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Usability of Eye Tracking for Studying the Benefits of E-learning Tutorials on Safe Moving and Handling Techniques.

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Abstract

Eye tracking is a measurement technology that quantifies the movement of eyes on a motive of interest, usually a screen. The technology has not before been used to evaluate the effect on e-learning used for teaching staff safe moving and handling techniques for moving patients. Based on four participants, we explored whether eye tracking could be used in combination with observations and interviews to assess the practical skills obtained after watching videos from an e-learning tutorial, teaching safe moving and handling techniques. The participants reported to obtain the most knowledge from what they saw in the video, rather than from what they heard or read. However, there was no clear correlation between time spent looking at Areas of Interests (AOI) in the videos and how the participants performed the safe moving and handling technique afterwards. Still eye tracking has potential as a measurement technology for providing objective knowledge that can be used to support qualitative data on the performance of practical skills in safe moving and handling techniques obtained by watching an e-learning tutorial.

Keywords:

Eye-tracking~~,~~e-Learning, Moving and Lifting Patients.

Introduction

It is estimated that about 40 % of all work injuries in the Danish healthcare system are caused by accidents related to moving and handling patients [1]. Interventions to reduce the risk of work injuries caused by the moving and handling of patients are often multi-dimensional. They generally include both the use of new patient-handling equipment, increased knowledge about safe moving and handling techniques and education and training in both use of equipment and techniques [2]. However, the principles and techniques taught on single courses are often not implemented in the workplace [3]. The limited effect of single courses calls for a more systematic and ongoing education regarding the use of patient-handling equipment and safe moving and handling techniques.

E-leaning in healthcare

E-learning is being used increasingly in healthcare as a flexible method to provide continuous education to healthcare professionals. Educational topics include practical skills such as safe moving and handling techniques. Over the last decades, the effect of e-learning in healthcare has been studied extensively. While some studies have failed to find evidence for the effect of e-learning compared to traditional education, others have found that e-learning had a positive effect on student knowledge and skills [4-6]. Despite discrepancies in the literature regarding the effects, there are several other advantages related to this type of education, such as flexibility and the ability to provide education for larger groups [6].

Only a few studies have assessed the effect of e-learning tutorials teaching safe moving and handling techniques. Harrington et al. concluded that there was a significant increase on the knowledge, and practices of nurses after completing an e-learning tutorial [7]. Similar results were found by Hayden et al., while Anderson et al. found that e-learning tutorials gave a better common interdisciplinary understanding and knowledge on safe moving and handling techniques [8,9].

The burden on the healthcare systems caused by the growing population of elders and dependents entail an increasing demand on healthcare professionals to possess the most recent knowledge in all areas. This demand can be difficult to accommodate by traditional education only [10]. Despite the uncertainty on the effect of e-learning tutorials in healthcare, it may be reasonable to expect that the use of e-learning in healthcare will continue to increase. Applying e-learning, it is possible to provide health care professionals with the most recent and relevant knowledge, despite time or location.

Eye tracking

Eye tracking has for the last decades been increasingly used to evaluate human-computer interaction [11]. Eye tracking is a measurement technology that can be used to obtain knowledge about where a person is looking on a motive of interest, usually a screen, for how long and in what sequences [11]. These measurements can be used to identify and analyze a person's visual attention or cognitive load while reading or searching the Internet [12]. In eye tracking, eye movements are typically processed and analyzed in fixations or saccades. A fixation is the period where the eye is relatively still, in order to capture the visual stimuli. A saccade is the series of quick movements that occur between two fixations. During a saccade the visual acuity is suppressed, meaning that visual stimuli are perceived during the fixations [12].

Most eye tracking studies deploy the eye-mind hypothesis published in 1980 by Just and Carpenter. According to this hypothesis, longer fixations are associated with a longer cognitive processing load [13]. Later studies have shown other results, but the general understanding is that the duration of a fixation can be used as an indicator of the degree of visual attention and of the complexity of the cognitive process, e.g. in learning [14,15]. However, the literature is scarce on eye tracking for evaluation of the obtained knowledge after using an e-learning tutorial. One study by Soh et al. tested student knowledge before and after completing an e-learning tutorial. In this study, the students both had a significant increase of 45% in the mean number of fixations and a decrease of 49% in the mean time to first fixation after using an e-learning tutorial [16]. The use of eye tracking for evaluating an e-learning tutorial on practical skills, such as safe moving and handling techniques, has not been found in the literature. Therefore, it was relevant to investigate the usability of eye tracking as a measurement technology for evaluating e-learning tutorials related to practical skills.

The aim of this study was to explore whether eye tracking in combination with the qualitative methods observation and interviews can be applied to assess practical skills obtained after watching e-learning videos regarding safe moving and handling techniques. Combining quantitative and qualitative methods using method triangulation, we could obtain a complementary objective and subjective knowledge on the correlation between a person´s visual attention, practical performance and experience when using an e-learning tutorial regarding safe moving and handling techniques.

Materials and Methods

Participants

Four participants accepted to participate in the study. The mean age was 29.5 (±4.5) years. All four participants were students from the master program in Clinical Science and Technology at Aalborg University, Denmark. Their bachelor degree varied, two of the participants were bachelors in nursing, one was an occupational therapist, and the last was a radiographer. The experience level among the participants varied, but none of the participants had attended any courses or had worked related to safe moving and handling techniques within the last two years.

Equipment

For this study we used a Tobii X2-30 eye tracker from Tobii Technology (Tobii AB, Stockholm, Sweden). The Tobii X2-30 has a sample rate of 30 Hz with an operating distance from eye tracker to participant on 40–90 cm (15.7–33.5″) and a gaze angle up to 36° [17]. The eye tracker was mounted at the bottom of a Dell Latitude E6540 laptop with a screen size of 15,6”.

E-learning tutorial

The Danish website, forflyt.dk, is administered by a non-profit organization (The Community of Work Environment for Welfare and Public Administration). This website contains an e-learning tutorial on safe moving and handling of patients. From this e-learning tutorial we chose 4 different videos, that demonstrated safe moving and handling techniques used in four different situations. The four situations were repositioning up in bed, hoisting from the floor, going from laying in a bed to standing upright and hoisting from bed to a wheelchair [18]

Each video contained both small video clips and still pictures with written text. Both the video clips and still pictures contained spoken text.

From the four videos we predefined 12 Areas of Interests (AOI). The predefined AOIs were chosen from a theoretical point of view and were all related to the demonstration of the correct use of different patient-handling equipment

Still pictures illustrating the 12 AOIs are shown in figure 1 and 2.

Figure 1-The AOI´s from video 1 and video 2

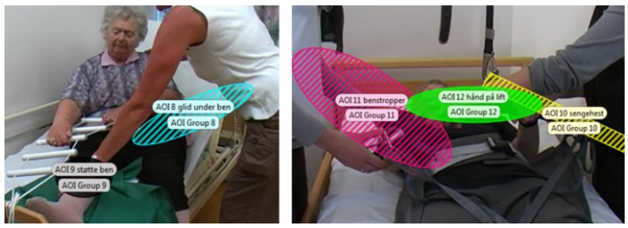

Figure 2- The AOI´s from video 3 and video 4

Study Design and Procedure

The procedure consisted of four sessions.

Before the beginning of the first session, a calibration procedure was carried out for each participant. During this calibration procedure the Tobii eye tracker measures the characteristics of the participants eyes and uses them together with an internal, physiological 3D eye model to calculate the gaze data. This individual model contains information on light refraction, shapes and reflection properties on different parts of the eye e.g. the placement of fovea, cornea etc. The measurements are stored in the Tobii Pro Studio Software, and therefore this procedure was only conducted prior to the participants watching of the first video [19].

In each session, the participants first watched a video demonstrating the use of patient-handling equipment and safe moving and handling technique in relation to a specific situation. While watching the videos, the participants' eye movements were measured using the Tobii X2-30 eye tracker. After watching the video, the participant performed the same safe moving and handling techniques as seen in the video.

After performing the safe moving and handling techniques, participants were interviewed on four questions relating to the video just seen.

Data Analysis

The data from the eye tracking recordings, the observations and interviews were all analyzed separately.

Data from eye tracking recordings

Data from eye tracking recordings were processed in the software program Tobii Pro Studio version 3.4.5. In this program, we drew the 12 AOIs, for all the 16 recordings (4 recordings for each of the four participants). Since there was a minor displacement between the video frames for the 16 recordings, the AOI was drawn one frame and one recording at a time. This way we could do the necessary relocations of the AOI according to the action in the underlying video. Only one AOI were activated at a time.
We also used Tobii Pro Studio to calculate the metrics for the individual and total fixation duration, and the number of fixations for the 12 AOIs from each participant.
Before calculating the metrics, we applied the Tobii I-VT filter. Amongst the I-VT filter presets, we chose to alter the following. Noise reduction was set to apply MovingMedian and a window size of 3 samples. Eye selection was set to Average to calculate data from both eyes when possible and on only one eye when both eyes could not be used. The Discard short fixations were set to discard fixations shorter than 80 ms.

The calculated metrics on the AOIs were then classified into seen or not seen using a threshold of 300 ms. If the participant's fixation on an AOI was longer than 300 ms, the fixation was classified as seen and given the value 1, and a 0 if the fixation were less than 300 ms.

Observations

The 16 recorded videos from the participants' practical performances were viewed and then classified as correct or incorrect performance. Correct performance was given the value 1 and an incorrect performance was given the value 0.

Interviews

The 16 interviews were processed as described by Kvale. The interviews were first transcribed and then coded into central themes. The central themes were then condensed into descriptive statements [20].

Combining data

The processed data from both the eye tracking and the observations for the AOIs of each video was combined in a matrix for each video. We then compared the matrix for each video and the interview data from the same video to qualify the matrix results using the participants' subjective statements.

Results

Video 1

The participants expressed that they obtained most knowledge from seeing the video, but also expressed that they found it difficult to see how specific techniques were performed. As shown in table 1, there was no correlation between seeing an AOI and performing it correctly, as none of the participants performed the moving and handling technique correctly.

Table 1- The results from eye tracking data and findings from observations, from video 1 (AOI no. 1-3)

Video 1	See		
Perform		Yes	No
	Yes	0	0
	No	6	6

Video 2

The results from this video indicated a minor correlation between seeing an AOI and performing it correctly, as shown in table 2 Data from the interviews showed that the participants felt that they obtained most knowledge from what they saw, but also what they heard. As reported on video 1, the participants were not always able to see clearly what was demonstrated. Also, the design of the video (mainly stops and repetitions) apparently made it difficult for the participants to remember what they had seen.

Table 2-The results from eye tracking data and findings from observations, from video 2 (AOI no. 4 – 7)

Video 2	See		
Perform		Yes	No
	Yes	7	5
	No	2	2

Video 3

Again, the participants reported that it was difficult to see the details, and that the lack of spoken text and design of the video made it difficult to remember. According to the results shown in table 3, only one AOI had been seen, while six AOIs had been performed correctly, indicating that there was no positive correlation between seeing an AOI and performing the technique correctly.

Table 3- The results from eye tracking data and findings from observations, from video 3 (AOI no. 8 – 9)

Video 3	See		
Perform		Yes	No
	Yes	1	5
	No	0	2

Video 4

Results from video 4, as seen in table 4, showed clear relations between having seen an AOI and performing it correctly and between not seeing it and not performing it correctly. Central themes found in the interviews were that the participants thought that even though they obtained most knowledge from seeing the video, there were still elements that they found disturbing, especially that the video depicted a healthcare professional playing a demented woman instead of just demonstrating a more neutral situation.

Table 4-The results from eye tracking data and findings from observations, from video 4 (AOI no. 10 – 12)

Video 4	See		
Perform		Yes	No
	Yes	5	2
	No	4	1

Discussion

The ability to perform safe moving and handling techniques requires practical skills and thus motor skills. Key factors when learning motor skills are the complexity, difficulty and recognizability of the specific task [21,22]. Two of the AOIs in video 1 were related to the use of a piece of slide sheet, which was folded using a special technique. Our results showed that even though two of the participants saw the AOIs, none of the participants performed the technique correctly. This could indicate that the task demonstrated in the AOIs was too difficult and complex for the participants to perform after seeing it only once. This was also reported by the participants in the following interview. When scoring the performance from the observation data, a correct performance required the participant to use the same technique as demonstrated in the video and not just any technique leading to the correct function of the slide sheet. If the performances were scored correct when the participant got the slide sheet to function in first attempt, the distribution of the matrix would have been different, as there would have been several of the participants who would have performed the task correctly.

The impact of complexity, difficulty and recognizability of tasks when learning motor skills may also influenced the results in video 2. As seen in Table 2 there was a minor tendency for a positive correlation between the number of AOIs that had been seen and a correct performance. Several of the AOIs for this video demonstrated the use of movements such as rolling, pushing and dragging. These movements contain motor skills that are probably more recognizable and intuitive for the participants, which could have had, an effect on their ability to transfer their knowledge from what they saw on the video to the performance [21,22]. This indicates that the AOIs were adequate in terms of complexity of the task demonstrated.

Movements relating to what is known as the natural pattern of movement may have influenced the results in video 3. Even though the participants expressed that they obtained most knowledge from what they saw, only one of the AOIs for that video was seen by a participant. Despite only one AOI being seen, the AOIs had been performed correctly in six out of eight cases. Both AOIs in this video were related to getting the patient's legs over the side of the bed, which is a common and intuitive movement for most people [21,22].

Another factor that may have influenced the results and findings could be the design of the videos in terms of camera angles and the use of spoken text.
As mentioned before, only one AOI in video 3 had been seen by a participant. In this video the two AOIs demonstrated an action related to the legs of the patient, which in the video were seen in on the left side corner. Studies show that people tend to gaze at faces and upper bodies and that they tend to gaze in the same area on a screen when seeing a scene [23,24]. It could be that the participants, when watching the video, have had their gaze on the patient's and assistant's faces and upper bodies and that they kept their attention in that area for this reason. Despite that there has only been one registered fixation above the 300 ms. threshold, it does not necessarily mean that the actions of the AOI were not perceived by the participants. Viewers are namely able to perceive and extract the gist of a scene from a brief 40-100 ms exposure [25]. It is possible that the participants, even by very short fixations got enough visual information to be able to perform the safe moving and handling technique correctly.

All videos involved a speaker telling what is being done in the video. The use of spoken text seems to cause increased visual attention [15,26]. In video 1, AOI no. 2 demonstrates an assistant moving a pillow, which is also told but without explaining why it is moved. All though this was seen by two participants, none of the four participants performed this AOI correctly. This could indicate that the verbal cue by the spoken text might have been to simple, not pointing out the relevance of why the pillow is moved. Also, the sequence is short, which could have caused participants to overlook it. Another example of an AOI not been performed by most of the participants is AOI no. 5 in video 2. This AOI demonstrates the how to apply a sling on a patient. The demonstration is not accompanied by spoken text but is quite long and takes 69 seconds. It was seen by three of the participants, but only performed correctly by one. This could indicate that despite the sequence being long, the lack of spoken text as a cue for guiding the visual attention could influence the participants' ability to perform it correctly. This could be supported by the results from video 4 where AOI no. 11 also demonstrates the application of a sling, but in this video, the demonstration is accompanied by spoken texts. All four of the participants saw the AOI and three performed it correctly, indicating that the spoken text had a positive influence on participant performance.

The results reported here suggest that even though the participants expressed obtaining most learning form what they saw, there were still a several factors, affecting their practical performance. Amongst the most important factors were difficulty in seeing how patient-handling equipment were used and the lack of spoken text to explain the correct usage. Also, the design of the video according to still pictures, repetitions i.e. were experienced by the participants as disturbing and making it difficult to remember the content of the video. As for the data from the eye tracking recordings and observations there were no clear correlation in the four videos, which was probably due to several factors, such as our choice of AOI according to the difficulty and complexity of the demonstrated technique, the difference in the design of the videos and our criteria for scoring the observations.

Conclusion

Including eye tracking in method triangulation has a potential for providing knowledge on the correlation between what a person sees, performs and experience, i.e. what people unconsciously focus on vs. the intended learning outcomes in the e-learning tutorial. This can be used to optimize usability tests and e-learning tutorials, in which the main purpose is to facilitate learning involving physical performance.

Limitations and further studies

Based on this study's strengths and limitations and the lack of similar studies, further research using a corresponding approach could provide more data to examine if it is possible to detect a more clear and detailed pattern, involving duration of fixations and the physical performance, to make stronger conclusions to validate eye tracking as a tool in assessing e-learning tutorials. Further studies could also include RCT studies, where pre- and posttest can determine whether there are differences in fixation times for respectively a control group that receives traditional education and an experimental group that receives education by an e-learning tutorial.

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