Haptic Guidance for Training Complex Skills in a Virtual Environment

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1. INTRODUCTION

My research group is broadly interested in how haptic and visual perception and spatial and perceptual-motor abilities interact in the performance of complex skills, especially in the domain of minimally invasive surgery. We use virtual environments both as a scientific tool to study human performance and as a training tool.

In theories of skill acquisition, the first step of learning a new skill is usually the cognitive understanding of the task. However, for some skills this is difficult because they depend on complex implicit procedural processing that is difficult to explicitly verbalize. For such skills, guidance may be beneficial. We have proposed haptic guidance, in which a haptic interface is used to physically guide the user through the desired motion or constrain the user's motion.

2. METHODS AND RESULTS

An example of a skill that requires complex visualization and perceptual-motor transformations is the use of an angled laparoscope. Our research group previously developed a virtual environment to simulate this skill. We have found that some novices, and experienced surgeons as well, have substantial difficulty learning this skill. Subjects with low spatial ability had significantly more difficulty. Even experts have limited ability to explicitly define their successful strategies in the skill, and we have not found a way to explain possible strategies to novices who struggle. Consequently, we devised the present experiment to evaluate whether haptic guidance would be effective in implicitly teaching novices to perform the skill.

In experiments with novice subjects, half were trained with guidance while the other half practiced the skill for an equal amount of time. Test sessions were alternated with four training or practice sessions. Although the performance of both groups improved significantly during the course of the experiment, the guidance group demonstrated significantly faster learning and performed better on the retention tests. The benefit of guidance differed depending on subjects' spatial ability. Subjects above the median in spatial ability learned the task equally well with or without guidance. Below-median subjects, however, learned significantly slower without guidance. With guidance, they learned as well as the high spatial group.

3. CONCLUSION

This experiment demonstrated the benefit of haptic guidance in training a complex visual-motor skill. We found individual differences in learning the skill depending on spatial ability. Subjects with low spatial ability particularly benefited from haptic guidance. This demonstrates the importance of focused training for essential surgical skills and accounting for individual differences in designing optimal training strategies.

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