Eye tracking habits as an objective measure of the progression of surgical skill

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Introduction:

The Da Vinci robot has been around for over two decades and has continued to make improvements to their system design and simulation to help trainees become more precise in movements and when operating. [1] As RAS becomes more widely used in urological practice, there are concerns that there is a paucity of ways to objectively measure urological trainees' surgical expertise.

To date, the current method of assessing urological trainees' surgical expertise is by evaluation by peer surgeons.[2] A promising route of objectively measuring proficiency in RAS is the utilization of eye tracking devices to detect eye gaze behaviors of subjects. Prior reports suggest that distinct and different eye gaze patterns can be observed between novice and expert surgeons.[3] In one of the earlier studies investigating eye tracking behaviors, Johansson et al found that during certain tasks like, grasping and reaching, the participant's eyes reached the target on average within half of a second before hand movements were initiated.[3]

However, there have only been a few studies that have reported on this eye tracking device and its utility. We sought to examine if there was a correlation between eye gaze behaviors of urological trainees to surgical experts as they advance in their level of training.

Methods:

The current study was approved by the IRB at our institution. Urology residents, fellows, and attendings were recruited to participate in this study. The participants were asked to watch a deidentified video of the bladder neck dissection during a radical prostatectomy and was not previously seen by any participant. The eye tracking measurements were collected using the Tobii-pro glasses while the participant was watching the pre-recorded video.

The eye tracking measurements were analyzed by utilizing an area-of -interest analysis with a target/non-target approach, in which an expert urological surgeon identified the region of interest throughout the video. An independent samples Kruskal- Wallis statistical analysis test was performed with the eye tracking measurements collected.

Results:

A total of 13 subjects were recruited and included 4 experts (attendings), 5 novices (PGY 1-3), and 4 intermediates (PGY5 and fellows). Novices were found to have significantly lower eye fixations (93.2% +/- 1.98) when compared to urological experts (98.0% +/- 1.02). Intermediates eye fixations were in the middle of both novices and experts (95.8% +/- 2.35) and all three groups were significantly different from each other (p=0.036, figure 1A). The average fixation for intermediates was longer (2.44 +/- 1.18) when compared to both novices (1.18 +/- 0.32 seconds) and experts (1.37+/- 0.46 seconds), but these findings were not statistically significant. Novices were found to have significantly more total visits for both target and non-target areas when compared to experts and intermediates had the most variation (p=0.02,figure 1B).

Discussion:

The results of the current study suggest that there is a measurable gradient in eye tracking fixation on target and non-targets as urological trainees progress in their level of training and as they progress in training begin to parallel those of urological experts. The use of eye tracking devices is being thoroughly researched in multiple surgical specialties and would have great utility in the field of urology as a growing number of procedures are being performed robotically.

A similar study conducted by Nespolo et al also utilized eye tracking devices to detect variations in eye gaze behaviors between expert ophthalmic surgeons compared to ophthalmology trainees.[4] In this study ophthalmic fellows and attendings overall cartesian distance traveled was significantly lower when compared to ophthalmic residents ($P < 0.02$).[4] However, this study showed that residents and fellows exhibited significantly more eye fixation to the display area where the surgical device was superimposed when compared to ophthalmic attendings.[4] This study also did not find a significant difference in the number and duration of fixation between ophthalmic trainees and attendings ($P > 0.3$).[4] In another study by Ji et al, there were two areas of interest (AOI) and this study found that attendings had a significantly lower duration of fixation when compared to trainees.[5] This study also noticed that trainees spent a significant longer duration of time fixated on the second area of interest compared to the first area of interest which indicated that trainees were less likely to notice the vagus nerve that was shown in area of interest 1 (AOI 1).[5]

In another study performed by Menekse and Cagiltay, this study compared novice surgeons, surgeons who have not previously performed an endoscopic surgery, to intermediates, surgeons who have observed and assisted in endoscopic procedures. [6] In this study both ENT and neurosurgery residents were included in this study and had to perform tasks in four different virtual reality scenarios with two of the scenarios including a surgical model.[6] In two of the four scenarios there was a statistically significant difference in eye fixations with a lower amount of fixation observed among intermediates compared to novice surgeons. [6]

Future studies should involve determining the optimal desired eye fixation duration and target areas for more urological procedures for this device to be useful for all urological procedures. Studies that have a larger sample size and are multi-institutional to assess the generalizability.

The findings of the current study and other studies suggest that there is a correlation between eye gaze and fixation behaviors to level of surgical expertise. The findings of the current study and prior reports suggest that eye tracking devices could provide a way to objectively measure surgical expertise amongst urological trainees.

One of the limitations of this study is the small sample size. More studies that include larger sample sizes and are multi-institutional should be implemented to better assess the capability and feasibility of utilizing eye tracking devices to objectively measure surgical

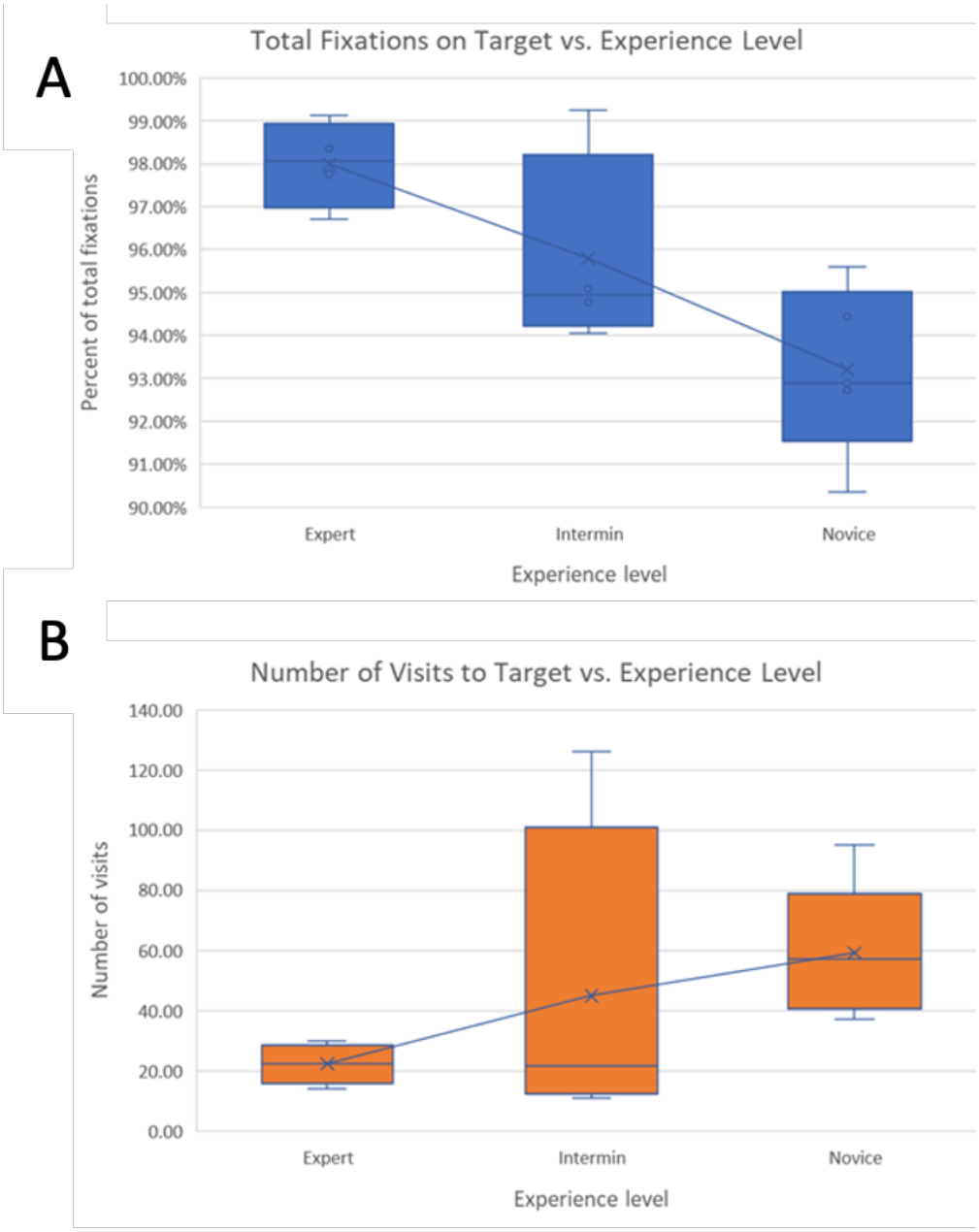
expertise. Another limitation of this study is the data was collected from subjects at different times during their work cycle. Additional studies need to be conducted whether subject fatigue could influence gaze and fixation behaviors and potentially alter the results which be more indicative of fatigue and not a lack of surgical expertise. The subjects included in this study had their eye tracking measurements acquired while they were viewing a pre-recording of a bladder dissection. Since watching the video that is pre-recorded is more passive and could influence the eye tracking measurement outcomes more studies should be conducted with eye tracking measurements acquired at the same time the procedure is being performed. We plan for the next phase of this project to involve collecting the eye tracking measurements while the procedure is being performed.

Conclusion:

The findings of the current study suggest that there is a trend in eye fixation duration and visits to both target and non-target areas that begins to parallel those of urological experts as trainees gain more training and exposure to surgical techniques. The findings of this study also suggest that eye tracking devices have the utility to objectively measure surgical expertise among trainees.

References:

1. 4. DiMaio S, Hanuschik M, Kreaden U. The da Vinci Surgical System. In: *Surgical Robotics*. New York, NY: Springer; 2011:199–217.
2. Aggarwal R, Moorthy K, Darzi A. Laparoscopic skills training and assessment. *Br J Surg* 2004;91:1549–1558
3. Johansson RS, Westling G, Backstrom A, Flanagan JR. Eye–hand coordination in object manipulation. *J Neurosci* 2001;21:6917–6932
4. Nespolo RG, Cole E, Wang D, Yi D, Leiderman YI. A Platform for Tracking Surgeon and Observer Gaze as a Surrogate for Attention in Ophthalmic Surgery. Ophthalmol Sci. 2022 Nov 8;3(2):100246. doi: 10.1016/j.xops.2022.100246. PMID: 36748062; PMCID: PMC9898791.
5. Ji Y, Kong Z, Deng Y, Chen J, Liu Y, Zhao L. The role of eye tracker in teaching video-assisted thoracoscopic surgery: the differences in visual strategies between novice and expert surgeons in thoracoscopic surgery. Ann Transl Med. 2022 May;10(10):592. doi: 10.21037/atm-22-2145. PMID: 35722359; PMCID: PMC9201158.
6. Menekse Dalveren GG, Cagiltay NE. Distinguishing Intermediate and Novice Surgeons by Eye Movements. Front Psychol. 2020 Sep 10;11:542752. doi: 10.3389/fpsyg.2020.542752. PMID: 33013592; PMCID: PMC7511664.



	Novice	Intermediate	Experts	P-Value
Eye Fixation to AOI (%)	93.2% +/- 1.98%	95.8% +/- 2.35%	98.0% +/- 1.02%	0.036
Average Fixation (s)	1.18 +/- 0.32 s	2.44 +/- 1.18 s	1.37+/- 0.46 s	>0.05

Table 1: Eye Fixation Percentage and Average Fixation in Seconds