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Observational learning from animated models: Effects of modality and reflection on transfer ☆

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ABSTRACT

Animated models use animations and explanations to teach how a problem is solved and why particular problem-solving methods are chosen. Often spoken explanations are proposed to accompany animations in order to prevent overloading the visual channel (i.e., the modality effect). In this study we adopt the hypothesis that the inferior performance of written text compared to spoken text is due to the fact that written text receives less attention and, consequently, less effortful processing. In a 2 × 2 factorial experiment ($N = 96$) with the factors modality (written, spoken) and reflection (reflection prompts, no reflection prompts) the hypothesis is tested that prompted reflection requires learners to explicitly attend to written explanations and carefully process them, thus yielding higher transfer performance, whereas for spoken explanations prompted reflection would have no effect on transfer performance. The results indeed showed the hypothesized interaction between modality and reflection prompts. They suggest that the modality effect can be compensated for when learners explicitly attend to the information and effortfully process it. This has implications for learning situations in which spoken explanations are no option, such as education for the hearing-impaired.

1. Introduction

We refer to the combined use of animations with explanatory text and pedagogical agents in modeling as 'animated models'. These animated models illustrate the solving of, for instance, scientific problems (e.g., solving a problem about gravity), mathematical problems (e.g., probability calculation problems), and search problems (e.g., finding information on the Internet). The pedagogical agent functions as a social model and guides the learner through the animation, by moving around the screen and guiding the learner's attention to specific parts of the animation, by addressing the learner in a personalized style and/or by showing which errors typically occur and how they may be avoided by the learner. For example, in solving a problem in the domain of probability calculation, it is important to know whether it is a 'drawing with or without replacement'. For novices this concept may be rather abstract and difficult to understand. An animation can visualize the concept by showing what is happening, for instance, in a situation with mobile phones. Imagine a mobile factory where in an assembly line six mobiles—each with a distinct color—are packed in a box. A controller blindly selects two mobiles to check them for deficiencies. The learner has to calculate the probability that the controller draws a yellow mobile and a blue mobile from the box. The animated model may show a box with six mobiles. The first mobile drawn from the box can be put away from the box. As shown in Fig. 1, the pedagogical agent may move to the mobile drawn and explain that a mobile that is drawn should not be put back because you do not want to draw an already checked mobile again. Then the group of remaining mobiles in the box becomes encircled. The pedagogical agent moves to the box with mobiles and explains that the second mobile will be selected from the remaining mobiles.

Animated models can be effective instructional methods for a number of reasons. To start with, they are in line with the current focus on lifelong learning and flexibility in task performance that increasingly emphasize the modeling of cognitive skills, such as problem solving and reasoning in a variety of domains (Jonassen, 1999). This type of modeling, also referred to as cognitive modeling, concerns covert cognitive processes that have to be explicated in order to become observable for learners. This enables learners not only to observe how a problem is solved, but also why a particular method is chosen. This type of information has proven to be beneficial for problem solving skills (Collins, 1991; Van Gog, Paas,

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Fig. 1. Screen shot of the 'Checking mobiles' animated model which displays and explains why this is a 'drawing without replacement'.

& van Merriënboer, 2004). Secondly, computer-based animations with verbal explanations are increasingly used to explicate the covert processes in cognitive modeling and seem to be in particular successful in learning abstract concepts and processes (Casey, 1996; Chee, 1995; Collins, 1991). Finally, developments in computer technology have facilitated the authoring and application of pedagogical agents, that is, computer-based characters that support learners with verbal feedback and guidance in order to engage them in more active learning (Clarebout, Elen, Johnson, & Shaw, 2002).

However, observing a poor designed animated model may easily overload the cognitive system. In this respect the split-attention effect is often cited in multimedia research. Split attention occurs when information from two (or more) sources must be processed simultaneously in order to derive meaning from the subject matter. Take for instance an animated model in which the written explanations are physically separated from the pictorial information. The learner has to mentally search, match, and integrate both sources of information (i.e., the animation and the text). It is impossible for the learner to attend both to the animation and the explanatory text when they are physically separated. This will cause much visual search, which is likely to pose a high load on the cognitive system without contributing to learning.

Cognitive load theory (CLT) tries to align the structure of information and the way it is presented with human cognitive architecture (Paas, Renkl, & Sweller, 2003; Paas, Renkl, & Sweller, 2004; Sweller, 1988; Sweller, 1999; Sweller, 2004; Sweller, van Merriënboer, & Paas, 1998; van Merriënboer & Sweller, 2005). CLT distinguishes between different categories of cognitive load. Intrinsic load is related to the complexity of the domain, whereas extrinsic load is determined by the manner in which the information is presented to learners. The load imposed by information and activities that hinder the learning process is called 'extraneous', whereas the load related to information and activities that foster the learning processes is called 'germane'. Intrinsic, extraneous, and germane load are considered additive in that, taken together, the total load cannot exceed the memory resources available, if learning is to be maximized (see Paas, Tuovinen, Tabbers, & van Gerven, 2003). An important objective of CLT is to decrease extraneous cognitive load and to enable learners to engage in learning activities required to perform effectively in tasks that impose germane cognitive load.

The split-attention effect can be regarded as an important source of extraneous cognitive load, after all the learner has to mentally search, match, and integrate the textual and pictorial information, which takes up much cognitive capacity without learning to commence. An instructional design guideline to overcome this split-attention effect that follows from cognitive load theory is the modality principle: Providing explanations in spoken format rather than in written format. Understanding new information involves the construction of separate mental representations for the verbal and the pictorial information and referential connections between these representations (Mayer, 2001; Mayer & Moreno, 2003). When verbal material is presented in spoken rather than in written format, cognitive demands on the visual channel are reduced which enables the learner to process the visual material and construct an adequate pictorial representation. Consequently, the verbal channel has sufficient cognitive resources to construct a verbal mental representation. Hence, the combined use of the visual channel for pictorial learning material and the verbal channel for the explanation of this material increases effectively available working memory capacity and facilitates learning (Ginns, 2005; Mousavi, Low, & Sweller, 1995).

Although the modality effect has proven its effectiveness (for a review, see Ginns, 2005), the use of the verbal channel is not always feasible. To start with, animated models with spoken explanations are technically more difficult to produce and demand additional hardware (speakers, headphones) that makes them more expensive. Secondly, for some groups of students, such as deaf or hearing-impaired students spoken explanations are no option, whereas the combination of pictorial information and textual explanations may nevertheless enhance their performance. Thirdly, there are complex tasks that put such a high demand on