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A desktop virtual environment trainer provides superior retention of a spatial assembly skill

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ABSTRACT

We compared the efficacy of a simple virtual environment (VE) training system with two media more commonly used to train people: paper and video tutorials. Participants learned how to solve a spatial puzzle in one of the three training media. People who trained with the VE spent more time training, however they performed significantly better than people in the other groups a week later.

Keywords

Virtual environments, virtual reality, training, spatial skills

INTRODUCTION

In the last decade, proposed applications for interactive 3-D computer graphical interfaces -- virtual environments -- have abounded. Yet there is very little empirical evidence about the effectiveness or efficiency of virtual environments (VE’s). In particular, it is often proposed that VE’s can be effective for training spatial knowledge and skills [1, 4, 5]. Recent evidence suggests that VE’s may be effective for training certain kinds of spatial knowledge [1, 5]; however, it has been empirically demonstrated that even relatively high fidelity VE trainers may not enable transfer of trained motor skills [2].

We believe that current VE interfaces can be more successfully used to train activities that requires cognitive rather than motor skills. In general, training the cognitive aspects of a spatial task requires less simulator fidelity and hence less expense [2, 4]. For example, consider training people how to assemble an object from many constituent parts. Today’s VE’s are better suited to train knowledge of how and where individual parts fit together, rather than the motor skills needed to perform the assembly. Theoretically, training of this type is feasible on existing widespread PC platforms, and because of its interactive nature may be superior to current training media especially when the task to be trained requires dynamic, three-dimensional thinking. However, there is little empirical evidence to support this claim.

Our aim was to demonstrate whether a simple and widely-accessible VE interface (keyboard and mouse) is as effective as commonly used media (e.g. written instructions or video tutorials) in training the solution to a spatial assembly puzzle. The effectiveness of each training medium was measured by performance in a real world transfer task given both immediately after training and one week later.

METHOD

Participants

A total of 40 people (17 men and 23 women) recruited from the University of Washington Psychology department’s Human Subject Pool participated in the experiment in return for extra credit in their introductory psychology course.

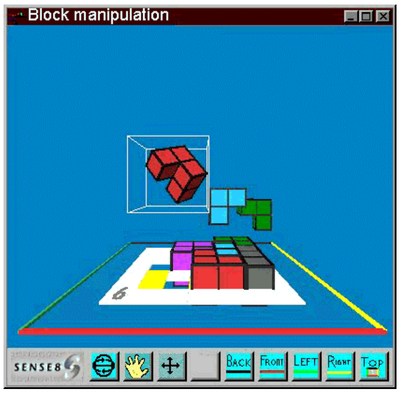
Materials and apparatus

The real world tasks on which all participants were tested involved correctly placing approximately ten blocks in a particular configuration in one of three ‘circuit boards.’ The circuit boards were flat structures (appx. 125 cm^2) with a pattern of holes cut into them. To solve each puzzle correctly, a participant had to insert each block into a specific location. Successful completion of this task required thinking about the spatial properties of the puzzle pieces.

Three training environments were developed to teach people how to perform this task: a paper tutorial, a video tutorial, and a VE trainer. A great deal of effort was devoted to making the paper and video tutorials effective and complete. These tutorials were constructed using modern principles of tutorial design [3].

The circuit boards and blocks were modeled in a VE using World Up® by SENSE8® Corporation on a Pentium® Pro

200 with a Diamond Fire GL 3000 graphics accelerator card. Participants who trained in the VE sat approximately 58 cm from a 40 cm x 30 cm (21 inch) flat-panel color monitor. The virtual interface (see figure below) allowed the user to select between three modes of interaction: 1) ‘*Navigation*’ mode allowed users to change the position and orientation of their viewpoint, 2) ‘*Pick*’ mode enabled users to translate the virtual blocks in the plane of the displayed scene, and 3) ‘*Rotation*’ mode enabled users to rotate the blocks. User interaction with the VE was accomplished solely through the mouse and keyboard. Mouse movements controlled navigation and translation of the blocks, while block rotations were accomplished through key strokes.



Procedure

Participants were randomly assigned to one of the three training conditions in which they learned how to solve three circuit board problems. All groups were given practice drills and quizzes to verify that they had learned the correct placement of the blocks. Participants who trained from the paper tutorial and the VE were given as much time as they needed to complete the training. Training time for the video group was constant. Immediately after completing the training for each circuit board, participants were timed on their ability to assemble it in the real world. Participants returned a week later and attempted to solve the same puzzles with no further training. They were also timed on this task.

RESULTS AND DISCUSSION

Training time

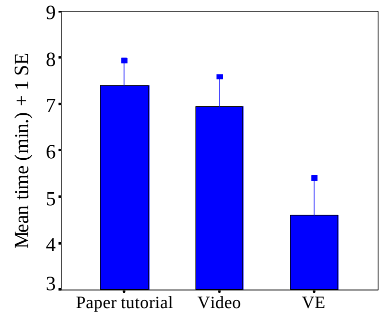
People took more time to train in the VE trainer (M = 18.18 min., SD = 6.64) than either the video group (6.72 min.) or the paper tutorial group (M = 5.47 min., SD = 1.66). The difference between the VE training time and that of each other group is significant by Tukey HSD tests.

Immediate transfer

Mean solution times immediately after training were relatively fast for each training condition (M = 0.95 min., SD = 0.83) indicating that each method was clearly effective at training the task. Differences in the effectiveness of training medium were tested using an analysis of covariance (ANCOVA) in which three levels of training and two levels of gender were entered as independent variables and the amount of time spent training was entered as a covariate. The mean time to solve each of the three puzzles immediately after training was the dependent measure. The analysis revealed no significant effect of any of the independent measures.

Long-term transfer (retention)

The same ANCOVA was performed on the solution times of participants’ performance a week later. This analysis yielded a significant main effect for training condition and no other significant effects. Contrasts showed that the solution times for people who had trained in the VE were significantly faster than either the paper tutorial group ($t(37)$ = 2.87, p = .007) or the video group ($t(37)$ = 2.40, p = .021) The figure above illustrates the effect of training condition on people’s long-term performance.



Training condition was the most powerful predictor of retention, accounting uniquely for 18% of the variance in solution times. Training time accounted uniquely for 5% and gender accounted uniquely for 5%. In total, the model fit by the ANCOVA accounted for 36% of the variance in solution times.

This relatively simple and widely available VE interface was more effective than current media for training a spatially challenging assembly skill with cognitive components. Presumably, this is because of the degree of interaction and manipulation that the VE medium affords.

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