When and why does animation enhance learning? A review

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Abstract

Does the use of animation in a learning context improve comprehension and / or knowledge acquisition, compared with static graphics? Animated graphics enable to depict the spatial organization of the components and its changes over time (Bétrancourt, Morisson and Tversky, 2001), or make explicit the dynamic changes of a process (Lowe & Schnotz, 2003). Several literature reviews (Bétrancourt and Tversky, 2000; Schneider, 2007; Tversky, Bauer-Morisson & Bétrancourt, 2002) found no conclusive findings regarding the benefit of animation compared to static graphics on learning outcomes.

Using a quantitative approach through factorial analysis, Schneider (2007) pointed out that the effect of animation varied according to the content domain. Nonetheless, the author did not provide the reasons why animation benefits in some domains and not others. A recent meta-analysis (Höffler & Leutner, 2007) found an overall positive effect of the use of animation over static pictures and identified some significant moderator variables, such as the realism and the type of learning content. However, the inclusion criteria defined by the authors excluded some famous studies. In addition, some moderator variables, suggested in the literature on animation, were not taken into account in the analysis.

In order to further identify the conditions under which animated graphics are beneficial for learning, we collected 57 articles (66 studies) comparing instructional materials containing animated versus static graphics. First, a qualitative review was conducted in order to draw the global picture that will be compared to previous reviews. Then, a meta-analysis will be conducted in order to assess the role of moderator variables suggested by previous literature,. This meta-analysis will identify the conditions under which animation can be beneficial to learning and provide new assumptions regarding the cognitive processes involved in learning from animation.

(287 words)

Extended Summary

Does the use of animation in a learning context improve comprehension and / or knowledge acquisition, compared with static illustrations? Previous research led to inconsistent findings,

depending on various factors related to the learning content, the learning situation, or the delivery features. Hence, a better question is to ask when and why do animations improve learning, which means identifying the conditions under which animated graphics are beneficial as well as the associated underlying cognitive processes.
Bétrancourt and Tversky (2000) defined animation as “any application which generates a series of frames, so that each frame appears as an alteration of the previous one, and where the sequence of frames is determined either by the designer or the user”. A clear advantage of an animation is its ability to convey changes over time (Lowe & Schnotz, 2003), whereas these changes are implicit in a static illustration. Animations offer a direct visualization of the microsteps that is the minute changes occurring in a dynamic system, which have to be inferred from a series of static graphics (Bétrancourt, Morisson and Tversky, 2001). Conversely, a series of simultaneously presented static graphics allows for the different states or steps within a depicted process to be consulted at any time, while an animation must be repeated as a whole (Bétrancourt et al., 2001). However, animations must be adequately processed in order to extract the necessary information for building a coherent mental model. The subprocesses - selection, organisation, and integration (Mayer, 2005) - may be hindered because the multiple components of the dynamic structure compete with the learner’s attention (Lowe, 1999).

Previous research reviews (Bétrancourt and Tversky, 2000; Schneider, 2007; Tversky, Bauer-Morisson & Bétrancourt, 2002) reports inconclusive findings regarding the benefit of animation compared to static graphics. Explanations for this discrepancy are manifold. First of all, unequal and non equivalent information content in experimental conditions may lead to differences. An animation may provide more information to the learner, since all the different steps included in the mechanism are explicitly and dynamically shown. The same information on the other hand has to be inferred from static illustrations. Another source of variation across studies is the level of interactivity and particularly the possibility to control the pace of the animated sequence (e.g., Fischer, Lowe & Schwan, 2006). The tasks used for measuring the learning outcomes also varied across studies. Schneider (2007) underlines that within the same study, the effect of animation could differ depending on the learning outcomes tested. For example, in a geographic time difference study (Schnotz, Böckheler and Grzondziel, 1999) the comprehension test determined an advantage of the animation over static graphics, whereas the mental simulation test showed the opposite pattern. However, this reviews used a qualitative approach that does not allow to identify precisely the factors mediating the effectiveness of animation. Schneider (2007) used a factorial analysis and

found varying effect depending on domains, but did not propose any explanation on the whys.

Recently, Höffler & Leutner (2007) conducted a meta-analysis and found an overall positive effect on using animation over static pictures. The analysis of different moderator variables revealed that animations were beneficial for learning procedural knowledge but not declarative or heuristics knowledge. However, the inclusion criteria defined by the authors excluded some famous studies. In addition, some moderator variables, suggested in the literature on animation, were not taken into account in the analysis.
Consequently, we conducted a review of literature including all studies reviewed by Höeffler and Leutner (2007) and added some more following the expansion of inclusion criteria. Overall, we collected 57 articles (66 studies).

A first qualitative analysis (n=66), based on the overall effect described by the authors, showed that animated graphics were superior to static ones in 30 studies, whereas 6 studies were in favour of static illustrations, and 23 found no significant difference between these two format presentations. Seven studies found distinct outcomes depending on learners' individual abilities, such as, for example, prior knowledge levels or spatial abilities. These global outcomes show that the interesting question is not whether animation is better than static graphics, but when and why is animation beneficial to learning. As Höffler and Leutner (2007), we adopted a quantitative approach through a meta-analysis that allows to statistically synthesize a large number of pair-wise comparisons. Its advantage over a qualitative review is that it is based on statistical outcomes and measures the effect size of the animation's efficiency. In addition to this overall finding effect, it is also possible to carry out sub-groups analyses, which would make it possible to highlight nonsignificant effects and therefore indicates the moderator variables influencing the global effect (Cucherat, 2002). Our analysis contained more than two hundred pair-wise comparisons on the overall effect. Detailed analysis among them (n=201) showed beneficial outcomes in favour of animation for 53 of them, 24 positives results for static illustrations and 124 showed no significant differences in the learning design. As the instructional learning design comparison was not the only focus of the compared studies, we could further distinguish among the overall effect by analyzing our pair-wise comparisons through moderator variables, which represent the differences among studies that have reliably affected their outcomes. Moderator categories, which have shown to moderate the animation efficiency, were identified from the literature such as the *specificity of the instructional learning content* – type of knowledge and instructional domain (Bétrancourt et al., 2000), *the delivery features convey by the dynamics*

– interactivity, animation presentation mode (Mayer, 2001), *the learning objectives*, *the forms of outcomes* and some *individual abilities* – prior knowledge level (ChanLin, 1998, 2001, Kalyuga, 2008) and spatial abilities level (Hegarty & Sims, 1994). The results of this meta-analysis, still in progress, will contribute in highlighting the underlying features and processes involved in learning from animation. Overall, our position is that the animation literature should focus more on the underlying cognitive processes involved and the visual information conveyed than on surface design issues.

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