Dealing With Multiple Documents on the WWW: The Role of Metacognition in the Formation of Documents Models

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Abstract

Drawing on the theory of documents representation (Perfetti, Rouet, & Britt, 1999), we argue that successfully dealing with multiple documents on the WWW requires readers to form documents models, that is, to deal with contents *and* sources. We present a study in which we tested the assumption that the use of metacognitive strategies is crucial to the formation of documents models. A total of 100 participants with little medical knowledge were asked to conduct an Internet research on a medical topic. Participants were randomly assigned to four experimental groups that either received evaluation prompts, monitoring prompts, both types of prompts, or no prompts. A control group took paper-and-pencil notes. Results showed that laypersons receiving evaluation prompts outperformed controls in terms of knowledge about sources. In addition, laypersons receiving monitoring prompts acquired significantly more knowledge about facts, and performed slightly better on a comprehension test. It is concluded that the results underline the importance of metacognition in dealing with multiple documents.

Introduction

Today, the Worldwide Web (WWW) plays an important role in the dissemination of health-related information for both experts and laypersons (Fox & Fallows, 2003). Laypersons often retrieve such information to find out about a specific disease or different treatment alternatives—particularly in the run-up to important health-related decisions. The information they retrieve may help them to make a knowledge-based decision–something that is taken commonly as an important precondition for patient compliance (O'Connor, 1995). The resulting learning situation differs from traditional learning settings in that laypersons certainly do not aim to become experts, yet need to develop a basic understanding of the relevant concepts (Bromme, Jucks, & Runde, 2005).

However, even when the information is available, laypersons may find it hard to deal with its complexity and heterogeneity. Relevant information is scattered across a multitude of different web sites (Bhavnani et al., 2003), making it necessary to integrate information, that is, to forge semantic links between information from different sources. This process may be hampered by a lack of the textual cues usually provided by authors in single texts (Goldman et al., 2004).

As well as the contents, laypersons have to deal with the sources of information (Hofer, 2004). Numerous studies have documented severe quality deficits in medical information provisions (see, for a review, Eysenbach, Powell, Kuss, & Eun-Ryoung, 2002). Awareness about source information is particularly important when searching for medical information on the WWW, because of the lack of "gatekeepers of credibility," such as editors and publishers (Britt & Aglinskas, 2002). Hence, the layperson's search for medical information on the WWW is an interesting and important example of learning from multiple documents, an issue that has mostly been analyzed up to now only in the academic context of schools and universities and with reference to printed documents (e.g., Britt & Aglinskas, 2002; Rouet, Britt, Mason, & Perfetti, 1996).

Theoretical Background

Dealing With Multiple Documents: The Theory of Documents Representation

Traditionally, research on how readers comprehend and represent written text has focused on single texts (e.g., Kintsch, 1998; Kintsch, & Van Dijk, 1978). However, readers often need to deal with more than one text, for example, when learning about a controversial historical issue or a complex scientific field in which different views or different pieces of information have to be gathered from different documents.

Recognizing the need to adapt traditional propositional models of text representation to the situation of multiple documents, Perfetti, Rouet, and Britt (1999) have developed the "theory of documents representation." Basically, this theory describes a text representation called "documents model" that the authors deem most appropriate for dealing with multiple documents.

In the documents model, information from different sources is represented in a highly integrated manner, with only core concepts being tagged for their sources. Britt, Perfetti, Sandak, and Rouet (1999) consider this model as "typical of a good reader's model of multiple-text learning" (p. 220). The documents model contains not only a representation of contents (situation model) but also a representation of sources and interrelations between documents (intertext model). In the intertext model, information about sources is represented in the form of document nodes that contain meta-information about sources, that is, information about the author, his or her position, intentions, and so forth. The document nodes are linked to selected propositions in the situation model.

However, empirical studies on the formation of documents models are rare, and many of their findings are inconsistent. Britt et al. (1999) showed that readers can in fact form documents models when dealing with multiple texts. Undergraduate students were quite accurate at identifying sources of information subsequent to reading a history text. Yet, they did not tag all information for their source. Similarly, Rouet et al. (1996) found that college students show some ability to integrate and relate information to sources. In their study, undergraduate history students integrated information from multiple documents and organized it into a coherent essay text. Furthermore, these students were aware of the different status

of different types of documents (e.g., historical essays vs. textbooks) and based their rankings of a document's trustworthiness on appropriate features such as the author's credentials or intentions. In contrast, Wineburg (1991) found that compared with high-school students, expert history readers integrated information from different sources and paid much greater attention to these sources. In line with this rather pessimistic view, Britt and Aglinskas (2002) reported that the spontaneous use of source information when dealing with multiple documents in history was rather low in college and high-school students.

Such inconsistencies reveal that one central question has yet to be answered sufficiently: Which factors determine whether readers actually form documents models? What leads them to integrate information and tag contents for their sources when dealing with multiple documents? Up to now, empirical studies addressing these questions have focused on the role of task characteristics (Britt & Aglinskas, 2002; Britt et al., 1999), features of the documents themselves (Britt et al., 1999), and the role of reader expertise (Rouet, Favart, Britt & Perfetti, 1997; Wineburg 1991). One of the main results supported by studies focusing on the role of task characteristics is that simple instructions to attend to source information are not sufficient to make readers deal with sources efficiently. Compared with readers receiving content instructions, readers receiving sourcing instructions neither performed better on a source identification task (Britt & Aglinskas, 2002), nor did they incorporate a larger amount of reliable information in a subsequent written essay (Britt et al., 1999).

Furthermore, expert-novice comparisons suggest an effect of expertise on dealing with sources in multiple documents situations. Wineburg (1991) reported that when confronted with a set of different history documents, history specialists qualified their choice of documents more accurately than novices did. Furthermore, specialists made extensive use of the sourcing heuristic, which involves attending to author information prior to reading a document. Novices, in contrast, applied this strategy only in a small number of cases.

However, Rouet, Britt, Favart and Perfetti (1997) pointed out that in Wineburg's (1991) study, history specialists did not just differ from novices with regard to content expertise, but also with regard to the degree of discipline expertise at their disposal. In other words, through extensive training in dealing with different kinds of history documents, history specialists possess more sophisticated models of discourse structures within their discipline (Dillon, 1991). This enables them to deal with multiple history documents more appropriately. In a comparison of graduate historians and graduate psychologists, Rouet et al. (1997) controlled for content expertise by choosing a historical topic unfamiliar to both groups. Results still showed significant differences between discipline experts and discipline novices. For instance, discipline experts were able to deal with the bias potentially included in participants' accounts. Furthermore, discipline experts tended to use multiple criteria when evaluating sources. Discipline novices, in contrast, based their evaluations mainly on content information and included less source information in their essays. This finding suggests that to fully understand which factors promote a successful processing of multiple documents, researchers need to address the concrete (meta-) cognitive strategies used by both expert and novice readers. Up to now, this has not been the focus of studies dealing with learning from multiple documents.

The Role of Metacognition in Forming Documents Models

In our research, we focus on the role of metacognition in dealing with multiple documents on the WWW. The term metacognition is commonly referred to as the knowledge and regulation of cognition. It involves processes like planning, monitoring, evaluating, and elaborating (Baker & Brown, 1984; Schraw & Moshman, 1995). With regard to learning from texts, there is a large body of empirical evidence underlining the importance of using metacognitive strategies. When reviewing the literature pertinent to this topic, Baker and Brown (1984) concluded that proficient young readers monitor their ongoing comprehension and adapt their reading speed accordingly. Furthermore, they regularly activate prior knowledge and integrate new information into existing knowledge schemes. With the rise of hypermedia-based learning environments in educational contexts, the use of metacognitive strategies has become even more important. Due to their nonlinearity, hypermedia-based learning environments afford a high amount of learner control, because learners have to make decisions on which information to access as well as the sequence in which to retrieve it (Dillon, 2002; Dillon & Gabbard, 1998). Furthermore, learners have to evaluate information in terms of its relevance to their current learning goal (Bannert, 2003). Evidence for the importance of metacognition in dealing with multiple documents in hypermedia-based learning environments comes from intervention studies that systematically promote the use of metacognition (Bannert, 2003; Lin & Lehman, 1999). For instance, Bannert (2003) found that learning outcomes as measured by a transfer test were higher for students who received metacognitive prompts than for a control group.

We assume that metacognitive strategies are even more important when dealing with multiple documents on the WWW. The fact that the amount of immediately available information is nearly unlimited on the WWW underlines the need for a reasonable selection of information and a thorough self-monitoring of the comprehension process. Furthermore, laypersons need to activate prior knowledge in order to integrate information from multiple texts and thereby build semantic connections between information from different sources. Finally, to gain knowledge about the sources, laypersons have to evaluate sources in terms of quality and credibility. This involves finding out about the author as well as his or her credentials, intentions, possible affiliations, and sponsors.

However, in an earlier study (Stadtler & Bromme, 2004), we found that university students with little knowledge about medicine showed rather low levels of metacognitive activity while searching the Internet for medical information, a finding which is consistent with studies on the use of strategies in hypermedia-based learning (e.g., Jonassen & Wang, 1993). Furthermore, use of the metacognitive strategies of monitoring, evaluating, and elaborating correlated significantly with

knowledge acquisition. This was true for both the acquisition of factual knowledge and the comprehension of the subject matter. Moreover, the use of evaluation strategies related positively to the quality of essays on the credibility of sources. These results, although correlative in nature, point to the importance of metacognitive strategy use when dealing with multiple documents on the WWW.

Development of the Metacognitive Tool *met.a.ware*

To further investigate the role of metacognition in dealing with multiple documents on the WWW, we developed the metacognitive tool *met.a.ware* (see Figure 1). The tool supports laypersons to deal with multiple documents on the WWW by encouraging them to use metacognitive strategies.

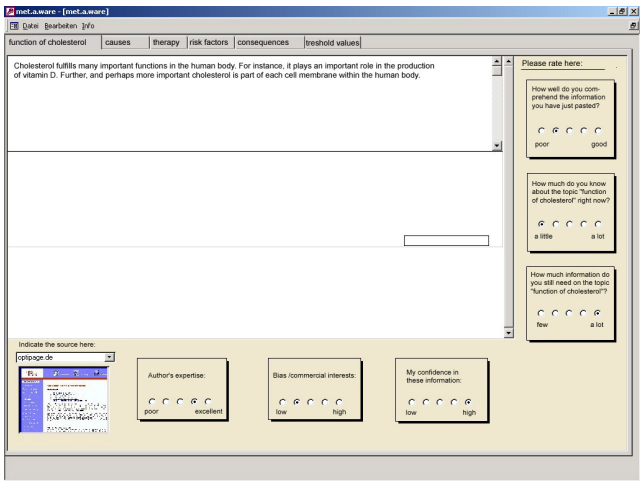

Figure1: Screenshot of the metacognitive tool *met.a.ware*

More precisely, *met.a.ware* enables laypersons to store the information they have found on the WWW systematically. They do this by assigning information to different tabs labeled with aspects of, in this case, the topic cholesterol (ontological classification) (see upper part of Figure 1). They are also prompted to engage in metacognitive activities (monitoring and evaluating). As an evaluation prompt, they are required to indicate the source of information each time they paste it into the system. They also have to rate the author's credentials, the bias of information, as well as their confidence in the information on 5-point scales (see lower part of Figure 1). As a monitoring prompt, laypersons are requested to assess how well they have comprehended information, how much they currently know about the specific aspect of cholesterol, and how much information they still need to search for regarding this aspect of cholesterol. Once again, they answer these items by rating them on 5-point scales (see right part of Figure 1).

All ratings are attached permanently to the specific contents and can be retrieved at all times during future Internet research. This means that the laypersons add an additional layer of meta-information to the contents stored in *met.a.ware*.

Predictions

We formulated the following hypotheses on the use of metacognitive prompts: We predicted that evaluation prompts would foster the acquisition of knowledge about sources (source knowledge hypothesis), and that evaluation prompts would improve their ability to indicate the source of information after their Internet research (sourcing hypothesis). Finally we predicted that monitoring prompts would support the acquisition of content knowledge (content knowledge hypothesis).

Method

Participants Participants were 100 undergraduate students at the University of Muenster (79 female, mean age 23 years). Prior knowledge about cholesterol was tested before the Internet search to ensure their layperson status in this domain. Two students scored more than 50%, and were dropped from all further analyses. The remaining 98 participants scored an average of 4.71 (SD = 2.32) out of 24 possible test points.

Scenario and Material Participants were instructed to conduct an Internet search to gather information for a fictitious friend. This friend had been diagnosed with a high level of cholesterol and needed to decide whether to consent to medical treatment. For their Internet search, participants were given a set of 15 preselected websites on the topic cholesterol. These web sites were accessible via a list of links presenting the URLs in alphabetical order. When selecting web sites, we took care to ensure that the resulting pool of information reflected the given heterogeneity of information available online in terms of information providers and their perspectives on this controversially discussed topic. Thus, we included web sites hosted by universities, companies from the food and pharmaceutical industries, and nutritionists or journals in the field of medicine. Web pages were displayed on a standard 17-in. computer screen and could be browsed using Microsoft Internet Explorer 6.

Design Participants were randomly assigned to one of four experimental groups that worked with different versions of *met.a.ware* or a control group that took paper-and-pencil notes (*paper* + *pencil* control group). The availability of metacognitive prompts was varied systematically across the four *met.a.ware* conditions. Participants received either evaluation prompts (*evaluation* group), monitoring prompts (*monitoring* group), both types of prompt (*evaluation* + *monitoring* group) or no prompts (*no prompts* group). All *met.a.ware* conditions were provided with tabs for ontological classification.

For the sake of completeness, we point out that to control for the effect of ontological classification, a second control group was introduced, that is not described in this article. This group worked with a plain text window that allowed them to copy and paste information from the WWW, but provided neither ontological classification nor metacognitive prompts (*text window* - control group). Results showed that the *text window* - control group did not differ significantly from either the *no prompts* group or the *paper* + *pencil* control group on any of the dependent measures. Because the effect of ontological classification falls outside the scope of this article, results from the *text window* - control group are not discussed any further. Similarly, we collected data on further variables (such as the epistemological beliefs of participants), which we

do not report in this paper, since they also fall outside the scope of this article.

Measures and Procedure Prior to the Internet research, participants completed questionnaires measuring their computer and Internet experience, as well as their interest in the topic cholesterol. Because no significant differences were found between groups, these variables were dropped from further analyses. Furthermore, prior knowledge was assessed with a 24-item multiple-choice test on factual knowledge. Need for cognition was measured with a questionnaire devised by Bless et al. (1994). Since both measures were found to correlate with laypersons' scores on the factual knowledge posttest, these variables were included as covariates in the analyses on the acquisition of factual knowledge.

Searching time was limited to 40 min in order to avoid time on task effects. Additionally, participants were asked to rate the perceived time pressure after they had finished their Internet research. Results did not reveal any differences between groups. After their Internet research, laypersons repeated the multiple-choice test on factual knowledge and answered four open questions measuring comprehension of the subject matter (**content knowledge**). These answers were scored qualitatively. Additionally, knowledge about sources was assessed with a multiple-choice test asking participants to recall facts about the sources of each web site visited (**source knowledge**). These included information such as the author's position, his or her affiliations, or the presence of commercial sponsors. To find out to what degree laypersons tag information for their sources, participants were also asked to write an argument based essay on whether they thought it was worth trying to reduce cholesterol levels, and name the source of each argument they used. These essays were scored in terms of the degree of sourcing, that is, the percentage of information correctly tagged for its source (**sourcing**). Notes taken during the Internet research were not available in the posttests. The whole session lasted about 100 min on average.

Results

Content Knowledge Table 1 depicts mean posttest scores and standard deviations for the five groups. An analysis of covariance (ANCOVA) on factual knowledge posttest scores controlling for prior knowledge and need for cognition revealed a significant difference between groups, $F(4, 91) = 2.90$, $p < .05$, $\eta^2 = .11$. The effect of the covariates prior knowledge and need for cognition was also significant, $F(4, 91) = 7.69$, $p < .01$, $\eta^2 = .08$ and $F(4, 91) = 8.47$, $p < .01$, $\eta^2 = .09$, respectively.

Table 1: Mean posttest scores and standard deviations for factual knowledge.

	M	*SD*
Evaluation	14.50	3.49
Monitoring	15.32	2.36
Evaluation + Monitoring	14.75	2.65
No prompts	13.75	3.71
Paper & pencil	13.00	3.62

To test our hypothesis that monitoring prompts would support the acquisition of factual knowledge more specifically, we performed planned contrasts between each experimental group and the *paper + pencil* control group.[1] Results showed a significant difference between the *monitoring* group and controls, $F(1, 91) = 10.35$, $p < .01$, $\eta^2 = .10$, and a trend between the *evaluation + monitoring* group and controls, $F(1, 91) = 3.66$, $p = .059$, $\eta^2 = .04$. As expected, no significant difference could be found between controls and the *no prompts* group, $F(1,93) = .53$, *ns*. However, we also obtained a significant difference between controls and the *evaluation* group, which was not predicted by our hypothesis, $F(1, 91) = 5.29$, $p < .05$, $\eta^2 = .06$.

To test whether the manipulation of metacognitive prompts impacted on the comprehension of the subject matter, we calculated an ANOVA on the comprehension scores. Means and standard deviations are shown in Table 2. Results showed that comprehension scores did not differ significantly between conditions, $F(4, 92) = 1.40$, *ns*.

Table 2: Mean scores and standard deviations for comprehension.

	M	*SD*
Evaluation	5.79	2.30
Monitoring	6.33	1.99
Evaluation + Monitoring	5.80	2.15
No prompts	5.43	2.19
Paper & pencil	5.09	1.69

Planned contrasts were carried out to test our hypothesis that the availability of monitoring prompts would affect comprehension of the subject matter. Results revealed a marginally significant trend between the *monitoring* group and controls, $F(1, 93) = 3.36$, $p < .10$, $\eta^2 = .04$. As predicted, no significant differences were found between controls and the *no prompts* group, $F(1, 93) = .25$, *ns*, or between controls and the *evaluation* group, $F(1, 93) = 1.09$, *ns*. However, we did not obtain a significant difference between controls and the *monitoring + evaluation* group either, which was not predicted by our hypothesis, $F(1, 93) = 1.13$, *ns*.

Source Knowledge Table 3 depicts the mean percentage of correct answers on the source test for the five groups. Percentages of correct answers were used instead of the total number of correct items, because participants were free to choose which web sites they visited. As a result, not all participants accessed all 15 web sites. We calculated an analysis of variance (ANOVA) with the percentage of correct answers on the source test as dependent variable. Results showed an overall effect for the variable *group*, $F(4, 93) = 4.27$, $p < .01$, $\eta^2 = .16$. To test our hypothesis that evaluation prompts would promote the acquisition of source knowledge, we performed planned contrasts between the control group and each of the four *met.a.ware* groups. In line with our hypothesis, the evaluation group, $F(1, 93) = 9.48$, $p < .01$, $\eta^2 = .09$, and the evaluation + monitoring group, $F(1, 93) = 8.87$, $p < .01$, $\eta^2 = .09$, significantly outperformed controls.

[1] An alpha-level of .05 was chosen for all significance testing involved in the calculation of planned comparisons unless otherwise indicated. Since the number of contrasts does not exceed the number of degrees of freedom of the hypothesis, the alpha-level was not adjusted (Rosenthal & Rosnow, 1985)

Table 3: Mean percentage correct on source test.

	M	*SD*
Evaluation	45.33	10.80
Monitoring	33.83	12.60
Evaluation + Monitoring	44.92	13.82
No prompts	37.97	13.43
Paper & pencil	32.79	12.72

Furthermore, no significant differences were found between controls and either the *no prompts* group, $F(1, 93) = 1.6$, *ns*, or the *monitoring* group, $F(1, 93) = .06$, *ns*.

Sourcing Participants produced an average of 3.54 (*SD* = 1.57) arguments in their essays in favor of lowering high cholesterol levels. The number of correctly sourced arguments was determined for each participant and related to the total number of arguments given. This produced an index of sourcing. Means and standard deviations for this index (mean percentage of arguments that were tagged correctly for their source) are shown in Table 4. We calculated an ANOVA with the percentage of correctly tagged arguments for the source as dependent variable. Results revealed no significant overall effect for group, $F(4, 93) = 1.76$, *ns*.

Table 4: Mean percentage of correctly sourced arguments.

	M	*SD*
Evaluation	62.17	39.15
Monitoring	42.72	44.28
Evaluation + Monitoring	65.42	42.86
No prompts	37.46	40.55
Paper & pencil	56.68	34.92

Although participants in the groups with evaluation prompts showed the highest mean percentage of correctly sourced arguments, planned contrasts comparing each group with controls failed to attain statistical significance for either the *evaluation* group, $F(1, 93) = .43$, *ns*, or the *evaluation + monitoring* group, $F(1, 93) = .82$, *ns*. Moreover, there were also no significant differences when either the monitoring group or the no prompts group were compared with controls. Therefore, the current data failed to support the sourcing hypothesis.

Because of this unpredicted result, we analyzed the handwritten notes of participants in the control group. In contradiction to what the findings of Britt and Aglinskas (2002) and our own previous study (Stadtler & Bromme, 2004) would suggest, the laypersons in our control condition exhibited a noteworthy amount of spontaneous sourcing of information gathered during their Internet searches. More precisely, 32% named at least one source in their notes, as compared to 20% (*met.a.ware* no prompts) and 21% (*met.a.ware*-Monitoring). Laypersons' spontaneous use of this particular metacognitive strategy may have compensated for the lack of prompting in the control group.

Discussion

The goal of the present study was to investigate the role of metacognition in dealing with multiple documents on the WWW. Drawing on the theory of documents representation (Perfetti et al., 1999) as well as findings on the role of metacognition in text comprehension, we hypothesized that applying the metacognitive strategies of monitoring and evaluation would help laypersons to form documents models. To a large extent, the results support our hypothesis. Compared with controls, participants receiving monitoring prompts acquired significantly more factual knowledge on the topic cholesterol. Furthermore, laypersons receiving only monitoring prompts performed slightly better on a comprehension test. Nonetheless, the *evaluation + monitoring* group did not differ significantly from controls in their comprehension of the subject matter. This may be because developing a high-level understanding within the given time limit of 40 min had been a rather demanding task for laypersons. Results of previous research (Stadtler & Bromme, 2004) has shown that when laypersons were confronted with our scenario, their first goal was to gather rather basic information such as what is an acceptable level of cholesterol in the blood or which diseases may result from high cholesterol levels. After they had gathered some basic knowledge on the topic, they then moved on to explore more complex issues such as the relationship between cholesterol and other factors causing a coronary heart disease. These practical constraints may well explain why the mean scores on the comprehension task in the present study did not differ between groups. Further research will need to address this issue by giving participants more study time not only to acquire basic facts but also develop a deeper understanding of the subject matter.

However, forming a full documents model does not just require knowledge about contents, but also a representation of knowledge about sources (Perfetti et al., 1999). This is particularly crucial when dealing with medical information on the WWW, because single documents may contain faulty or biased information and not always provide a reliable account. This is why we gave laypersons evaluation prompts requiring them to rate information in terms of its credibility. Results on testing source knowledge revealed that evaluation prompts improved performance: Members of both the *evaluation* group and the *evaluation + monitoring* group recalled more information about sources than controls. This underlines the importance of metacognitive strategies in the formation of source knowledge as well.

Finally, we do not find an effect of evaluation prompts on the sourcing of information in an essay task. Although the groups receiving evaluation prompts tagged the highest proportion of information for their source, they did not differ significantly from controls. Analyses of the notes taken during Internet research showed that laypersons in the control group showed a considerable amount of spontaneous source tagging, which may have compensated for the lack of prompting. Therefore, our results suggest that future research on metacognitive training tools like *met.a.ware* needs to take into account spontaneous usage of metacognitive strategies more explicitly.

In sum, the present study provides evidence that the use of metacognition is crucial for the formation of documents models when dealing with multiple documents on the WWW. Using metacognitive prompts for monitoring and evaluation increased knowledge on both contents and sources. The results open up the possibility of designing intervention pro-

grams to support laypersons in dealing with multiple documents on the WWW by fostering the use of metacognitive strategies.

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