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Learning with summaries: Effects of representation mode and type of learning activity on comprehension and transfer

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ABSTRACT

The purpose of the experiment was to examine whether students better understand a science text when they are asked to self-generate summaries or to study predefined summaries. Furthermore, we tested the effects of verbal and pictorial summaries. The experiment followed a 2 × 2 design with representation mode (verbal vs. pictorial) and learning activity (self-generating vs. studying) as experimental factors. The main dependent variables were learning performance, measured by a comprehension and a transfer test, and strategy use, measured by self-report scales. Seventy-one students (Grade 10) participated in the study. The results showed that studying predefined summaries in a pictorial representation mode facilitated deep understanding. Furthermore, mediation analysis showed that the effect of representational mode was mediated by students' spatial representations of learning content. The effect of spatial representations was in turn facilitated by mental imagery activities.

1. Introduction

Learning with summaries is of high practical relevance in school contexts and is an important component of complex reading strategy training programs (e.g., Spörer, Brunstein, & Kieschke, 2009). The effects of summary strategies have been investigated in learning with single and multiple texts (Bråten & Strømsø, 2010; Gil, Bråten, Vidal-Abarca, & Strømsø, 2010a; Mateos, Martin, Villalón, & Luna, 2008). Students are commonly asked either to self-construct summaries or to study already constructed (expert) summaries (León, 1997; Wade-Stein & Kintsch, 2004; Westby, Culatta, Lawrence, & Hall-Kenyon, 2010). Apart from the relevance of summaries, Anderson and Armbruster (2000) pointed out that the summarization strategy itself has not been systematically investigated. Therefore, the main purpose of this study was to more closely investigate the effects and conditions under which learning with summaries is beneficial. We concentrated on two questions. First, does the representation mode of summaries—that is, whether they are verbal or pictorial in nature—affect learning performance in terms of comprehension and transfer performance? Second, does the specific type of learning activity affect performance? That is, is it helpful to foster active processing of text content by asking students to summarize text paragraphs by themselves or, on the other hand, is it sufficient simply to provide the learner with predefined summaries? Furthermore, our purpose was to investigate the students' strategic processing while learning with summaries and to investigate interrelations between their strategic processing and learning performance.

When students read a passage of an expository text, it is assumed that they mentally form a gist or higher level representation of what they have read (Brown, Day, & Jones, 1983; Kintsch, 1998; Kintsch & van Dijk, 1978). This mental gist represents the main points of the text in an abstract or condensed form. When students are asked to write a summary about the text, they must draw on this gist and develop a text-specific organization in order to transform their mental gist into written text (Flower & Hayes, 1980; Taylor & Beach, 1984). At the same time, readers must be sensitive to the organization of the text with regard to superordinate and subordinate ideas.

Researchers suggest that summarization activities help a learner to focus on the important ideas in a text and to integrate these ideas by building relations between them (Hidi & Anderson, 1986; Schmalhofer & Glavanov, 1986; Westby et al., 2010; Wittrock & Alesandrini, 1990). Furthermore, the process of summarization encourages learners to reconstruct the meaning of a text in a more concise and generalized form (Wade-Stein & Kintsch, 2004). From a learning-strategy perspective, summary writing is seen as an activity that fosters the organization and integration of text-based

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ideas (Mayer, 1996; Pressley & Harris, 2006; Weinstein & Mayer, 1986). These processes, in turn, help the learner to construct a structure for organizing the text that facilitates recall and comprehension.

1.1. Do representation mode and type of learning activity affect learning performance?

1.1.1. Representation mode

Although research on learning with summaries has primarily focused on verbal summaries, by definition, a summary does not have to be verbal (in nature) but can also have a pictorial format (e.g., Mayer, Bove, Bryman, Mars, & Tapangco, 1996). Mayer et al. (1996), for example, constructed a pictorial summary that contained a sequence of simple illustrations depicting the main steps in the process of lightning. This type of summary presents the main ideas of the text and their relations as does a verbal summary, but in a different format. One advantage of the pictorial format compared to the verbal format is that it makes spatial relations among components explicit and thereby helps the learner to identify these relations (Larkin & Simon, 1987). This is particularly important when texts describe complex spatial relations between objects and elements, as is typical of science texts; for example, the structure of molecules and their chemical bonds (Leopold & Leutner, 2012) or the mechanisms of a car's braking system (Mayer & Gallini, 1990). Also, these texts often remain challenging for students (Best, Rowe, Ozuru, & McNamara, 2005). Verbal summaries, by contrast, maintain the sequential structure of a text. Therefore, it is more difficult to recognize the spatial and structural relations of the particular components and objects that are described by the text.

We expect these representational differences (of verbal and pictorial summaries) to affect a learner's internal representation of the text. A student who studies a text and is asked to create a pictorial summary is more likely to focus on the structural and spatial relations of the referential objects than a student who is asked to create a verbal summary. Therefore, the student is more likely to construct an internal representation of the referential objects—a mental model of the text content. One main characteristic of mental models is that they possess inherent structural features that are associated with the objects they represent by structural or functional analogy (Johnson-Laird, 1983). These features allow us to manipulate the models and read off relational information. Therefore, mental models provide a basis for drawing inferences and are crucial for developing a deeper understanding of text content. However, when the student creates a verbal summary, he or she is more likely to focus on the structure of the text and on text-based processing (Kintsch, 1998). When writing a summary, the student can keep the same sequential organization as that employed in the original text (Mateos et al., 2008). Consequently, his or her attention is more directed toward representing the information stated in the text than on constructing a mental model of the referential objects and their relations (Leopold & Leutner, 2012; McNamara, Ozuru, Best, & O'Reilly, 2007). In view of the potential of mental models to promote deeper understanding, we expect learners who learn with pictorial summaries to better understand a text that describes spatial relations than learners who learn with verbal summaries. We expect this advantage of pictorial over verbal summaries to be independent of whether these summaries are self-constructed by the learner or are provided to them. The reason is that the representational differences of verbal and pictorial summaries apply to both self-constructed and predefined summaries.

Empirical support for these hypotheses comprises two lines of research. First, strategies that are focused on text-based processing have been compared to strategies that are focused on model-based processing. Alesandrini (1981), for example, instructed students to study a science chapter about electrochemistry by either writing paraphrases (text-focused) or drawing pictures (model-focused) for each paragraph in the chapter. In addition, students were told to be analytical, by focusing on details, or holistic, by focusing on inclusive concepts, or did not receive any specific instructions. The results of a test with factual, comprehension, and transfer questions showed an effect of mode of processing such that the drawing groups exceeded the verbal groups. The instructions to focus on details or inclusive concepts did not affect the results. Related results were found by Leopold and Leutner (2012). They compared a verbal summary strategy (Experiment 2) and a verbal main-idea-selection strategy (Experiment 1) with a strategy in which students were asked to construct drawings. On comprehension and transfer tests, the drawing groups showed better results than the summary groups and the main idea groups did. These results support the importance of constructing pictorial representations in order to understand instructional texts.

Second, there is a large body of research indicating that presenting information by words and pictures, rather than by words alone, facilitates learning and understanding (Mayer, 2009; Schnotz & Bannert, 2003). The so-called *multimedia effect*, for example, provides evidence that supports this view (see Mayer, 2009, for a review). The benefit of adding pictorial adjuncts to text is based on the fact that pictures and words provide two qualitatively different systems for representing knowledge that complement each other (Paivio, 1986; Schnotz & Bannert, 2003). If we apply these ideas to text learning by summarization, a pictorial rather than a verbal summary introduces a complementary representation to the instructional text and should therefore facilitate learning and understanding.

Both approaches support the advantage of pictorial representations. The only difference is that in the first line of studies, students were asked to self-construct these representations, whereas they were presented with predefined pictures in the second line of studies. In view of these results, the question arises as to whether self-constructed or predefined summaries facilitate understanding more effectively.

1.1.2. Learning activity

Learning-strategy approaches and theories of self-regulated learning (Pintrich, 2000; Zimmerman, 2001) emphasize the importance of the learner actively processing the learning materials. The active-processing assumption is based on the idea that deep and meaningful learning requires learners to select important ideas, organize them into a coherent structure, and integrate them with relevant prior knowledge, thereby affecting the encoding process (Kiewra, 1989; Mayer, 1996; Weinstein & Mayer, 1986). These processes are rooted in the generative learning model proposed by Wittrock (1990) and are essential for the generation effect (Foos, Mora, & Tkacz, 1994). When learners are asked to construct summaries, they (in fact) are required to actively process the text, that is, to select important concepts and to organize their relations (Wittrock & Alesandrini, 1990). When learners are asked to construct a pictorial summary, they are moreover required to transform textual information into pictorial information, that is, to create referential connections between components of the text and components of the picture to be drawn (Van Meter & Garner, 2005). Conversely, when learners are presented with predefined summaries, this is not necessarily the case. Although predefined summaries contain information that is already selected and organized, learners do not necessarily have to actively process and mentally reconstruct this information. Learners do not have to create referential connections between components of the text and components of the picture when studying a text with pictures. Thus, when students are asked to self-generate summaries, they are challenged