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Animations and static pictures: The influence of prompting and time of testing

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ABSTRACT

Static pictures have an informational disadvantage for dynamic processes compared to animations. It was investigated whether this disadvantage can be compensated by prompting learners to process the specific dynamic information. It was assumed that this processing would lead to a longer lasting knowledge representation. A 2 x 2 x 2 between-subject design with visualization format (static picture vs. animation), prompt (present vs. absent) and time of testing (immediate vs. after one week) was utilized ($N = 263$). Participants performed better on test questions about the dynamic information after learning with the animation compared to the static picture. Prompting learners led to higher perceived difficulty, less overconfidence and better performance in a factual knowledge test addressing the prompted information. The quality of the answers to the prompts mediated the knowledge differences between visualization conditions. However, prompts did not compensate for the informational disadvantage of static pictures, irrespective of time of testing.

1. Introduction

Animations can possess an informational advantage compared to static pictures. In the present study, it was investigated whether this corresponding informational disadvantage of static pictures can be compensated by prompting learners to actively engage with the instructional material, thereby inferring the missing information. Moreover, it was examined whether this engagement would lead to a longer lasting knowledge representation.

1.1. *Learning with animations compared to static pictures*

There is a rather mixed pattern of results when comparing the effects of animations to static pictures on learning (Berney & Bétrancourt, 2016; Höffler & Leutner, 2007; Schnotz & Lowe, 2008; Tversky, Bauer-Morrison, & Bétrancourt, 2002). This might be partly traced back to the fact that it can depend on the properties of a respective animation, whether it hampers or fosters learning. Hence, it has been advocated to reason why a given animation may promote learning as well as to understand the underlying mechanisms that are supportive for learning with animations (Bétrancourt, 2005; Hegarty, 2004; Kühl, Scheiter, Gerjets, & Gemballa, 2011; Lowe & Schnotz, 2014; Lowe, 2004). To comply with these requests, it seems reasonable to take a closer look on the associated processing demands in learning with animations compared to static pictures.

Possible drawbacks in processing animations are their transience (e.g., Ayres & Paas, 2007; Castro-Alonso, Ayres, & Paas, 2014; Castro-Alonso, Ayres, Wong, & Paas, 2018) as well as their visual complexity (cf. overwhelming demands; Lowe, 2004). These two potential properties of animations can unnecessarily load the limited capacity of working memory. In the context of Cognitive Load Theory (Paas & Sweller, 2014; Sweller, Ayres, & Kalyuga, 2011), processing demands that do not contribute to a better understanding of the content, but hamper learning, are called extraneous cognitive load. However, the potential drawback of transience does not necessarily apply, but can for instance be neglected when the information in the animation is repeatedly shown (Schnotz & Lowe, 2008). Similarly, the potential drawback of visual complexity is diminished when the most relevant components are cued (e.g., Koning, Tabbers, Rikers, & Paas, 2009; Kühl, Scheiter, & Gerjets, 2012), and does even not apply, when only one element within the animation is moving and moreover this element is crucial for understanding the content (Schnotz & Lowe, 2008).

On the other hand, a potential advantage of an animation over a static picture is its inherent property to directly show spatial and temporal changes, such as changes in the velocity of a moving object (e.g., Kühl, Scheiter, Gerjets, & Edelmann, 2011; Lowe & Schnotz, 2014). Thereby, this dynamic information can directly be read off from the animation, which in turn reduces processing demands onto a learner (cf. Scaife &

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Rogers, 1996) or extraneous cognitive load, respectively. In contrast, with a static picture, this dynamic information needs to be inferred by a learner. However, it is rather unusual that learners with static pictures spontaneously infer such information (e.g., Hegarty, Kriz, & Cate, 2003). Hence, it is conceivable that directly showing these changes in the velocity of an object by means of an animation is supportive in understanding these changes during learning. This better understanding during the process of learning should in turn result in better learning outcomes, particularly for knowledge tests that address the understanding of these dynamic features.

To conclude, when on the one hand the potential drawbacks of animations, namely their transience and visual complexity, are diminished, and on the other hand their informational advantage (e.g., depicting changes in velocity) is exploited, animations should be better suited for learning than static pictures, particularly for those concepts that are related to their informational advantage (cf. congruence principle; Tversky et al., 2002). For the current study, such a focused instructional animation (i.e., transience and visual complexity were diminished, but an informational advantage given) was used. In a previous study, it could already be shown that this animation led to more effortful processing and better learning outcomes compared to a static picture (Kühl, Stebner, Navratil, Fehringer, & Münzer, 2018).

However, even though such a focused animation possesses an informational advantage over a static picture, there might nevertheless be conditions where the corresponding informational disadvantage of static pictures might be compensated by means of instructional methods. In this regard, one strategy might lie in prompting learners to actively engage with the instructional material, thereby generating the missing information (cf. elaborative interrogations; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013) that constitutes the informational disadvantage of static pictures.

1.2. Prompting learners to active processing

As emphasized in cognitive theories of learning and instruction, overall there is a general agreement that learners need to actively engage and process instructional material for gaining a better understanding of the content (e.g., Chi, 2009; Mayer, 2009; Sweller et al., 2011). However, when provided with instructional explanations, learners are not necessarily engaging in deeper processing automatically. This lack of effort in learning with instructional explanation might be traced back to an overconfidence in the learning success (e.g., Berthold & Renkl, 2010), leading to a rather shallow processing of the information. To overcome this shallow processing, there are several established or promising instructional means to foster active learning, for instance by introducing challenges (for overviews see Bjork & Bjork, 2011; Dunlosky et al., 2013; Fiorella & Mayer, 2016). Such introduced challenges may initially be perceived as demanding and difficult for learners – thereby possibly reducing overconfidence in learning – but should finally trigger learners to deeply process the information. Hence, they are supposed to be desirable with regard to knowledge acquisition, and may be subsumed within the framework of so-called desirable difficulties (cf. Bjork & Bjork, 2011).

Thereby, one comparatively easy to implement method is to explicitly prompt learners to more deeply engage with the content (e.g., Bannert & Reimann, 2012; Renkl & Scheiter, 2017; Roelle, Berthold, & Renkl, 2014). At this, one very promising type of prompts asks learners to process specific and relevant concepts of a content (specific prompts; cf. McCrudden & Schraw, 2007). There is empirical evidence that such focused processing prompts lead to a better knowledge about the concepts that are addressed by the prompts (cf. McCrudden & Schraw, 2007), but not necessarily for the concepts that are not addressed by the prompts (cf. Berthold & Renkl, 2010; McCrudden & Schraw, 2007). The quality in answering these prompts during learning can be an indicator of the performance of a later knowledge test and, moreover, explain observed differences between conditions (e.g., Roelle et al., 2014), and hence serve as a mediator.

With respect to the current study, one can provide prompts that ask learners to process the information that constitutes the informational disadvantage of a static picture compared to an animation, namely depicting dynamic features (i.e., changes in velocity). With such a prompt, it is conceivable that learners with animations do not need to deeply engage with the contents, since they do not need to infer this information, but can directly read off the information from the animation. On the other hand, learners with static pictures need to actively process and infer the information that constitutes the informational advantage of the animation. However, since learners with static pictures seldom spontaneously engage in active learning activities and in inferring missing information (e.g., Hegarty et al., 2003), particularly learners with static pictures might rely and benefit from these prompts. Therefore, if this strategy of prompting learners to actively process this specific content works out, the disadvantage of static pictures for learning might be compensated, thereby also leading learners to invest more effort and concentration (germane resources).

Especially for instructional methods that are supposed to lead to a more active processing, it is advocated – for instance in the context of desirable difficulties (cf. Bjork & Bjork, 2011) – to have a closer look on time of testing (immediate vs. delayed knowledge tests), which will be explicated next.

1.3. Time of testing

In the vast majority of studies that address learning with text and visualizations, learning success is usually assessed immediately after learning (cf. Mayer, 2009; Schweppe & Rummer, 2016). However, the aspect of assessing learning outcomes with a delayed knowledge test is still largely underrepresented in this field – even though there are exceptions and the topic is gaining more attention recently (Johnson & Mayer, 2009; Palmiter & Elkerton, 1993; Schweppe & Rummer, 2016; Schweppe, Eitel, & Rummer, 2015; Ziegler & Stern, 2014). Such delayed tests are crucial, for at least two reasons: First, generally speaking, the higher goal of learning should be in establishing long lasting knowledge representations, which in turn might be best assessed by a delayed knowledge test (e.g., one week after the instruction). Second, delayed knowledge tests compared to immediate knowledge tests can moreover reveal different and even inverted patterns of learning success and, hence, new important insights about the appropriateness of an instructional method (e.g., Johnson & Mayer, 2009; Roediger & Karpicke, 2006; Schweppe & Rummer, 2016; Ziegler & Stern, 2014). Concerning the latter point, in the context of desirable difficulties, it is argued that such a different pattern of results occur especially for instructional methods that prevent from shallow processing and are characterized by an active engagement. This more active engagement leads to deeper processing, which in turn is supposed to result in knowledge representations that are less susceptible to forgetting (Bjork & Bjork, 2011; Craik & Lockhart, 1972). Thus, an active engagement might especially pay-off in the long run (cf. Bjork & Bjork, 2011; Roediger & Karpicke, 2006; Schweppe & Rummer, 2016).

Applying this reasoning to the current study, it may be argued that prompting learners to actively engage with the instructional material might lead to a better lasting knowledge representation. Since a better lasting knowledge representation might be best assessed by a delayed knowledge test (Bjork & Bjork, 2011; Schweppe & Rummer, 2016), the benefits of prompting learners might become especially evident in a delayed test. Moreover and more precisely, one can suppose that particularly learners with static pictures – but not necessarily learners with animations – engage deeper with prompts since they need to infer the information, whereas learners with animations only need to engage to a lesser extent, since they can simply read off the information from the animation. Hence, it can be speculated that when prompts are present, learners receiving static pictures might even outperform their counterparts receiving animations in a delayed test. When no prompts are