Children's Reading of Printed Text and Hypertext with Navigation Overviews: The Role of Comprehension, Sustained Attention, and Visuo-spatial Abilities

Ladislao Salmerón & Victoria García

ERI Lectura & Department of Developmental and Educational Psychology

University of Valencia, Spain

Contact address:

Ladislao Salmerón

Department of Developmental and Educational Psychology - University of Valencia

Avda. Blasco Ibáñez, 21. 46010 Valencia, Spain

ladislao.salmeron@valencia.edu

Hypertexts include new structural features, such as navigable graphical overviews, that dramatically change the way students interact with texts. Nevertheless, at school students traditionally practice literacy skills appropriate for reading and comprehending printed texts. We explored the possibility that those skills might not be the same as the ones required to master hypertext reading. Specifically, we tested the hypothesis that hypertext structural features, such as navigable graphical overviews, might scaffold students with low comprehension and sustained-attention abilities, but demand higher involvement of visuo-spatial skills. Results from a group of sixth-grade students only partially supported the hypertext structural hypothesis: while students with low sustained-attention abilities scored higher on questions demanding the integration of information in the hypertext version, the impact of comprehension and visuo-spatial abilities on performance did not differ between text types. Finally, we discuss the theoretical and potential instructional applications of the results.

A major change in reading and studying on the Internet is that students interact with hypertext documents for reading assignments. Hypertexts are information systems in which the contents are organized in an interrelated network with nodes that are documents and links that allow flexible access between these documents. At school, students traditionally practice literacy skills appropriate for reading and comprehending printed texts. Proponents of the New Literacies framework question whether mastering those cognitive skills is enough to be a fluent reader in hypertext (Leu et al., 2004; Sutherland-Smith, 2002). On the one hand, reading hypertext might require mastering additional skills. On the other hand, some skills that are essential in printed text reading might be less important in hypertext. The goal of the current study is to shed light on this issue, by comparing the role played by important cognitive factors in children's comprehension when they read printed and hypertext documents with navigation overviews. We focused on hypertexts that support students' navigation only through a graphical overview, not through embedded links in the text as commonly found in many systems. This kind of hypertext not only provides a fair amount of navigation freedom to the students but also helps them not get lost in the network of links (Salmerón, Baccino, Cañas, Madrid, & Fajardo, 2009). Thus, the pedagogical applications deserve to be explored in depth.

Why might reading printed text and hypertext with navigation overviews demand a set of different cognitive factors of our pupils? The main argument is that hypertexts include new features that dramatically change the way readers interact with texts (cf. Kozma, 1994; Reinking, 2001; Wells & McCrory, 2011): hypertexts include text passages (i.e., nodes) interconnected by hyperlinks and a set of structural features to convey this interconnection of links. Regarding the first issue, hypertext documents do not offer a unique way to read them, but leave students the freedom to choose their own reading path. This feature offers great flexibility for learning, because students can adjust their reading sequence to their particular learning goals (Salmerón, Kintsch, & Kintsch, 2010). Although in principle printed texts can also be read in any particular sequence, they are usually written by authors in a fixed way, so that the text will be cohesive only if it is read in the order intended by the authors, that is, from the beginning to the end (e.g., Britton, 1994). Regarding hypertext's structural features, educational hypertext may include navigation schemes that convey to readers the interconnection of nodes and facilitate navigation across the pages (Cuddihy & Spyridakis, 2012). These navigation schemes come in different display types, such as tables of content (as in Wikipedia pages), navigation menu links, or navigation overviews (see the example in Figure 1). Overviews might facilitate readers' organization of their mental representation of the text (Lorch & Lorch, 1996; Mayer, 1979), especially if they pay close attention to it at the beginning of their study session (Salmerón et al., 2009; Salmerón & García, 2011). In that case, students might use the overview as a mental schema in which to incorporate the information distributed across the different nodes. Although printed texts can also include graphical overviews emphasizing the organization of the ideas in the text, the overviews are not necessarily used to guide the students' reading sequence, and can be easily ignored.

The specific reading features of hypertexts not only facilitate students' reading and comprehension but also impose new difficulties. For example, deciding which hyperlink to follow after reading a particular node might be a challenge for some students without the necessary skills who might get lost in the hypertext (Conklin, 1987; DeStefano & LeFevre, 2007). In addition, to navigate efficiently (e.g., without coming back many times to an already visited irrelevant node), students need to remember the location of the information in the different nodes visited (Payne & Reader, 2006).

Therefore, students may need to master different cognitive factors than those used in printed text reading to cope with the new reading features of hypertexts. Recent studies explored this issue by comparing the impact of several cognitive factors on reading performance in different text formats (Shapiro & Niederhauser, 2004). Although there is evidence that important factors in printed text comprehension play a substantial role in hypertext, such as topic background knowledge (Amadieu, Tricot, & Mariné, 2011) or metacomprehension (Azevedo, Guthrie, & Seibert, 2004; Coiro & Dobler, 2007), other studies suggest that some important skills may play different roles in comprehending printed text or hypertext (e.g., Leu et al., 2004). Next, we review these studies, by focusing on three important factors: comprehension skills, sustained attention, and visuo-spatial abilities.

Cognitive Factors and Reading of Printed Text and Hypertext with Navigational Overviews

Comprehension skills are a set of basic reading procedures that students practice extensively in elementary school, such as decoding, identifying statements, and integrating ideas efficiently (e.g., Perfetti, 1994). Prior research suggests that comprehension skills, as measured on conventional reading tests, might be less decisive for comprehension when students read a hypertext than when reading a printed text. In this line, Naumann, Richter, Christmann, and Groeben (2008) found that undergraduate students' comprehension skills had a major role in predicting reading comprehension in a linear version of an expository text, but the effect diminished when predicting scores in a hypertext version of the same text provided with a navigation overview. Similarly, Leu et al. (2005) found a correlation close to 0 between scores a standardized reading skills test and performance scores on an Internet reading task in a sample of trained young students. To explain these results, Naumann et al. (2008) proposed the hypertext scaffolding hypothesis: structural cues available in hypertext documents, such as navigation overviews representing the structure of the text, might scaffold the comprehension efforts of students with low reading skills. Without such a scaffold, students with low comprehension skills might be overwhelmed by the task of organizing the text information into a coherent representation.

- Insert Figure 1 about here-

The role of sustained attention might also be different in comprehending printed text and hypertext with navigational overviews. This skill can be defined as the ability to keep focusing on meaning construction activities and to inhibit features alien to the reading task (Kupietz, 1990). Sustained attention is essential for printed text reading due to the incremental nature of comprehension (Lam & Beale, 1999), because failing to identify important ideas or relationships at one point may limit comprehension of forthcoming text. To the best of our knowledge, no previous studies have compared the relationship between sustained-attention skills and printed text and hypertext comprehension. Nevertheless, results from reading intervention studies suggest that the ability to sustain attention on reading tasks might play a lesser role in computer reading. Particularly less skilled readers might benefit from reading on computers. In this line, studies with young students with low sustained-attention abilities found that computerized reading programs increased the students' attention to the reading tasks (Clarfield & Stoner, 2005; Rabiner, Murray, Skinner, & Malone, 2009). Similarly, research with undergraduate students with attention-deficit/hyperactivity disorder revealed that they correctly answered more questions on a reading test when they were displayed on a computer rather than on paper (Lee, Osborne, & Carpenter, 2010). A potential cause of this effect is that computerized texts include instructional features that might help students with short attention spans focus their attention on relevant information and avoid features alien to the reading task, such as the presentation of text information in small pieces (i.e., hypertext nodes), the repetition of important information across the reading session (e.g., the organization of the text conveyed in the navigation map) (Rabiner et al., 2009), or the presentation of one question at a time in a computerized reading test situation (Lee et al., 2010).

Although previous studies have found a positive effect of computer reading for students with low sustained-attention levels, this effect might not be generalizable to all kinds of hypertext. For example, if a hypertext includes embedded links in the text, students may have to constantly decide about the relevance of the links, while keeping track of reading and comprehending the text (i.e., the "cognitive overhead" concept, Conklin, 1987). In this case, students with low sustained-attention levels might find it hard to discard appealing yet irrelevant content, which might interfere with the students' learning (cf. Lawless & Kulikowich, 1996).

Finally, the role of visuo-spatial abilities has also been explored in reading printed text and hypertext with navigational overviews. Visuo-spatial abilities are usually defined as the ability to store and manipulate spatial and visual information (Baddeley, 1986, 2003). Prior studies suggest that these skills do not play a relevant role in young students' printed text comprehension (Seigneuric, Ehrlich, Oakhill, & Yuill, 2000). In contrast, visuo-spatial abilities are considered an essential skill in hypertext reading, because they might help students orient themselves in the hypertext structure. For example, Pazzaglia, Toso, and Cacciamani (2008) found that children's visuo-spatial skills correlated with the correct representation of the organization of nodes in the hypertext. Rouet, Vörös, and Pléh (2012) obtained similar results in a sample of undergraduate students. A representation of the hypertext organization might help orient students in the hypertext, and subsequently facilitate several comprehension processes, such as locating relevant information.

Although the reviewed studies represent a critical advance in the field, they also present some limitations: the findings are based mostly on populations of undergraduate students, and thus, these studies are difficult to generalize to younger students (Lee et al., 2010; Naumann et al., 2008; Vörös et al., 2009, 2011). The studies explored the isolated effect of one major cognitive factor on hypertext comprehension without considering the combined effect of other important factors (Clarfield & Stoner, 2005; Lee et al., 2010; Rabiner et al., 2009; Vörös et al., 2009), or they did not compare the effects of the cognitive factors in a printed text (or a computerized linear version of the text) and a hypertext version of the documents (Clarfield & Stoner, 2005; Rabiner et al., 2009; Pazzaglia et al., 2008). We addressed these issues in a new study.

Hypotheses

Most of the reviewed evidence concurs with the fact that hypertext navigation overviews change the way students read the text, and therefore so do the cognitive demands of the reading task. After reviewing the evidence, we test the hypertext structural hypothesis stating that the impact of important cognitive factors (i.e., comprehension skills, sustained attention, and visuo-spatial abilities) on students' performance might vary depending on how the structural features of hypertexts shape students' reading behavior (cf. Naumann et al., 2008). On the one hand, some hypertext structural features, such as navigational overviews, make the structure of the text more salient (Goldman & Rakestraw, 2000), which can assist students with low comprehension and sustained-attention skills to organize and to focus on relevant information. Thus, the impact of these cognitive skills on final comprehension would be lower in hypertext than in printed text. On the contrary, the need to build a representation of the hypertext structure to get oriented in that medium implies that high visuo-spatial skills are needed to succeed in hypertext with navigation overviews, contrary to what occurs in printed text.

The hypertext structural hypothesis implies that hypertext structural features support comprehension by facilitating the integration of related ideas that are presented in separated nodes of the hypertext (i.e., integrate questions, OECD, 2009). For example, by displaying in a navigation overview two nodes in the same hierarchical branch students might be aware that the information from those nodes will probably be related. However, hypertext features might not necessarily facilitate identifying ideas in a node (i.e., retrieve questions, OECD, 2009), because the structural features do not convey information about the organization of a particular node.

As a test for this hypothesis, we performed a study that assessed the combined impact of relevant cognitive factors (i.e., comprehension skills, sustained attention, and visuo-spatial abilities) on the comprehension outcomes of sixth-grade students, when reading either a printed text or a hypertext version of an expository text with a navigation overview.

Method

Participants

Sixty-six sixth-grade students (11 years old) from a state-funded school in Valencia, Spain, participated in the study. The study was conducted in three intact classrooms. Of the sample, 56.6% were female students. All participants were native Spanish speakers. None of the students had been diagnosed as learning disabled by the school psychologist. On average, students had been using computers for 3.6 years (SD = 1.2) and the Internet for 2.8 years (SD = 1.5).

Materials

Printed text and hypertext. All students read an expository text, “Daily Life in Ancient Rome” (Espinós, Masià, Sánchez, & Villar, 1987), used in the participating school as complementary material. It was composed of 2,382 words, divided into 20 nodes. An introductory section was linked to five main sections (i.e., society, work, fashion, religion, and shows in Ancient Rome). Each section included three or four subsections. The original text was revised to simplify and adapt it to the hypertextual environment: we rewrote the text subheadings/hypertext links to ensure they clearly conveyed the main topic of the text section/hypertext node. Printed and hypertext versions of the document included the same information, and an effort was made to make them visually identical. To this end, the pages of the printed text corresponded to high-quality screen captures of the hypertext version.

The document was accompanied by a navigation overview that made explicit the hierarchical structure of the text by organizing the related sections/nodes under the same hierarchy branch. Students who worked with the printed text saw the graphical overview on the initial page of their booklet. Those who worked with the hypertext saw the navigation overview on the first screen of the hypertext, and had to use the overview to navigate across the different nodes by clicking on the map links. The hypertext did not include embedded links in the text. Therefore, students necessarily had to go back to the navigation overview to decide which node to read next.

Comprehension questions. We constructed 12 comprehension questions (six true-false and six multiple-choice). Six retrieving questions requested information that was stated in a single section/node. For example, a retrieving question asked, “Slaves in Ancient Rome were born and died being slaves; thus, they could not change their social status. True or false?” The answer to this question was included in the section “How Masters and Slaves Worked in Roman Society.” Another six integrating questions requested students relate information that appeared in at least two different sections/nodes (e.g., “The social status of women in Ancient Rome was similar to that of slaves, because they could not vote or have a job as a politician. True or false?” To answer this question, students had to refer to information included in the sections “Women in Roman Society” and “How Masters and Slaves Worked in Roman Society”).

Comprehension skills test. We used the Test of Comprehension Strategies (Vidal-Abarca et al., 2007), a standardized paper-and-pencil test in Spanish, composed of two expository texts and 10 multiple-choice questions per text. Questions targeted different comprehension processes as proposed by Kintsch (1998).

Sustained-attention test. We used the test on perception of differences (Thurstone & Yela, 1985). The test is composed of 60 groups of three similar faces, in which one is different from the rest by only one feature. In 3 min, the student has to point out as many different faces as possible. This test has been widely used to measure sustained attention in middle school students (e.g., Crespo-Eguilaz, Narbona, Peralta, & Reparaz, 2006).

Visuo-spatial abilities test. We used the visuo-spatial subcomponent of the standardized intelligence test BADyG (Yuste, 2001). Students are presented with incomplete geometric figures and have to select the partial image that fits in the incomplete figure.

Procedure

The study involved two sessions of approximately 45 min each. In the first session, we assessed the cognitive factors indicated above (i.e., comprehension skills, sustained attention, and visuo-spatial abilities) in the students’ classroom. In the second session, students were randomly distributed in the printed text or hypertext version conditions. Both groups were given the same reading instructions: first, they had to read the whole text as if they were preparing for a test, and later they had to answer the questions. The students were allowed to go back to the text if needed. Finally, they were explicitly told to thoroughly check the navigation overview provided with the printed text/hypertext, because it could help them to better understand the information. Additionally, students in the hypertext group were told to use the navigation overview to navigate through the system. They practiced with an example until they felt confident about how to move across pages with the navigation overview. All students worked individually at their own pace.

Results

First, we checked with *t*-tests that the groups did not differ on the cognitive factors assessed. As expected, there were no differences between groups in their scores for the comprehension skills, $t(65) = -0.05$, $p = .96$; sustained-attention skills, $t(65) = 0.09$, $p = .93$; and visuo-spatial skills tests, $t(65) = -0.94$, $p = .35$ (Table 1).

—Insert Table 1 about here—

Next, we calculated Pearson correlations between the cognitive factors assessed on the comprehension scores (retrieve and integrate questions) by type of text (printed and hypertext) (Table 2). Comprehension skills positively correlated to comprehension scores (integrate questions) in both types of text, while sustained-attention positively correlated only to comprehension in printed text (retrieve and integrate questions). Nevertheless, visuo-spatial skills did not correlate with comprehension scores in any of the text types. Thus, we excluded this variable in the subsequent regression analysis in which we considered the combined effect of the cognitive factors and type of text on comprehension scores.

—Insert Table 2 about here—

Finally, we assessed the effect of the significant cognitive factors (i.e., comprehension and sustained-attention skills) on comprehension scores by text type (printed text and hypertext). We ran multiple regression analyses with interaction terms (Aiken & West, 1991). Scores on the comprehension and sustained-attention skills tests were entered simultaneously into the regression model together with the type of text and the interaction terms. Type of text was entered as a contrast-coded dummy variable (printed text coded with -0.5 and hypertext with 0.5). Cognitive factor variables were entered as *z*-standardized variables. The results of the regression model for the retrieve question scores are summarized in Table 3 (left columns). Although the resulting model was not significant, there was a main effect of comprehension skills, revealing an overall positive relationship between these skills and the scores for the retrieve questions for printed text and hypertext conditions. No other effects resulted in significant differences.

—Insert Table 3 here—

The results of the regression model for integrate questions scores are summarized in Table 3 (right columns). The analysis resulted in a statistically significant model, with type of text, comprehension skills, and the interaction between type of text and sustained attention reaching significance levels. Students' scores on the integrate questions were higher in the hypertext than in the printed text condition. As in the retrieve questions, there was an overall positive relationship between comprehension skills and the scores on the integrate questions. Finally, simple slopes analyses revealed that whereas sustained-attention skill was positively related to scores for the integrate questions in the printed text group ($B = 0.38$, $SEB = 0.15$, $t(60) = 2.66$, $p = .01$), the effect was negligible in the hypertext group, $B = -0.07$, $SEB = 0.16$, $t(60) = -0.44$, $p = .66$ (Figure 2).

—Insert Figure 2 here—

Discussion

Results from our study partially support the view that relevant cognitive abilities play different roles in shaping students' comprehension of printed text and hypertext with navigation overviews. Specifically, we evaluated the hypothesis that hypertext structural features might assist students with low comprehension and sustained-attention abilities, but might also demand higher involvement of visuo-spatial skills. In this section, we summarize the results from the study that provide new insights concerning this hypothesis, and we discuss limitations of the study and possible future directions.

Reading Printed Text or Hypertext with Navigation Overviews

The results show that hypertext with a navigation overview supports better integration of information than a printed version of the text. This beneficial effect is in line with the results from a recent meta-analysis on the effects of pupils' computer reading on comprehension, which reveals that new technologies can support students' comprehension (Moran, Ferdig, Pearson, Wardrop, & Blomeyer, 2008). In this sense, the hypertext structural hypothesis suggests that most students benefit from the fact that in the hypertext version of the document they have to use the navigation map to move between nodes of information. By repeatedly accessing the navigation map, students grasp the organization of the information in the hypertext, which in turn can help them integrate the information distributed across different nodes (i.e., integrate questions). This explanation is also consistent with the fact that the hypertext version does not influence the comprehension of isolated ideas (i.e., retrieve questions), because the hypertext structural features (i.e., navigation map) do not represent the organization of ideas inside a particular node.

We should be cautious not to generalize the beneficial effects of hypertext over printed text other than in systems with characteristics similar to the one used in our study: hypertext provided with a hierarchical and navigable overview without embedded links in the text. Indeed, prior research has revealed that using hypertexts without such overviews might be too challenging for less knowledgeable students, because they might not be able to navigate in a meaningful way on their own (Salmerón, Kintsch, & Cañas, 2006). In this last scenario, a more linear reading, such as the one assisted in printed text, might be more favorable for less skilled students.

Cognitive Abilities and the Hypertext Structural Hypothesis

How does the presence of hypertext structural features modulate the effect of different cognitive abilities on comprehension? Our study compares the predictive power of sustained-attention, comprehension, and visuo-spatial skills in printed text and hypertext. Consistent with our hypothesis, participants with low sustained attention benefit from reading a hypertext with a navigable map to a higher extent than by reading a printed text version. This result concurs with previous studies that stress the importance of new technologies for students with attentional difficulties. Specifically, the use of a navigation map to read the hypertext might function as a repetition cue of important information (i.e., the text organization) during the whole reading session (Rabiner et al., 2009). In the case of the printed text version, students with low sustained-attention levels could easily skip the graphical overview presented on the first page of the booklet, and without this scaffold might find it difficult to integrate the text information into an organized representation. In this line, Culbreth (2005) reported that students with attentional difficulties read the introductory information at the beginning of a textbook significantly less often than students without such difficulties.

Regarding the role of comprehension skills, results from our study do not concur with the hypertext structural hypothesis: the impact of these abilities on sixth-grade students' performance is similarly powerful in printed text and hypertext. This pattern of results opposes the results reported by Naumann et al. (2008), based on a population of undergraduate students. One potential explanation for this conflicting result is the existing difference in comprehension abilities between sixth-grade and undergraduate students. Lower comprehension abilities of younger students are reflected in the fact that they have incomplete knowledge of the structural features of expository texts (Goldman & Rakestraw, 2000; Rouet & Coutelet, 2008). Therefore, students with low comprehension abilities from our study might have not known how to fully take advantage of the hypertext overview. Indeed, when students are trained in a series of strategies to cope with the specific demands of Internet reading, prior comprehension skills decrease their influence on performance (Leu et al., 2004).

Although our explanation based on a lack of structural knowledge of less skilled students is tentative and deserves further research, these results demonstrate that no generalizations from such different populations should be made. Developmental studies are necessary instead to gain insight into literacy intervention guidelines at different educational stages. Indeed, other studies evaluating comprehension processes in hypertext have found big differences among groups from high school and college students. For example, Green and Azevedo (2007) found that high school students employ fewer and less effective self-regulation processes than college students.

Finally, regarding the impact of visuo-spatial skills on printed text and hypertext with a navigation overview, our results apparently do not concur with the hypertext structural hypothesis: the relation between these skills and performance is low in printed text and hypertext. Therefore, using a navigation overview does not require the use of additional visuo-spatial resources. Two potential explanations might clarify this unexpected result. On the one hand, our results are restricted to a hypertext system with an overview organized as a hierarchy of five main branches, with 20 nodes of information. More complex overviews, such those organized in a complex puzzle-like interconnected fashion, might indeed demand extra cognitive resources (cf. Schwartz et al., 2004). On the other hand, recent works suggest that the involvement of visuo-spatial skills in hypertext reading is mediated by the document characteristics: while their role in comprehension might be important when the system does not include structural cues to support the reader's orientation such as navigation overviews (Pazzaglia et al., 2008), their effect is lowered by the inclusion of such overviews (Vörös et al., 2009, 2011). Whereas visuo-spatial skills are important for keeping track of the structure of the information, the presence of a navigation overview displaying the hypertext structure might help students become oriented in the hypertext.

In sum, our results help to qualify the hypertext structural hypothesis: hierarchical overviews might not only assist students with low sustained-attention abilities but also do not impose the additional involvement of visuo-spatial skills.

Implications for Instruction and Future Research

Hypertext navigation overviews are powerful instructional features that can assist students provided that they use the overviews as structural cues to organize the hypertext information (Salmerón et al., 2010; Salmerón & García, 2011). Our study concurs with the previous literature conducted mostly with undergraduate students, and extends the beneficial effects of navigable hierarchical overviews to sixth-grade students (see also Puntambekar & Goldstein, 2007). In addition, navigation overviews might prevent the disorientation risks associated with completely free navigation. Therefore, based on the current evidence, including navigable overviews in educational hypertexts is highly recommended. Teachers might take advantage of several Internet services that offer the opportunity to freely create such documents online, such as CmapsTools (cmap.ihmc.us) or Spicynodes (www.spicynodes.com).

Our study provides initial evidence that hypertext navigation overviews are particularly useful for students with low sustained-attention skills. This guideline concurs with existing recommendations for using hypermedia systems to promote accessible educational materials (Rose, Meyer, & Hitchcock, 2005). Further research is required to determine to what extent this evidence applies to other types of hypertext structural features, such as adaptive hyperlinks, and to populations diagnosed with severe attentional deficits (cf. Solomonidou, Garagouni-Areou, & Zafiropoulou, 2004).

Finally, researchers have recently analyzed to what extent the benefits of navigable overviews can be boosted by integrating in hypertexts the potential effects of concept mapping (Amadieu, Tricot, & Mariné, 2009). In this new learning task, students not only have to navigate to learn from a hypertext but also have to actively self-organize the nodes in the overview during the learning session. Thus, the task is intended to merge the benefits of active processing with those of the structural information of overviews. Preliminary evidence reveals that the task can be fruitful for graduate-level students (Amadieu et al., 2009). Nevertheless, future research should determine if this learning activity is suitable for middle and high school students, and which cognitive skills are required to benefit from it.

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Figure Caption

Figure 1. Example of an educational hypertext with a navigation overview (source www.spicynodes.com).

Figure 2. Regression of sustained attention skills on integrate questions scores by type of text.


search...
Days, Weeks, Months, and Years
Delve Deeper
Engage Your Imagination
Calendars of the Past
Learn About Our Calendar
Anecdotes and Anomalies
Explore Calendars through the Ages
Other Calendars Used Today
Writing Dates Correctly
Equinoxes and Solstices
Spicynodes

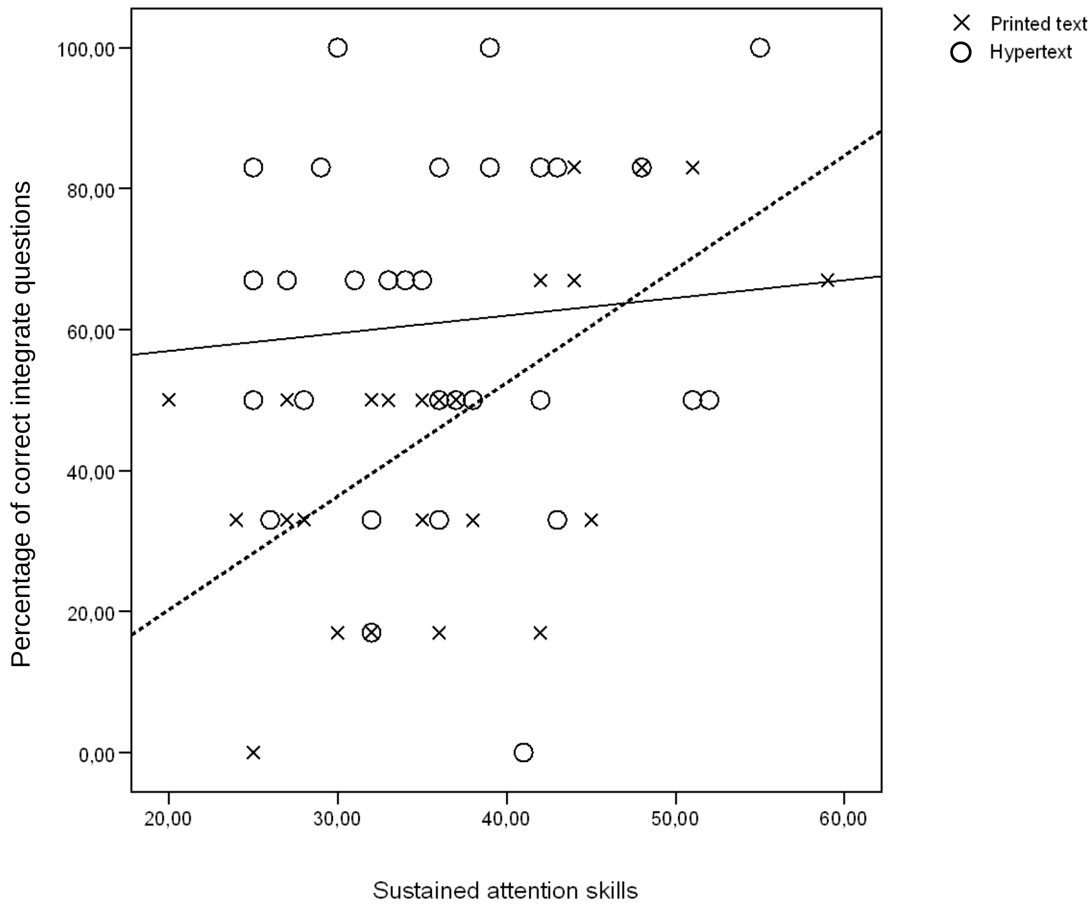
Printed text
Hypertext
Percentage of correct integrate questions
100,00
80,00
60,00
40,00
20,00
0,00
20,00
30,00
40,00
50,00
60,00
Sustained attention skills

Table 1

Average percentile ranks of the cognitive factors assessed by type of text

	Printed text	Hypertext
Comprehension skills	51.38 (30.09)	51.75 (26.30)
Sustained-attention	55.43 (27.33)	58.10 (23.22)
Visuo-spatial skills	33.27 (23.25)	39.13 (20.93)

Note. Data represents the corresponding percentile ranks.

Table 2

Correlations between cognitive factors and performance scores by type of text

	Printed text		Hypertext	
	Retrieve	Integrate	Retrieve	Integrate
Comprehension skills	0.25	0.58 ***	0.32	0.47 **
Sustained-attention	0.38 *	0.59 ***	-0.06	0.18
Visuo-spatial skills	0.17	0.33	0.01	0.14

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

Table 3

Summary of multiple regression analysis for the effects of Comprehension and Sustained-attention skills and Type of Text on comprehension scores

	Retrieve questions			Integrate questions		
	B	SE_B	*t*	*B*	SE_B	*t*
Intercept (B_0)	-0.04	0.37		-0.69	0.32	
Type of text [a]	0.02	0.24	0.07	0.42	0.20	2.11 *
Comprehension skills [b]	0.24	0.12	1.98 *	0.45	0.10	4.32 ***
Sustained-attention [b]	0.10	0.13	0.80	0.16	0.11	1.50
Text x Comprehension skills	0.25	0.25	0.99	0.18	0.21	0.88
Text x Sustained attention	-0.42	0.26	-1.64	-0.47	022	-2.15 *
Model fit	R^2 = .13			R^2 = .38		
Omnibus test	*F*(5,60) = 1.85			*F*(5,60) = 7.39 ***		

Note. [a] Dummy-coded, Printed text = -0.5, Hypertext = 0.5, [b] z-standardized.

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