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Working memory capacity and reading skill moderate the effectiveness of strategy training in learning from hypertext ☆

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Abstract

Cognitive and metacognitive strategies are particularly important for learning with hypertext. The effectiveness of strategy training, however, depends on available working memory resources. Thus, especially learners high on working memory capacity can profit from strategy training, while learners low on working memory capacity might easily be overtaxed. In addition, efficient basic reading comprehension processes are important for strategy training to be successful: When both the newly acquired strategies and poorly routinized basic reading comprehension processes compete for working memory resources, navigation within the hypertext and learning might deteriorate rather than improve. In an experiment, 64 undergraduates learned with a comprehensive expository hypertext after receiving either a cognitive or a metacognitive or no strategy training. In line with the predictions, learners high on working memory capacity or reading skill could profit from learning strategy training in terms of learning outcomes and the quality of their navigational behavior. Learners low on working memory capacity or reading skill, in contrast, performed worse in both training conditions compared to the control condition. The improvement in learning outcomes for skilled learners as well as the impairment in learning outcomes for unskilled learners could be shown to be indirect effects mediated by the quality of navigational behavior.

Keywords: Hypertext; Learning strategies; Log files; Reading skill; Strategy training; Working memory

Hypertexts are non-linear computer-based texts that consist of individual pages connected via hyperlinks. Readers may navigate from one page to another by clicking on a hyperlink. Compared to learning with expository texts that follow a linear structure, learning from expository hypertext can be beneficial in complex learning tasks because hypertexts provide learners with more degrees of freedom in accessing and organizing information according to their specific needs and interests. At the same time, the non-linearity of hypertexts poses higher demands on the self-regulatory skills of learners (e.g., Shapiro & Niederhauser, 2004). Learning strategies may be particularly important to take advantage of the hypertext's non-linearity (Azevedo, Guthrie, & Seibert, 2004). Accordingly, learning strategy training which is explicitly tailored to the specific characteristics of expository hypertexts promises to have large positive effects on the efficiency of the learning process and the quality of learning outcomes (Azevedo & Cromley, 2004). From an aptitude–treatment-interaction perspective, however, not all kinds of learners may be expected to benefit from this training to the same extent. In this article, we will argue that the availability of ample working memory resources is a crucial precondition for learning strategy training to be successful. This is because learning strategies are resource-demanding,

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especially when these strategies have been acquired only recently. As a consequence, learners with small working memory capacities or poorly routinized basic reading comprehension processes are easily overtaxed, which may even lead to deteriorated learning outcomes after training.

In the following sections, we will start with an account of strategic processing in hypertext use, following Weinstein and Mayer's (1986) classification of cognitive and metacognitive learning strategies. We will especially dwell on the role of working memory capacity for the efficient use of newly acquired strategies, and on the relationship of available working memory and reading skill. From these two lines of research, we will derive the prediction that individual differences in working memory capacity and reading skill moderate the efficient use of newly acquired strategic knowledge in a similar fashion: While learning strategy training may have positive effects on learning with hypertext in learners with a high working memory capacity or well-routinized basic reading comprehension processes, they may even be harmful in learners with a low working memory capacity or poorly routinized basic reading comprehension processes. We tested these predictions in a training experiment in which university students were given a training of cognitive or metacognitive learning strategies. In addition to assessing learning outcomes, we also monitored learners' navigational behavior while interacting with the hypertext. In this way, we were able to investigate whether the hypothesized effects of learning strategy training, working memory capacity and reading skill on learning outcomes are mediated by the quality of navigational behavior.

1. Strategic processing in learning with hypertext

Learning strategies are activities that learners may intentionally engage in to improve or regulate learning processes. Following the traditional conceptualization of metacognitive skills as second-order cognitive processes (Brown, Bransford, Ferrara, & Campione, 1983), we adopt the distinction between cognitive and metacognitive learning strategies that has been put forward by Weinstein and Mayer (1986) and others (e.g., Pintrich, Smith, Garcia, & McKeachie, 1993). We view this distinction as a useful heuristic. However, it is important to note that our argument is also consistent with frameworks of self-regulated learning that present a unitary perspective (for example, the information-processing model proposed by Winne, 2001).

Cognitive strategies are strategic information-processing activities. Two types of cognitive strategies that may be particularly relevant for learning with hypertext are organization and elaboration. Organization strategies are directed at grasping the semantic macrostructure, i.e. the topical and conceptual structure of learning materials (van Dijk & Kintsch, 1983). In learning with hypertext, organization strategies may support learners in actively constructing a macrostructural representation of the text contents despite the lack of a specific sequence in which topics and subtopics are introduced. In addition, organization strategies may help learners to understand how a given hypertext is structured in technical terms (e.g., its link structure and the available navigational features). Elaboration strategies are directed at the construction of a situation model of the text content, i.e. a referential representation that integrates information from the text with prior knowledge (van Dijk & Kintsch, 1983). Elaboration strategies may be especially helpful in learning with hypertexts because they support learners to infer semantic and conceptual relationships between contents of different nodes in the hypertext. In contrast to linear expository texts that guide learners in the construction of a coherent situation model, hypertexts require a much greater deal of active elaboration.

Metacognitive strategies are second-level processes that control and regulate information-processing activities (e.g., cognitive learning strategies). Two types of metacognitive strategies which may be particularly relevant for learning with hypertext are planning and monitoring (e.g., McNamara & Shapiro, 2005). Learners use planning strategies to break down a general learning goal into more specific subgoals or to decide, for example, what they want to study, which kinds of learning materials they want to use, or when they want to study these materials. In contrast to typical linear expository texts, hypertexts leave it to the learner to select particular contents and to decide on the order in which these contents are processed. Therefore, the use of planning strategies may be regarded as essential for learning with hypertext. Monitoring strategies refer to activities such as observing one's own progress in learning, checking on whether the current learning activities still serve the actual learning goal, or detecting comprehension difficulties that make it necessary to consult other parts of the learning materials. Similar to planning, the non-linear structure and the greater degrees of freedom of expository hypertexts requires a great deal of monitoring activities on behalf of the learner.

In line with these considerations, a number of experimental and correlational studies have demonstrated that the use of cognitive and metacognitive strategies can indeed foster learning with hypertext (Azevedo & Cromley, 2004; Azevedo et al., 2004; Young, 1996). For example, Azevedo and Cromley (2004) conducted a training study on learning with hypermedia. In the course of the training, students were instructed to make use of self-regulated learning (SRL) strategies. The bundle of strategies that was taught to participants comprised of cognitive strategies (such as knowledge elaboration, prior knowledge activation or summarization) as well as metacognitive strategies (such as planning and monitoring). Students who had received the SRL training performed much better than untrained students, and think-aloud data indicated that they implemented SRL strategies in a better way than untrained participants.

Similar results were reported by Richter, Naumann, Brunner and Christmann (2005) who also found that cognitive learning strategies (assessed by think-aloud protocols) enhanced learning outcomes by improving learners' interaction with the hypertext, i.e. their navigational behavior. Generally, learners differ greatly in their selection of hypertext pages, the time they spent on these pages, and their navigational paths (e.g., Shapiro, 1998; Shapiro & Niederhauser, 2004). It is likely that some aspects of navigational behavior reflect the application of