Gamers Today, Surgeons Tomorrow?

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ABSTRACT

Faced with an age of reliance on technology and innovative advances, surgeons are using cutting-edge robotic systems to perform complex procedures and virtual reality simulators for specialized skill training. The virtual environment and controllers in surgical simulators are reminiscent of those in videogames. So, can playing video games develop skills similar to those used in robotic surgery?

This paper compares the performance of video gamers, medical students, and "lay people" to expert robotic surgeons on a robotic surgery simulator. Participants recruited from the UCF College of Medicine, UCF FIEA, and Florida Hospital completed a demographic questionnaire. The subjects then performed three computer-based perceptual tests and participated in two warm-up tasks on the Mimic dV-Trainer to familiarize themselves with the system. The experiment then measured their performance over eight trials of two core simulated exercises. After completing these trials, participants completed a post-questionnaire about their experience.

Analysis of the data did not verify differences between the groups for the perceptual tests except for the time to complete scores in the Flanker and subsidizing tasks, in which expert surgeons took significantly longer than other groups. Significant differences were found between the groups for the first and eighth trials of the simulated exercises, with surgeons performing better than other groups. All groups improved significantly from trial one to trial eight, with surgeons performing better than all groups. Gaming console type positively correlated with Overall Score in the Ring & Rail exercise, as well as Time and Economy of Motion in the suturing exercise. No other correlations were found.

The results are in contrast with prior literature on video game experience in laparoscopic surgery, suggesting that gaming abilities do not translate to all surgical modalities. Future research is necessary to further examine the impact alternative skillsets may have on surgical skills.

ABOUT THE AUTHORS

Alyssa D.S. Tanaka, M.S. is a Research Scientist at Florida Hospital Nicholson Center. Her research work focuses on robotic surgery simulation and effective surgeon training. Her current projects include rapid prototyping of surgical education devices, the validation of a robotic surgical curriculum and evaluation of robotic simulation systems. She is a Modeling and Simulation PhD student at the University of Central Florida and previously earned a M.S. in Modeling and Simulation, Graduate Simulation Certificate in Instructional Design, and a B.S. in Psychology and Cognitive Sciences from the University of Central Florida. She holds a diploma in robotic surgery from the Department of Surgery, University of Nancy, France.

Courtney Graddy, MHA is a Human Studies Research Coordinator at the Celebration Health Research Institute where she manages projects aimed at improving patient health outcomes, employee health, process improvement and simulation research. Her current projects focus on integrating technology into standard of care and evaluating its effects on patient health and patient satisfaction, as well as evaluating teaching modalities used to train surgeons. Her career began at the North Florida South Georgia Veterans Health

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Manuela Perez, M.D., Ph.D. is a practicing General Surgeon at the University Hospital of Nancy-France, where she also serves as an Assistant Professor in General Surgery and Anatomy. Dr. Perez has been practicing medicine for 14 years and graduated with her PhD in Robotic Surgery, with a thesis entitled "Telesurgery: From Training to Implementation." Currently, she is working as a Research Fellow at the Florida Hospital Nicholson Center and working under a grant from the Department of Defense researching various aspects of Telesurgery.

Roger Smith, Ph.D. is an expert in the development of simulation devices and training programs. He has spent 25 years creating leading-edge simulators for the Department of Defense and Intelligence agencies, as well as accredited methods for training with these devices. He is currently the Chief Technology Officer for the Florida Hospital Nicholson Center where he is responsible for establishing the technology strategy and leading research experiments. He has served as the CTO for the U.S. Army PEO for Simulation, Training and Instrumentation (PEO-STRI); VP and CTO for training systems at Titan Corp; and Vice President of Technology at BTG Inc. He holds a Ph.D. in Computer Science, a Doctorate in Management, and an M.S. in Statistics. He has published 3 professional textbooks on simulation, 10 book chapters, and over 100 journal and conference papers. His most recent book is *A CTO Thinks About Innovation*. He has served on the editorial boards of the *Transactions on Modeling and Computer Simulation* and the *Research Technology Management* journals.

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INTRODUCTION

Surgery is generally described as fitting into one of two modalities—open and minimally invasive, the latter of which includes laparoscopic and robotic-assisted (i.e. robotic surgery) procedures. Robotic surgery, the most recent iteration of laparoscopy, typically implies that the surgeon's movements are facilitated through a computer driven system to manipulate surgical tools. This field evolved from the prospect of surgeons performing life saving procedures on soldiers in combat zones from remote locations anywhere in the world, an application referred to as telesurgery.

This concept has not completely come to fruition, however the fundamental research resulted in the commercial the daVinci Surgical System that is now used to perform everyday procedures in urologic, gynecologic, ENT, and general surgery specialties called the daVinci Surgical System (Barbash, Friedman, Glied, & Steiner, 2014; Serati et al., 2014; Maan, Gibbins, Al-Jabri, & D'Souza, 2012; Luca et al., 2013; Zureikat et al., 2013). The surgeon manipulates controllers at the surgeon console to manage up to four robotic arms, including a camera, attached to a separate patient cart. The camera provides true stereoscopic vision to the surgeon, facilitating a synthetic tactile sensation and depth perception. Attached to the other robotic arms are various instruments, which move in a similar manner as the surgeon's hands (Figure 1).

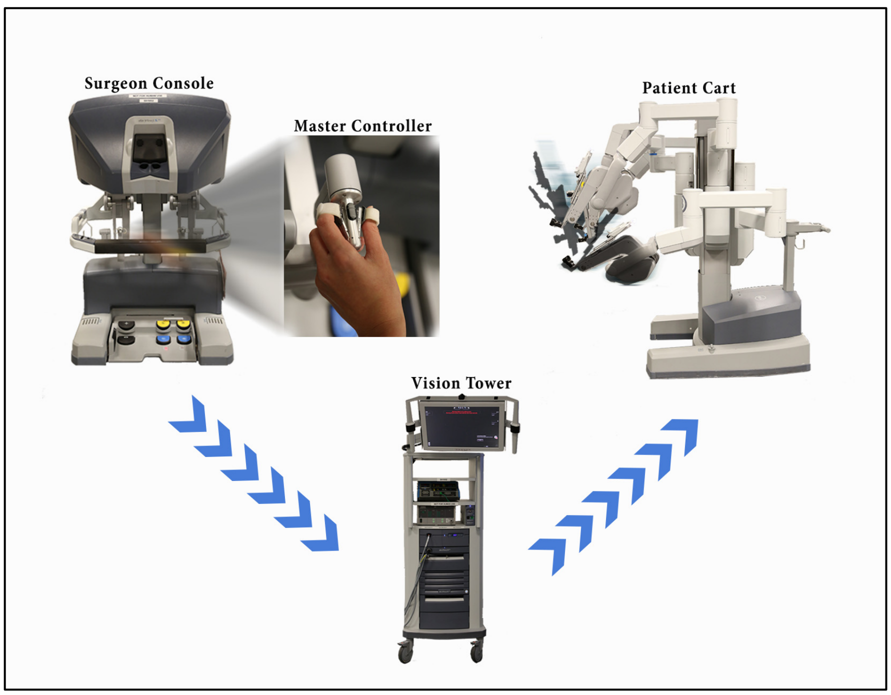

Figure 1. The daVinci System

While this system integrates robotics into medicine in a way that may seem more science fiction than reality, society is actually connecting with technology in unforeseen ways. Traditional surgical skills are being transcended by cutting-edge technologies, which require surgeons to possess distinct skill sets from those of the past and which overcome a learning curve to acquire the technical (i.e. psychomotor) skills associated with using the daVinci system. Efforts have focused on developing specialized curricula for the training of such skills (e.g. the Fundamentals of Robotic Surgery and Robotic Training Network), but can learning curves be reduced to facilitate a faster acquisition of skills in surgical trainees?

Previous research has established that trainees with video game experience demonstrate increased abilities on basic laparoscopic skill trainings (Rosenthal et al., 2011; Grantcharov, Bardram, Funch-Jensen & Rosenberg, 2003; Rosser et al., 2007). Also, video games have proven to be valuable training tools for basic laparoscopic skills (Rosser, Gentile, Hanigan, & Danner et al., 2012; Badurdeen et al., 2010; Ju, Chang, Buckley, & Wang, 2012; Bokhari et al., 2010; Schlickum, Hedman, Enochsson, Kjellin, & Fellander- Tsai, 2009; Giannotti et al., 2013). Certain genres of video games have established effects on perceptual skills similar to those required by robotic surgeons, yet few have attempted to make a connection between video game experience and robotic surgical skills (Green & Bavelier, 2012; Green & Bavelier, 2007; Chien et al., 2013; Harper et al., 2007).

Thus, this research aims to examine the performance of experienced video gamers while using a robotic surgery simulator, and compare the performance of this population with experienced robotic surgeons, medical students, and laypeople. The purpose is to determine the effect that video game usage may have on the perceptual abilities that are used for robotic surgery. Contrary to previous research that used surgical trainees with minimal gaming experience, this research aimed to utilize subjects with high levels of gaming experience and compare their abilities to subjects with different levels of expertise. This study also looks at the groups' ability to acquire basic surgical skills using the simulator.

METHODS

Recruitment

Participants in this study included video game experts (VGEs), expert robotic surgeons, medical students, and "laypeople" (i.e. individuals without formal medical education or extensive gaming experience). VGEs were recruited from a local university offering degrees specializing in game design and development (i.e. Florida Interactive and Entertainment Academy [FIEA]). Potential VGE subjects were required to be enrolled in a game design program and self-report daily videogame play of at least two hours per day, five days per week. Expert robotic surgeons were recruited from Florida Hospital, Florida Hospital Nicholson Center training courses, and at relevant surgical conferences. These individuals were practicing physicians and self-report performing at least 100 robotic surgical procedures, of which he or she performed at least 50% of the procedure on the surgical console. Medical students were recruited from the University of Central Florida College of Medicine (UCF CoM) and laypeople were recruited from all data collection sites. Potential subjects were excluded from the study in the case of having experience in more than one participant category (e.g. a medical student or expert robotic surgeon who engages in regular gameplay of more than two hours per week).

Materials

All subjects completed a pre-questionnaire, which gathered demographic information (e.g., age, gender, handedness, hours of weekly gameplay, number of robotic cases). The participants then performed three computer-based perceptual tests: a Flanker compatibility task, a subsidizing task, and a Multiple Object Tracking (MOT) test. The Flanker compatibility test requires the participant to indicate the orientation of a single arrow in the center of a group of several other arrows. The arrows are randomly generated to all face the same orientation (congruent) or face the opposite direction of the target arrow in the center (incongruent). This tests attentional capacity by requiring the subject to focus solely on the relevant arrow and ignoring other stimuli. The subsidizing task also assesses attentional capacity by requiring subjects to identify the number of dots that appear on the screen by pressing the associated number key. In the MOT task, users must track specific objects while they move across the screen with other identical objects, which assesses visual attention (Figure 2).

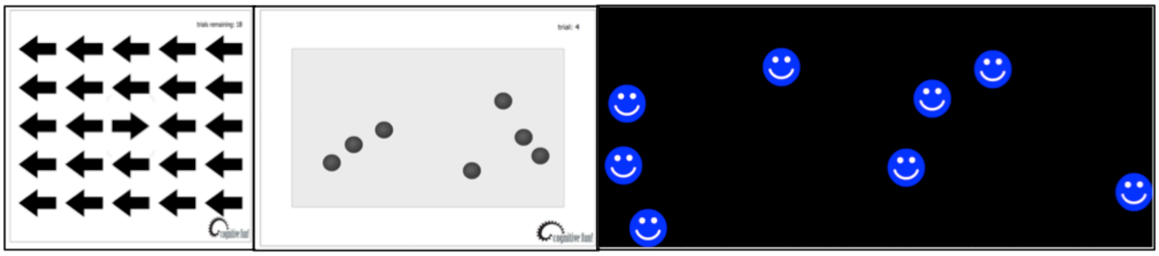

Figure 2. Examples of the Flanker, subsidizing, and MOT tasks

Participants then performed two warm-up exercises on the Mimic dV-Trainer, Pick & Place and Basic Camera Targeting, to familiarize themselves with the system and system controls. All subjects then performed eight trials of two core exercises to test various basic skills (Table 1). Ring & Rail 1 and Suture Sponge 1 will serve as the primary exercises for data collection. After completing all exercises on the dV-Trainer, specific metrics are shown to the participants: Overall Score, Economy of Motion, Time to Complete, Excessive Instrument Force, Instruments Out of View, and Master Workspace Range. These primary metrics are exported for each exercise and used with other metrics to form the scoring system.

Table 1. dV-Trainer exercise descriptions

Exercise	Purpose	Objective	Skills Trained
Warm-up Exercises			
Pick & Place	Introduction to using stereo vision and EndoWrist instruments for picking up and placing objects.	Place colored objects in matching colored containers.	Endowrist Manipulation
Basic Camera Targeting	Learn to accurately position the camera while working in a large workspace while practicing to keep the instruments in view and developing stereo depth acuity.	Manipulate the camera to position light blue sphere camera targets in the center of your screen's dark blue crosshairs.	Camera Control
Core Exercises			
Ring & Rail 1	Coordinate control of an object's position and orientation along a trajectory using the EndoWrist instruments	Pick up a ring and guide the ring along a curved rail	Endowrist manipulation, Camera Control
Basic Suture Sponge	Improve dexterity and accuracy when driving a needle through a deformable object.	Insert and extract a needle through several targets on the edge of a sponge with random variations in their positions.	Endowrist manipulation, Camera Control, Needle Control, Needle Driving

After completing all trials, participants completed a post-questionnaire regarding their experience with the system (Figure 3).

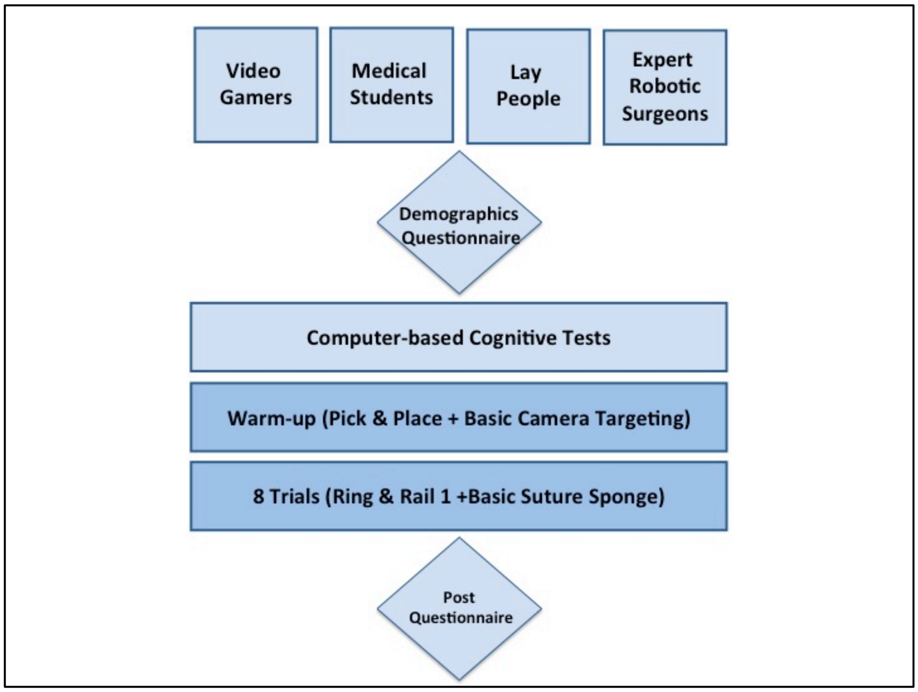

Figure 3. Order of study procedures

RESULTS

Demographics

Table 2 shows descriptive characteristics of the participants. Gamers indicated playing on average 11.71 hours of video games per week and having 17.85 years of gaming experience. On average, expert robotic surgeons performed 503 total robotic cases and 127 cases per year. While none of the expert surgeons reported currently playing video games, 29% indicated playing video games in the past. Thirty-three percent of lay people also indicated playing video games in the past.

Table 2. Descriptive statistics

Descriptive Statistics				
	Gamers	Medical Students	Laypeople	Experts
n=	40	24	42	7
Age	25.38	25.63	29.45	42
Male	77.5%	70.83%	52.38%	71.43%
Female	22.5%	29.17%	47.62%	28.57%
Right Handed	87.50%	95.83%	83.33%	100%
Left Handed	12.50%	4.17%	16.67%	0%

Cognitive Tests

For the Flanker and the subsidizing tasks, an ANOVA was performed to compare the four groups in terms of percent of correct responses and average response time (ms) for incongruent and congruent arrows. No statistical differences were found for the percent correct for the Flanker test, however completion times for the congruent and incongruent representations were significantly different between the groups (Congruent $p<0.005$; Incongruent $p=0.007$). Expert robotic surgeons took longer in both instances to perform the tasks (Table 3).

Table 3. Analysis of cognitive tests

Descriptives

	Flanker					***Subsidizing***				
	Percent Correct	*Std. Dev*	*Congr . Time*	*Std. Dev*	*Time Incongr.*	*Std. Dev*	*Percent Correct*	*Std. Dev*	*Time*	*Std. Dev*
Gamers	97.37	3.63	438.72	54.24	487.60	60.21	80.97	11.25	921.40	116.87
Medical Students	97.62	4.90	410.14	45.92	465.85	64.70	74.36	14.34	957.99	148.45
Lay people	97.98	3.32	469.81	88.86	525.70	93.84	74.21	14.95	991.94	138.00
Experts	98.57	2.44	525.12	147.32	554.65	95.24	71.93	13.40	1133.64	84.22

ANOVA

		df	**F**	**Sig**
Flanker	Percent Correct	3, 107	0.303	.823
	Congruent Time	3, 106	5.358	.002
	Incongruent Time	3, 107	4.285	.007
Subsidizing	Percent	3, 109	2.310	.081
	Time	3, 109	5.980	.001

No significant differences were found for the percent correct on the subsidizing task for any groups using a Kruskal-Wallis test. Similarly to the Flanker test, completion times were significantly different between the groups (p=0.001), with expert surgeons performing slower than the other groups. The MOT test was analyzed using a non-parametric test to compare the number of correct responses. No significant differences were found for any groups for the MOT test.

The cognitive scores were also analyzed in terms of certain demographic responses to determine if an association exists between the demographic characteristics and the cognitive test scores. A Pearson correlation coefficient was calculated. The characteristic of age positively correlated with the Flanker Time (p=0.008) and Flanker Incongruent Time (p<0.005). Age negatively correlated with the hours of weekly video game play (p=0.010). Age was also negatively correlated with the number of correct responses in the normal level of difficulty MOT task (p<0.001).

Simulator Scores

The simulator scores were analyzed in terms of three performance metrics for both simulated exercises: Overall Score, Economy of Motion, and Time to Complete. Overall Score is a composite score comprised of multiple performance metrics, including Economy of Motion and Time to Complete. Economy of motion is the total distance that the instrument tips moved and is measured in centimeters. Time to Complete is the total number of seconds required by the user to perform the exercise.

An ANOVA was used to determine if differences existed between the groups for the first (i.e. Trial 1) and the last (i.e. Trial 8) of the Ring & Rail 1 and Suture Sponge for the performance metrics. The groups performed significantly different for the performance metrics for trial 1 in both exercises except for the Overall Score of Ring & Rail. Using a Least Significant Difference Test, experts performed significantly better than other groups for the metrics. Similar results were found for trial 8 of both exercises. Experts again performed significantly better than all groups in trial 8 for both exercises scores all metrics (Table 4).

Table 4. Analysis of simulator scores for Trial 1 and Trial 8

ANOVA							
Trial 1				**Trial 8**			
Ring & Rail 1							
	df	***F***	***Sig.***		***df***	***F***	***Sig.***
Overall Score	3, 112	2.251	0.086	**Overall Score**	3, 112	1.369	0.256
Economy of Motion	3, 112	2.795	< 0.05	**Economy of Motion**	3, 112	6.314	< 0.005
Time	3, 111	5.050	< 0.005	**Time**	3, 112	5.278	< 0.005
Suture Sponge							
Overall Score	3, 112	8.948	< 0.001	**Overall Score**	3, 112	4.316	< 0.05
Economy of Motion	3, 112	5.175	< 0.005	**Economy of Motion**	3, 112	5.518	< 0.005
Time	3, 112	9.244	< 0.001	**Time**	3, 112	8.383	< 0.001

The simulator performances were also analyzed using an ANOVA to determine if differences exist between the groups in terms of the change in performance from trial 1 to trial 8 for both exercises separately (Table 5). A difference existed in the average Overall Score and Economy of Motion metrics from trial 1 to trial 8 for all groups in the Ring & Rail 1 exercise (Overall Score $p<0.001$; Economy of Motion $p<0.001$). Experts were found to be significantly different from the other groups for both metrics (Overall Score $p=0.045$; Economy of Motion $p=0.002$). A significant interaction was found between the trials and the groups for the Time metrics ($p=0.006$). The main effects of the trials were not examined due to this interaction.

Table 5. Analysis of change in simulator scores from trial 1 to trial 8

ANOVA						
	Ring & Rail 1			**Suture Sponge**		
	Overall Score	***Economy of Motion***	***Time to Complete***	***Overall Score***	***Economy of Motion***	***Time to Complete***
df	3, 109	3, 109	3, 108	3, 109	3, 109	3, 109
F	2.772	5.468	5.583	8.520	6.887	12.641
Sig	.045	.002	.001	< .001	< .001	< .001

A difference existed in the average Overall Score and the Economy of Motion metrics from trial 1 to trial 8 for all groups in the Suture Sponge exercise (Overall score $p<0.001$; Economy of Motion $p<0.001$). Experts were also found to be significantly different from the other groups for both metrics (Overall Score $p<0.001$; Economy of Motion $p<0.001$). A significant interaction was found between the trials and the groups for the Time metric ($p=0.011$). The main effects of the trials were not examined due to this interaction. The average of each metric across the eight trials for each exercise can be seen in Figure 4 and Figure 5.

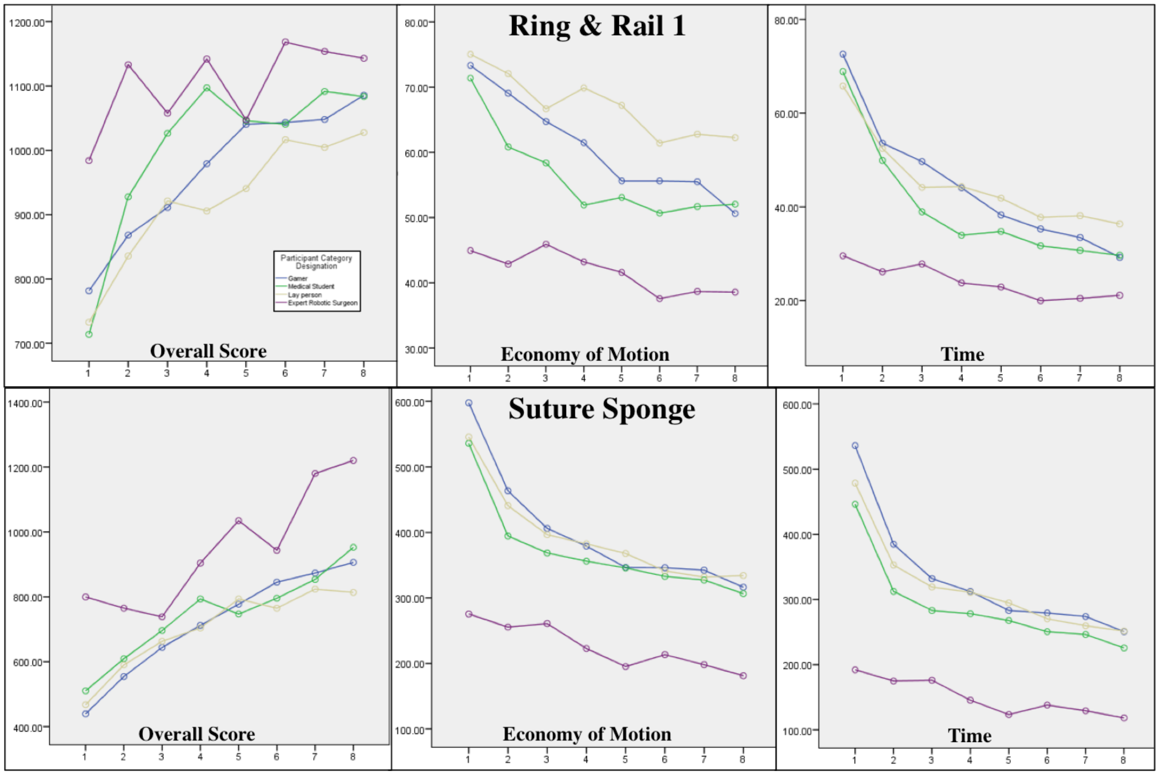

Figure 4. Average scores for groups across eight trials

An analysis was conducted to determine if an association existed between the perceptual test scores and the simulator metrics for the two exercises. The Flanker scores for the percent of correct responses negatively correlated with time to complete for the Ring and Rail 1 exercise (p=0.006). This suggests that as the correct response percentage increased the time taken to complete the exercise decreased. No other Ring & Rail 1 metrics correlated with the perceptual tests. No associations were found between the Suture Sponge scores and the perceptual test scores. The subsidizing and MOT task scores were not significantly correlated with any metric values for Ring and Rail 1 or Suture Sponge.

Video Games

The video game experience of the subjects was also analyzed to determine if certain aspects of video game play were associated with simulation scores. For this analysis the type of game and console played by the subjects was used. The game type ranged from not using videogames, playing slow-paced strategy games (e.g. puzzle games), playing both types of games, or playing fast-paced action games (e.g. first person shooters). The console type ranged from not playing video games, using a controller with minimal hand movement (e.g. Playstation4), using all controller types, or using a controller that may require larger movements (e.g. Wii).

No significant correlations were found between the type of video game or console played and the performance metrics for either exercise for trial 1. A significant positive correlation for Overall Score and the type of console was found for trial 8 of Ring and Rail 1 (p=0.049). This association suggests that as the movement to control the game increased, the Overall Score increased. A significant positive correlation was found between the type of console and Economy of Motion and Time for trial 8 of Suture Sponge (Economy of Motion p=0.044; Time to Complete p=0.002). This suggests that as the movement to control the video game increased, the time to complete and the distance traveled by the instrument tips increased (i.e. slower and less efficient with movements).

DISCUSSION

The assumption that video gamers will perform better than others using a virtual reality robotic surgery simulator is very common. The manipulation of the hand controls and the users interaction with the synthetic environment seem comparable to that of a video game. Contrary to these similarities and prior literature in laparoscopy, video gamers in this study did not perform better than other groups including the "Average Joe" in a robotic surgery simulator. The results did suggest that subjects who use higher movement game controllers (i.e. Ninetendo Wii) scored higher in the Ring & Rail 1 exercise. However, those individuals also took longer and were less efficient with their movements in the Suturing exercise.

The results from this study align with the few studies that have examined the impact of video game play on robotic surgical skills. Chien et al. (2013) found that in comparison to a group using task specific virtual reality training, a control group using video game training did not perform as well on an actual task using the surgical robot. The authors also found that using a video game to train actually had a negative impact on the post-training performance. Harper et al. (2007) found that video game players tied significantly fewer knots using the surgical robot and also suggest that video games may have a negative impact on surgical skills.

Why does prior video game experience impact basic laparoscopic skills, but not robotic? Differences may be contributed to the distinctness of the systems that the users are interacting. The skills developed in two-dimension video games may transfer more appropriately to laparoscopic surgery, which uses a two-dimensional screen, as opposed to the three-dimensional view in robotics. Laparoscopy involves contrasting movements to the primarily fine motor movements of robotic surgery and it is possible that gamers are more inclined with the manual dexterity associated with laparoscopy.

While this study was unable to validate enhanced abilities of video gamers in robotic surgery, the results demonstrated that the effect video game play has on surgical skills is nuanced by the surgical technique. In a technologically dependent society where video games have become an integral past time, this analysis of skills will likely become more valuable as other fields leverage the gaming generation's experience into training. The findings can be generalized to domains outside of medicine utilizing robotic and computer-controlled systems (e.g. unmanned vehicle operation), speaking to the scope of the gamers' abilities and pointing to the capacity within these systems.

Future research should examine the impact alternative skillsets may have on a user's abilities in a robotic surgery system (e.g. playing sports). The gamers in this study did not perform significantly better than lay people, which may imply that other factors or hobbies contributed to the performance. Only one surgical robot currently exists, however others have realized the technological advances and future iterations of surgical robotic systems are imminent. As these new technologies enter the market, it will be critical to evaluate how these skillsets may be valuable to the field of robotic surgery.

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