



Interaction between prior knowledge and concept-map structure on hypertext comprehension, coherence of reading orders and disorientation

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ABSTRACT

The study examined the interaction effects of prior knowledge and hypertexts structure (network vs. hierarchy) on comprehension. Comprehension was investigated analyzing jointly three dependent variables: comprehension outcomes, coherence of the reading sequences and feelings of disorientation. The results supported most of the assumptions showing an interaction effect on each measure. For low prior knowledge readers, a hierarchical structure improved comprehension performance, helped them to follow coherent reading sequences and reduced their feelings of disorientation. For high prior knowledge readers, comprehension performance and feelings of disorientation were not affected by the type of structure. Moreover, prior knowledge was a relevant resource to cope with the cognitive requirements of reading non-linear texts. In the network condition, prior knowledge supported better comprehension, led the readers to follow more coherent reading sequences and limited their feelings of disorientation. The discussion dealt with processes based on prior knowledge involved in hypertext comprehension, and stressed the need for conducting further investigations on the nature of the on-line inferences and on relations between performance, navigation and disorientation.

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1. Introduction

For 20 years hypertext systems have received more and more interest as instructional devices. As for more classic learning materials (e.g. learning from texts), prior domain knowledge plays a main role in comprehension and learning (for the literature reviews see, Amadiou and Tricot, 2006; Dillon and Gabbard, 1998; Shapiro and Niederhauser, 2004; Shlechter, 1993). Prior knowledge is a relevant resource for coping with cognitive demands entailed by learning from hypertexts (Scheiter and Gerjets, 2007; Scheiter et al., 2009). Because hypertexts organize information in a non-linear way, readers have to control their reading, evaluate their information needs and seek information by selecting links (Shapiro and Niederhauser, 2004). Reading non-linear information causes discontinuous processing of hypertext contents (Storrer, 2002) and may hamper the construction of a coherent mental representation of hypertext contents, because readers experience difficulties establishing semantic relations between information nodes (Salmérón et al., 2005, 2006). Converse to a network structure, a more linear or hierarchical structure is usually expected to reduce navigational and comprehension difficulties (DeStefano and Lefevre, 2007; Potelle and Rouet, 2003; Scheiter and Gerjets, 2007). Indeed, either such a structure guides navigation (e.g. a linear structure allows only backward and forward jumps) or it conveys a represen-

tation of content organization as a concept map for instance. Concept maps are classically defined as meaningful representations of concepts and their relations; they are “a schematic device for representing a set of concept meanings embedded in a framework of propositions” (Novak and Gowin, 1984, p. 15).

Inquiring into the effects of prior knowledge according to the type of structure on hypertexts comprehension allows understanding of how a knowledge base might help readers to cope with these requirements and difficulties. Outcomes measures provide indications on the level of performance, yet, they do not provide an exhaustive understanding of the underlying cognitive mechanisms. To study difficulties and cognitive processes during hypertexts comprehension, additional data is needed. Firstly, recording and examination of navigation behaviors should allow inferring the underlying cognitive processes. Because comprehension involves semantic processing to construct coherent and elaborated mental representations (Kintsch, 1988), studying how readers construct their reading sequences should inform on the on-line inferences drawn by readers. Secondly, taking into account the disorientation in hypertexts experienced by readers should inform about the processing which causes difficulties and may hamper comprehension. Readers' disorientation refers to difficulties knowing where they are in a hypertext and how to reach a target location (Conklin, 1987). Because disorientation is mainly measured and examined in research on information seeking tasks (e.g. McDonald and Stevenson, 1996), empirical evidences of disorientation in hypertext comprehension tasks are required.

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Hence, the current study aims firstly to use jointly the measures of comprehension outcomes, navigation and disorientation in order to improve our understanding of the effects of prior domain knowledge and hypertext structures on hypertexts comprehension. Secondly, the study proposed to use different measures of navigation (measures of coherence of reading sequences) in order to identify the types of cognitive processes engaged during hypertexts reading.

1.1. Prior knowledge and comprehension outcomes

In the literature about hypertexts, the interaction effects between the level of prior knowledge and the type of hypertext structure received much interest (e.g. Amadieu et al., 2009a; Calisir et al., 2008; Potelle and Rouet, 2003; Scheiter and Gerjets, 2007). Most of the studies investigating the effects of prior knowledge used global measure of comprehension or learning. The majority of the empirical results confirmed a lack of effect of the different hypertext structures for high prior knowledge readers and a positive effect of guiding structures, such as hierarchical structures, for low prior knowledge readers (Calisir and Gurel, 2003; Gay, 1986; Lee and Lee, 1991; Patel et al., 1998; Recker and Piroli, 1995; Shin et al., 1994). A concept representation of the contents (de Jong and van der Hulst, 2002) as well as a structure limiting navigation (Kerwin, 2006) supports low prior knowledge readers' performance. However, the nature of the comprehension processes remains unclear in this set of studies because only a global measure of comprehension performance was considered.

For 10 years, several studies have attempted to infer the nature of the comprehension processes on the basis of the assessment of different levels of texts representation: text base and situation model (Kintsch, 1988). The text-base is a representation implying text propositions explicitly mentioned in texts while the situation model is a representation implying information from both texts and readers' prior knowledge base. In order to construct an elaborate situation model, readers have to infer relations between elements of texts information. Usually, the assessment method of situation models in hypertext comprehension consists of questions requiring inferential activity to connect different information from different nodes (Amadieu et al., 2009a; Madrid et al., 2009; Salmerón et al., 2005). Within this framework of the Construction-Integration model, it may be expected that prior knowledge would mainly promote inferences to construct deep representation of hypertexts contents, that is, a good situation model. Unfortunately, the results on the levels of texts representation have a low consistency and do not support this assumption. Studies indicated that prior knowledge supports comprehension only at the situation model level (Amadieu et al., 2009a; Hofman and van Oostendorp, 1999; Mishra and Yadav, 2006; Müller-Kalthoff and Möller, 2006; Salmerón et al., 2006 second experiment; Shapiro, 1999); conversely, other studies showed a positive effect of prior knowledge only at the text base level (Le Bigot and Rouet, 2007; Salmerón et al., 2005, 2006 first experiment); and finally, other studies pointed out a positive effect of prior knowledge on both levels of representation (Müller-Kalthoff and Möller, 2003, 2004; Potelle and Rouet, 2003).

This state of the art highlights inconsistent results that may be explained by the heterogeneous methodologies of the studies (e.g. complexity of comprehension tasks, features of hypertexts, knowledge domains, etc.). Therefore, it is necessary (a) to continue investigating the levels of texts representation and (b) to investigate additionally the on-line comprehension processes rather than examining outcomes measures only. Indeed, our comprehension of the cognitive processes would benefit from additional investigations on readers' navigation that provide information about on-line processes engaged in construction of texts representations.

1.2. Prior knowledge and navigation

Studying reading behaviors would give more reliable information about the nature of on-line cognitive processes than alone outcomes measures. The methods used to assess navigation usually imply either quantitative measures (e.g. number of opened nodes, navigation patterns) or qualitative measures (e.g. interviews). The research on navigation indicated that high prior knowledge readers exhibited a deep and elaborate navigation, consisting in exploration of a topic in detail, while low prior knowledge readers explored different topics superficially, for example conducting systematic or shallow explorations (Carmel et al., 1992). This shallow exploration would help low prior knowledge readers to understand the relations between the main topics of a hypertext. Last et al. (2001) confirmed that low prior knowledge readers used less elaborate strategies, more based on the hypertext structure (methodical and exhaustive pathways) whereas high prior knowledge readers used elaborate strategies searching familiar contents or those related to his/her interests. High prior knowledge readers follow more structured navigation patterns (Ford and Chen, 2000; Mishra and Yadav, 2006; Rezende and de Souza Barros, 2008). These studies provide important findings explaining how prior knowledge may support navigation in hypertexts. Nevertheless, the lack of cognitive model does not allow interpreting the cognitive processes during navigation. Furthermore, because most of the results come from qualitative studies (Last et al., 2001; Mishra and Yadav, 2006; Rezende and de Souza Barros, 2008), the development of quantitative measures of navigation should increase the reliability of the findings and should allow comparisons between studies.

Since a few years, studies have used texts comprehension models (Kintsch, 1988) to investigate cognitive processes engaged in establishing semantic connections between concepts (between text sections) to construct a coherent mental model of contents. Coherence in reading hypertexts refers to the strength of the semantic relations between the text sections. A high coherence between two text sections (e.g. sharing similar concepts) helps the reader to incorporate the textual information from the text section into what has been previously read. A low coherence between text sections lead readers to generate necessary inferences to maintain coherence and may consume the resources of the reader (Foltz, 1996). Two text sections may share different types of semantic relations, for instance, temporal-causal, referential (argument overlap) or spatial relations (Zwaan and Radvansky, 1998).

A recent experiment on coherence of reading sequences in a hypertext with a network concept map (Amadieu et al., 2009a) confirmed that prior knowledge supported more coherent reading sequences (navigation respecting the temporal-causal relations between text sections). The studies which focused on referential coherence (Salmerón et al., 2005, 2006) did not corroborate any effect of prior knowledge on the coherence of the reading sequences. Nevertheless, the results obtained by Salmerón et al. (2005) revealed that low prior knowledge benefited from high coherent reading sequences (only on the situation model measures) whereas high prior knowledge readers benefited from low coherent reading sequences (only on the situation model measures). These findings stressed that prior knowledge might promote deep processing of hypertexts when readers encounter coherence gaps. It supports inferential activity to fill in the coherence gaps and thus a deeper subsequent comprehension.

Therefore, experiments should be carried out on the coherence of reading sequences with demanding hypertexts (i.e. non-linear structures like a network structure) that does not guide reading sequences as a hierarchical hypertext for instance. Furthermore, the previous studies focused on different types of navigation coherence and tested only one measure of coherence. Assessing coher-

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