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Strategic learning from expository animations: Short- and mid-term effects

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ABSTRACT

In an experimental study, we investigated whether making use of a cognitive learning strategy (1) improves learning from different expository animations, (2) leads to an acquisition of knowledge which is available beyond the learning period, and (3) equally benefits students with low and high cognitive ability alike. A total of 152 sixth graders participated in the study: 69 students learned from an animation about the dances of honeybees and 83 students learned from an animation about sailing. With respect to both animations, the students who made use of the learning strategy significantly outperformed the students who had to write a summary. Effect sizes are medium to large. The beneficial effects of the learning strategy were also verified one week after the learning took place. The results of this study do not support the assumption that students with low and high cognitive ability benefit differently from the strategy.

1. Introduction

Expository animations are being employed more and more in education with the intention of enhancing students' understanding of both complex processes and abstract concepts that involve changes over space and time. Mayer and Moreno (2002) define an animation as an external representation with three main characteristics: (1) it is a pictorial representation, (2) it depicts apparent movement, and (3) it consists of objects that are artificially created through drawing or some other modeling technique. According to Ploetzner and Lowe (2012), expository animations "… provide an explicit explanation of the entities, structures, and processes involved in the subject matter to be learned" (p. 782). Despite the rapid and widespread adoption of expository animations in education, research has produced very heterogeneous results as to their effects on learning (for reviews see Anglin, Vaez, & Cunningham, 2003; Bétrancourt & Tversky, 2000; Höffler & Leutner, 2007; Ploetzner & Lowe, 2012; Tversky, Morrison, & Bétrancourt, 2002).

Expository animations, however, not only offer various opportunities for learning (cf. Bétrancourt, 2005), they also place further demands on students. Additional perceptual, attentional, and cognitive processes are required to memorize and understand the information presented. Research on learning from expository animations has demonstrated that many students are unable to cope with these requirements, especially if they possess relatively little knowledge about the content of the animation (e.g., Lowe, 1999, 2003, 2004, 2008).

How can learning from expository animations then be enhanced? The most common approach to improve learning from expository animations is to design the animations in accord with principles that are based on theories and models of human learning (cf. Lowe & Schnotz, 2008; Mayer, 2001, 2005a). This approach essentially aims at designing animations in such a manner that the identification and selection, as well as the organization and integration of information are made as easy as possible. Examples of important design principles are: providing learners with control over the pace of the animation (Bétrancourt, 2005), combining the animation with spoken rather than written text (Low & Sweller, 2005), and highlighting relevant components of the pictorial display (Mayer, 2005b). Over the past 15 years, this approach has produced mixed results as to the effects that the various design principles have on learning (cf. Bétrancourt & Tversky, 2000; de Koning, Tabbers, Rikers, & Paas, 2009; Ginns, 2005; Ploetzner & Lowe, 2012; Tversky et al., 2002).

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A far less common approach to enhance learning from expository animations is to stimulate specific learning activities which in turn enable students to approach challenging animations in a competent manner. Hegarty, Kriz, and Cate (2003), for instance, encouraged students to identify important components and processes, as well as their causal relations within an expository animation. Moreno and Valdez (2005) required students to justify how a set of sub-sequences from an animation could be arranged to yield a coherent expository animation. Mason, Lowe, and Tornatora (2013) asked students to generate drawings in order to explain the animated subject matter. Up until now, only Kombartzky, Ploetzner, Schlag, and Metz (2010) have proposed and empirically evaluated a comprehensive cognitive strategy for learning from expository animations.

According to Streblow and Schiefele (2006), a learning strategy is defined as "… (a) a sequence of efficient learning techniques, which (b) are used in a goal-oriented and flexible way, (c) are increasingly automatically processed, but (d) remain consciously applied" (p. 353, translation by the authors). Learning techniques denote specific internal learning activities such as remembering a piece of information and establishing a relation between pieces of information, or external learning activities such as marking a segment of a text or a region of a picture (Streblow & Schiefele, 2006). For instance, the generation of self-explanations to mentally relate different pieces of presented information denotes an effective technique for learning from text (Chi, de Leeuw, Chiu, & LaVancher, 1994) as well as from static diagrams (Ainsworth & Loizou, 2003). If several learning techniques are employed in a coordinated and goal-oriented way, they form a learning strategy. Cognitive learning strategies serve to process information effectively and efficiently, to save information in long-term memory, and to support the retrieval of information from long-term memory (cf. Weinstein & Mayer, 1986). But which learning activities are important and should be taken into consideration when designing a strategy for learning from expository animations?

Mayer's (2001) Cognitive Theory of Multimedia Learning describes the cognitive processes that are relevant to the successful processing of different representations such as printed or spoken texts as well as static or dynamic pictures. In accord with Atkinson and Shiffrin (1971), as well as Baddeley (1986), it is assumed that the human memory is made up of three main components: the sensory registers, the working memory, and the long-term memory. The working memory plays a pivotal roll in processing information. Mayer (2001) formulates three basic assumptions concerning the working memory. First, the working memory consists of an auditory-verbal and a visual-pictorial channel (cf. Baddeley 1986; Paivio 1986). Second, the capacity of the working memory is limited, i.e., only a limited amount of information can be processed simultaneously (cf. Atkinson & Shiffrin 1971; Baddeley 1986). Third, successful learning from different representations requires (1) the selection of relevant verbal and pictorial information, (2) the organization of the selected information to construct a verbal and a pictorial model, and (3) the integration of the verbal and pictorial model into one coherent mental structure by making use of prior knowledge. Furthermore, it is assumed that verbal information can be mentally transformed into a pictorial representation (e.g., the construction of a mental image that depicts a verbal description) and vice versa (e.g., the mental verbalization of an image). According to Ainsworth (2006), transformations denote the – partial – translation of one representation to another representation. Because each representation has its own strengths and weaknesses with respect to expressiveness and processability, transformations can support the students in exploiting the presented information more effectively and efficiently. Similar assumptions as expressed in Mayer's Cognitive Theory of Multimedia Learning underlie the Integrated Model of Text and Picture Comprehension by Schnotz and Bannert (2003). In both theories, the processes of information selection, information organization, information transformation, and information integration are regarded as being essential for successful learning from multimedia.

Kombartzky et al. (2010) have conceptualized a cognitive strategy for learning from narrated expository animations which aims to stimulate, sustain, and support the different cognitive processes just described. The strategy is made up of eight learning techniques:

- Orientation and formulation of expectations: (1) observe and listen to the animation and articulate what can be learned from the animation.
- Selection and organization of information: (2) identify and sketch important frames, (3) identify and take notes of important statements, (4) identify and mark important regions in the frames, (5) identify and mark important assertions in the statements, (6) label regions in the frames.
- Transformation and integration of information: (7) articulate relations between frames and statements in your own words, (8) summarize the overall process in your own words.

Two previous studies have demonstrated that the students who made use of the learning strategy learned more successfully from a narrated animation about the dances of honeybees than did those who wrote a summary about the animated process (cf. Kombartzky et al., 2010). This paper builds further upon the research described above. An experimental study was conducted to investigate three additional research questions. First, does the proposed strategy also improve learning from other expository animations? This question addresses the generalizability of the learning strategy's effectiveness. Second, does the use of the proposed strategy result in an acquisition of knowledge that is available beyond the learning period? This question addresses the sustainability of the learning strategy's effectiveness. Third, does the proposed strategy benefit students with low and high cognitive ability alike? This question addresses possible aptitude–treatment interactions between the use of the strategy and student characteristics.

2. Study

2.1. Research questions and hypotheses

The first research question is whether the learning strategy can be successfully applied to narrated animations different than the one used in previous research. Since the learning strategy proposed by Kombartzky et al. (2010) is not specifically tailored to the content of the employed animation, we expect that the use of the strategy would also enhance learning from other narrated animations. To test this hypothesis, we investigated learning from two different animations: an animation about the dances of honeybees and an animation about sailing.

The second research question examines whether the valuable effects of the learning strategy prove to be beneficial beyond the learning period. Kombartzky et al. (2010) assessed the knowledge acquired by the students only at one point in time, namely immediately after the