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Predictors of Manual Dexterity in Simulation-Based Cataract Surgery

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Abstract

Introduction The aim of this study is to determine if prior experience with fine motor hobbies influences a surgeon-in-training's performance on a cataract surgical simulator.

Materials and Methods Medical students ($n = 70$) performed navigation, forceps, and capsulorhexis simulations using the Eyesi Ophthalmosurgical Simulator. Participants were surveyed regarding fine motor hobby experiences, including musical instruments, video games, sewing, knitting, origami, painting, crafting, jewelry making, drawing, and extracurricular dissection.

Results Medical students with extracurricular dissection experience, including work in research laboratories involving microscopic animal dissection, did significantly better on the forceps simulator task ($p = 0.009$). Medical students with drawing experience performed better on capsulorhexis ($p = 0.031$). No other fine motor hobbies were significant for improving simulator scores.

Conclusion Drawing and extracurricular dissection lend to improved technical ability on the cataract surgical simulator. This research continues the conversation regarding fine motor hobbies that correlate with microsurgical ability and adds to the growing area of research regarding the selection and training of ophthalmology residents.

Keywords

- cataract surgery
- resident education
- surgical simulator

Teaching microsurgery to ophthalmology residents is a challenging endeavor for even the most experienced of surgeons. While certain residents seem to have innate surgical ability, others find operative procedures more difficult and struggle to reach their surgical milestones. While most of these residents do reach a level of surgical proficiency by the time they graduate, there are some who do not. In a 2006 national survey by the Accreditation Council on Graduate Medical Education (ACGME), about one in ten ophthalmology residents were identified as having have difficulty with surgical learning.[1] Most struggling residents were not recognized until their last year of residency training, at a point when time for remediation was limited. These residents were advised to pursue nonsurgical subspecialties or a fellowship for additional surgical training.

Despite its importance in our field, manual dexterity is not routinely screened for or assessed during resident selection; a process that relies largely on the academic achievement, research, and clinical experience of our applicants. The ability to predict technical ability before selection for a residency in ophthalmology may be a way to graduate a greater number of residents who are confident and competent surgeons. In the same ACGME survey, one-half of the graduates who entered a surgical practice felt unhappy with their performance.[1] By selecting applicants who display the potential to become competent surgeons, we might not only improve patient care, but we might avoid the emotional toll that surgical inadequacy takes on an ophthalmologists' mental health.

Researchers have proposed various methods of predicting surgical skill. One area of research focuses on identifying

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experiences and hobbies that may correlate with better surgical ability. Video games and/or musical instrument experience have been shown to positively predict surgical performance in several surgical subspecialties, including ophthalmology.[2] Our study aimed to determine if certain fine motor hobbies, skills, or experiences correlate with medical student technical ability on the Eyesi Ophthalmosurgical Simulator.

Methods

Institutional Review Board Committee approval was obtained. Current medical students at the affiliated medical college were recruited with flyers and emails to the medical student body. The study enrollment period was from June to October 2018. Inclusion was limited to current medical students over the age of 18.

At the start of the research session, the nature and possible consequences of the study were explained to the participants, and informed consent was obtained. Participants were next presented with a tutorial on the Eyesi Ophthalmosurgical Simulator, which reviewed basic anatomy of the anterior segment and the proper use of the simulator microscope and foot pedal. Participants were given instructions and a demo video on three cataract simulator modules: navigation, forceps, and capsulorhexis (►**Fig. 1**). Participants then performed each simulation task twice. The simulator generated a performance score from 0 to 100 for each task. Scores for each participant were recorded. Following the simulation, participants filled out a survey to identify prior experience in fine motor activities and the amount of time spent practicing the activities. The survey also asked about prior experience observing or assisting cataract surgery. Demographic and personal information, including age, handedness, specialty interest, and year in medical school, were recorded.

Data Analysis

The scores for each simulator trial were averaged, resulting in one score per task per participant. For each fine motor hobby, participants were determined to be "experienced" or "nonexperienced." Inclusion in the experienced category was defined as 4 or more hours per month of engagement with the fine motor category as per prior research.[3] Experienced and nonexperienced participants were compared across each fine motor hobby category with Mann–Whitney U statistical analysis two-tailed tests and post-hoc Dunn's test.

In a subanalysis, the "experienced" group was divided into two subgroups, "active participants" or "former participants," for each fine motor hobby. The active participants were defined by recent participation in the fine motor hobby over the past 5 years. The simulator task scores were compared for the active participants and former participants with Mann–Whitney U statistical analysis.

The video game and musical instrument categories were further divided into subcategories. Video games were divided into "console," "PC," "handheld device," "other," and "multiple subtypes." Musical instruments were divided into "strings," "brass," "woodwinds," "percussion," "piano," and "multiple subtypes." Kruskal–Wallis statistical analysis was performed to assess if any specific subtype of video games or musical instruments was associated with higher simulator task scores.

Results

Seventy medical students participated in the study. The demographic information, including age, gender, year of medical school training and handedness, is presented in ►**Table 1**. Twenty-eight (40%) students had previously observed cataract surgery and two (3%) students had previously assisted in cataract surgery. Sex, handedness, medical school year of training, interest in ophthalmology, previously observing, or assisting cataract surgery were not correlated with a significant difference in performance.

Sixty-seven (95%) students responded as having experience with a fine motor hobby. The distribution of fine motor hobbies is outlined in ►**Table 2**. Video game playing was the most common hobby (52 students, 74%) followed by musical instrument playing (51 students, 73%). Extracurricular dissection experience (7 students, 10%) included anatomy tutoring ($n = 1$), cadaver research ($n = 1$), chicken embryo stereoscopic dissection ($n = 1$), laboratory Drosophila dissection ($n = 1$), and laboratory mouse surgery ($n = 3$). These

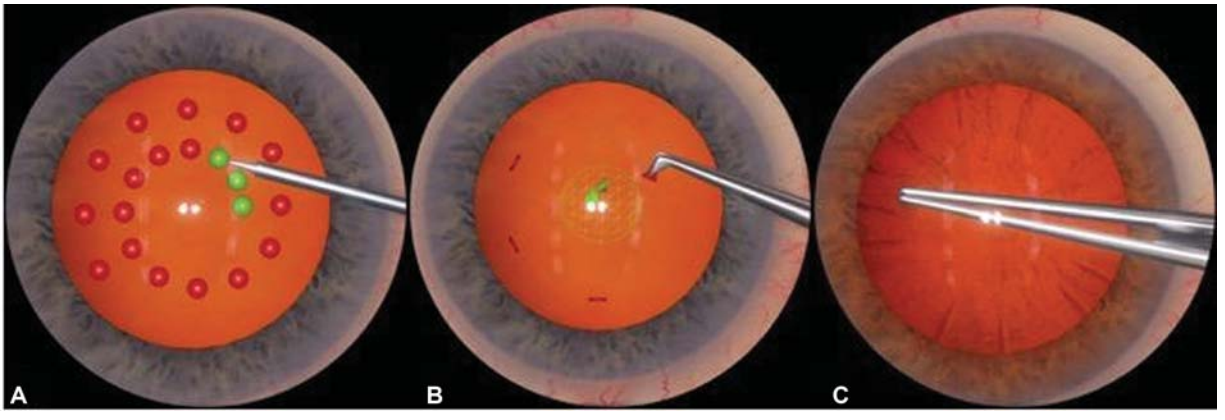

Fig. 1 Eyesi Ophthalmosurgical Simulator tasks from VR Magic training modules. (**A**) Navigation, (**B**) forceps, (**C**) capsulorhexis. Reproduced with permission from VR Magic.

Table 1 Participant demographics

		n	%
Sex	Female	27	39
	Male	43	61
Average age (y)	24 (± 2.6)		
Year of medical school training	Year 1	22	31
	Year 2	16	23
	Year 3	25	36
	Year 4	7	10
Handedness	Right	67	96
	Left	3	4
Interest in ophthalmology	Yes	54	77
	No	16	23
Previously seen cataract surgery	Yes	28	40
	No	62	60
Previously assisted cataract surgery	Yes	2	3
	No	68	97

Table 2 Distribution of fine motor hobbies among medical students

Fine motor hobby	*n*	%
Video game playing	52	74
Musical instrument playing	51	73
Drawing	24	34
Painting	16	23
Knitting	11	16
Sewing	10	14
Origami	9	13
Crafting	9	13
Extracurricular dissection	7	10
Jewelry making	2	3

dissection experiences occurred at research laboratories in the medical school or at the medical students' former undergraduate universities. Anatomy tutoring participation was a voluntary extracurricular activity offered to second-year medical students or above at the medical school.

Scores for the simulator ranged from 0 to 98 (navigation task range, 0–57; forceps task range, 0–86; capsulorhexis task range, 0–98). The average simulator scores for medical students who reported experience with fine motor hobbies are outlined in ►**Table 3**. For medical students with extracurricular dissection experience, the average simulator score was statistically higher for forceps ($p = 0.009$) when compared with medical students without extracurricular dissection experience (►**Fig. 2**). Average scores for medical students with drawing experience were statistically higher for the capsulorhexis module ($p = 0.031$) when compared with medical students without drawing experience (►**Fig. 3**). No other hobby resulted in a statistically significant increase in scores.

There was no subcategory of instrument or video game type that leant to significantly different scores. Active versus former participation in each fine motor hobby did not show a significant difference.

Discussion

As one of the few microsurgical specialties, ophthalmology requires a high level of manual dexterity and a unique technical skill set. The teaching of ophthalmic surgery can be challenging, as residents often enter training with no microsurgical experience and display a wide range of technical ability. Surgical simulation is one modality that can help young surgeons practice their fine motor skills in a safe, controlled environment and has demonstrated particular success when applied to microsurgical specialties, including ophthalmology.[4,5] Cataract surgical simulators are now used in the majority of ophthalmology residency programs, and their use is associated with a decreased rate of cataract surgery complications among resident surgeons.[6]

Although microsurgical ability can be refined during training, the inherent technical ability of the resident must not be overlooked. Some residents continue to have difficulty with microsurgery despite rigorous surgical training and may be unable to obtain the minimum level of competence needed to enter surgical practice.[1] This presumably can have negative effects on a physician's self-confidence and emotional well-being, and can interfere with satisfactory patient care.[7]

The ability to screen for surgical ability is currently missing from our residency selection process. In a 2019 review of United States ophthalmology residency programs by Lu et al, only one program director out of 63 surveyed was actively using surgical aptitude testing for resident selection.[8] The researchers found that although the majority of program directors desire to use surgical aptitude measures in residency selection, they also believe that the currently available surgical aptitude tests are not reliable predictors of future microsurgical ability. Researchers have proposed various methods to measure and predict resident surgical ability with mixed success. One strategy employs hands-on visuospatial and manual dexterity assessments at residency interviews. Kirby used a finger dexterity test and tweezer dexterity test during ophthalmology residency interviews, and later compared the results of the dexterity tests to observed surgical skill during residency training.[9] These two tests did not have a statistically significant correlation with actual observed surgical skill. Similar dexterity assessments have also been reported to screen prospective neurosurgical and otolaryngology residents with variable predictive success.[10,11] Applicant anxiety or nervousness may confound a true assessment. In addition to unclear predictability, such testing may be a burden on interview days, which are limited by time restraints.

Personal characteristics reported on a residency application may be a faster and more reliable way to predict resident technical aptitude, and prior research has investigated

Table 3 Simulator scores for medical students with fine motor experience

Fine motor experience	Average navigation score	*p*-Value	Average forceps score	*p*-Value	Average capsulorhexis score	*p*-Value
Video game playing	25.20	0.552	30.61	0.105	22.90	0.807
Musical instrument playing	26.95	0.265	29.89	0.210	19.32	0.743
Drawing	26.76	0.592	34.87	0.260	34.45[a]	0.031[a]
Painting	23.69	0.868	22.27	0.406	23.96	0.962
Knitting	19.25	0.244	28.42	0.983	35.67	0.272
Sewing	25.50	0.940	28.15	0.986	30.00	0.435
Origami	27.38	0.684	29.06	0.682	21.38	0.815
Crafting	29.13	0.573	32.13	0.544	34.38	0.441
Extracurricular dissection	30.64	0.352	53.00[a]	0.009[a]	36.93	0.104
Jewelry making	40.00	0.486	69.50	0.114	35.50	0.571

[a]Statistically significant, $p < 0.05$.

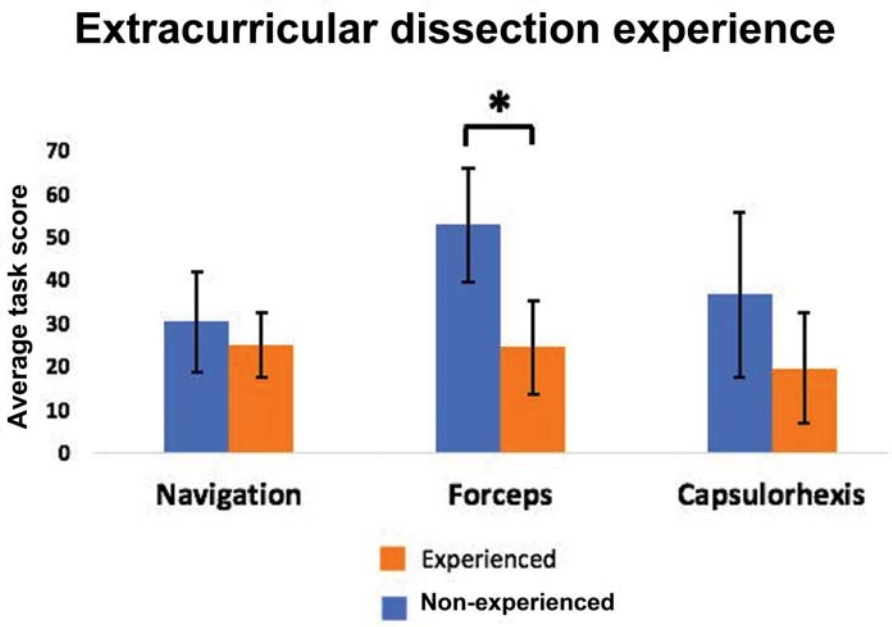

Fig. 2 Extracurricular dissection experience. $^{*}p < 0.05$.

whether certain hobbies may influence surgical performance. Video game and musical instrument experience have been shown to positively predict laparoscopic surgery[12] and robotic surgery[13] performance but their effects on microsurgical procedures have been mixed. Osborn et al found no effect of video game or musical instrument experience on otolaryngology microsurgical performance.[3] Chung et al found a positive effect of video game, but not musical instrument experience on ophthalmology simulator performance.[2] Our research did not find any correlation between musical instrument or video game playing on microsurgical simulator scores.

Our research did find that drawing and extracurricular dissection experience correlates with higher scores on the Eyesi Ophthalmosurgical Simulator, findings that have not been previously reported. Drawing and dissection are unique hobbies, in that both involve fine manipulation of the tip of a long instrument. We propose that it is this precise use of the fingertips that most closely resembles the fine movements required in cataract surgery and that best prepares a microsurgeon. Dissection experience may provide an additional advantage of practicing fine motor movements under a surgical microscope.[14]

The study has some limitations. The participant pool underrepresented 4th year medical students (10% of total participants). In addition, a high proportion of the medical students recruited for the study expressed an interest in ophthalmology (77%). This may have been a result of

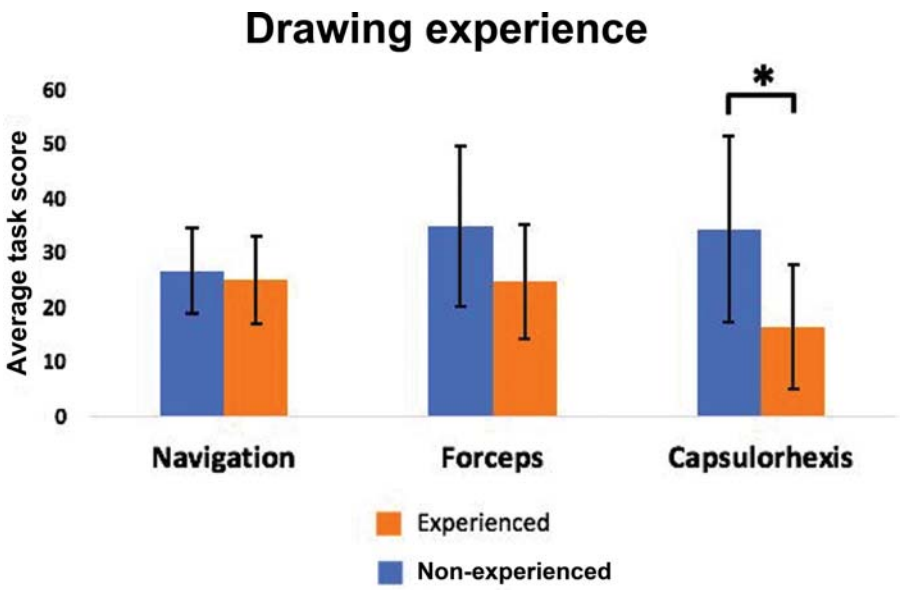

Fig. 3 Drawing experience. $^{*}p < 0.05$.

recruitment through flyers and emails sent to the student body, which likely selected for medical students who already had a motivation to learn more about ophthalmology. In addition, information about fine motor hobbies was self-reported by participants, and was therefore subject to recall bias.

Overall, our findings suggest that ophthalmology applicants who report experience with drawing or extracurricular dissection may be more adept at practicing and mastering microsurgical skills. Although this conclusion is based on simulated surgery, studies have found that success on the simulator correlates with success in the operating room.[15–17] This information may aid in the residency selection process as a way to select for surgical ability; a parameter that is not routinely screened for despite its importance in our field. By incorporating predictors of surgical success in our selection criteria, we might avoid the challenges that are faced by residents who are not able to meet their surgical milestones.

Note

This study was previously presented at the Association for Research in Vision and Ophthalmology Annual Meeting, Poster Presentation; 2019 April 28; Vancouver, BC. All authors fulfill the criteria for authorship and take responsibility for the integrity of the work as a whole.

Conflict of Interest

None declared.

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