

GLOBAL AND LOCAL OVERVIEWS AS STRUCTURAL AIDS IN A HYPERTEXT LEARNING ENVIRONMENT

*Thiemo Müller-Kalthoff^{A**}, Jens Möller^A, and Elke Wild^B*

^A *University of Kiel, Germany*

^B *University of Bielefeld, Germany*

Abstract (English)

Abstract: The present study investigated how different graphical overviews affected learning with hypertexts, given differing levels of learners' prior knowledge, on $N = 87$ students. Overall, the learners seemed to profit more from global overviews (of the overall structure) than from local overviews (of several substructures). This was true in particular when the subject of investigation were learning outcomes at the macro-level of the text. With low prior knowledge, the learners showed better comprehension when they had access to a graphical summary of content. For learners with high prior knowledge, a more demanding graphical browser type was particularly useful when the text required deeper comprehension at the micro-level.

Abstract (German)

Zusammenfassung: In der vorliegenden Studie zum Lernen mit Hypertexten wurde an $N = 87$ Studierenden die Eignung unterschiedlicher graphischer Übersichten bei unterschiedlichem Lerner-Vorwissen überprüft. Insgesamt scheinen die Lerner mehr von globalen Übersichten (über die Gesamtstruktur) als von lokalen Übersichten (über mehrere Teilstrukturen) zu profitieren. Dies gilt insbesondere dann, wenn es um die Lernleistung auf der Makroebene des Textes ging. Bei niedrigem Vorwissen der Lernenden resultierten bessere Verstehensleistungen, wenn eine graphische Inhaltsübersicht genutzt werden konnte. Für Personen mit hohem Vorwissen erwies sich eine anspruchsvollere graphische Browservariante als förderlich, gerade dann, wenn es um das tiefer gehende Verstehen auf der Mikroebene des Textes ging.

INTRODUCTION

There are a series of navigational aids assumed to help learners in their free navigation through hypertext learning environments (for a summary, see Dias, Gomes & Correia, 1999). The majority of authors see graphical overviews of the document structure as an indispensable navigational aid. The main objective of the present study is to test the suitability of graphical overviews to learning with hypertexts, taking into account the moderating influence of learners' prior knowledge of the material in question. We compare four types of graphical overviews that have received little attention in previous studies to date: 1. a global summary of content; 2. a combination of local summaries of content; 3. a global browser; 4. a combination of local browsers.

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** Corresponding author. Department of Psychology, University of Kiel, Germany, Olshausenstr. 75, D-24118 Kiel, Germany. Email: mueller-kalthoff@psychologie.uni-kiel.de.

Navigational aids as structural information

Graphical overviews of the document structure have generally been considered useful in enabling readers to more easily construct a kind of cognitive map of the hypertext environment (e.g., Samarapungavan & Beishuizen, 1994). According to the “Visual Argument Hypothesis” (Vekiri, 2002), graphical representations make it easier to connect the concepts within a text. This reduces the demand on cognitive resources that could otherwise, under the assumption of limited working memory (summary in Miyake & Shah, 1999), lead to deficits in learning (“cognitive load theory”; e.g., Chandler & Sweller, 1991, 1996). A series of empirical studies on the effectiveness of graphical representations in linear texts have substantiated this hypothesis (see overview in Vekiri, 2002).

The research findings on the effectiveness of navigational aids for learning with hypertexts have not been unequivocal, however: many studies have found that the different types of overviews produced no significant differences in the answers to multiple-choice or open-ended questions (for example, Brinkerhoff, Klein & Koroghlanian, 2001). Some studies have even found that participants provided with a navigational aid were outperformed by a control group without this form of support (e.g., Jonassen & Wang, 1993). Other studies have substantiated the assumed benefits of overviews for learning (e.g., Müller-Kalthoff & Möller, 2005; Puntambekar, Stylianou & Hübscher, 2003). The evidence does seem to indicate that graphical overviews are more conducive to learning than purely *textual* overviews (for a summary, see also the meta-analytic findings in Chen & Rada, 1996). It is unclear, however, which specific characteristics of graphical overviews (type, presentation, and structure) lead to differences in learning performance.

On the influence of prior knowledge on learning with navigational aids

Some studies on the effects of navigational aids have taken into account the influence of domain-specific prior knowledge. Their findings support the basic assumption that individuals with a low level of prior knowledge stand to benefit most from navigational support. For example, learners who are low in prior knowledge of hypertexts often display greater problems navigating through hypertext learning environments than learners with high prior knowledge (e.g., Dillon, 1991). On the other hand, excessively complex learning aids can cause cognitive overload in people with low prior knowledge (see Heiß, Eckhardt & Schnotz, 2003). Hofman and van Oostendorp (1999), for example, found that a graphical overview actually impaired comprehension in learners with low prior knowledge, which they interpreted as evidence that dealing with the graphic overview distracted the participants from concentrating on the actual text content. Simple graphical aids (such as hierarchical overviews and/or summaries of content) may be better suited for learners with low prior knowledge (see, e.g., Möller & Müller-Kalthoff, 2000; Müller-Kalthoff & Möller, 2005; Potelle & Rouet, 2003; Shapiro, 1999).

People with high prior knowledge in a particular domain already possess a cognitive representation of the material, and a simple navigational overview is

thus often of little use to them. Studies on what is known as the “expertise reversal effect” (Kalyuga, Ayres, Chandler & Sweller, 2002) have even shown that instructional materials designed to help learners with low prior knowledge can impair knowledge acquisition among learners with high prior knowledge. It is possible that individuals with high prior knowledge benefit more from aids that assume a certain basic understanding of the text content (Seufert, 2003).

In a previous study, we compared a global summary of content and a global browser (Müller-Kalthoff & Möller, 2005). While graphical summaries of content offer a more structured overview of the central concepts and semantic connections within a hypertext, graphical browsers offer a detailed visualization of the *entire* structure of hypertext nodes and links (see *Fig. 1*; see Method section for further details). The results of this study were consistent with previous research on the effectiveness of graphical overviews (e.g., Dee-Lucas, 1996; Jonassen & Wang, 1993): we found that using the less complex graphical summary of content produced clear learning advantages over the graphical browser. Furthermore, the advantages appeared both for persons with low prior knowledge and for those with high prior knowledge. The question remains open, however, whether learning success differs according to the prior knowledge of the learner when also taking into account local overviews that only visualize individual subordinate points (and not the entire structure). Most empirical studies on the effectiveness of graphical overviews do not differentiate between global and local overviews (see, however, the different phases of development in the hypertext system “Intermedia”; e.g., Utting & Yankelovich, 1989). Chou and Lin (1998) found that the global overview of their 94-page hypertext made navigation significantly easier, while local overviews were not able to offer useful help (see also Jonassen & Wang, 1993). Gupta and Gramopadhye (1995) compared a less extensive 37-node hypertext with a more extensive 77-node hypertext and showed that a local overview was particularly useful in navigating the smaller document. In neither of the studies was the learner’s prior knowledge taken into account.

The construction-integration model

The construction-integration model (Kintsch, 1998) offers a number of interesting possibilities for differentiating the dependent variable learning outcomes. The model postulates that while reading a text, one constructs a propositional “text base” that acts as a foundation for summarizing and retaining the text. This text base has a macro-structure and a micro-structure. Only by constructing a “situation model” integrating elements of prior knowledge into the text base can one attain a deeper understanding of the connections. The model suggests, furthermore, that the coherence of the text base plays a particularly decisive role for people with low prior knowledge.

Kintsch (1994) draws a clear distinction in learning outcomes between “superficial” learning and “deep” learning (see also Gerdes, 1997). Superficial learning, in the sense of merely retaining information, is above all rote learning without any deeper understanding. Deep learning, in contrast, requires that connections among different elements of the content be recognized and integrated into already existing knowledge structures (see van Dijk and Kintsch, 1983). To merely retain

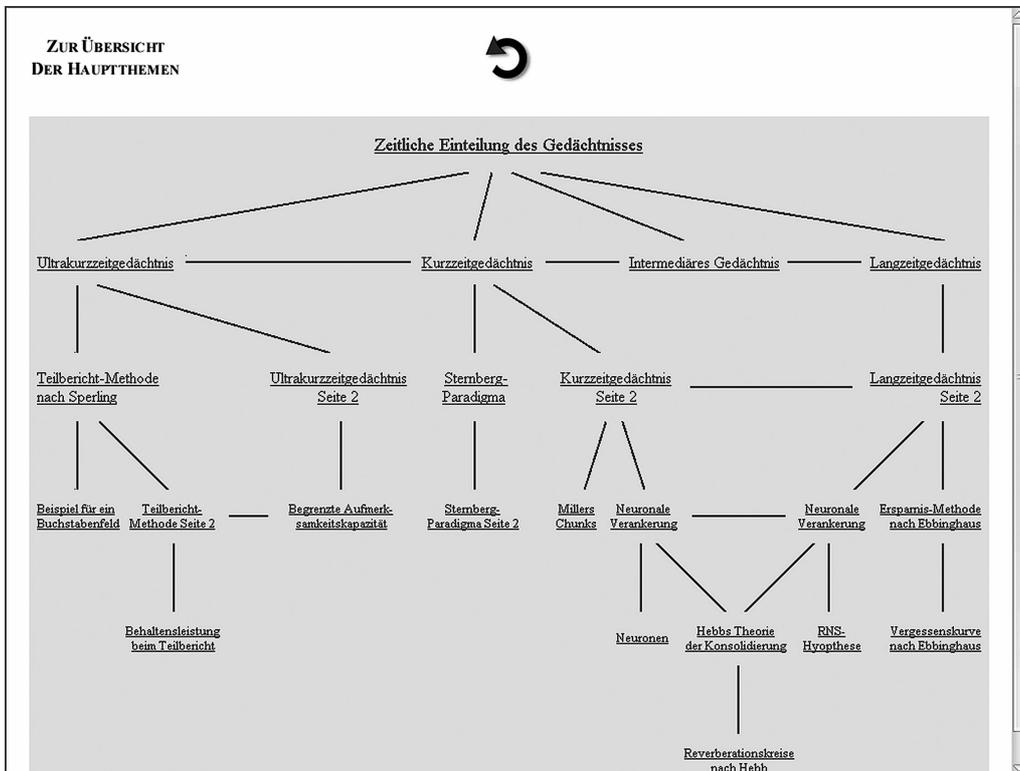
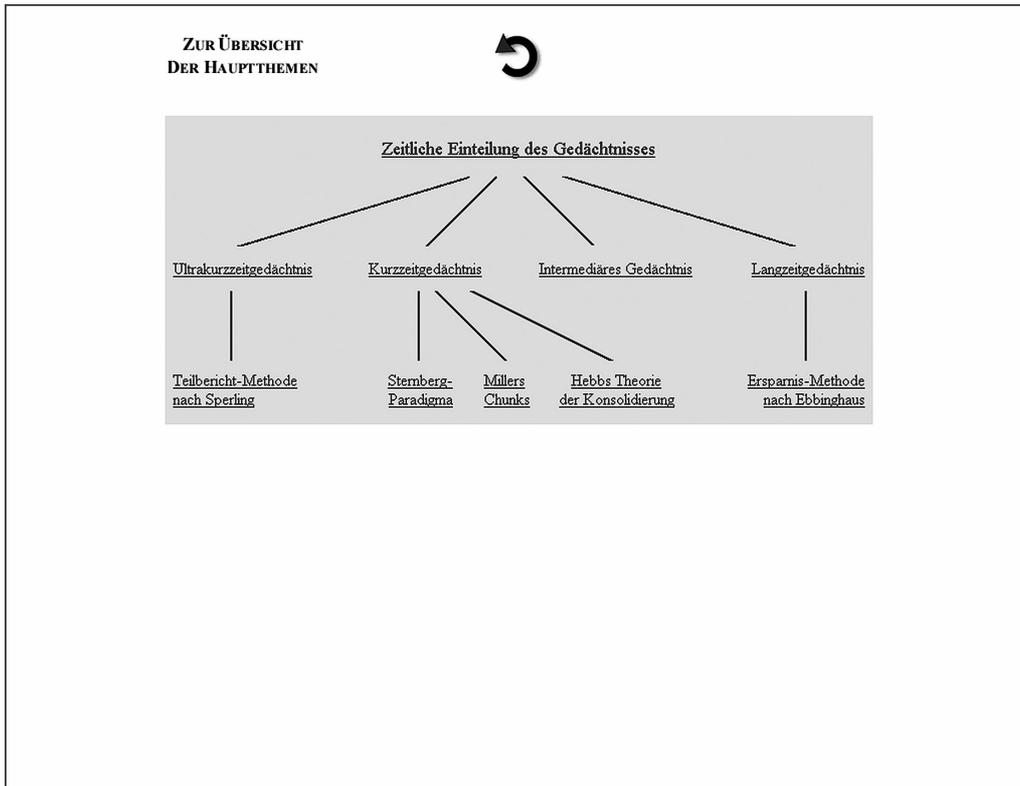


Fig. 1: Sample screenshots (in black and white) from the global overview of content (above and the global browser (below)

information, a coherent text is more helpful than a less coherent text, for both individuals with low prior knowledge and those with high prior knowledge. Deeper understanding depends on the interaction between text coherence and prior knowledge: while for learners with low prior knowledge, a coherent text leads to better learning outcomes than a less coherent text, the additional cognitive load that a less coherent text imposes on the learner can have a positive effect on the creation of the situation model and can thus lead to better learning outcomes in individuals with high prior knowledge (for empirical evidence, see McNamara, Kintsch, Butler Songer & Kintsch, 1996).

SPECIFYING THE RESEARCH QUESTION AND HYPOTHESES

The main objective of this study is to investigate the differing learning outcomes achieved when comparing graphical summaries of content and browsers on the one hand, and their presentations in global and local form on the other, taking into account the moderating influence of the learner's prior knowledge of the subject in question. Of particular interest here are any differences that may emerge between factual knowledge (in the sense of simply retaining information) and structural knowledge (suggesting deeper-level learning in the sense of comprehension). We attempt to create the basis for a more detailed analysis of the underlying connections by differentiating both factual and structural knowledge in macro-propositions and micro-propositions (see Method section for details; on this procedure see Hofman & van Oostendorp, 1999). These differentiations lead to four measures of learning outcomes.

We test the following hypotheses on learning processes that occur when using navigational aids:

1. Comparing summary of content and browser. We start from the assumption that a graphical overview is more useful than a graphical browser when the learner's prior knowledge is low (*Hypothesis 1a*). The usual explanation is that a simple summary of content provides adequate visualization of the global structure of the text for such individuals (e.g., Möller & Müller-Kalthoff, 2000; Potelle & Rouet, 2003), while the browser distracts from the actual process of knowledge acquisition (Hofman & van Oostendorp, 1999). What should be considered is that the detailed visualization of all nodes and links in a browser is not necessarily a more suitable way to structure a text. Although browsers incorporate the cognitive guidance provided by graphical summaries of content, this basic structure is "buried" in an abundance of additional information. Based on the findings of Dee-Lucas (1996) (cf. McNamara et al., 1996, on text learning) we assume that with increasing prior knowledge, learners benefit more from a summary of content than a browser *only* for attaining factual knowledge of macro-propositions (*Hypothesis 1b*). At the same time, with increasing prior knowledge, learners benefit more from a browser than for a summary of content for acquiring structural knowledge of micro-propositions (*Hypothesis 1c*). This is due to the fact that the more complex browser increases the necessity for elaboration (cf. Kintsch, 1994, on text learning).

It may be that these effects take more specific forms with different kinds of overviews (i.e., global or local). In contrast to global overviews, local overviews

demand that a number of substructures be mentally “interconnected” in order to construct a cognitive map of the overall structure. Thus, local overviews (like browsers) also require a more active structuring of the learning material. In order to compare global and local summaries of content and global and local browsers, we test the following hypotheses:

2. *Comparison of global and local summaries of content.* A global summary of content fosters higher knowledge increases on macro-propositions than a combination of local summaries of content. This is true, according to Müller-Kalthoff and Möller (2005), both with low and high prior knowledge of learners (*Hypothesis 2*).

3. *Comparison of global and local browsers.* Following on the findings in Müller-Kalthoff and Möller (2005), we hypothesize that with increasing prior knowledge, learners attain more structural knowledge on micro-propositions using local browsers than using global browsers (*Hypothesis 3*). It is possible that only the complex combination of local browsers forces learners with high prior knowledge to engage in more active structuring, and thus to elaborate their existing stock of knowledge.

METHOD

Sample

Participants in this study were a total of $N = 87$ students majoring in a variety of subjects at the Universities of Bielefeld and Kiel, Germany. The majority were women (77%). Participants ranged in age from 18 to 39 years (mean age $M = 24.13$, $SD = 3.96$).

Hypertext

The present study used a databank-based hypertext that was mainly hierarchical in structure to investigate the topic of “Learning and Memory”, like a series of previous studies (e.g., Möller & Müller-Kalthoff, 2000; Müller-Kalthoff & Möller, 2003). In the form adapted to the present study, there are a total of 23 central concepts that are distributed between the two chapters “Temporal Allocation of Memory” and “Allocation of Memory by Content”. The central concepts contain the main information on the text’s content (and correspond approximately to the macro-propositions of the theory of Kintsch, 1998). The hypertext encompasses a total of 59 nodes, 15 figures, and a total of approximately 5,000 words. The user navigates among the nodes in the hypertext mainly through unidirectional “embedded links” and by clicking on the buttons “back” (to the previously accessed node; chronological backtrack) and “overview”.

Experimental design and conditions

An experimental design was created with four conditions for the factor graphical overview. Each group of participants was provided with a *global summary of content* ($N = 22$) or a *combination of local summaries of content* ($N = 23$). The

two other groups were given a version of the *global browser* ($N = 19$) or a version of the *local browser* ($N = 23$). Taking one control group without an overview into account produced only the weak results expected for this group; we therefore do not mention them further in the following.

To realize the experimental conditions, a different version of the same hypertext was created for each of the experimental conditions. All overview types consist of a summary of the main topics (with links to the first few pages of the introduction and two hypertext chapters) and corresponding chapter overviews, which either show the total chapter structure (Chapter 1, Chapter 2) in one (global) view, or in each case, a different part thereof (local). All overviews contain headings that can be clicked on (links) and are structured hierarchically (corresponding with the hypertext structure).

Examples of the graphical overviews are shown in *Fig. 1* (page 4) and *Fig. 2*. The summaries of content show the central concepts and the corresponding semantic connections (visualized as lines) and thus offer a content-related mode of orientation (*Fig. 1*, above). The graphical browsers, however, offer a complete representation of *all* nodes in the hypertext and *all* direct links (lines) between the nodes (*Fig. 1*, below) (see Müller-Kalthoff & Möller, 2005).

The different versions of global overviews each present the entire chapter structure at a glance (*Fig. 1*). The local overviews can be described as extracts from the global overview, each of them presenting only one part of the hypertext's structure at the "current location" (and never the overall structure) (see Chou &

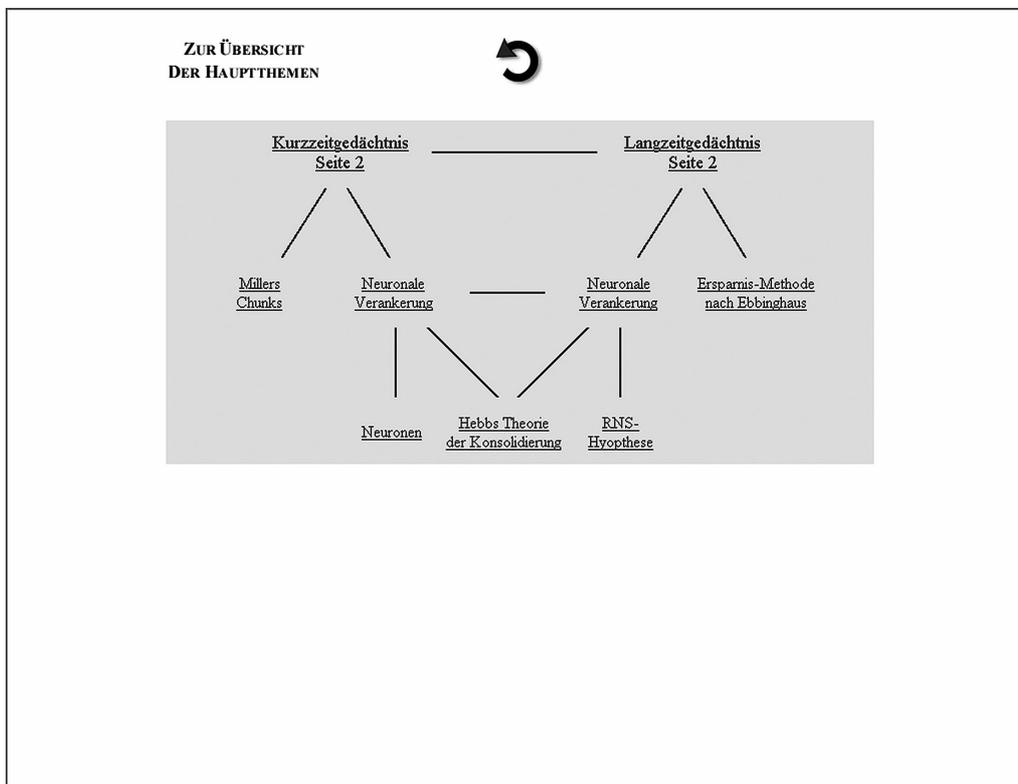


Fig. 2: Local extract from the global browser in Fig. 1 (sample screenshot in black and white)

Lin, 1998). The user sees the current node and all the nodes connected to it (in order to establish context) as well as all bordering nodes and connections (“immediate vicinity”). Fig. 2 displays the differences between the global and the local presentation taking the graphical browser as an example.

Measurement of prior knowledge

The learner variable “prior knowledge” was operationalized through 20 multiple-choice questions with four possible answers designed to assess participants’ factual knowledge in the domain of “Learning and Memory” (example item: “Who introduced the concept of the chunk? (1) George Miller. (2) Hermann Ebbinghaus. (3) Saul Sternberg. (4) Hans Markowitsch.”). The position of the correct answers was varied at random. Because some questions had more than one correct answer, the highest possible score was 35. The reliability of the test (Cronbach’s α) was .67. Prior knowledge was treated as continuous variable in the statistical analyses.

Test of learning outcomes

Learning outcomes were evaluated based on four classes of knowledge questions (see Hofman & van Oostendorp, 1999): facts—macro-questions, facts—micro-questions, structure—macro-questions, and structure—micro-questions. Two trained evaluators sorted the answers into the four classes described, achieving 88% agreement (cf. Hofman & van Oostendorp, 1999). Where their decisions differed, they attempted to reach consensus through discussion (see *Appendix* for examples of questions).

To test *factual knowledge*, the same items used to measure the variable prior knowledge were given to participants (in reversed order). To answer the questions, it was necessary only to retrieve simple facts or names (contained in the text base); the correct answers could be drawn directly from the text. For *structural knowledge*, 20 further multiple-choice questions were formulated with four possible answers each. To answer these questions, participants needed to be able to recognize relationships (similarities, differences) between different units of information, and/or draw the appropriate conclusions. Participants could not derive the correct answers directly from the text, but had to exert some effort at comprehension (in the sense of constructing a situational model). Because some questions had more than one correct answer, the highest possible score was 49.

Questions on *macro-propositions* tapped knowledge on the central nodes and concepts of the hypertext, while questions on *micro-propositions* dealt with more detailed information. The internal consistencies were $\alpha = .83$ for the factual knowledge test (macro: $\alpha = .70$, micro: $\alpha = .72$) and $\alpha = .87$ for the structural knowledge test (macro: $\alpha = .80$, micro: $\alpha = .75$).

Procedure

A maximum of eight participants were tested in parallel per session. After a few introductory words on the part of the experiment leader, participants received the prior knowledge test. After this, the online part of the experiment began with a

brief introduction to the basic principles of hypertexts, a description of the particular hypertext used, and information on the procedure for the online experiment. In order to compare differences in performance and trace their relationships to the independent variables, the participants were given a 35-minute time limit to work through the hypertext. They were *instructed* to learn the content of the hypertext carefully, and informed that they would be asked questions about it later. After working through the hypertext, they answered the questions on factual and structural knowledge.

RESULTS

In the following, we first present the descriptive relationships among the variables, before using regression analyses to analyze the influence of prior knowledge on learning outcomes in the four experimental groups.

Descriptive Results

The mean values and standard deviations of the variable prior knowledge and the learning indicators for the experimental groups are presented in *Table 1*. As expected, the correlation analysis showed significant correlations between prior knowledge and the four learning indicators ($.53 < r(87) < .70$) as well as among the learning indicators ($.50 < r(87) < .64$). No gender differences among the participants were discerned in this study (all $t(85) < .76$, *ns*). In addition, it was shown that there were no significant differences in prior knowledge between the different groups of participants ($F(3, 83) = .44$, *ns*).

Results of the Regression Analyses

Contrast codes offer a well-suited model for testing our hypotheses by means of regression analysis (see the detailed discussion in Cohen, Cohen, West & Aiken, 2003). As predictors, we used the experimental factor, the learner variable prior knowledge, and the interaction between the two variables. The experimental factor is represented by **G**, the complete set of four experimental groups (coded as

Table 1: Means and standard deviations (in parentheses) of the variables under consideration

	Prior knowledge	Factual knowledge		Structural knowledge	
		Macro	Micro	Macro	Micro
Global content	13.27 (5.38)	10.41 (3.11)	10.36 (4.24)	13.41 (4.44)	14.05 (5.05)
Global browser	14.42 (5.05)	10.32 (2.61)	12.42 (4.14)	13.68 (5.14)	14.68 (5.31)
Local content	13.22 (4.68)	8.35 (3.19)	10.04 (2.92)	9.52 (4.22)	13.39 (3.09)
Local browser	12.83 (3.31)	8.57 (2.63)	10.17 (3.17)	11.26 (4.06)	14.04 (3.56)
Total	13.39 (4.60)	9.36 (3.01)	10.68 (3.69)	11.87 (4.69)	14.01 (4.24)

Table 2: The dependent variables factual and structural knowledge as functions of the factor overview and of the learner variable prior knowledge (linear regression)

Predictors	Factual knowledge				Structural knowledge			
	Macro ^a		Micro ^b		Macro ^c		Micro ^d	
	b	SE	b	SE	b	SE	b	SE
C ₁	-.02	.18	.24	.16	.16	.17	.11	.18
C ₂	-.67**	.25	-.08	.22	-.82**	.24	-.15	.25
C ₃	-.38	.26	-.33	.23	-.27	.25	.13	.27
PK	.52***	.10	.70***	.08	.53***	.09	.60***	.10
C ₁ x PK	.06	.10	.11	.08	.15	.09	.24*	.10
C ₂ x PK	.05	.09	-.02	.07	.01	.08	.00	.09
C ₃ x PK	.01	.11	.02	.09	-.03	.10	.04	.11

Notes: $N = 87$; b = unstandardized regression coefficients for predictors entered simultaneously in the total equation. Standardized values were computed for the dependent variables and the learner variable prior knowledge (PK). Details on the coding of the contrast variables C₁ to C₃ of the experimental factor are given in the text.

^a Result for the total equation: $R^2 = .36$, $F(7, 79) = 6.36$, $p < .001$

^b Result for the total equation: $R^2 = .52$, $F(7, 79) = 12.40$, $p < .001$

^c Result for the total equation: $R^2 = .41$, $F(7, 79) = 7.99$, $p < .001$

^d Result for the total equation: $R^2 = .35$, $F(7, 79) = 6.16$, $p < .001$

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

$g - 1 = 3$ contrast variables). Contrast variable C₁ contrasts the unweighted mean value of the two experimental groups in the summary of content (global, local; both coded $-1/2$) with the unweighted mean value of the two browser groups (global, local; each coded $1/2$) and tests the expectations in Hypotheses 1a to 1c (in interaction with the continuous variable **V**). Contrast variable C₂ contrasts the global version of the summary of content ($-1/2$) with the local version of summary of content ($1/2$) and tests Hypothesis 2; the groups with browsers were excluded from this contrast and coded as 0. Correspondingly, contrast variable C₃ contrasts the two browser groups (global: $-1/2$ vs. local: $1/2$; 0 = remaining groups) and tests Hypothesis 3. The interaction between **G** and the learner variable **V** (prior knowledge) is completely depicted by the set $\mathbf{G} \times \mathbf{V}$ (consisting of the z-standardized product terms of the three contrast variables with **V**).

Table 2 shows the unstandardized regression coefficients with simultaneous integration of the predictors into the full equation. We found, as expected, that prior knowledge was a statistically significant predictor of all four learning indicators. Furthermore, we found the expected interaction effect between contrast variable C₁ with prior knowledge for structural knowledge on micro-propositions ($b = .24$). Both in the group with the graphical summary of content ($N = 45$) and in the group with the graphical browser ($N = 42$), higher prior knowledge was associated with higher structural knowledge of micro-propositions. This relationship was significantly weaker in the group with the summary of content ($r(45) = .41$, $p < .01$) than in the group with the browser ($r(42) = .71$,

$p < .001$; $z = -2.05$, $p < .05$). This means that prior knowledge played a more central role when working with a browser than when working with a summary of content. With low prior knowledge, participants with a summary of content scored higher than those with a browser (Hypothesis 1a). With increasing prior knowledge, the effect was reversed and the browser group scored higher (Hypothesis 1c). With regard to the remaining learning measures (except for factual knowledge of macro-propositions), it was hypothesized that the use of a graphical summary of content would produce significantly more favorable learning outcomes for those with low prior knowledge than for those with high prior knowledge. No results confirming this hypothesis were obtained, however.

The *contrast variable* C_2 (comparing global and local summaries of content) proved to be a significant predictor for learning achievement on the macro-level of the text. This was true both for factual knowledge and for structural knowledge. People who had been provided with a global summary of content scored higher than those with a local summary of content (Hypothesis 2). *Contrast* C_3 (global vs. local browser) was small and non-significant overall. No further interaction effects were found. Hypothesis 3, which postulated that learners with high prior knowledge would profit more from a local browser than from a global browser, could thus not be confirmed.

DISCUSSION

In order to better understand and explain the effects of navigational aids, this study compared four types of graphical overviews—global summaries of content and global browsers and their local counterparts—taking into account the moderating influence of prior knowledge. It was found that the interaction between navigational aids and prior knowledge was a significant predictor for deeper-level comprehension. As expected, prior knowledge played a less important role in learning with summaries of content than with browsers. A detailed depiction of all nodes and links in the browser caused problems, especially for people with low prior knowledge (cf. Hofman & van Oostendorp, 1999). Such individuals benefited instead from a simple (“structured”) overview of the material in the form of a summary of content—a finding that corresponds to findings from the series of previous studies on the influence of prior knowledge cited in the theoretical section above (e.g., Möller & Müller-Kalthoff, 2000; Potelle & Rouet, 2003). For people with high prior knowledge, however, it was found that the more challenging presentation in browser form was an advantage. These individuals already possess a cognitive representation of the content, and the structuring of content has little effect. For them, the browser demands that they engage in active structuring of the learning material, which apparently facilitates a more in-depth processing of the material (cf. McNamara et al., 1996). These differences appeared only in relation to structural knowledge and only at the micro-level of the text. This finding corresponds to the prediction that results from Kintsch’s (1998) theory of text processing.

As expected, the different modes of overview presentation (global vs. local) proved to be a decisive factor influencing learning achievement. It appears that a global (total) overview is more conducive to learning from hypertexts than a com-

combination of several local (partial) overviews (cf. Chou & Lin, 1998). Presumably, these local overviews tie up cognitive capacities and distract from the actual acquisition of knowledge, and require that their individual sub-structures be mentally “linked up” to construct a cognitive map of the whole hypertext structure. The global summary of content in particular significantly outperformed the local summary of content in this study. This was true both with low and high prior knowledge, but only when dealing with structural and factual knowledge at the macro-level of the text, and not at the micro-level. Comparable differences could not be identified for the two more challenging overviews in browser form.

These findings suggest that (for a hypertext which is still relatively small in size), local overview types can easily become too overloaded with information and not offer appropriate support („extraneous cognitive load“; e.g., Brünken, Seufert & Zander, 2005; Paas, Renkl & Sweller, 2003). The usefulness of local overviews for fostering deeper comprehension of a text, as postulated by some authors (e.g., Vora & Helander, 1997), could not be confirmed in this study. For this purpose, it may be useful to follow the suggestion of Chou and Lin (1998) to structure local overviews more around individual sections that are self-contained in terms of content and—e.g., in response to the user’s demand—to present an overview of all nodes and links on a specific topic area (instead of the current location and “immediate vicinity” as in the present study).

Future research will need to specify further conditions in order to define criteria for designing navigational aids to be used in hypertext learning environments. Along with the differentiations made here between overview types (summary of content vs. browser) and presentations (global vs. local), a number of factors should be taken into account that can obstruct the comparability of results and prevent generalizable conclusions. Not only should the characteristics of navigational aids be taken into account, but their appropriateness to specific hypertext aspects: (1) In more *extensive hypertexts* than the present one, for example, one is soon faced with the paradoxical situation of having to provide navigational aids to help users find their way around the many overviews (cf. Nielsen, 1995). It is thus urgently necessary to find appropriate forms of (initially reduced) presentation that enable appropriate structuring of the text material (Müller-Kalthoff & Möller, 2006). (2) Several studies have been able to show that the explicit statement of *learning goals* may have a more positive effect on learning outcomes than even the use of overviews (e.g., Dee-Lucas, 1996). (3) Finally, taking into account *individual learner variables* (see Dillon & Gabbard, 1998; Unz & Hesse, 1999) can not only help reveal further decisive factors, but also establish a pedagogical foundation (cf. Brünken & Leutner, 2000) for developing adaptive systems tailored to user needs.

APPENDIX

Factual knowledge

(A) *Question on macro-propositions*: Who introduced the concept of the chunk?
 (1) George Miller. (2) Hermann Ebbinghaus. (3) Saul Sternberg. (4) Hans Markowitsch. (This question is classified as a question on macro-propositions, since Miller’s Chunks are a central concept in the hypertext.)

(B) *Question on micro-propositions*: Which brain lobe contributes most to the functioning of declarative memory? (1) The frontal lobe. (2) The parietal lobe. (3) The temporal lobe. (4) The occipital lobe.

Structural knowledge

(C) *Question on macro-propositions*: Which similarities exist between Miller and Sternberg? (1) Both deal with the same kind of memory. (2) Both deal with ultra-short-term memory. (3) Both deal with the same kind of memory as Sperling. (4) Both deal with a different kind of memory than Ebbinghaus.

(D) *Question on micro-propositions*: What is the result of classical conditioning? (1) A US-UR connection. (2) A CS-US connection. (3) A CS-CR connection. (4) A US-UR connection.

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REFERENCES

- Brinkerhoff, J. D., Klein, J. D. & Koroghlanian, C. M. (2001). Effects of overviews and computer experience on learning from hypertext. *Journal of Educational Computing Research*, 25, 427–440.
- Brünken, R. & Leutner, D. (2000). Neue Medien als Gegenstand empirischer pädagogischer Analyse: Stand der Forschung und Perspektiven [New media as the subject of empirical pedagogical analysis: state of research and research perspectives]. In D. Leutner & R. Brünken (Eds.), *Neue Medien in Unterricht, Aus- und Weiterbildung. Aktuelle Ergebnisse empirischer pädagogischer Forschung* (pp. 7–16). Münster: Waxmann.
- Brünken, R., Seufert, T. & Zander, S. (2005). Förderung der Kohärenzbildung beim Lernen mit multiplen Repräsentationen [Fostering coherence formation in learning with multiple representations]. *Zeitschrift für Pädagogische Psychologie / German Journal of Educational Psychology*, 19, 61–75.
- Chandler, P. & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, 8, 293–332.
- Chandler, P. & Sweller, J. (1996). Cognitive load while learning to use a computer program. *Applied Cognitive Psychology*, 10, 151–170.
- Chen, C. & Rada, R. (1996). Interacting with hypertext: A meta-analysis of experimental studies. *Human-Computer Interaction*, 11, 125–156.
- Chou, C. & Lin, H. (1998). The effect of navigation map types and cognitive styles on learners' performance in a computer-networked hypertext learning system. *Journal of Educational Multimedia and Hypermedia*, 7, 151–176.
- Cohen, J., Cohen, P., West, S. G. & Aiken, L. S. (2003). *Applied multiple regression / correlation analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum.
- Dee-Lucas, D. (1996). Effects of overview structure on study strategies and text representations for instructional hypertext. In J.-F. Rouet, J. J. Levonen, A. Dillon & R. J. Spiro (Eds.), *Hypertext and cognition* (pp.73–107). Mahwah, NJ: Lawrence Erlbaum.
- Dias, P., Gomes, M. J. & Correia, A. P. (1999). Disorientation in hypermedia environments: Mechanisms to support navigation. *Journal of Educational Computing Research*, 20, 93–117.
- Dillon, A. (1991). Readers' models of text structure: The case of academic materials. *International Journal of Man-Machine Studies*, 35, 913–925.
- Dillon, A. & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research*, 68, 322–349.

- Gerdes, H. (1997). *Lernen mit Text und Hypertext [Learning with text and hypertext]*. Lengerich: Pabst.
- Gupta, M. & Gramopadhye, A. K. (1995). An evaluation of different navigational tools in using hypertext. *Computers and Industrial Engineering*, 29, 437–441.
- Heiß, A., Eckhardt, A. & Schnotz, W. (2003). Selbst- und Fremdsteuerung beim Lernen mit Hypermedien [Self-regulation and instructional guidance in learning from hypermedia]. *Zeitschrift für Pädagogische Psychologie / German Journal of Educational Psychology*, 17, 211–220.
- Hofman, R. & van Oostendorp, H. (1999). Cognitive effects of a structural overview in a hypertext. *British Journal of Educational Technology*, 30, 129–140.
- Jonassen, D. H. & Wang, S. (1993). Acquiring structural knowledge from semantically structured hypertext. *Journal of Computer-Based Instruction*, 20, 1–8.
- Kalyuga, S., Ayres, P., Chandler, P. & Sweller, J. (2003) The Expertise Reversal Effect. *Educational Psychologist*, 38, 23–32.
- Kintsch, W. (1994). Text comprehension, memory, and learning. *American Psychologist*, 49, 294–303.
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge: Cambridge University Press.
- McNamara, D. S., Kintsch, E., Butler Songer, N. & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text. *Cognition and Instruction*, 14, 1–43.
- Miyake, A. & Shah, P. (Eds.) (1999). *Models of working memory. Mechanisms of active maintenance and executive control*. Cambridge: Cambridge University Press.
- Möller, J. & Müller-Kalthoff, T. (2000). Lernen mit Hypertext: Effekte von Navigationshilfen und Vorwissen [Learning with Hypertext: the impact of navigational aids and prior knowledge]. *Zeitschrift für Pädagogische Psychologie / German Journal of Educational Psychology*, 14, 116–123.
- Müller-Kalthoff, T. & Möller, J. (2003). The effects of graphical overviews, prior knowledge, and self-concept on hypertext disorientation and learning achievement. *Journal of Educational Multimedia and Hypermedia*, 12, 117–134.
- Müller-Kalthoff, T. & Möller, J. (2005). Zum Effekt unterschiedlicher Navigationshilfen beim Lernen mit Hypertexten [The effects of different graphical overviews on hypertext learning achievement]. *Zeitschrift für Pädagogische Psychologie / German Journal of Educational Psychology*, 19, 49–60.
- Müller-Kalthoff, T. & Möller, J. (2006). Browsing while reading: effects of instructional design and learners' prior knowledge. *ALT-J Research in Learning Technology*, 14, 183–198.
- Nielsen, J. (1995). *Multimedia and hypertext: the internet and beyond*. San Diego: Academic Press.
- Paas, F., Renkl, A., Sweller, J. (Eds.) (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist*, 38, Special Issue.
- Potelle, H. & Rouet, J.-F. (2003). Effects of content representation and readers' prior knowledge on the comprehension of hypertext. *International Journal of Human-Computer Studies*, 58, 327–345.
- Puntambekar, S., Stylianou, A. & Hübscher, R. (2003). Improving navigation and learning in hypertext environments with navigable concept maps. *Human-Computer Interaction*, 18, 395–428.
- Samarapungavan, A. & Beishuizen, J. (1994). Domain expertise and knowledge acquisition from “nonlinear” expository text. *Computers in Human Behavior*, 10, 77–91.
- Seufert, T. (2003). Supporting coherence formation in learning from multiple representations. *Learning and Instruction*, 13, 227–237.
- Shapiro, A. M. (1999). The relationship between prior knowledge and interactive overviews during hypermedia-aided learning. *Journal of Educational Computing Research*, 20, 143–167.
- Unz, D. C. & Hesse, F. W. (1999). The use of hypertext for learning. *Journal of Educational Computing Research*, 20, 279–295.
- Utting, K. & Yankelovich, N. (1989). Context and orientation in hypermedia networks. *ACM Transactions on Information Systems*, 7, 58–84.

- van Dijk, T. A. & Kintsch, W. (1983). *Strategies of discourse comprehension*. New York: Academic Press.
- Vekiri, I. (2002). What is the value of graphical displays in learning? *Educational Psychology Review, 14*, 261–312.
- Vora, P. R. & Helander, M. G. (1997). Hypertext and its implications for the internet. In M. Helander, T. K. Landauer & P. Prabhu (Eds.), *Handbook of Human-Computer Interaction* (pp. 877–914). Elsevier: North Holland.