The Open Journal of Occupational Therapy

Volume 11
Issue 2 *Spring 2023*

Article 11

April 2023

Novice and Expert Observer Accuracy of the Threshold Wheelchair Skill: A Pilot Eye-Tracking Study

Diane E. MacKenzie
Dalhousie University - Canada, Diane.mackenzie@dal.ca

R. Lee Kirby
Nova Scotia Health and Dalhousie University - Canada, lee.kirby@nshealth.ca

Cher Smith
Nova Scotia Health - Canada, cher.smith@nshealth.ca

Zainab Al Lawati
Canada, zainabj495@gmail.com

Eric Lee
Dalhousie University - Canada, er744504@dal.ca

Sorayya Askari
Dalhousie University - Canada, sorayya.askari@dal.ca

Recommended Citation

MacKenzie, D. E., Kirby, R., Smith, C., Al Lawati, Z., Lee, E., & Askari, S. (2023). Novice and Expert Observer Accuracy of the Threshold Wheelchair Skill: A Pilot Eye-Tracking Study. *The Open Journal of Occupational Therapy, 11*(2), 1-10. https://doi.org/10.15453/2168-6408.2043

Novice and Expert Observer Accuracy of the Threshold Wheelchair Skill: A Pilot Eye-Tracking Study

Abstract

Background: Moving a wheelchair over a low threshold is an entry-level mobility skill. Observation is critical to the assessment and training of this skill. The primary objective of this exploratory pilot study was to determine if a difference between novice and expert visual attention allocation pattern was linked to the accuracy of rating skill performance and decision confidence.

Methods: Twelve expert occupational therapists and nine non-expert occupational therapy students observed 30 first-attempt recordings of able-bodied persons learning the low threshold skill. Randomized recordings included 10 recordings from each rating group of “pass,” “pass with difficulty" (pwd), and “fail.” Skill ratings, confidence ratings, time to decision, and SR Eyelink 1000+ monitored eye movements were recorded.

Results: No significant group differences were found in the correct identification skill rating, though significant relationships were found with experts rating higher confidence in their decision-making and generally faster reaction times. While trends of eye movements differences were found between groups, only the number of areas of interest viewed in pwd videos was a potential rating correctness predictor.

Conclusion: Improved confidence in decision-making did not mean improved assessment accuracy. The pwd video stimuli created the opportunity for assessing observation patterns differences. Further study is recommended.

Comments

The authors declare that they have no competing financial, professional, or personal interest that might have influenced the performance or presentation of the work described in this manuscript.

Keywords

expertise, eye-tracking, observation, threshold skill, training, wheelchair

Cover Page Footnote

The equipment for this project used in Diane MacKenzie’s lab was funded by grants from CFI: John R. Evans Leader’s Fund and the Nova Scotia Research and Innovation Trust. We would like to thank Kaila Bishop, Emma Travers, and Cameron Drysdale for their contributions to preparing the eye-tracking stimuli used in this study. We also thank Dr. David Westwood for his thoughtful review of a previous version of this manuscript.

Credentials Display

Diane E MacKenzie, PhD, OT Reg.(N.S.), OTR; R. Lee Kirby, MD, FRCPC; Cher Smith, MSc, OT Reg.(N.S.); Zainab Al Lawati, MD; Eric Lee, BSc; Sorayya Askari, PhD, OT Reg.(N.S.)

DOI: 10.15453/2168-6408.2043

In 2008, the World Health Organization (WHO) estimated approximately 65 million people with mobility restrictions needed a wheelchair. The prevalence of disability has continued to rise worldwide in part because of increases in chronic diseases and the aging population (WHO, 2021). The wheelchair is one of the most common mobility devices and an important therapeutic tool in rehabilitation. Research studies have documented a range of benefits related to wheelchair use, such as improved mobility and participation (Hosseini et al., 2012), reduced caregiver burden (Davies et al., 2003; Frank et al., 2010), reduced likelihood of placement in long-term care facilities, and improved quality of life (Auger et al., 2008; Kirby et al., 2021; Pettersson et al., 2007; Sakakibara et al., 2013). Because particular skills are required to use a wheelchair safely, wheelchair skills training is an essential best practice element for new users (WHO, 2008).

The Wheelchair Skills Training Program (WSTP) (Keeler et al., 2019; Tu et al., 2017) is a training intervention that has a clinically meaningful short-term impact on new wheelchair users. The WSTP offers both an assessment (Wheelchair Skills Test [WST]) and a standardized training method (Wheelchair Skills Training Program [WSTP]). Component skills are categorized as indoor, community, or advanced. One of the key entry-level skills for getting a moving manual wheelchair over an obstacle is the 2 cm threshold skill. Mastery of this skill is an essential step for building toward advanced skills for more challenging surfaces (e.g., curbs, potholes). According to WSTP protocol, the therapist provides one piece of feedback on performance after observing a skill which means that observational skills are central to the effectiveness of the therapist. While there have been studies evaluating experiential learning designs and their effectiveness on students' confidence and self-efficacy in delivering wheelchair skills training (Giesbrecht et al., 2021; Rushton & Daoust, 2019), to our knowledge, there has been no work investigating the underlying observation.

Literature Review

Observation is the act of using visual perceptual skills to obtain information relevant to assessment and making therapeutic decisions for intervention. Observation is often assessed using measures of eye movements, such as fixations in relation to key features in a visual scene (Hayhoe & Ballard, 2005; Malcolm & Henderson, 2010). Previous studies have suggested there is an interactive relationship between an individual's initial view of a scene (Land & Hayhoe, 2001), their knowledge of the task, and the subsequent specificity of where they direct their eye movements (Castelhano & Henderson, 2007) to optimize their performance in an ongoing task (Torralba et al., 2006). Skilled observers adapt their pattern of eye movements to the cognitive and behavioral activity required for the assigned task, suggesting an important role for top-down control via prior knowledge (Boot et al., 2009).

Skilled observation and patterns of eye movements have been studied in populations, such as pilots searching control panels, soccer goalies anticipating ball placement, radiologists identifying tumors and fractures, occupational therapists judging safety, movement analysis by physical therapists, and expert referees (e.g., Babadi Aghakhanpour et al., 2021; Kundel et al., 2008; MacKenzie & Westwood, 2015; McDuff et al., 2020; Savelsbergh et al., 2002; Schriver et al., 2008). Observation, including identification of key pieces of data, pattern recognition, and interpretation of significance and meaning, has been recognized as a key element in medical decision-making (Brunyé et al., 2019) and medical education (Ashraf et al., 2018).

In an evaluation setting, an observer must recognize patterns, identify key features, quickly select relevant features to address, and make decisions. Some studies have found that experienced therapists have more and briefer fixations (MacKenzie & Westwood, 2015; McDuff, 2020), while others (Bernhardt et al., 2002) found no difference in eye movement patterns but, nevertheless, reduced reaction time and better interpretation accuracy. In the context of the WST, one might expect that experienced trainers and therapists would have superior observational abilities compared to novices, given the need to extract key information rapidly in real time. Furthermore, it should be possible to train novices to become better observers by training the behaviors seen in skilled observers. It is not currently known which task-specific stimuli or features should be attended to and integrated into the learner's repertoire of recognition for the 2 cm threshold skill. Given the WST requires the evaluator to observe the skill, identify potential issues, and suggest one immediate correction, identifying relevant features for an observer's visual attention is clinically meaningful. Enhancing this task awareness may not only assist with assessment accuracy but will provide insight into developing guidelines for observation, evaluation, and training.

Moving a manual wheelchair over an obstacle is an essential skill for wheelchair users in the community (Morgan et al., 2015). A previous study (Al Lawati et al., 2017) used an expert panel to review recordings of 214 able-bodied people learning the skill of getting over a 2 cm threshold using the momentum method. From an analysis of the frequency and nature of the errors encountered on the first attempt of the skill, we identified three phases where errors typically occur: approach, popping, and leaning. It is unknown whether clinicians are able to accurately rate and identify the specific error(s) that require feedback based on real-time observation of new wheelchair users or their caregivers. Experience and expertise are purported to increase a clinicians' ability to use multiple-category reasoning to support their clinical judgments (Hayes & Chen, 2008). Still, it is unclear if observation skills during the assessment of wheelchair skills are different between novice and expert occupational therapists.

The objective of this exploratory study was to compare observational behaviors between experts (trained occupational therapists) and novices (occupational therapy students) during assessments of wheelchair users getting over a 2 cm threshold. The goals of the study were to measure patterns of visual fixations and determine whether these patterns are linked to the accuracy of rating skill performance, identification of the skill's phase error, decision reaction time, and confidence in decisions. In addition, we analyzed the consistency of interaction with the categories of the threshold video stimuli to inform future studies or training using these materials.

Method

This exploratory pilot study used a case-control design (trained vs. novice observers) with experimental manipulation of stimulus type (pass, pass with difficulty, fail). The local Health Authority Research Ethics Board reviewed and approved this study.

Participants

Participants recruited for this study's expert group were licensed occupational therapists with at least 3 years of clinical experience and trained in the WST 4.3 version (Kirby et al., 2015). The novice group was recruited from a cohort of occupational therapy students in their first year of an MSc(OT) training program. Purposive contact in the expert group triggered a word-of-mouth recruitment process. Recruitment materials were sent to students through the approved school protocols, and interested participants completed a self-screening process before determining study eligibility. Participants self-screened for (a) normal or corrected-to-normal visual acuity wearing contact lenses and (b) no known visual or neurological condition restricting coordinated eye movements, visual and cognitive processing skills, head and neck control in a seated position, or coordinated upper-limb fine-motor control. All of the participants provided informed written consent.

DOI: 10.15453/2168-6408.2043

Instrumentation and Procedure

The video stimuli in this study were randomly drawn from a pool of videos from a previous study that used a fixed camera positioned lateral to the 2 cm threshold (2 cm high, 1.5 m wide, and 10 cm in the line of progression in a manual wheelchair) (Kirby et al., 2015). The threshold skill was recorded from the lateral perspective of the person completing the approach, popping, and leaning phases using the momentum method. Using the WST 4.3 rating scale (Kirby et al., 2015), two experienced wheelchair skills evaluators viewed 214 first-attempt recordings and rated them into categories of "pass," "pass with difficulty (pwd)," or "fail." Consensus ratings were achieved by reviewing full-speed and slow-motion replays. From the pool of 214 recordings, 30 videos were randomly selected with, 10 recordings from each category (pass, pwd, or fail). It was unknown if a category type would reveal differences between experts and novices in terms of the variables studied.

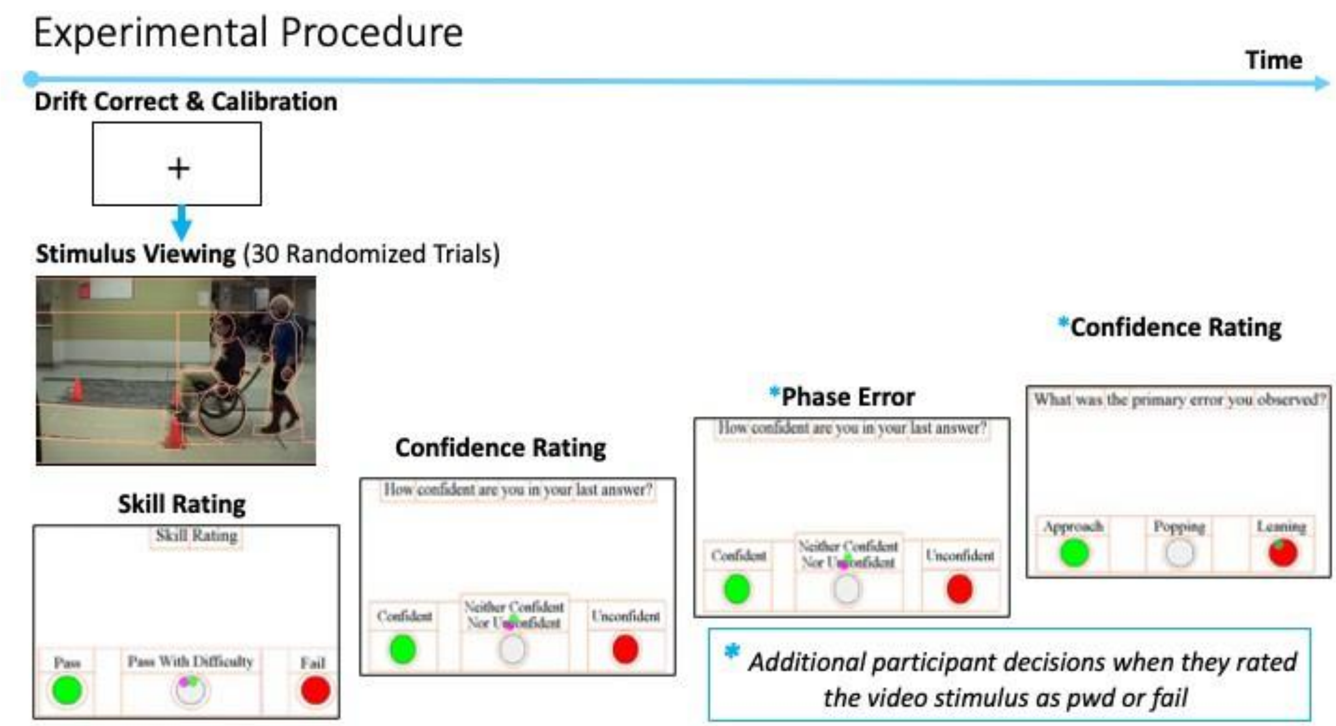
Each of the 30 videos was overlaid with a unique and detailed dynamic areas-of-interest (AOI) map using SR Experiment Builder (https://www.sr-research.com/experiment-builder/). The AOI maps were unique to each video and permitted an assignment of measured fixations from the participants into meaningful features in the video rather than abstract spatial co-ordinates. The AOI data could be analyzed independently or combined into larger AOI (e.g., lower body with wheelchair and hand of client, upper body/head of the client, off client on spotter or environment). Video stimuli were presented on a monitor, and eye movements were recorded using an EyeLink 1000+ desktop remote mount camera without head stabilization.

EyeLink DataViewer software (SR Research Ltd., n.d.) was used to generate measures of fixation count, dwell time, and saccades from raw eye position data. Skill ratings (pass, pwd, fail), identification of skill phase errors only for pwd and fail videos (approach, popping, leaning), confidence of skill and phase ratings (using a Likert type scale with visual anchors of 1 = *unconfident*, 3 = *neither confident nor unconfident*, and 5 = *confident*), confidence of phase error rating, and time to decision(s) were also recorded for analysis. The participants' eye movement data and keyboard entries were recorded to a text file, exported into Microsoft Excel (2021), cleaned, and ultimately exported to SPSS v.27.0™ for statistical analysis.

Following written informed consent, a target sticker was placed on the participant's forehead between their eyes, and they were seated in a height-adjustable chair with their eyes aligned to the upper quarter of the computer monitor. Nine-point calibration, validation, and recording of binocular eye movements (1000 Hz) were carried out in the same viewing plane used to display the stimuli. The participants were given one practice trial to view the skill rating definitions (pass, fail, pwd) and the phase rating definitions (approaching, popping, leaning), as well as practice with the keyboard for recording their decisions and confidence ratings. They could repeat the practice trial if they wanted more time or comfort with the keyboard.

Before each experimental trial, a drift correction and calibration were done to ensure the continued accuracy of the recordings. Figure 1 outlines the experimental procedure from the start of experiment calibration to the completion of the task. The participants observed 30 videos of individuals learning the wheelchair threshold skill. The 10 recordings from each rating group of pass, pwd, and fail were presented in random order. No audio was used with the presentations.

Figure 1
Experimental Procedure



Data Analysis

Chi-square tests were used to identify associations among variables of rating accuracy, participant type (expert vs. novice), and confidence ratings. Likelihood ratio and Freeman-Halton corrections were used to address any violations. A mixed ANOVA of group (expert vs. novice) and video type (pass, pwd, fail) was completed using the grand means for fixation count and fixation dwell time, skill accuracy, and reaction time. The Greenhouse-Geisser correction was applied for any violation of sphericity < 0.75, and the adjusted degrees of freedom are reported. A mixed analysis of variance (ANOVA) was also used for individual videos in each type (pass, pwd, fail) to explore if any videos were significantly different from the rest of the set. Logistic regression was run to see if any of the variables collected were predictive of the level of expertise across the different types of videos. An alpha threshold of .05 was used for all statistical analyses.

Descriptive analysis for trends in how the expert and novice groups viewed the videos was completed frame by frame using compiled group time-stamped eye gaze data. As noted in the method section, we aggregated the individual AOIs into the larger regions of lower body/wheelchair of the user, upper body/head, and away from the wheelchair user (i.e., looking to the threshold, spotter, and/or other locations). We were interested to understand if there was a pattern across video types that may have assisted in achieving the correct rating.

Results

Twenty-one participants completed this study and ranged in age from 22 to 40 years. Table 1 includes the means and standard deviations for eye movement variables and reaction times by group and video type. There was a significant main effect of video type for fixation count, first dwell time, second dwell time, and skill rating reaction time. There was no significant difference in the number of correctly identified images across groups. The total number of AOI viewed in the pass and fail videos were similar,

DOI: 10.15453/2168-6408.2043

but the experts had a higher AOI count in the pwd videos. In addition, while the experts had shorter mean RTs in the pass and fail video-rated videos, they had longer RT in the pwd category, perhaps suggesting difficult choices increase the time to decision (Milosavljevic et al., 2011).

Table 1
Group and Video Type Means and Mixed ANOVA results

	Pass		**Fail**		**Pwd**				
	Expert	**Novice**	**Expert**	**Novice**	**Expert**	**Novice**	***F***	***p***	**η_p^2**
Fixation Count *	10.72 [.48]	9.41 [.56]	12.27 [.54]	10.87 [.63]	16.49 [.76]	14.71 [.88]	172.66	<.001	.90
1st Fixation Dwell Duration (ms) *	241.38 [17.29]	271.51 [19.96]	241.93 [17.58]	286.50 [20.30]	257.66 [21.88]	326.38 [25.26]	3.35	.046	.15
2nd Fixation Dwell Duration (ms) *	396.83 [21.33]	424.82 [24.63]	422.23 [46.91]	529.27 [54.17]	554.54 [66.63]	654.53 [76.93]	11.28	<.001	.37
AOI *	5.58 [.51]	5.67 [.59]	5.58 [.33]	5.22 [.38]	9.08 [.49]	7.56 [.57]	26.69	<.001	.58
Correct Skill Rating	9.08 [.32]	8.67 [.37]	9.08 [.19]	9.22 [.22]	7.92 [.61]	6.78 [.70]	1.23	.32	.12
Skill Rating Reaction Time (ms) *	1166.79 [448.17]	1818.24 [1097.55]	1748.87 [330.28]	2293.91 [1457.53]	2258.74 [814.93]	2444.06 [1423.63]	5.04	.03	.21

Note: * Main effect of video type.

Table 2 contains the results from the 3x3 Chi-square test of independence, which assessed the association between the group type and confidence ratings in both the correctly and incorrectly rated videos. Significant associations were found between the group type and confidence ratings in the correctly rated pass videos, fail, and pwd videos. In all cases, the experts recorded a higher ranking of confidence. For the incorrectly rated videos, there was a statistically significant association between the group type and the confidence ranking in the incorrectly rated pass video, with the experts recording a higher ranking of confidence. However, in the incorrectly identified fail and pwd, there was no statistically significant relationship between the group type and the confidence ranking.

Logistic Regression Results

The participants in the expert group rated themselves as more confident, but none of the variables under study significantly predicted the level of skill rating accuracy of the participants. The following variables were included in the stepwise logistic regression models: the total correct rating of pass/fail/pwd, confidence for the rating decisions, phase identification confidence, reaction time to decision, mean fixation count, the first area of interest location, mean first fixation dwell time, the second area of interest location, and mean of the second fixation dwell time. However, when controlling for the pass and fail total AOI, pwd total AOI was a significant predictor of the ability to correctly rate the skills: OR = 2.554, 95% CI = 1.000-6.522, P-value = 0.050.

Table 2
3x3 Chi-Square Test of Confidence Rating by Video Type, Group, and Level of Correctness

			Confidence Rating Count (%)				
			Unconfident	*Neither*	*Confident*	X^2	*p*
Pass	*Not Correct*	*Novice*	1 (8.3)	3 (25)	8 (66.7)	X^2 (2, N = 210) = 6.35	.042[a]
		Expert	0 (0)	0 (0)	12 (100)		
	Correct	*Novice*	3 (3.8)	15 (19.2)	60 (76.9)	X^2 (2, N = 210) = 12.43	.002[a]
		Expert	1 (.9)	5 (4.6)	102 (94.4)		
Fail	*Not Correct*	*Novice*	0 (0)	1 (14.3)	6 (85.7)		.148[b]
		Expert	0 (0)	0 (0)	12 (100)		
	Correct	*Novice*	1 (1.2)	8 (9.6)	74 (89.2)	X^2 (2, N = 210) = 10.35	.006[a]
		Expert	0 (0)	1 (.9)	107 (99.1)		
Pwd	*Not Correct*	*Novice*	0 (0)	6 (20.7)	23.3 (79.3)		.355[b]
		Expert	0 (0)	3 (11.5)	23 (88.5)		
	Correct	*Novice*	2 (3.3)	11 (18)	48 (78.7)	X^2 (2, N = 210) = 1.51	.469[a]
		Expert	1 (1.1)	13 (13.8)	80 (85.1)		

Note: [a]Likelihood Ratio; [b]Freeman-Halton

Descriptive Findings

We explored whether the first fixation location was associated with the ability to correctly rate the video, regardless of the group. As mentioned above, the individual AOIs were aggregated into three areas of lower wheelchair user, the upper wheelchair user, and away (anywhere on the screen other than the wheelchair user). Table 3 provides the descriptive data for the number of first fixation locations collapsed across all of the participants per video category, together with the percentage of correct ratings per first fixation location. The most striking difference in first fixation locations to percentage correct occurred in the pwd videos category. While the percentage correct dropped for those who looked in the lower and away AOI first, the most dramatic difference in being able to rate the pwd video correctly occurred for those whose first fixation was in the upper AOI.

Table 3
First Fixation Location and Correct Rating Percentage Across Video Type

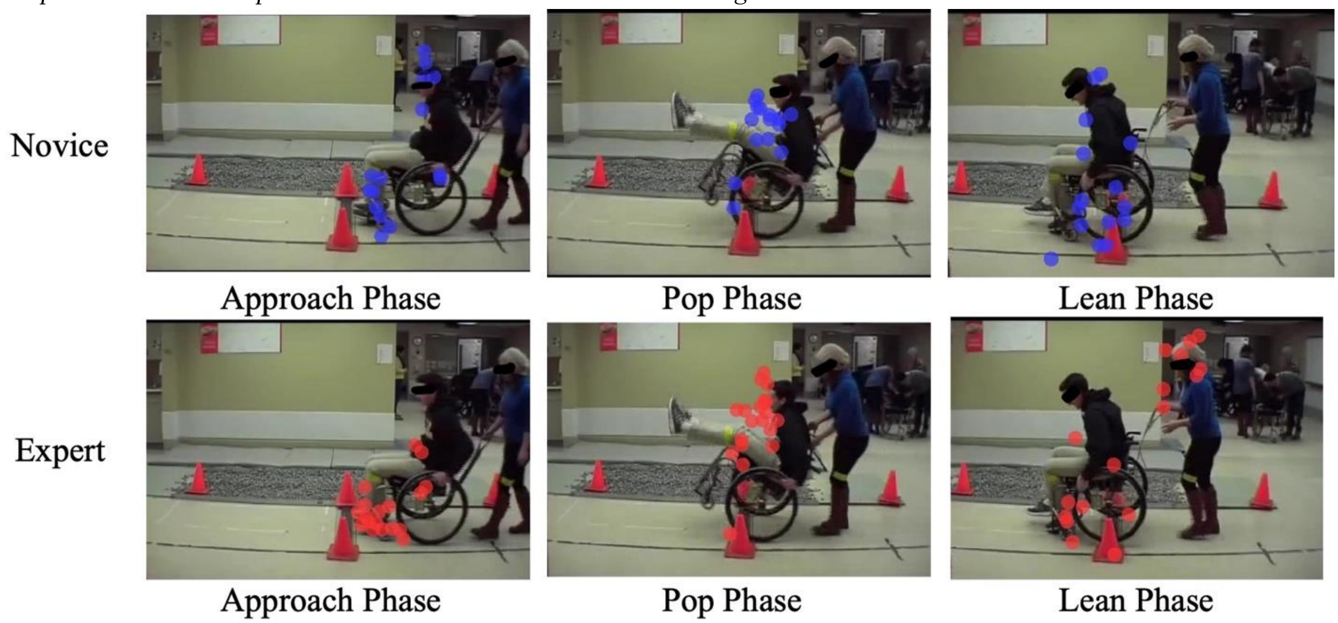
	Pass		Fail		Pwd	
First Fixation Location	**Fixation Total**	**Correct (%)**	**Fixation Total**	**Correct (%)**	**Fixation Total**	**Correct (%)**
Lower	140	129 (92)	144	128 (88)	150	113 (75)
Upper	21	21 (100)	29	26 (89)	22	13 (59)
Away	49	41 (84)	37	32 (86)	38	29 (76)

A descriptive image analysis of the three phases of the threshold skill (approach, pop, and lean) was completed by compiling each group's time-stamped eye gaze points. Figure 2 illustrates fixation location differences between the novice and expert groups at precise time stamps while viewing a recording with a "fail" rating. Patterns of eye movements do not always lend themselves to static statistical analysis. Further, frame-by-frame descriptive analysis found that the experts tended to have similar gaze sequences in their group. They tended to look first at the wheelchair user, then either at the threshold and/or the upper part of the wheelchair user. After the wheelchair user crossed the line before the threshold, most of the experts switched to fixate on the threshold and the wheelchair user's feet. After the patient was over the threshold, the expert group tended to look toward the face of the wheelchair user or spotter. The looking toward the face by the expert group tended to occur in the videos where there were overt safety concerns, as illustrated in the fail video in Figure 2.

Frame-by-frame descriptive analysis indicated that novice gaze patterns were not consistent. Some novices followed the wheelchair user, similar to the expert group pattern, and others looked higher on the patient, such as their upper trunk/head or spotter. The novices then tended to look at the threshold either before the wheelchair user was there or when the wheelchair user was attempting a second try over the threshold.

Figure 2

Compiled Novice and Expert Fixation Locations on a 'Fail' Recording



Discussion

To our knowledge, this is the first study to explore the gaze behavior of expert occupational therapists and non-expert occupational therapy students during observation and evaluation of the 2 cm threshold wheelchair task. The threshold task is an entry-level wheelchair skill required for more challenging mobility surfaces, so it is important that the observer identifies and trains the correct skill for success. While there is growing evidence on the effectiveness of wheelchair skills training methods and learner confidence (e.g., Giesbrecht et al., 2021), there is less known on the best method for observing or for training observation of wheelchair skills.

In this exploratory pilot study, there was a lack of statistical differences in eye-tracking dependent variables between the groups, but there were trends together with the descriptive data similar to other studies with expert and novice occupational therapy observers (e.g., MacKenzie & Westwood, 2015). Overall, the expert group tended to have more fixations and shorter first and second dwell per video type, and the expert group tended to move their eyes more quickly than the novice group. An increased number of fixations has been noted to be a marker of expertise in dynamic situations and appears to correspond to a more frequent updating of critical data related to the clinical need. However, patterns of eye movements related to expertise also depend on the task characteristics. For example, Babadi Aghakhanpour et al. (2021) found expert fencing referees had fewer fixations and longer dwell times. An array of medical imaging studies has also shown differences between novices and experts are not always found for eye movements (number of fixations or dwell times), but locations and patterns of eye movements are important for decision-making (e.g., Leveque et al., 2018). The lack of group differences in eye movement in this study may suggest the overall stimuli set may have been too obvious for rating and not sensitive enough to highlight the qualitative differences observed in the time-stamped collated group fixations. In other words, the threshold skill task might not have required a high level of pattern recognition expertise to reach the correct decision (Klostermann & Moeinirad, 2020).

The expert group also had a faster reaction time for the pass and fail videos, but longer reaction time for the pwd, indicating perhaps the pwd videos were more challenging to rate and required more processing time to decide, suggesting difficult choices increase time to decision (Milosavljevic et al., 2011). While experts were not significantly different in the overall correct identification of the rating or phase rating, their scores expressed more confidence in their decision-making.

The finding that the experts were more confident in their ratings, even when incorrect, is noteworthy for clinicians and educators involved with wheelchair skill training. Improving confidence does not necessarily improve observation accuracy. Eye-tracking has become much more readily available and has a presence in some health profession education, offering an opportunity to further study key features for wheelchair skills assessment and training and develop observation training modules to improve observation accuracy over time. Specific patterns or strategies for seeking salient information to support decision-making accuracy require observers to use relevant cues from the dynamic scene. In observation-based dynamic assessments, such as the WST, there is a need to investigate beyond "what" an observer may look at and also their patterns for what they seek to "see" and use in their decision-making process.

Limitations

This was an exploratory pilot study with a purposeful small sample size that necessarily limited the statistical power to detect group differences. Trends similar to other novice and expert studies can be seen, but the findings may not be generalized. Also, while the video stimuli were ecologically valid, the task complexity and length may not have been long enough to differentiate novice and expert observation patterns statistically. For example, there is a clear pass or fail for this skill, and the length of the skill may not be long enough to capture differences in eye gaze behavior. In addition, the videos were recorded in a mobility center with motion in the background, not unlike a practice setting. However, this might have been distracting, particularly given it was a short video, and by looking away to other features in the background the key element may have been missed.

Finally, in this study, the observation perspective was to the lateral surface of the wheelchair user, but in practice, the therapist may also be the spotter positioned behind the wheelchair. Future studies should also address the variation in the viewing vantage point and accuracy of assessment and/or skill for training. This could be done by varied perspective video preparation and/or with mobile eye trackers. In addition, a think-aloud process where the therapist is probed about influential features or factors may assist with understanding the cognitive processes underlying their decisions.

Implications and Future Research

Observation is an integral part of wheelchair skills assessment and training. Information gathered by observation informs decision-making for rating skills and associated intervention. Identification and development of observational skills or pattern recognition for dynamic visually based assessments, such as the WST, requires further study and development to improve observation and assessment accuracy. Improved confidence does not mean improved assessment accuracy.

Our next steps involve developing visual stimuli for the full WST, which will help to broaden our understanding of identifying key features contributing to observation accuracy for the assessment and training of skills. This will assist with laying the foundation for identifying specificity of training needs for observation and observation for correction.

References

Al Lawati, Z., Kirby, R. L., Smith, C., MacKenzie, D., Theriault, C., & Matheson, K. (2017). Getting a manual wheelchair over a threshold using the momentum method: A descriptive study of common errors. *Archives of Physical Medicine and Rehabilitation*, *98*(10), 2097–2099. https://doi.org/10.1016/j.apmr.2017.04.023

Ashraf, H., Sodergren, M.H., Merali, N., Mylonas, G., Singh, H. & Darzi, A. (2018). Eye-tracking technology in medical education: A systematic review. *Medical Teacher*, *40*(1), 62–69. https://doi.org/10.1080/0142159X.2017.1391373

Auger, C., Demers, L., Gélinas, I., Jutai, J., Fuhrer, M. J., & DeRuyter, F. (2008). Powered mobility for middle-aged and older adults: Systematic review of outcomes and appraisal of published evidence. *American Journal of Physical Medicine Rehabilitation*, *87*(8), 666–680. https://doi.org/10.1097/PHM.0b013e31816de163

Babadi Aghakhanpour, N., Abdoli, B., Farsi, A., & Moeinirad, S. (2021). Comparison of visual search behavior and decision-making accuracy in expert and novice fencing referees. *Optometry and Vision Science*, *98*(7), 783–788. https://doi.org/10.1097/OPX.0000000000001726

Bernhardt, J., Matyas, T., & Bate, P. (2002). Does experience predict observational kinematic assessment? *Physiotherapy Therapy and Practice*, *18*, 141–149. https://doi.org/10.1080/09593980290058535

Boot, W. R., Becic, E., & Kramer, A. F. (2009). Stable individual differences in search strategy? The effect of task demands and motivational factors on scanning strategy in visual search. *Journal of Vision*, *13*, 1–16. https://doi.org/10.1167/9.3.7

Brunyé, T. T., Drew, T., Weaver, D. L., & Elmore, J. G. (2019). A review of eye tracking for understanding and improving diagnostic interpretation. *Cognitive Research*, *4*(7), 1–16. https://doi.org/10.1186/s41235-019-0159-2

Castelhano, M. S., & Henderson, J. M. (2007). Initial scene representations facilitate eye movement guidance in visual search. *Journal of Experimental Psychology: Human Perception and Performance*, *33*(4), 753–763. https://doi.org/10.1037/0096-1523.33.4.753

Davies, A., De Souza, L. H., Frank, A. O. (2003). Changes in the quality of life in severely disabled people following provision of powered indoor/outdoor chairs. *Disability and Rehabilitation*, *25*(6), 286–90. https://doi.org/10.1080/0963828021000043734

Frank, A., Neophytou, C., Frank, J., & de Souza, L. (2010). Electric-powered indoor/outdoor wheelchairs (EPIOCs): Users' views of influence on family, friends and carers. *Disability Rehabilitation Assistive Technology*, *5*(5), 327–338. https://doi.org/10.3109/17483101003746352

Giesbrecht, E., Carreiro, N., & Mack, C. (2021). Improvement and retention of wheelchair skills for training for students in entry-level occupational therapy education. *American Journal of Occupational Therapy*, *75*(1), 1–9. https://doi.org/10.5014/ajot.2021.040428

Hayes, B. K., & Chen, T. H. (2008). Clinical expertise and reasoning with uncertain categories. *Psychonomic Bulletin & Review*, *15*(5), 1002–1007. https://doi.org/10.3758/PBR.15.5.1002

Hayhoe, M., & Ballard, D. (2005). Eye movements in natural behavior. *Trends in Cognitive Sciences*, *9*(4), 188–194. https://doi.org/10.1016/j.tics.2005.02.009

Hosseini, S. M., Oyster, M. L., Kirby, R. L., Harrington, A. L., & Boninger, M. L. (2012). Manual wheelchair skills capacity predicts quality of life and community integration in persons with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*, *93* (12), 2237–2243. https://doi.org/10.1016/j.apmr.2012.05.021

Keeler, L., Kirby, R. L., Parker, K., McLean, K. D., & Hayden, J. A. (2019). Effectiveness of the Wheelchair Skills Training Program: A systematic review and meta-analysis. *Disability and Rehabilitation: Assistive Technology*, *14*(4), 391–409. https://doi.org/10.1080/17483107.2018.1456566

Kirby, R. L., Smith, C., Parker, K., McAllister, M., Boyce, J., Rushton, P. W., Routhier, F., Best, K. L., Mortenson, B., & Brandt, A. (2015). The Wheelchair Skills Program manual Version 4.3. https://www.wheelchairskillsprogram.ca/wp-content/uploads/2018/04/The_Wheelchair_Skills_Program_Manual.1.pdf?_ga=2.103536901.481528819.1643732148-1910041817.1643732148

Kirby, R. L., Rushton, P. W., Smith, C., Routhier, F., Archambault, P. S., Axelson, P. W., Best, K. L., Betz, K., Burrola-Mendez, Y., Contepomi, S., Cowan, R.E., Giesbrecht, E., Kenyon, L.K., Koontz, A., Lettre, J., MacKenzie, D., Mortenson, B., Parker, K., Smith, E., . . . Worobey, L. (2021). *The Wheelchair Skills Program Manual Version 5.2*. https://wheelchairskillsprogram.ca/wp-content/uploads/WSP-Manual-version-5.2.2.approved-version.docx

Klostermann, A., & Moeinirad, S. (2020). Fewer fixations of longer duration? Expert gaze behavior revisited. *German Journal of Exercise and Sport Research*, *50*, 146–161. https://doi.org/10.1007/s12662-019-00616-y

Kundel, H. L., Nodine, C. F., Krupinski, E. A., & Mello-Thoms, C. (2008). Using gaze-tracking data and mixture distribution analysis to support a holistic model for the detection of cancers on mammograms. *Academic Radiology*, *15*(7), 881–886. https://doi.org/10.1016/j.acra.2008.01.023

Land, M. F., & Hayhoe, M. (2001). In what ways do eye movements contribute to everyday activities? *Vision Research*, *41*, 3559–3565. https://doi.org/10.1016/S0042-6989(01)00102-X

Leveque, L., Bosmans, H., Cockmartrin, L., & Liu, H. (2018). State of the art: Eye-tracking studies in medical imaging. *IEEE Access*, *6*, 37023– 37034. https://doi.org/10.1109/ACCESS.2018.2851451

MacKenzie, D. E., & Westwood, D. A. (2015). Investigating visual attention during scene perception of safe and unsafe occupational performance. *Canadian Journal of Occupational Therapy*, *82*(4), 224–234. https://doi.org/10.1177/0008417414568010

Malcolm, G. L., & Henderson, J. M. (2010). Combining top-down processes to guide eye movements during real-world scene search. *Journal of Vision*, *10*(2), 1–11. https://doi.org/10.1167/10.2.4

McDuff, K., Benaim, A., Wong, M., Burley, A., Gandhi, P., Wallace, A., Brooks, D., Vaughan-Graham, J., & Patterson, K. K. (2021). Analyzing the eye gaze behaviour of students and experienced physiotherapists during observational movement analysis. *Physiotherapy Canada*, *73*(2), 129–135. https://doi.org/10.3138/ptc-2019-0047

Milosavljevic, M., Koch, C., & Rangel, A. (2011). Consumers can make decisions in as little as a third of a second.

Judgment and Decision Making, *6*(6), 520–530. https://doi.org/10.1017/S1930297500002485

Morgan, K. A., Engsberg, J. R., & Gray, D. B. (2015). Important wheelchair skills for new manual wheelchair users: health care professional and wheelchair user perspectives. *Disability and Rehabilitation: Assistive Technology*, *12*(1), 28–38. https://doi.org/10.3109/17483107.2015.1063015

Pettersson, I., Ahlström, G., & Törnquist, K. (2007). The value of an outdoor powered wheelchair with regard to the quality of life of persons with stroke: A follow-up study. Assistive Technology, *19*(3), 143–153. https://doi.org/10.1080/10400435.2007.10131871

Rushton, P. W., & Daoust, G. (2019). Wheelchair skills training for occupational therapy students: Comparison of university-course versus “boot-camp” approaches. *Disability and Rehabilitation: Assistive Technology*, *14*(6), 595–601. https://doi.org/10.1080/17483107.2018.1486468

Sakakibara, B. M., Miller, W. C., Souza, M., Nikolova, V., & Best, K. L. (2013). Wheelchair skills training to improve confidence with using a manual wheelchair among older adults: A pilot study. *Archives of Physical Medicine and Rehabilitation*, *94*(6), 1031–1037. https://doi.org/10.1016/j.apmr.2013.01.016

Schriver, A. T., Morrow, D. G., Wickens, C. D., & Talleur, D. A. (2008). Expertise differences in attentional strategies related to pilot decision making. *Human Factors, 50*(6), 864–878. https://doi.org/10.1518/001872008X374974

Torralba, A., Oliva, A., Castelhano, M. S., & Henderson, J. M. (2006). Contextual guidance of eye movements and attention in real-world scenes: The role of global features in object search. *Psychological Review*, *113*(4), 766–786. https://doi.org/10.1037/0033-295X.113.4.766

Tu, C. J., Liu, L., Wang, W., Du, H. P., Wang, Y. M., Xu, Y. B., & Li, P. (2017). Effectiveness and safety of wheelchair skills training program in improving the wheelchair skills capacity: A systematic review. *Clinical Rehabilitation*, *31*(12), 1573–1582. https://doi.org/10.1177/0269215517712043

World Health Organization. (2008). *Guidelines on the provision of manual wheelchairs in less resourced settings*. https://www.who.int/publications/i/item/9789241547482

World Health Organization. (2021). *Disability and Health*. https://www.un.org/development/desa/disabilities/resources/factsheet-on-persons-with-disabilities.html