# The Role of Spatial Ability when Learning from an Instructional Animation or a Series of Static Pictures

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**Abstract**

24 students learned about a chemical process either from animation or static pictures taken from the animation at four crucial points. An aptitude-treatment interaction was obtained in which spatial ability plays a compensating role: Low-spatial ability students showed poor learning outcomes when learning from pictures while high-spatial students did not; when learning from animation, however, learning outcome was high independently from spatial ability. Results are in line with a cognitive theory of multimedia learning which states that constructing mental animations (Hegarty, Kriz & Cate, 2003) from poorly-designed materials needs spatial ability; with well-designed animated learning materials, however, spatial ability is not required. At the symposium, results of a larger follow-up study will be available. We hope to replicate the present findings and will report about a third condition with more static pictures, which supposedly will facilitate the creation of a mental animation and therefore is expected to be as effective as the animation condition.

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## Theoretical Framework and Purpose

Animations in learning and instruction have been the focus of much research in recent years. The enthusiasm of the first years, in which the potential of dynamic visualization seemed to be boundless, gave way to a more pragmatic view. Tversky, Morrison and Betrancourt (2002) showed that animations often had no advantages over still pictures; but when they had, more information was available in the animated than in the static version. On the other hand a meta-analysis (Hoeffler & Leutner, submitted) of 76 pair-wise comparisons of static pictures versus animations found an advantage of animations for learning success. It still remains unclear when animations may be the better choice; as they provide information of transient nature, they might provide the learner immediately with an adequate mental animation. On the other hand, Hegarty, Kriz & Cate (2003) propose that especially static pictures are able to help the learner to develop such a mental model. The present study compares an animated version of a learning environment with an equivalent one which instead includes a series of static pictures. Although the series consists of key pictures, it is not expected that they lead to learning results as good as with the animation.

Another focus of the present study is on learners' spatial ability. The ability of creating an animated mental model of a process should strongly be linked to spatial ability, in particular to the ability of mentally imagining the movement of objects in space. Therefore, students with lower spatial ability are expected to have more problems in learning with static pictures of a process – i.e. in constructing a mental model of the process – than students with higher spatial ability. On the other hand, students with lower spatial ability are expected to profit from learning with an animation of the process more than students with higher spatial ability. Thus, spatial ability and the type of learning material (animation versus static pictures) should interact in terms of an aptitude-treatment interaction. However, in this case spatial ability is not seen as an "enhancer of well-designed instruction" (Mayer, 2001, p. 178); to the contrary, spatial ability is seen as a compensator of poorly-designed instruction: High-spatial ability learners are expected to be able to compensate learning difficulties due to static pictures, whereas low-spatial ability learners are not. Therefore, when learning with static pictures, we predict spatial ability to correlate stronger with learning outcome than when learning with animations.

**Research Design**

In a first pilot study, 24 participants (college students; 92% female) learned in two different multimedia learning environments about chemical processes of laundry: 13 participants were presented with a Flash-animation about the role of surfactants during laundry; 11 were presented with a series of four static pictures (stills of the animation) instead of the animation. In both conditions subjects listened to the same verbal narration explaining the chemical process depicted in the animation and the series of pictures. The overall learning time was 5 min. on average.

All participants were asked for their grade-point average and were tested beforehand on spatial ability, using a paper folding test (Ekstrom, French, Harman, 1976). After learning, a post-test was administered including multiple-choice- and open questions concerning declarative knowledge and deeper comprehension. Self-experienced cognitive load during learning, as a control variable, was measured according to Paas & van Merrienboer (1993).

It was hypothesized that learning outcome as the dependent variable would show an aptitude-treatment interaction effect of spatial ability (aptitude) and type of learning material (animation versus static pictures as treatment). More precisely, spatial ability was expected to play the role of a compensator in terms of compensating for the detrimental effects of a poorly-designed multimedia learning environment with pictures instead of an animation for constructing meaning of a chemical process description.

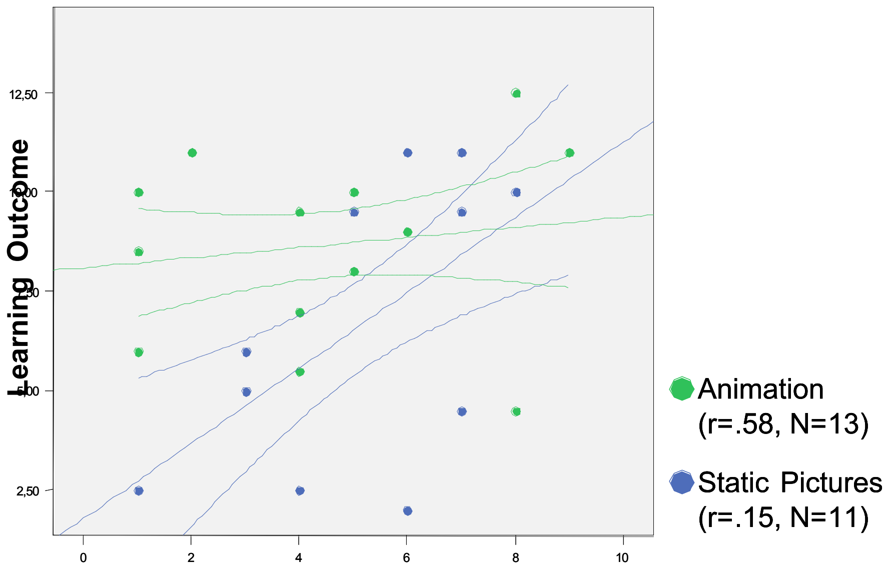


Figure 1: Learning outcome

as a function of spatial ability and type of multimedia learning material

(within-group regression lines with 75 %-confidence intervals)

**Results**

In Figure 1 the results are depicted. Obviously, the figure displays an aptitude-treatment-interaction of the expected type: There is a strong correlation of spatial ability and learning outcome in the static-pictures group and a weak correlation of the two variables in the animation group. Computing a general linear model and controlling for grade-point average, the interaction is statistically significant, $F(1,19)=4.626$, $p=.045$, $MSE=7{,}006$, $eta2=.196$, whereas the main effects of both spatial ability, $F(1,19)=2.753$, $p=.113$, and type of learning material, $F(1,19)=2.584$, $p=.124$, fail to reach statistical significance. The overall descriptive statistics are $M=7.75$, $sd=3.09$, $r=.27$; for the animation group the statistics are $M=6.68$, $sd=3.59$, $r=.58$; for the static pictures group the statistics are $M=8.65$, $sd=2.38$, $r=.15$. When self-experienced cognitive load is entered into the linear model as a control variable the interaction effect does not vanish. Furthermore, the results pattern does not change substantially when the down-right animation outlier point (8, 4.50) in Figure 1 is removed from the analysis. In this case, the aptitude-treatment interaction is still statistically significant, $F(1,18)=3.062$, p(one-tailed)=.049, $MSE=6.060$, $eta2=.145$. However, spatial ability, $F(1,22)=5.222$, $p=.035$, $eta2=.225$, as well as type of learning materials, $F(1,22)=5.039$, $p=.037$, $eta2=.221$, turn out to be statistically significant when removing the outlier.

**Theoretical and Practical Implications**

This study is a first step to investigate the general possibility of replacing an animation with a series of static pictures. As predicted, only four pictures – although they illustrate key moments of the process in question and provide no comprehension problem for high-spatial ability students – have not been enough to evoke deeper understanding and learning of facts for low-spatial ability students. It is assumed that with more static pictures better learning outcomes as good as with the animation may occur, because even low-spatial students may be able to create an adequate mental animation of the process given that more pictures are presented to them. Such a finding could provide an explanation for contradictory results concerning the usefulness of animations compared to static pictures in the past (Hoeffler & Leutner, submitted): In general, static pictures might be learning aids as capable as animations (Hegarty, Kriz & Cate, 2003); but in many cases, just too few static pictures had been offered. Thus, it might be possible that in many cases the development of an expensive animation could often be saved.

As to aptitude-treatment interactions in multimedia learning (see Mayer's "individual differences" principle; Mayer, 2001), evidence was found that spatial ability seems to play a crucial role in constructing a mental animation from pictures and therefore is important to be considered in choosing between animations and static pictures for purposes of learning and instruction. It seems that - although animations are often not generally better than static pictures for learning - in particular students with low spatial ability can profit from animations. On the other hand, when multimedia materials do not include animations in order to depict a process to be learned then spatial ability seems to play the role of a compensator: High-spatial ability students seem to be able to compensate the negative effects of poorly-designed learning materials in order to construct a mental animation from a small number of static pictures.

The present study found some hints concerning the role of spatial ability in learning with multimedia. On the one hand, the results are in line with results of Plass et al. (2003) who found that low-spatial ability learners performed worse than high-spatial ability learners on incidental vocabulary learning during reading a second language story when pictorial information on words had to be looked up, whereas no such difference was found when verbal information on words had to be looked up. On the other hand, the present results seem to be in contrast to recent research on the role of spatial ability in learning with instructional animations compared to learning with static pictures (Hegarty, 2005, p. 457). It should be noted, however, that the present study is a first pilot study with a rather small number of participants and, thus, has rather low statistical power for uncovering instructional effects. Further research is needed in order to replicate the present findings. At the moment, a larger study with about 70 participants is being conducted. In this follow-up study a learning environment with a series of eleven instead of four static pictures is added as a third treatment condition in order to match the animation. We are confident that we will be able to present the results of this study at the symposium as well.

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