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Using video and static pictures to improve learning of procedural contents

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ABSTRACT

Animations and videos are often designed to present information that involves change over time, in such a way as to aid understanding and facilitate learning. However, in many studies, static displays have been found to be just as beneficial and sometimes better. In this study, we investigated the impact of presenting together both a video recording and a series of static pictures. In experiment 1, we compared 3 conditions (1) video shown alone, (2) static pictures displayed alone, and (3) video plus static pictures. On average the best learning scores were found for the 3rd condition. In experiment 2 we investigated how best to present the static pictures, by examining the number of pictures required (low vs. high frequency) and their appearance type (static vs. dynamic). We found that the dynamic presentation of pictures was superior to the static pictures mode; and showing fewer pictures (low frequency) was more beneficial. Overall the findings support the effectiveness of a combination of instructional animation with static pictures. However, the number of static pictures, which are used, is an important moderating factor.

1. Introduction

The use of computers for educational purposes has become increasingly common. Recent studies on multimedia presentations have produced various recommendations for helping designers to use multimedia with efficiency in various learning environments (see Mayer, 2005, for a review). This can be seen in the case of temporal contexts depicting continuous changes over time. In some experiments, using dynamic visualizations such as an animation or video could help learners build a more relevant internal representation of the content presented than static visualizations allow. Tversky, Morrison, and Betrancourt (2002) explained this effect by the "*congruence principle*" that occurs when the external representation presented by the learning material is close in nature to the internal representation needed for a relevant understanding of the content. Hence, the use of dynamic visualizations such as animations (Betrancourt, 2005; Tversky et al., 2002), sequential displays (Jamet, 2008; Jamet & Arguel, 2008), or video (Zacks & Tversky, 2003) are potentially well suited to learning content possessing temporal factors as a dimension (i.e., phenomena involving change over time). However, some studies have not shown dynamic representations to be consistently superior to static representations (Mayer, Hegarty, Mayer, & Campbell, 2005; for reviews see Betrancourt & Tversky, 2000; Höffler & Leutner, 2007; Park & Hopkins, 1993).

1.1. Dynamic visualizations

According to Betrancourt and Tversky (2000), the term "animation" refers to any representation which generates a series of frames, so that each frame appears as an alteration of the previous one, and represents an evolution in time. Thus, the term animation can refer to a rapid succession of pictures as in a cartoon, to animations made with a computer, or video clips made with a camera. Using animations in a learning environment can potentially present several advantages over static representations (e.g., Höffler & Leutner, 2007; Park & Hopkins, 1993). Firstly, because animations are able to use information from an analogical point of view (i.e., using an iconic depictive representation rather than a symbolic description representation), they can help the viewer to build relevant internal representation (Schnotz & Bannert, 2003). This seems to be particularly true when learning materials with high levels of visuo-spatial content, such as configurations of three-dimensional physical systems (Hegarty, 2005), or descriptions of the layout of several elements on a map, such as atmospheric systems (Lowe, 1993). Secondly, animation is by definition a rapid succession of pictures indicating a series of movements, manifestations and disappearances of graphic elements. Hence animations can be easily adapted to depict dynamic information involving changes over time because of the similarity in relation with time (Tversky et al., 2002). Thirdly, because animations are continuous, they give more information than a series of static pictures would. Thus, by explicitly showing the micro-steps needed between each important change, animations can be adapted for presenting continuous phenomenon because the learner is not required to infer

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how phenomena change from one step to the next (Betrancourt & Tversky, 2000). Fourthly, recent findings seem to indicate that the advantage of using animations instead of series of statics could be especially relevant for depicting some human-motor skills. Thus, authors showed that learning such contents as tying a knot or making a paper-folding can be improved by using a video-based material rather than series of statics (Ayres, Marcus, Chan, & Qian, 2009; Wong et al., 2009). Nevertheless, despite such potential advantages animations have not been found to be that effective in learning environments (Betrancourt & Tversky, 2000; Park & Hopkins, 1993).

Several explanations for the relative ineffectiveness of animations have been proposed. One of them is related to the "*congruence principle*" formulated by Tversky et al. (2002). This principle can explain the failings of animation in cases where the content to be learnt is not dynamic and/or a dynamic internal representation of the content is not essential for learning. Hence, from a cognitive load theory (see Sweller, 2005) perspective using dynamic representation such as animations, in situations where static representation alone would be sufficient, can lead to an increase in extraneous cognitive load. By presenting too much information at the same time, extraneous cognitive load is created leading to poorer learning (Sweller, 2005; Sweller & Chandler, 1994). In this case too much visual information is unhelpful.

Another possible explanation for the ineffectiveness of animations is their transient nature. As animations present dynamically temporal information at a constant rate, it can be difficult for the learner to sufficiently process information that is visible only for a short time before vanishing (see Ainsworth & VanLabeke, 2004; Ayres & Paas, 2007). Thus, holding important information in working memory while constructing a coherent internal representation with complementary information could increase the cognitive load (Sweller & Chandler, 1994). In such situations, the learner has no control over the pace of presentation of disappearing information. The comparison between animation and a series of static pictures is analogous with the comparison between an aural presentation and a printed text presentation. In the latter case, learners can read some passages quickly and others slowly, can compare several passages if necessary and have the possibility of re-reading any section if they misunderstand a specific element. In contrast, while watching animations or listening to aural speeches, learners cannot afford to miss any important information because it would be a permanent loss, and therefore, having perceived specific information as important it has to be kept active in working memory before being integrated with other information. Hence retaining and integrating information is very resource intensive on working memory.

There are two possible means to avoid the problems related with the transient nature of animation. First, in some cases, the disappearance of past information could be avoided by displaying key static pictures from the animation to remove the transience of some information elements (Rebetez, Bétrancourt, Sanguin, & Dillenbourg, 2005). This would permit learners to keep a visual trace of past events and allow them to review earlier information as necessary. In most cases, however, the dense content of animations makes this kind of presentation impractical as the visualization may become perceptually overloaded and, by consequence, very unclear for viewers. Second, learners can be given the possibility to control the pace of information with a "slider bar" or simply a "stop" and "play" button (Betrancourt, 2005; Hasler, Kersten, & Sweller, 2007). While using this "*interactivity principle*", the effectiveness of instructional animations can be improved. By giving the control to learners, they can avoid missing information and can slow down the pace of the learning material when it becomes more difficult to understand. In addition, while learning a cause-and-effect system from a presentation, user interactivity can be beneficial by allowing the segmentation of the presentation into chunks that will be more easily organized into a mental model (Mayer & Chandler, 2001).

The act of controlling the pace of a learning material can be problematic by itself. Indeed, using an interface to control pace is another activity the learners must cope with at the same time as learning the document. This added activity could be demanding in attention and detract from the principal task of learning the document (Hegarty, 2005). Also, the interface requires extra skills. Learners must master its use, which may be particularly problematic for people who do not usually use computers. Furthermore, asking learners to control the pace of the learning material is similar to asking them to have a specific relationship with it in which they identify its most relevant information (Hegarty et al., 2007). Consequently since interactivity involves strategies (Lowe, 1999), the lack of appropriate strategies could lead the learners to the problem of needing to identify and select relevant information, and lead to increased cognitive load (Schwan & Riempp, 2004).

Because using an interface and actively selecting relevant and transient information is cognitively demanding, in some cases the learners prefer not to use this possibility. For example, a study by Hasler et al. (2007) found that a group with learner control (able to stop an animation) learnt better than a group without learner control (unable to stop an animation), in spite of rarely using the interactive facility. How can this result be explained since all learners were confronted with the same visualization and its transient information? Perhaps this difference can be explained by the instructions given to learners before the learning phase. For example, Hegarty and her colleagues found better results for learners asked to *mentally animate* a system (a flushing cistern) from static diagrams before the learning phase than for those with no specific instructions (Hegarty, Kriz, & Cate, 2003; Hegarty, Narayanan, & Freitas, 2002). They concluded that people often learn more effectively if they are more active in the learning process. Similarly, in Hasler et al.'s study, the experimenter asked some participants to only watch the learning material, but asked others to use the interface of control if necessary. In this situation, we could envisage that the participants would not have the same perception of the learning material since the ones offered interface control have to actively partake in the multimedia presentation in order to gauge if a break was needed, even though they may not have used this possibility.

1.2. Combining video and static pictures in learning procedural content

Documents presenting procedural contents describe the evolution of a phenomena or a succession of actions over time and have several characteristics. The procedures are characterized by the existence of a beginning and an end, and between these two extreme points, there are a succession of steps describing each action or some steps of the procedure. The order of these steps is very important and an inversion can disable the execution or the comprehension of the procedure as a whole. Therefore, using multimedia presentations instead of paper-based documents could potentially provide an alternative way for helping the learning of procedural contents (Brunyé, Taylor, Rapp, & Spiro, 2006).

To keep the advantages of animations (i.e., for conveying temporal information) and reduce their limitations, an alternative format of presentation is proposed. In this format, animations are accompanied by both spoken text and static pictures. In this way, the depiction of micro-steps from the procedure and its natural development are maintained. Moreover, the static pictures are visible throughout the animation and act to limit the transience of the animation (see Fig. 1). The negative impact of the *split attention effect* (Ayres & Sweller, 2005; Chandler & Sweller, 1991; Sweller & Chandler, 1994) between static pictures and animation