So much information. But which is important? Which is true? Supporting laypersons' informal learning from science based evidence on the Internet.

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Abstract

In our 'Knowledge Society', the Worldwide Web (WWW) plays an important role in the dissemination of science-related information, for example on health topics. Laypersons often retrieve such information to find out about a specific disease or different treatment alternatives. However, in case of contradictory evidence laypersons have to decide which document and which argument they want to believe. We argue that to a certain degree, laypersons' judgments about which expert to believe are based on epistemological beliefs about the nature of science based knowledge.The resulting learning situation can best be described as an instance of 'Informal Learning', since it differs from traditional learning settings in several ways.
After exploring this type of learning situation more deeply we present the cognitive tool *met.a.ware*. The tool supports laypersons to deal with scientific information on the WWW by prompting them to use metacognitive strategies (monitoring and evaluating). We present some evidence on the impact of *met.a.ware* on learning and we discuss the importance of epistemological beliefs for laypersons dealing with science information on the Internet.

Introduction

Our modern industrial societies make it increasingly necessary for laypersons to deal with expert information in many areas of everyday life – be it as a patient, client or customer. Laypersons often retrieve such information, which used to be available to experts exclusively (Bromme, Jucks & Runde 2005), from the Internet. Consider for example a patient who had got a certain diagnosis from her doctor. Often she will be eager to learn more about this specific disease or about different treatment alternatives. If she has at least a little command of Internet browsers and search engines, she will retrieve a plethora of health-related documents within a few seconds. These documents may help her to eventually make a knowledge-based decision about her compliance with the suggested therapy (Morahan-Martin, 2004). However, features such as the structure and the quality of scientific information on the Internet impose considerable constraints on laypersons' Internet research. In what follows, we will argue that the Internet could be an enabling technology for laypersons' learning and understanding of science related matters, when and only when laypersons dispose of metacognitive knowledge and strategies necessary to deal with heterogeneous information of varying quality and veracity from multiple sources.

In numerous case studies deficits in the quality of medical information on the Internet have been documented (for a review, see Eysenbach, Powell, Kuss, & Eun-Ryoung, 2002). As a reaction to these findings attempts have been made, to introduce independent certification systems to warrant the accuracy of medical information provisions (e.g. www.hon.ch; www.medcircle.org). However currently, there are different competing approaches, and most of the available information is uncertified. As a consequence, it is still up to the layperson to decide whether to trust the information on offer (Wittwer, Bromme & Jucks, 2004). We argue that this decision should be based on **source knowledge**, that is knowledge about the author of a document, her credentials as well as her motives (cfr. Perfetti, Rouet & Britt, 1999). For instance, when reading a document about the relationship between lung cancer and smoking it is important to know if the document has been published by a tobacco company or by a governmental health office. Thus, source knowledge enables laypersons to reflect on the reliability of information.

However, even when the information found seems to be trustworthy, laypersons may find it hard to deal with its complexity and heterogeneity. Relevant information is scattered across a multitude of different web sites making it necessary to integrate information, that is, to forge semantic links between information from different sources. While authors of a single document mostly offer some support for a reader to extract its main message (for example by including headings, paragraphs and by textual cues), these cues are missing in multiple documents situations (Goldman & Rakestraw, 2000).

Furthermore, the information provisions laypersons encounter during Internet research are not only heterogeneous with regard to quality but also with regard to 'genre'. For example, information in electronic versions of scientific journals is written in a scientific style which is solely intended for the scientific discourse among experts. Nevertheless, it can be assumed that laypersons, too, access these periodicals on the Internet. Besides, there is also information explicitly intended for layperson use, though not tailored to the requirements of specific individuals (see for instance "Frequently asked Questions"-sections in which experts answer selected patient questions). Thus, in the course of the Internet research, the information from many heterogeneous documents has to be integrated (or decisively excluded). Inspired by the theory of documents representation, which has been put forward by Perfetti, Rouet and Britt (1999), we argue that laypersons should develop an integrated text representation, which includes both **source knowledge** as well as **knowledge about contents**.

The resulting learning situation differs from traditional learning settings in that laypersons certainly do not aim to become experts, and that there is no curriculum and no teacher, either. It is rather an interesting case of **'informal learning'**, which takes place outside educational institutions, and is mostly internally motivated without the availability of extrinsic feedback. It is also problem-oriented learning as the learning process is structured by the practical problems which motivate the Internet research and by the social context within which the research is done. Due to the absence of instructional support, the situation described can be assumed to require a considerable degree of self-regulation and the well-directed use of metacognitive strategies by laypersons.

Theoretical Background

The role of metacognition in dealing with scientific information on the Internet. The empirical evidence underlining the importance of metacognitive strategies with regard to *learning from texts* is rich. For instance, in a review, Baker and Brown (1984) pointed out that proficient young readers frequently monitor their ongoing comprehension and adapt their further reading process accordingly. Furthermore, they regularly activate prior knowledge and integrate new information into existing knowledge schemes. According to Rouet and Eme (2002), proficient readers further dispose of a high amount of metatextual knowledge, i.e. knowledge about the function of text features such as headings, paragraphs or first and final sentences in a paragraph and text comprehension activities.

With the rise of *hypermedia-based learning environments* in educational contexts, the importance of metacognitive strategies has been even stressed. The simultaneous availability of many strategic alternatives causes a considerable metacognitive complexity, which in turn affords a high amount of learner control (Veenman, Wilhelm & Beshuizen, 2004). Learners have to make decisions on which information to access as well as the sequence in which to retrieve it. Evidence for the importance of metacognition in hypermedia-based learning has been found in intervention studies in which learning performance could be improved by systematic metacognitive support. These intervention studies have been successfully conducted in an array of different domains, such as biology (Lin & Lehman, 1999), computer sciences (Schmidt & Ford, 2003) or physics (Veenman, Wilhelm & Beshuizen, 2004).

With regard to students' search for research based evidence on science topics, in other words, with regard to just the scenario we are discussing here, Barbara Hofer (2004) recently has proposed to extend the notion of metacognition. Traditionally, most researchers use the term to refer to the knowledge and regulation of cognition, involving strategies like planning, monitoring, evaluating, and elaborating (Baker & Brown, 1984; Schraw & Moshman, 1995). Hofer suggests to include e*pistemological beliefs and judgments*, for example about the veracity of information. A learner's beliefs about whether knowledge is certain or tentative might impact on his or her willingness to pursue for further evidence, a learners' strategies for the assessment of credibility might influence the search for counterevidence and so forth. Therefore, awareness about ones own standards for credibility judgements and knowledge about where to look for source information is also part of metacognitive knowledge. Hofer argues that these processes particularly come into play in situations where readers are confronted with conflicting information from different sources and thereby have to decide which information to trust.

In our view such metacognitive strategies are of particular importance when dealing with complex scientic information on the Internet. The nearly unlimited amount of immediately available information on the Internet stresses the need for a reasonable selection of information and a thorough self-monitoring of the comprehension process. Besides, 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 using think aloud methodology, we found that university students with little medical knowledge showed only moderate levels of metacognitive activity (Stadtler & Bromme, 2004). Qualitative analyses of metacognitive activity further revealed that laypersons used inadequate criteria to judge the reliability of information provisions. They relied heavily on predictive judgments uttered before opening a website as well as general impressions about the professionality of a website's layout uttered shortly after accessing a website. In contrast to this, laypersons rarely searched for author information or tried to find out about possible affiliations with commercial sponsors. This finding is in line with the results of Eysenbach and Köhler (2002). The authors report that adult laypersons were able to name adequate criteria for assessing a website's reliability when explicitly asked to do so, but did not actually use them when conducting an Internet research on a medical topic. It is also in line with the observations Hofer (2004) made when she asked students to think aloud when searching for science related information in the WWW. Only some of their subjects made deliberate epistemological judgments and for most of them it was not a thoughtful process.

Interestingly, in our study use of the metacognitive strategies of monitoring, evaluating, and elaborating correlated significantly with knowledge acquisition. This result could be obtained for both the acquisition of factual knowledge as well as 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, have two main implications. Firstly, the results point to the importance of metacognitive strategy use when dealing with scientific information on the Internet. At the same time, the results of our previous study offer the potential to foster metacognitive activity in order to support laypersons' informal learning from science information on the Internet.

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

To support learners in settings of informal learning we developed the metacognitive tool *met.a.ware* (see Figure 1). In this vein, we will also further investigate the role of metacognition in dealing with multiple documents on the WWW (cfr. Stadtler & Bromme, in press). *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 ontological categories which underlie the topic cholesterol (see upper part of Figure 1).

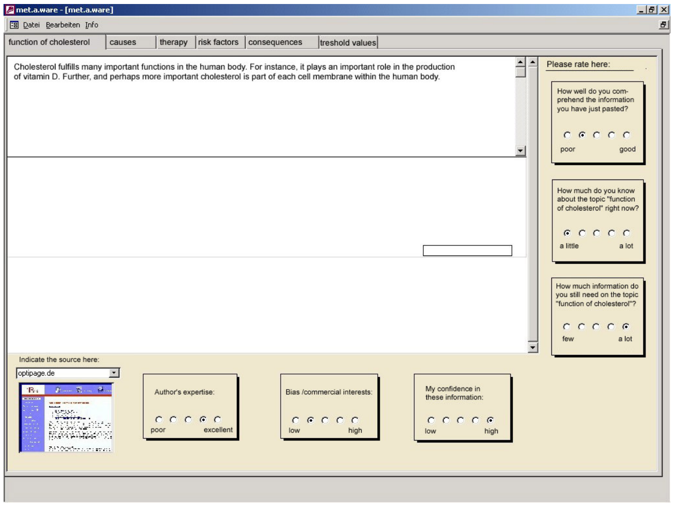

Figure1: Screenshot of the metacognitive tool *met.a.ware*

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 predicted that monitoring prompts would foster the acquisition of content knowledge (content knowledge hypothesis). We further 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 laypersons receiving evaluation prompts would produce more arguments to justify their credibility judgments (justification of credibility rating 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**). Participants were also asked to rate the credibility of the three most appreciated websites and to produce arguments to justify their ratings (**justification of credibility judgments**). 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*
Monitoring	15.32	2.36
Evaluation + Monitoring	14.75	2.65
Evaluation	14.50	3.49
No prompts	13.75	3.71
Control group (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: Means and standard deviations for comprehension.

	M	*SD*
Monitoring	6.33	1.99
Evaluation + Monitoring	5.80	2.15
Evaluation	5.79	2.30
No prompts	5.43	2.19
Control group (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.

Table 3: Mean percentage correct on source test.

	M	*SD*
Evaluation	45.33	10.80
Evaluation + Monitoring	44.92	13.82
Monitoring	33.83	12.60
No prompts	37.97	13.43
Control group (paper & pencil)	32.79	12.72

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 outper-

[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)

formed controls. 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
Evaluation + Monitoring	65.42	42.86
Monitoring	42.72	44.28
No prompts	37.46	40.55
Control group (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.

Justification of credibility judgements To analyse the number and type of arguments which laypersons produced in order to justify their credibility judgments, we used a self-developed categorization scheme. Laypersons' arguments were either classified as relating to the layout (e.g. the professionalism, availability of pop-up ads), the content (e.g. internal consistency, agreement with information from other websites), or the author (e.g. his expertise, perceived motives) of a website (cfr. Wittwer, Jucks & Bromme, 2004). Interrater-agreement for the coding process was high, CR = 95%.

A analysis of variance (MANOVA) did not reveal a multivariate effect of the factor condition, $F(12, 279) = 1.41$, *ns*. Thus, laypersons did not differ with respect to the overall number of arguments produced. However, univariate tests showed a significant effect of the factor condition with respect to the number of arguments in the category *Source*, $F(4, 93) = 2.92$, $p < .05$, $\eta^2 = .11$. No significant differences could be found with regard to the other categories, all Fs > .68, *ns*. As can be shown with planned contrasts, the *evaluation* group produced significantly more arguments focusing on the author of a website than the paper+pencil control group, $F(1, 93) = 4.33$, $p < .05$, $\eta^2 = .04$. The *evaluation + monitoring* group showed a tendency towards more arguments in the category *Source* than the control group, $F(1, 93) = 2.96$, $p = .089$, $\eta^2 = .03$. Thus, the results confirm our hypothesis only partially. Laypersons receiving evaluation-prompts produced more arguments focusing on the author of a website than controls. However, they did not produce more arguments with regard to content and the website's layout.

Discussion

The tool *met.a.ware* supports laypersons to deal with scientific information on the Internet by encouraging them to use metacognitive strategies. The goal of the present study was to test the possibility of fostering metacognition within settings of informal learning when searching for information in the WWW. In this vein we also wanted to investigate the role of metacognition in dealing with multiple documents on the WWW. Drawing on findings on the role of metacognition in text comprehension as well as on the theory of documents representation (Perfetti et al., 1999) 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.

As Hofer (2004) has suggested, evaluating the credibility of a document should be conceived as a part of metacognitive processes. 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. With regard to the explicitly given arguments for credibility judgments the *evaluation group* outperformed the other groups. Both results (recalling sources as well as justifying credibility judgments by referring to sources) underline that it is possible to foster metacognitive strategies in the formation of source knowledge by means of prompting.

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 dealing with scientific information 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 programs to support laypersons in such settings of informal learning. On a theoretical level they endorse the inclusion of epistemological beliefs and judgments into the concept of metacognition (Hofer, 2004).

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