ANIMATION IN PERFORMANCE SUPPORT: USE IT OR LOSE IT

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ABSTRACT

There is a strongly held belief that the use of animation in multimedia instruction can enhance learning. While the research literature is somewhat mixed, animation, when used along with sound instructional principles, can have a significant impact on learning (Mayer, 2002; Hansen, Narayanan, & Hegarty, 2002). This research effort investigated the use of animations in a performance-aiding environment in order to derive basic guidance for the use of animated graphic material for delivery in electronic performance support applications. Earlier pilot research showed many participants failed to engage animations provided. Thus, the current study investigated not only possible components of animation presentation (animation, text and narration) and their contributions to task performance, but the frequency of use and control of the animation, as well.

Ninety participants were assigned to one of the six conditions of a 2 x 3 (User Control by Modality) between-subject experimental design. The two levels of User Control included participant initiated animation or system initiated animation. The three levels of Modality included 1) animation alone, 2) animation with text, or 3) animation with a corresponding vocal narration of the text instruction. Participants were asked to assemble a thirteen piece wooden puzzle by following instructions delivered on a laptop computer. Dependent measures were time to task completion, accuracy of task performance, and frequency of animation use. Individual difference measures such as spatial ability and goal orientation were also collected.

Results showed that participants who interacted with the animation more often and who showed higher levels of spatial ability were more accurate in task performance. This paper will describe the results of this study and discuss the possible implications for the use and design of animation in the context of performance support.

AUTHORS

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BACKGROUND

There is a strongly held belief that the use of animation in multimedia instruction can enhance learning. While the research literature is somewhat mixed, animation, when used along with sound instructional principles, can have a significant positive impact on learning. In fact, many recent research efforts have concentrated on the use of cognitively derived principles of learning in making the case for the use of animation (Mayer, 2002; Hansen, Narayanan, & Hegarty, 2002). Thus, guidance exists for the use of animation in a learning environment. However, animation may also be of use for performance support applications. These applications include electronic technical manuals or Electronic Performance Support Systems (EPSS).

The Navy as well as other DoD organizations and private industry are converting and acquiring technical documentation in electronic form. Therefore, it is critical to examine how various multimedia formats contribute to performance. Certainly, electronic documentation has the potential to alleviate costly and bulky paper products and add efficiency to the updating processes. But from a human performance perspective, questions remain as to how electronic formats can best be utilized to assist users in the performance of their job.

An understanding of the contributions of multimedia, specifically for the use in performance support applications, is needed. Thus, the goal of the current research was to address specific research questions such as:

- *Do animations enhance task performance?*
- *Does narration of task procedures enhance the use of animations in performance support?*
- *What guidance can be given to developers as to how the animation should be delivered?*

The current research sought to address these questions by applying the available research literature on animation and learning to the concept of performance support.

Animation and Learning

During the past decade, a great amount of research has been devoted to understanding the contribution of technology to education and training. Throughout most of this time, the research addressing the efficacy of multimedia courseware has provided mixed results. Lack of suitable control conditions and evaluations of technology done by those who have developed them are just some of the factors that limit the research community's ability to make strong conclusions as to the contribution of technology to the learning environment (Fletcher, 1996). Moreover, the lack of a sound theoretical basis from which to derive research conclusions further hinders progress in understanding the use of technologies for education and training.

More recent research on the use of animations in multimedia applications provided a cognitive basis for understanding how animations can contribute to learning. Specifically, Mayer and colleagues (Mayer, 1997; Mayer and Anderson, 1991; Mayer & Anderson, 1992; Mayer, Heiser, & Loon, 2001; Mayer and Moreno, 1998) produced a number of principles of animation in learning through a series of empirical assessments. The cognitive theory of multimedia is based on three assumptions (Mayer & Moreno, 2002):

1) There are separate channels for processing visual/pictorial representations and auditory/verbal representations;

2) Only a few pieces of information can be actively processed at any one time in each channel; and

3) Meaningful learning occurs when the learner engages in cognitive processes such as selecting relevant material, organizing it into a coherent representation and integrating it with existing knowledge.

Based on this theory, seven principles for the design of multimedia presentations involving animation were derived (see Table 1).

Table 1: Principle of Animation in Learning (Mayer & Moreno, 2002).

Principle	Guidance
1. Multimedia	Animation with text better than text alone.
2. Spatial Contiguity	On-screen text should be presented directly next to the animation it's describing rather than far from the corresponding action in the animation.
3. Temporal Contiguity	Animation and text should be presented at the same time rather than separated in time.
4. Coherence	Extraneous words, sounds (including music) and video should be excluded.
5. Modality	Animation and narration work better than animation and on-screen text.
6. Redundancy	Animation and narration work better than animation, narration and on-screen text.
7. Personalization	Narration should be conversational rather than formal in style.

While the instruction studied by Mayer and Moreno (2002) dealt with concrete subjects (e.g., pumps, brakes, etc.), Hansen, Narayanan, and Hegarty (2002) applied similar principles to a more abstract subject, the design of computer algorithms (see Table 2). These principles include targeting the employment of animations, text, static and interactive examples to support specific learning objectives, the presentation of learning in discrete segments, the use of a variety of illustrated views, and the promotion of interactivity between the learner and the media.

Table 2: Principles of Animation (Hansen et al., 2002)

Principle	Guidance
1. Media	Use specific media to support specific learning objectives.
2. Discrete segments	Present each step and accompany that animation with explanations.
3. Variety	Use various animations to illustrate different views.
4. Participation	Promote student interaction with animation.

Animation for Performance Support

Before applying guidance to a performance support context based on the learning literature, it is critical to differentiate *learning* from *performance*. A fairly well documented phenomenon shows that instruction that produces immediate performance outcomes differs from instruction that produces generalization and retention. Schmidt and Bjork (1992) point to several fallacies associated with training procedures. Using examples from a number of different studies, Schmidt and Bjork argued that manipulations that maximize performance during training can be detrimental in the long term, whereas manipulations that degrade the speed of acquisition can support long-term goals of retention and transfer.

There are fairly obvious differences between performance aiding and training. Errors in performance during training can stimulate learning and offer insight into deep principles of system functioning (Frese & Altmann, 1989). In a training context, knowledge or performance deficiencies can be identified and targeted for remediation. Training seeks to maximize recall and provide scaffolding to facilitate greater understanding.

Performance aiding is not concerned with a greater system understanding, but rather with accomplishing a task *now*. Therefore, it cannot be assumed that multimedia designed for effective learning would be effective for performance support. Gaining an understanding of the contribution of multimedia in a performance support task would be invaluable.

Guidance as to the proper delivery of multimedia is also needed. Specifically, in a pilot study designed to test the efficacy of animations for performance support, Hodak, Griffin, Ricci and Connelly (2005) found that users would not always invoke an animation providing guidance for a performance support task – even when directed to do so during training. While Hodak et al. could not determine if the animation significantly improved participant performance, one unexpected finding was the pervasive lack of use of the animation. Thus, one objective of the current study was to determine whether users should be given a choice to invoke the animation or whether the animation should initiate without user control.

Certainly, the notion of forcing the animation is somewhat in contrast to the principles expressed by Hansen et al. (2002) in terms of allowing the user interaction with the system. However, if a performer is to achieve any gain in task performance from animation, the animation, at a minimum, must be initially invoked.

An understanding of the contributions of multimedia, specifically for the use in performance support applications, is needed. The objective of this study was to not only determine the efficacy of animation and narration on the performance of a procedural task, it seeks to point out the difference between learning and performance support environments, as well.

Method

Ninety college students recruited from a local university were assigned to one of six experimental conditions. Participants included 43 males and 47 females and ranged in age from 18 to 56. The experimental design was a 2 x 3 (User Control x Modality) between subjects design. The two levels of user control differed as to whether or not the participant began the animation by pressing a “Play” button at the start of the each step, “User-started,” or whether the animation began immediately at the start of each step, “Automatic.” Thus, for participants assigned to the “User Started” conditions, animation only initiated when the participant pressed the “play” button. For participants assigned to the “Automatic” conditions, the animation began immediately without input from the participant.

The three levels of modality differed in the combination of modalities (Animation Alone, Animation with Text Instruction, and Animation with Text Instruction and Narrated Instruction). Brief descriptions of the Modality conditions are provided below.

Animation with No Text. Animation was displayed without any other support (i.e., no text, no narration).

Animation with Text. Animation was displayed on the right side of the screen, with text instructions of the entire step on the left side of the screen.

Animation with Text and Narration. As the animation instruction for the step plays, recorded audio narration plays in real-time according to position in the step’s timeline. The narration presented was the spoken word of the full text on the left side of the screen.

Apparatus

The experimental test bed consisted of a thirteen-piece wooden puzzle and a laptop computer with animated computer-support software. The wooden puzzle presented a test-bed whose manipulation tasks are similar in nature to many maintenance tasks (e.g., assembling gear boxes, alignment of slat rigging, installation of hydraulic tubing, etc.). However, participants did not require any prerequisite training or tools for the safe manipulation of its pieces. There were seven steps in the entire procedure, each step consisting of two or more sub-tasks.

The information presented on the laptop was apportioned approximately half and half between text and graphic animation. The animation images appeared on the right side of the screen and the text (when applicable) appeared on the left side of the screen (see Figure 1). For participants assigned to the No Text conditions, the left side of the screen was blank.

The animation side of the screen had control buttons and a dragging bar located at the bottom center that allowed the participant to stop, start, rewind, and fast forward the animation. Finally, the animation interface contained a large “Facilitator” button on the lower right side of the screen. This button allowed the facilitator to control the start of each step of the assembly task.

Procedure

Upon arrival, participants were told the purpose of the study and that their task would be to complete the assembly of a wooden puzzle. Following completion of an informed consent form, a brief demographic survey, and a spatial ability test (Shepard & Metzler, 1971), participants received training on the use of the laptop and performance support software, including the functions of each of the control buttons. They were then provided practice time in order to become familiar with the user interface.

As part of the training, participants were instructed to announce aloud after completing each of the seven steps “I am finished,” indicating that they believed they had finished the current step. This was done in

Figure 1: Example Screen - Animation with Text, User-started.

order to get an accurate time measure for each step and to allow the facilitator to check the accuracy of the assembly and insure the participant would begin the next step with a properly assembled puzzle.

If the step was not completed correctly, the facilitator completed the step correctly out of view of the participant. Once the step was correctly completed by either the participant or, if necessary, the facilitator, the participant was allowed to navigate to the next step. Following completion of the experimental task, participants completed an exit survey and a goal orientation survey.

Measures

Dependent measures included Task Time, Task Accuracy, and Total Use. Task Time was calculated by summing the time taken for each of the seven steps. This allowed for a more equal comparison between groups as it did not include interruption time by the facilitator to check the accuracy of the assembly.

Task Accuracy was calculated by summing the number of steps completed correctly. Thus, a perfectly accurate participant would score a seven (7). Total Use was calculated by summing the number of occasions the participant stopped, started, or paused the animation. For participants assigned to the automatic condition, one interaction was automatically included for each step. This allowed comparison to the User Control group in terms of the amount of interactivity. For participants assigned to the user control condition, data was analyzed independently in determining whether the animation was actually invoked.

RESULTS

Correlations

An initial bivariate correlational analysis showed age, total use, and spatial ability were significantly correlated with Task Accuracy (see Table 3).

Table 3: Bivariate Correlations

	Age	Sex	Total Use	Task Time	Task Accuracy	Spatial Ability	Goal Orientation
Age	1.0	-.04	-.11	.03	-.43**	-.242*	-.04
Gender		1.0	.09	.25*	-.176	-.306**	.02
Total Use			1.0	.38**	.25*	.05	.05
Task Time				1.0	-.19	.25*	-.05
Task Accuracy					1.0	.37**	-.04
Spatial Ability						1.0	-.13
Goal Orientation							1.0

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed)

Younger participants, participants who used the animation more often, and participants with higher spatial ability, performed the experimental task more accurately. Goal orientation was not significantly correlated with the three dependent measures and was thus dropped from subsequent analyses.

Total Task time showed a negative, although not statistically significant, correlation with Task Accuracy. Task Time was, however, significantly and positively correlated with Total Use. Men were more likely to take longer to complete the task then women and the male participants in this study tended to have lower spatial ability scores.

Multivariate Analysis of Variance

A two way Multivariate Analysis of Variance (MANOVA) was conducted to determine the effect of Modality and User Control on the three dependent variables, Total Time, Total Accuracy, and Total Use. The MANOVA included Spatial Ability, Age, and Gender as covariates. A significant main effect was found for Modality (Wilks Lambda, F = .764, p = .002) and a significant interaction effect was found for Modality and User Control, (Wilks Lambda, F = 3.289, p = .004). Analyses of variances (ANOVA) on each dependent variable were conducted as follow-up tests to the MANOVA.

Total Time

A univariate ANOVA for Total Time was significant for Modality, $F(2, 81) = 3.32$, $p = .01$. Means and standard deviations for Total Time are presented in Table 4.

Table 4: Total Time Means and Standard Deviations in Seconds by Condition

	No Text	Text	Text/ Narration	Total
Auto-mated	452.20 (266.62)	508.07 (301.72)	546.27 (195.61)	502.18 (255.51)
Manual	571.73 (269.32)	789.27 (388.04)	490.07 (150.92)	617.02 (307.48)
Total	511.97 (270.24)	648.67 (370.26)	518.17 (174.02)	

As visualized in Figure 2, pairwise comparisons showed participants assigned to the Text condition took significantly longer time to complete the experimental task than those assigned to the Narration conditions and the No Text conditions ($p <$ 05).

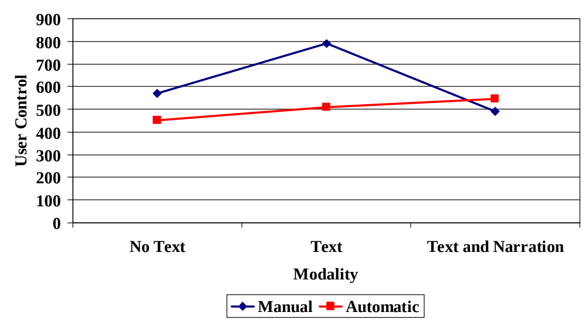

Figure 2: Total Time by Condition.

Further, independent sample T-Tests showed that participants assigned to the Manual/Text condition took significantly longer to complete the task than participants assigned to the Automatic/Text condition. Similar T-Tests applied to the No-Text condition and the Text and Narration Condition showed no significant difference between Manual and Automatic groups: $t(28) = .-1.22$, $p = .2$ and $t(28) = .88$, p=.39 3, respectively.

Total Use

The means and standard deviations for Total Use are shown in Table 5. Univariate ANOVA for Total Use was significant for Modality, $F\ (2, 81) = 3.184$, $p = .047$. Follow-up pairwise comparisons showed participants assigned to the No Text condition used the animation significantly more often than the Text Group, $p < .05$.

Table 5: Total Use Means and Standard Deviations by Condition

	No Text	Text	Text/ Narration	Total
Auto-mated	22.93 (30.40)	24.60 (23.35)	30.40 (21.86)	25.98 (25.10)
Manual	47.60 (40.97)	15.60 (14.88)	17.73 (20.89)	26.98 (31.01)
Total	31.77 (38.93)	16.60 (19.26)	20.57 (21.21)	

Further analysis examining the use of the animation found that six (6) participants assigned to the User-Control condition did not use the animation at all; seven (7) participants assigned to the Automated condition did not use the animation after it began.

Accuracy

A univariate ANOVA for Accuracy was not significant, $F\ (2,81) = 1.46$, p =.24. Means and standard deviations are presented in Table 5.

Table 6: Total Accuracy Means and Standard Deviations by Condition

	No Text	Text	Text/ Narration	Total
Auto-mated	3.93 (1.71)	5.07 (1.22)	5.13 (1.06)	4.71 (1.44)
Manual	4.73 (1.91)	3.67 (1.84)	4.13 (2.26)	4.18 (2.01)
Total	4.33 (1.83)	4.37 (1.69)	4.63 (1.81)	

DISCUSSION

Participants assigned to the Text conditions took significantly longer to complete the experimental task as compared to those assigned to the No Text or the Text and Animation conditions. Further analyses showed differential effects of User Control in that participants assigned to the Text/Manual condition took significantly longer to complete the task than those participants assigned Text/Automated condition. It is likely that these individuals were depending heavily on their interpretation of the text rather than observing the animated assembly. This is evident in the fact that these participants used the animation less than participants in any of the other experimental cells (see Table 6). Further, participants who had no text or who had narration showed no differential effect of User Control.

While there was no significant difference between experimental groups with regard to Task Accuracy, Total Use of the animation showed a significant positive correlation with Task Accuracy. Spatial Ability and Age were also significantly correlated with Task Accuracy. The significant correlation of age with task accuracy is most likely due to our younger participants having higher spatial ability. Most importantly, the results of this study indicate that when participants engaged the animation more frequently, their performance was more accurate.

Participants assigned to the No Text condition were significantly more likely to engage the simulation. Intuitively, these participants were actively using the animation as it was their only form of information (i.e., no text or narration available).

Much like the results of earlier testing (Hodak et al, 2005), a great number of participants never controlled the animation. Thirteen participants in total (6 in the User Control group and 7 in the Automated group) never stopped or paused the animation. Further, those 6 participants in the User Control group never even started the animation. Thus, those six users attempted to perform the task without the complete aid of the performance support software.

CONCLUSIONS

Are there differences in performance support and training environments? The results of this study did not support Mayer's Modality principle – the principle that animation and narration works better than animation and on-screen text (Mayer & Moreno,

2002) in the context of performance support in terms of accuracy. There was no difference found in task accuracy that could be attributed to narration.

The results of this study did agree with the Participation principle of Hansen et al. (2002). In both training and performance support environments, the greater the interaction between the student/worker and the animation, the larger the chance of learning and better job performance. Thus, any manipulation that would encourage the user to interact with the animation might be expected to support better performance.

The current effort dealt with a specific performance context: a procedural, lock-step assembly task. Results of this effort may not apply to other performance support contexts (i.e., troubleshooting). Further, some of the findings here are not consistent with the learning research literature. Therefore, it should not be assumed that they will apply to other contexts, either. Because the use of EPSS systems is likely to rise, further research in this area is necessary.

Finally, both the current study and the previous pilot effort revealed a consistent phenomenon where participants, if given the chance (i.e., User Control), ignored engaging the animation all together. Current research suggests that the more the animation is engaged, the better the resulting performance. Therefore, the decision to initially engage the animation should not be left to the user. Rather, animations should initiate automatically and then allow for user control (i.e., rewind, forward, pause) as needed.

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