The Effect of Split Attention in Surgical Education

Erol Özçelik[1], Nergiz Ercil Cagiltay[2], Gokhan Sengul[1],
Emre Tuner[2], and Bulent Unal[3]

[1] Atilim University Computer Engineering Department, Kızılcaşar Mahallesi, 06836 İncek Gölbaşı – Ankara, Turkey
[2] Atilim University Software Engineering Department, Kızılcaşar Mahallesi, 06836 İncek Gölbaşı – Ankara, Turkey
[3] Atilim University, Department of Industrial Product Design, Kızılcaşar Mahallesi, 06836 İncek Gölbaşı – Ankara, Turkey
eozcelik@atilim.edu.tr

Abstract. Surgical education through simulation is an important area to improve the level of education and to decrease the risks, ethical considerations and cost of the educational environments. In the literature there are several studies conducted to better understand the effect of these simulation environments on learning. However among those studies the human-computer interaction point of view is very limited. Surgeons need to look at radiological images such as magnetic resonance images (MRI) to be sure about the location of the patient's tumor during a surgical operation. Thus, they go back and forth between physically separated places (e.g. the operating table and light screen display for MRI volume sets). This study is conducted to investigate the effect of presenting different information sources in close proximity on human performance in surgical education. For this purpose, we have developed a surgical education simulation scenario which is controlled by a haptic interface. To better understand the effect of split attention in surgical education, an experimental study is conducted with 27 subjects. The descriptive results of study show that even the integrated group performed the tasks with a higher accuracy level (by traveling less distance, entering less wrong directions and hitting less walls), the results are not statistically significant. Accordingly, even there are some evidences about the effect of split attention on surgical simulation environments, the results of this study need to be validated by controlling students' skill levels on controlling the haptic devices and 2D/3D space perception skills. The results of this study may guide the system developers to better design the HCI interface of their designs especially for the area of surgical simulation.

1 Introduction

The Cognitive Theory of Multimedia Learning (Mayer, 2011) suggests that when information sources are presented far from each other rather than close to each other, performance of users decreases. It is suggested that searching for information consumes limited resources in the mind and consequently fewer cognitive resources will be available for the current task (Kalyuga, Chandler, & Sweller, 1999). As a

P. Zaphiris and A. Ioannou (Eds.): LCT 2014, Part II, LNCS 8524, pp. 3–10, 2014.

result, unnecessarily splitting of attention between information sources causes cognitive load that interferes with task performance (van Merrinboer & Sweller, 2005). In light of these theoretical suggestions, the goal of this study is to investigate the effect of spatial distance of different information sources on human performance in surgical education. For this purpose, we have developed a surgical education simulation scenario which is controlled by a haptic interface. To better understand the effect of split attention in surgical education, an experimental study is conducted. In this study, learners use the haptic simulator in order to navigate to a goal place that is presented either in the same screen or in a screen that is apart to the simulator's screen. Half of the learners complete the tasks in an integrated environment and the rest complete the tasks in a split environment. Performance is measured in terms of accuracy and task completion time. The study is conducted by 27 participants who have the same background and having no previous training on the surgical operation. The data is collected by the computer simulation measurements that are automatically recorded by the simulation system on the performance and behaviors of the trainee while using the simulator individually. We believe that this study will guide the user interface designers for surgical education simulation systems to better design and guide trainees.

2 Research Methodology

In this study, to better understand the effect of split attention in surgical education, first a surgical simulation environment that is controlled by a haptic device is developed. This simulation is basically developed for endoscopic surgery purposes. In this type of surgery operations, natural body cavities are used as entry points of the operations. In these kind of operations surgeons use a special type of camera namely endoscope, reach the operation location and complete the operation by the help of special surgical equipment. Although these kinds of surgeries have their advantages, they come with certain problems. One of the major problems is that endoscopic view is two-dimensional, not three-dimensional. In that concern, lack of depth perception can cause serious injuries and even cause patient deaths if not handled carefully in the training period. Surgeon has to operate without having the three-dimensional view and has to gain critical hand-eye coordination skills (Cotin, Delingette & Ayache, 2000). Additionally, surgeons are required to perform the operations causing minimal damage to the surgical area. Hence the accuracy of the surgeon during the operation is important. The surgical simulation tool is designed and developed according to these requirements. Below the details of the research study is provided.

3 Participants

The participants of the study were 27 undergraduate students of Atilim University who were taking Computer Games and Simulation course. They participated in the experiment for extra course credit. The participants ages were ranging from 20 to 26 years old (M = 23.67, SD = 1.49). The majority (70 %) of the participants were male.

4 Endoscopic Surgery Simulation Tool (ESST)

The endoscopic surgery simulation tool that is developed for this study is developed based on a three dimensional (3D) model of a simulated environment containing different branches of vessel like holes as seen in Figure 1. The designed model has 2 branches of vessel like holes (Figure 1).

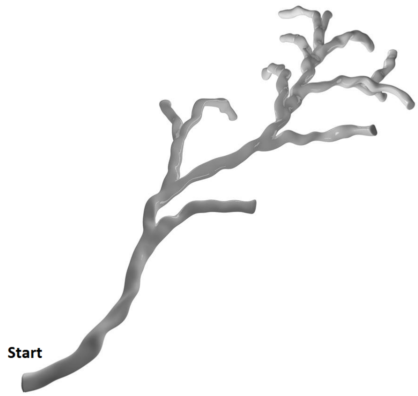

Fig. 1. ESST Model Branches

The participants are able to move inside the 3D model starting from the "Start" point as shown in Figure 1. Figure 1 shows the structure of the 3D Model used for ESST and Figure 2 shows the 3D view of the model while the users move inside the model. This view is prepared to simulate an endoscopic view of the surgical operations.

Fig. 2. ESST Model 3D View

The participants can move inside the 3D modeled environment by using a special haptic device which provides more senses about the simulated environment. As seen in Figure 3, the haptic device is used as an endoscope (a tool having a camera showing the surgical environment in two-dimensional view).

Fig. 3. The Haptic interface of the ESST Model

The ESST is prepared by distributing 10 green balls in 10 branches of the model as seen in Figure 4. Hence, the ESST model designed as containing 10 target nodes as numbered in Figure 4.

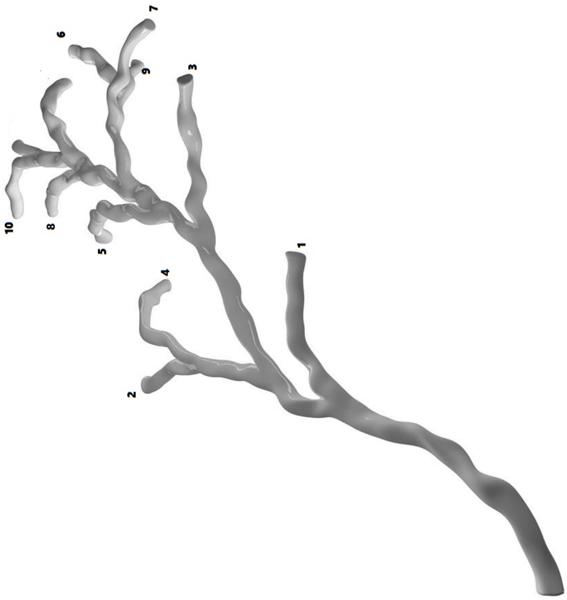

Fig. 4. The Target nodes in ESST Model

Additional to the ESST, a map is prepared for the experimental design showing the structure of the model and the locations of each target in three different perspectives: top, right and left views of the model map as seen in Figure 5.

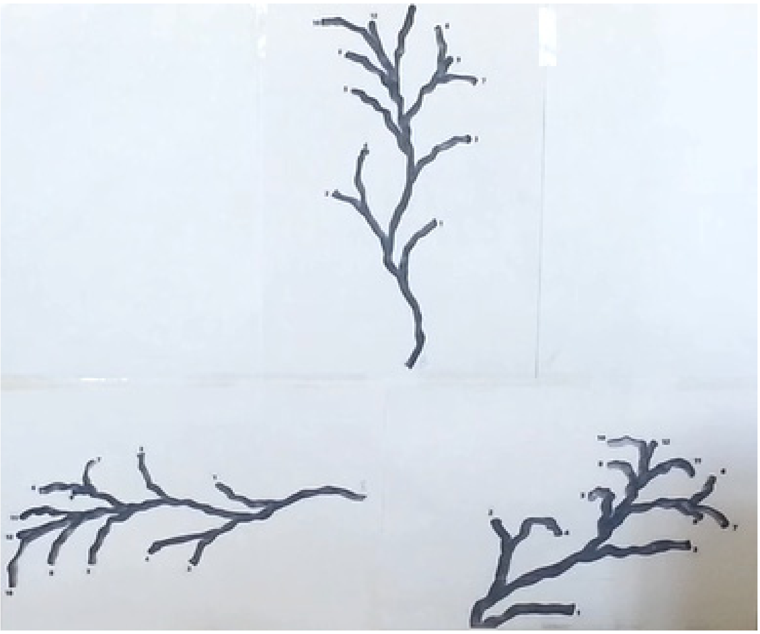

Fig. 5. ESST Model Maps

The participants are asked to find each target and clear it from the environment starting from the start point of the mode (Figure 1) and following the related path as shown in the model map (Figure 5). The participants are asked to clear the targets in an ordered way as shown in the ESST model map (Figure 5). In other words, the participants are asked to start from the starting point of the model view and first clear target 1 by following the first right branch of the model. Immediately after the participant clears target 1, the participants is replaced to the start point and asked to clear target 2 by following the path from the start point of the ESST model map. Immediately after clearing target 10, the experiment ends. The participants are also able to see the target number on the model screen that is aimed to be cleared in the current time period. Hence the participants are required to analyze the ESST model map in order to better understand the path to be followed in order to clear the identified target. During this process they are also asked to complete all task in minimum time period by traveling minimum path. Additionally they are also requested not to hit the walls and move in gentle steps. This design is prepared according to the requirements of endoscopic surgery environments. Accordingly, as seen in Figure 6, the haptic interface is also designed as sensible as in the endoscopic surgery environments. The system recorded time spent for completing each task (task completion time), the distance traveled during completing each trial (traveled path distance), number of entrance of wrong paths during completing each task (wrong direction count) and number of hits to the walls (hits to the walls).

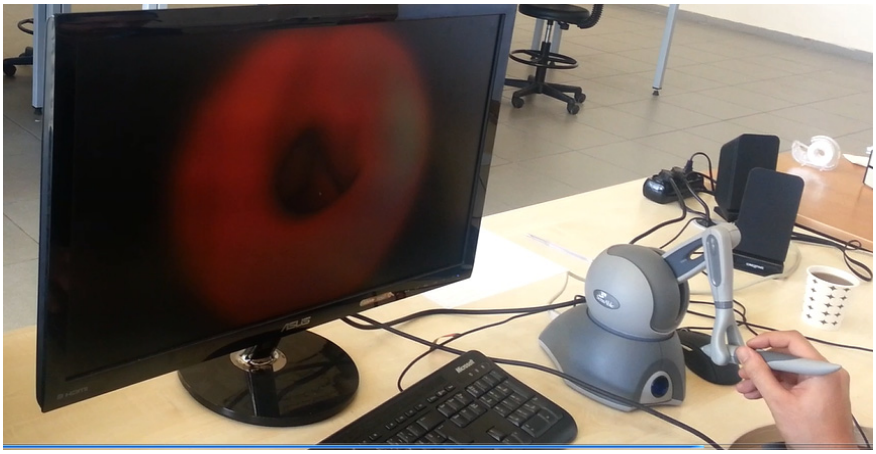

Fig. 6. ESST Interface

5 Research Procedure

The participants are assigned 10 trials (clear 10 targets from the environment) to be completed in this simulation environment. The participants are asked to complete each trial in a short time period and without touching the walls of the model. The participants are divided into two groups randomly according to their entrance order to the laboratory. The integrated group performs the tasks in the simulation environment where the ESST Model Map is placed next to the computer monitor , very close to the simulation screen (Figure 7).

Fig. 7. Group 1: ESST Model Map Placed Next to ESST Screen (Integrated Group)

As seen from Figure 8, the participants in the split group are asked to perform the tasks, but the ESST Model Map is placed away from the ESST screen.

Fig. 8. Group 2: ESST Model Map Placed Away from the ESST Screen (Split Group)

Each participant is given 2 tries in order to better understand the environment and the usage of the haptic device in the training phase. The mentioned dependent variables are recorded automatically by the simulation tool.

6 Results

An independent samples t-test was run to examine the effect of group on task completion time. The results showed that the effect of group was not significant, t (25) = .15, p = .88. The effect of group on distance of the traveled path was not significant, t (25) = .23, p = .07. No significant effect of group was found on number of wrong directions followed, t (25) = .15, p = .88 and on number of hits to the walls, t (25) = .69, p = .50. The non-significant results of statistical analysis may be due to high variance observed in the dependent variables (see Table 1) and to diverse skills of the participants.

Table 1. The dependent variables with respect to the group

	Task competition time		**Traveled path distance**		**Wrong direction count**		**Hits to the walls**	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Integrated Group	49.47	20.27	3902.22	7228.78	1.47	0.63	135.32	51.79
Split Group	50.98	30.89	14406.68	30081.80	1.51	0.66	150.49	62.41

7 Discussions and Conclusion

In this study, the effect of split attention on human performance in an environment which reflects the endoscopic surgery simulation environments. In this environment a haptic device is used for representing an endoscopic view. The results of this study show that even the integrated group performed the tasks with a higher accuracy (by traveling less distance, entering less wrong directions and less hitting the walls), the results are not statistically significant. We believe that the main reason for this non-significant result is the high standard deviations. In other words, there was a big deviation among the performance of each participant. In this study all participants were having the same background. However, in this study the skill levels of each participant need to be considered as well. In this environment participants had to operate without having the three-dimensional view and had to gain critical hand-eye coordination skills as in endoscopic surgery operation environments (Cotin, Delingette & Ayache, 2000). Additionally, their 2D/3D space perception (Greco et al., 2010) was another important skill affecting their performance. Finally their ability to control the haptic device was another factor affecting their performance. We believe that the participants who have gained these skills in their earlier experiences with game environments may outperform the others which in turn caused the variance in the standard deviation values. For example playing games by using joystick or similar devices may be an affective factor for better skills on haptic control. In this study we did not collect this democratic information from the participants. Hence by controlling the participants' skill levels for controlling the haptic device and for cognitive processes of 2D/3D space perception skills, this variation in the standard deviations may be eliminated.

Acknowledgement. This study is conducted for improving the scenario designs of the educational materials which are developed for neurosurgery education project (ECE: Tubitak 1001, Project No: 112K287) purposes. The authors would like to thank the support of TÜBİTAK 1001 program for realizing the ECE project.

References

1. Cotin, S., Delingette, H., Ayache, N.: A hybrid elastic model for real-time cutting, deformations, and force feedback for surgery training and simulation. The Visual Computer 16, 437–452 (2000)
2. Greco, E.F., Regehr, G., Okrainec, A.: Identifying and Classifying Problem Areas in Laparoscopic Skills Acquisition: Can Simulators Help? Academic Medicine 85(10), S5–S8 (2010)
3. Kalyuga, S., Chandler, P., Sweller, J.: Managing split-attention and redundancy in multimedia instruction. Applied Cognitive Psychology 13, 351–371 (1999)
4. Mayer, R.E.: Multimedia learning. University Press, Cambridge (2001)
5. Van Merrienboer, J.J., Sweller, J.: Cognitive load theory and complex learning: Recent developments and future directions. Educational Psychology Review 17(2), 147–177 (2005)