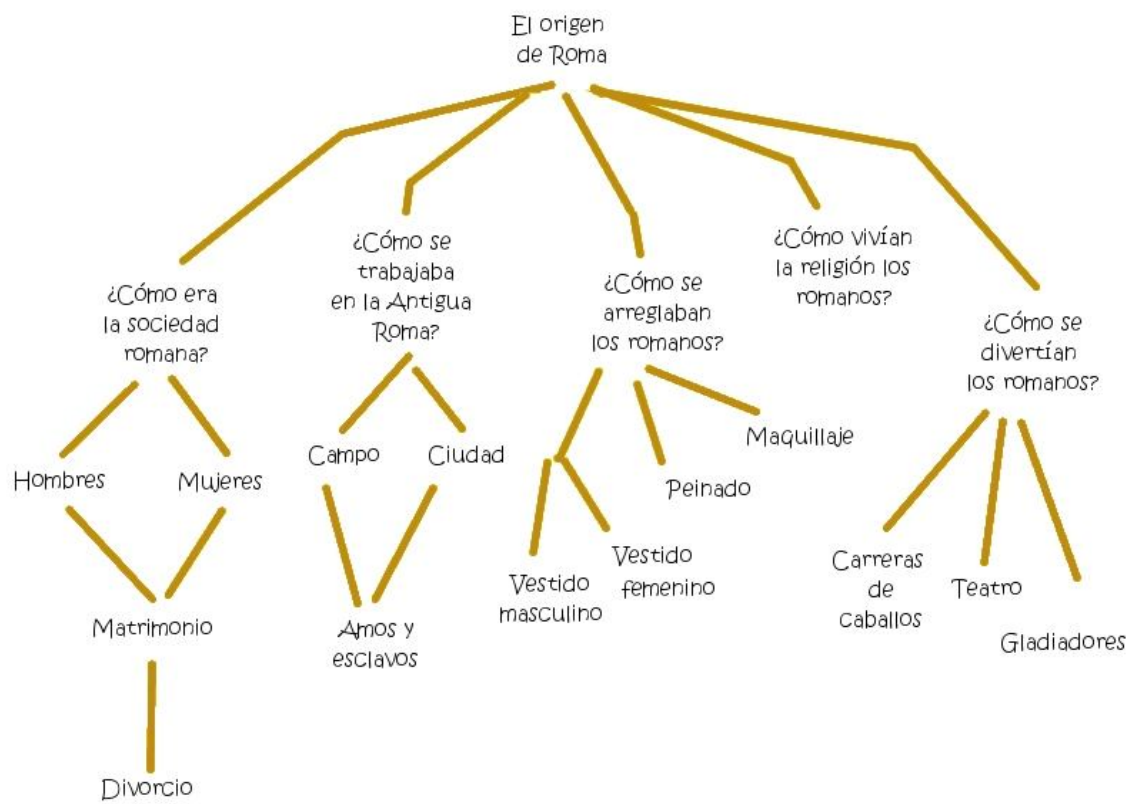
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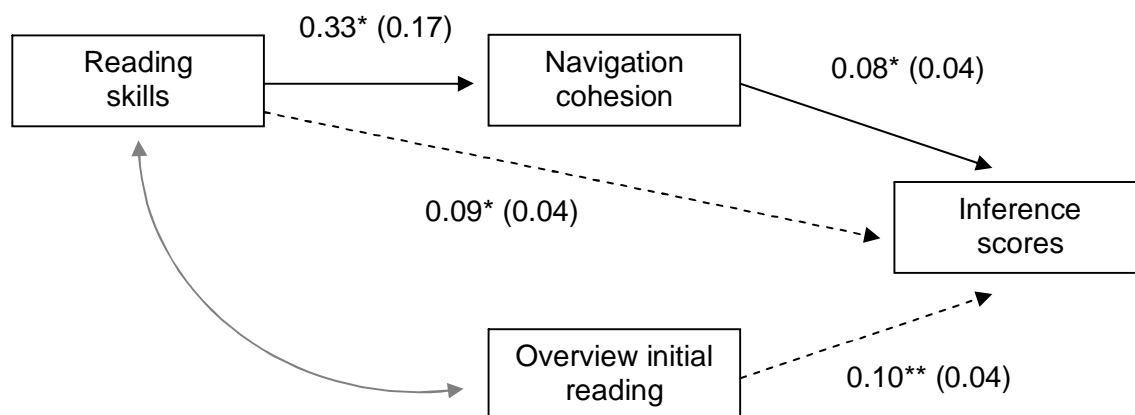
Figure 1. Graphical representation of the three possible models to explain the relationship between reading skills, navigation strategies and comprehension in electronic reading.

Figure 2. Screenshot of the navigational overview used in the study.

Figure 3. Simple mediation model for reading skills as predictor, navigation cohesion as mediator, overview initial reading as covariate, and inference scores as dependent variable.

Independent model**Side-effect model****Mediation model**





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

$R^2 = .44$

Table 1

Summary of Correlations, Means, and Standard Deviations for Scores on Reading Skills, Navigation Measures, and Comprehension Outcomes

Variables	1	2	3	4	5	6	7
1. Reading skills	-						
2. Navigation cohesion	.38*	-					
3. Overview initial reading	.01	-.08	-				
4. Overview subsequent reading	-.24	-.11	.01	-			
5. Text reading time	-.04	-.01	.15	-.14	-		
6. Text-base scores	.31*	.23	.04	-.18	.01	-	
7. Inference scores	.47**	.44**	.37**	-.23	.13	.30 *	-
<i>M</i>	4.81	.41	231	1743	496	61.62	58.59
<i>SD</i>	1.91	.02	164	604	111	28.71	26.96

Note. * $p < .05$, ** $p < .01$, one-tailed. Variables 3-5 are expressed in milliseconds per word, and 6-7 in percentage of correct responses.

Table 2

Summary of Multiple Regression Analysis for the Effects of Reading Skills and Navigation Measures on Comprehension Scores

	Inference scores	Text-base scores
<u>Variable</u>	<u>B</u>	<u>B</u>
Constant	0.58	0.61
Reading skills	0.36 *	0.29
Path cohesion	0.31 *	0.07
Overview initial reading	0.40 *	0.04
R^2	.44	.1
F	7.48 **	1.12

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