Healthcare and Medical Devices, Vol. 171, 2025, 69–80
https://doi.org/10.54941/ahfe1006192

Elicitation of Risk Perception Strategies in Emergency Rooms Based on KYT Technique and Eye Tracking Stimulated Retrospections: Comparisons Between Doctors and Nurses

Hirotaka Aoki[1], Koji Morishita[2], Takanori Urano[2], Tomohiro Adachi[2], Mai Kinoshita[2], and Atsushi Kudo[2]

[1]Shibaura Institute of Technology, Tokyo, Japan
[2]Institute of Science Tokyo, Tokyo, Japan

ABSTRACT

In the present paper, we aim at eliciting risk perception strategies from medical doctors and nurses in emergency rooms (ERs). To analyze the typical cognitive processes in ERs, the KYT (Kiken Yochi Training, hazard prediction training in English) technique is adopted. A series of KYT-styled experiments in which fifteen medical doctors majoring in emergency and critical care medicine and fourteen nurses participated are carried out. In risk perception strategy elicitation processes, a series of cognitive task analyses including an effective debriefing procedure aided by eye movement recordings as well as eye movement data interpretation scheme are developed and applied to identify individual risk perception strategy and its characteristics.

Keywords: Risk perception, Expertise analysis, Elicitation of skilled strategy, Acute care surgery, Eye movement analysis

INTRODUCTION

In emergency rooms (ERs), various kinds of patients in severe conditions who need appropriate primary care come without any prior appointment. From patient safety point of view, one of the most critical clinical processes of medical staffs in ERs (e.g., doctors, nurses, co-medicals and so on) is to detect symptoms that may relate to potential risks/hazards to prevent severe incidents/accidents. These processes should be performed very rapidly. The detecting processes can be characterized as mixture of intuitive and analytical processes. In some cases, the former process (i.e., intuitive process) seems to be a key factor to enhance the level of safety since this enables us to perform quick counteractions to potential risks/hazards. However, it is usually difficult to analyze the detecting processes including intuitive processes since they are automated and performed unconsciously.

In the present paper, we apply a combinatorial approach in which both of effective debriefing procedure aided by eye movement recordings and

eye movement data interpretation scheme are used to elicitations of risk perception strategies in ERs. This is because it has been suggested that eye movement recordings have a great potential ability for analyzing human perceptual/cognitive processes that are performed automatically such as skill- and rule-based behaviors (e.g., Rasmussen, 1986). The underlying idea of the methodology used for the elicitation of inner strategies in medical domain here is based on the authors prior research (Aoki et al., 2023).

The objective of the present paper is to elicit individual risk perception strategy of medical staffs in ERs, and to clarify its characteristics. To emulate real conditions found in ERs, we adopt simplified Kiken Yochi Training (KYT). The original version of KYT or hazard prediction training is a method that was developed in Japan (e.g., Ito et al., 2014) KYT is a practice on identifications of potential hazards in photos/illustrations of specified workplaces and group discussions about hazardous factors found (e.g., Ji, 2014). Through the training sessions including discussions, it can be expected that participants identify and understand types of potential hazards/risks in the specified workplace, and determine action plans rapidly and appropriately. In the present study, we adopt a simplified procedure of KYT to replicate the real working condition.

SIMPLIFIED KYT-STYLED EXPERIMENT

Participant

Fifteen doctors majoring in emergency and critical care medicine and fourteen nurses participated in our experiment. The fifteen doctors included two groups of eleven specialists and four residents. The mean year of experience of doctor in specialist groups was 14.4, and its range were from 7 to 26 years. The fourteen nurses included three groups of three experts, five senior and six junior nurses. The mean year and its range of experience were 23.3 (21-27), 13.2 (7-17) and 3.3 (2-6) for expert, senior and junior nurses, respectively. Expert and senior nurses having approximately 7 year of more experience could take roles of “leaders” who are responsible for the nurses’ tasks at ER/ICU in the hospital.

Ethics approval was granted by the Shibaura Institute of Technology Review Board (24-010) and the Institute of Science Tokyo Review Board (2023227 and M2023-216) All participants were provided written informed consent prior to the experiment.

Table 1: Photos used in the experiment.

Photo ID	Scene Depicted	Salient Risks/Hazards Predicted by Authors
1	An aged male patient who is mechanically ventilated is lying in a bed in an ICU room. He is under restraint.	An unusually equipped tube. Inappropriate restraint.

Continued

Table 1: Continued

Photo ID	Scene Depicted	Salient Risks/Hazards Predicted by Authors
2	An aged male patient's position is changed by two nurses in an ICU room. H is mechanically ventilated.	Accidental decannulation.
3	An aged male patient seems to sit up in bed. He is equipped a urinary catheter.	Accidental decannulation/ decatheterization. Falls.
4	A patient equipped an extracorporeal membrane oxygenation (ECMO) in a bed is moved by doctors and a clinical engineer.	Accidental decannulation.
5	A group of doctors and nurses are performing an emergency surgery (operation for a thoracotomy) in an ER.	High workload and time-pressure caused by a patient's severe condition.
6	A room for initial care is shown.	N/A

Photos Exposed

Six photos taken in the ER/ICU at the hospital were shown to participants. In four out of five photos, a patient in various conditions are depicted. The last photo showed a scene of the room for primary care. The scenes shown in the photos are summarized in Table 2.

Task

The experimental task was to determine what should do in the situation shown in four photos (i.e., Photos 1 to 5). Each participant was asked to assume that he/she came to the scene in daily working conditions. He/she was asked to decide what he/she should do (e.g., try to communicate with a patient immediately) at the given situations. Additionally, a participant was asked to give his/her recognitions about the followings: how much he/she should do the action decided in two levels (necessary and only when available) and what potential risks/hazards were found. As for photo 6, a participant was asked to assume that he/she was waiting for a patient who would come by an ambulance. He/she was asked to check whether all the medical equipment/devices are set or not.

Procedure

Upon arrival at our experimental site, each participant was briefed on the overall objective of the experiment, the tasks to be conducted, debriefing procedures in which eye tracking data are used as cues and calibration procedure of the eye tracker (Tobii X-3 120, Sweden). Before starting experimental task sessions, a participant completed one practice circuit using a typical example of an illustration. This illustration (not a photo) showed a scene in which an aged female inpatient was having a dose of her medicine by herself in a bed. After carrying out calibration for the eye tracking system,

experimental tasks using six photos were started. After seeing each one of photos 1-5, a participant verbally reported his/her action decided very briefly. After seeing photo 6, he/she reported whether the room shown was available or not for initial care. Eye tracking data during all the task were recorded. The experimental environment is shown in Figure 1.

Figure 1: Experimental environment (photo 4).

After the experimental task, a debriefing session in which eye tracking data were shown to the participant started. In the debriefing session, eye tracking data recorded while seeing photos were shown to each participant. With the participant's own eye tracking data, a series of questions were given to the participant in a semi-structured interview style. The questions were developed to elicit risk perception strategies. The question categories and their typical question items are summarized in Table 2.

Table 2: Question categories and their example question items.

Category	Cognitive Aspects to be Elucidated	Example Question Items
Risk/hazard perceived	Risks/hazards that should be solved.	Did you find some risk/hazard which should be counteracted immediately?
	Risks/hazards that are counteracted appropriately.	Did you find something that may be a risk/hazard but was counteracted appropriately?
Action	Planned actions that he/she would take in the give situation.	Considering the situation shown, did you have something you'd like to do immediately? What did you like to do? How much do you think it was necessary to do so? (only if the answer to the above-mentioned question is yes)

Continued

Table 2: Continued

Category	Cognitive Aspects to be Elucidated	Example Question Items
Situation awareness	First impression and its reason	What was your first impression? Did you feel that the scene involved something problematic or not?
	Areas attended first	In what part did you see first? What part attracted your attention first? etc.
	First impression and its reason	You mentioned that your first impression was positive/negative, why?
	Areas to which much attention are paid intentionally	Were there any area to which you paid much attention?
	Holistic perception strategy	Throughout observing the situation, what were your key objectives?
Others	Lessons learnt by seeing own eye tracking data	Did you find something from your own eye tracking data?

RESULT

Risks/Hazards Detected

Among photos 1-6, photo 1 shows a typical scene found frequently. The photo shows a scene where a mechanically ventilated patient is lying under restraint condition in an ICU room. In this paper, we focus on the photo. Before analyzing data, we performed preliminary risks/hazards detection with the following two experts: A professor of acute critical care and disaster medicine (second author) and a head nurse of the trauma and acute critical care medical center (fifth author). The two experts carefully examined the photo individually, and identified possible risks/hazards found in the scene. They included not only the potential risks/hazards, but those which seemed very scarce. Additionally, each of experts gave a rating to each risk/hazard as very important, important or trivial/not-likely from their perspectives of a skilled medical doctor and nurse.

Table 3 shows the potential risks/hazards identified by the two experts and the percentages of participants (doctors and nurses except two experts) who mentioned the corresponding risk/hazard in their first impression. In this analysis, the risk/hazard mentioned in the beginning part of the interview is focused. The data does not mean that the participants missed the risk/hazard in the experiment. In the following interview sessions, additional risks/hazards were mentioned by most of the participants. We are discussing what risk/hazard was pointed out by participants first.

As shown in the table, twenty-four risks/hazards were identified by the experts. The potential risks/hazards are classified into four groups. The

risks/hazards that are recognized as very important ones by both experts are classified into the first group. The risks/hazards that are recognized as very important only by only the expert doctor (Professor in medicine) are classified into the second group, and those that are recognized as very important only by the expert nurse are classified into the third group. The rest are classified into the fourth group.

Notable tendencies could be found in the table. It seems that the accidental decatheteraization of tracheotomy tube is a key risk/hazard perceived by both of doctors and nurses. Considering the facts that the number of risks/hazards that are not mentioned by doctors in the first impression is higher than those by nurses, we may be able to say that the doctors tended to focus on a little specific risks/hazards (i.e., medical treatment related risks/hazards). Nurses, on the other hand, may tend to focus on medical treatment related risks/hazards and environment-related ones (e.g., uncomfortable posture of a patient).

Table 3: Percentages of participants who mentioned potential risks/hazards in their first impressions.

Group	Potential Risk/Hazard	Participant	
		Dr	Ns
1. Very important from both of doctors' and nurses' point of view	The level of vital sign may be abnormal	20.0%	11.1%
	The ventilator shows an abnormal value	30.0%	22.2%
	Accidental decatheterization of tracheotomy tube	60.0%	88.9%
	Accidental decatheterization of drain	0%	11.1%
	Cuff pressure tube may be damaged	0%	11.1%
	Thrombus in legs	30.0%	0%
	Accidental disconnection of lines	10.0%	11.1%
2. Very important from doctors' point of view	Lack of oxygen for patient	10.0%	0%
	Falls	40.0%	11.1%
	Pressure ulcers	0%	0%
	Pulmonorary aspiration (water of humidifying device)	0%	11.1%
	Uncomfortable posture	0%	22.2%
	Pressure marks from a foot pump	0%	11.1%
3. Very important from nurses' point of view	Hard to see waveforms of end-tidal CO_2	30.0%	11.1%

Continued

Table 3: Continued

Group	Potential Risk/Hazard	Participant	
		Dr	Ns
	Pulmonorary aspiration/vomition (pilot balloon)	0%	11.1%
	Aspiration pneumonia (feeding tube)	40.0%	22.2%
	Accidental disconnection of cuff pressure tube	10.0%	22.2%
4. Others	Asphyxia	10.0%	0%
	Unnecessary tubes on the ground	10.0%	22.2%
	Untidy drain	0%	11.1%
	Difficulty of communication with the patient	0%	11.1%
	Difficulty of immediate actions	10.0%	0%
	Patient's privacy	0%	0%
	Risk of hypothermia	0%	0%

Attentional Allocation Strategies Elucidated by Eye Tracking Data

In the analysis of tendencies of attention allocation during observing the situation shown in the photo, total fixation durations for areas of interest (e.g., a patient and objects found in the scene) were calculated. Table 4 shows the cumulative percentages of the total fixation duration for each area of interests for each participant group. The areas are listed in the order of duration of fixations for each group. From the percentage, we identified areas contributing to approximately 80% of total fixation duration. Such areas can be characterized as areas including "key information" since each participant group paid most of their attention to the specific area as an overall trend. The areas characterized as "key information" for each participant group are italicized in Table 4.

The table seems to show differences caused by participants' background and their experience very clearly. Doctors showed relatively lower numbers of key information compared to nurses. This implies that nurses paid attention to the much more widely compared to doctors. In doctors, specialists who have enough knowledge and experience paid attention more widely than residents. This can be interpreted that the novice focused on only very limited areas which were directly connected with critical information.

It may be conjectured that the clear tendency found here is attributed the same cause discussed in Table 3. Doctors may observe medical treatment related areas mainly, and nurses may observe both of medical treatment related areas and environment-related areas. This seems to indicate the importance and effectiveness of a team of doctors and nurses for efficient and safe operations in a hospital.

Table 4: Cumulative percentages of total fixation duration for each area for each participant group (key information exceeding approx. 80% are italicized).

Dr.		Ns.							
Specialist		Resident		Expert		Senior		Junior	
Vital sign monitor	17.3%	*Patient's face*	22.3%	*Patient's face*	12.1%	*Ventilator*	8.5%	*Patient's face*	21.3%
Ventilator	33.7%	*Enternal nutrient*	40.4%	*Breathing tube*	22.5%	*Bed side guard*	17.1%	*Breathing tube*	34.1%
Patient's face	46.8%	*Vital sign monitor*	58.5%	*Ventilator*	31.3%	*Enternal nutrient*	24.9%	*Enternal nutrient*	41.3%
Enternal nutrient	57.6%	*Ventilator*	70.5%	*Vital sign monitor*	39.5%	*Vital sign monitor*	32.5%	*Bed side guard*	47.8%
Bed side guard	63.5%	*Breathing tube*	76.6%	*Enternal nutrient*	46.5%	*Patient's face*	40.0%	*Foot pump (left leg)*	52.4%
Breathing tube	67.3%	Tracheotomy tube	80.6%	*Bed side guard*	53.2%	*Foot pump (left leg)*	45.0%	*Vital sign monitor*	56.8%
IV drip	70.1%	Foot pump (left leg)	84.1%	*IV drip*	56.1%	*Breathing tube*	49.4%	*Ventilator*	61.0%
Foot pump (left leg)	72.8%	Bed side guard	85.2%	*Foot pump (left leg)*	58.9%	*IV drip*	52.0%	*Tubes (cuff pressure)*	63.3%
Power supply tap	75.2%	Foot pump (right leg)	86.1%	*Sphygmomanometer (cuff pressure)*	60.7%	*Bed side guard*	54.1%	*Oxygen cylinder*	64.8%
Tracheotomy tube	77.0%	Power supply tap	86.9%	*Power supply tap*	61.9%	*Heating and humidifying device*	55.6%	*Cables of a sphygmomanometer*	66.4%
Oxygen cylinder	78.3%	Heating and humidifying device	86.9%	*Tubes (cuff pressure)*	62.9%	*Mittens*	56.7%	*Sphygmomanometer (cuff pressure)*	67.3%
Sphygmomanometer (cuff pressure)	79.5%	IV drip	86.9%	*Tracheotomy tube*	64.0%	*Retraining band*	57.6%	*Tracheotomy tube*	68.1%
Right toes	80.4%	Sphygmomanometer (cuff pressure)	86.9%	*Foot pump (right leg)*	64.9%	*Right toes*	58.4%	*Mittens*	68.4%

Continued

Table 4: Continued

Dr.	Ns.								
Left toes	80.7%	Mittens	86.9%	*Heating and humidifying device*	65.8%	*Power supply tap*	59.1%	*Heating and humidifying device*	68.4%
Tubes (cuff pressure)	81.0%	Cables of a sphygmomanometer	86.9%	*Oxygen cylinder*	66.6%	*Tracheotomy tube*	59.8%	*IV drip*	68.4%
Retraining band	81.2%	Oxygen cylinder	86.9%	*Right toes*	67.3%	*Cables of a sphygmomanometer*	60.4%	*Power suply tap*	68.4%
cables of a sphygmomanometer	81.3%	Tubes	86.9%	*Retraining band*	68.1%	*Foot pump (right leg)*	61.0%	*Foot pump (right leg)*	68.4%
Foot pump (right leg)	81.4%	Retraining band	86.9%	*Cables of a sphygmomanometer*	68.4%	*Tubes (cuff pressure)*	61.4%	*Retraining band*	68.4%
Heating and humidifying device	81.4%	Right toes	86.9%	*Mittens*	68.6%	*Left toes*	61.8%	*Right toes*	68.4%
Mittens	81.4%	Left toes	86.9%	*Left toes*	68.7%	*Oxygen cylinder*	62.1%	*Left toes*	68.4%

Risk Perception Strategies Interpreted by Eye Tracking Stimulated Retrospections

In this section, possible strategies taken when observing the scene in Photo 1 are focused. By classifying the comments obtained in the eye tracking stimulated retrospections, the strategies attributed to each participant group were elicited inductively. Table 5 shows the preliminary results of strategies inferred and their corresponding comments.

Table 5: Strategies inferred by comments obtained in retrospections stimulate by eye tracking data.

Participant Group	Example Comments Obtained by the Eye Tracking Stimulated Retrospections	Typical Strategy Inferred Preliminarily
Dr Specialist	The breathing tube was the most salient at the very beginning of observation. I always check the vital sign monitor, ventilator, nutrient etc. that are directly connected to some medical device. I tend not to see the retaining bands first. I check the situation of IV drips. Additionally, I always pay attention to the face of patient because it gives much information. In this case, I felt that the patient's arousal level seems a bit low. Also I see the bed side guard which is my routine.	Taking very rational/logical routine processes at any moment from effective medical treatment point of view
Resident	I cannot see the waveforms from vital sign. I check a power supply tap only when it is needed. For example, when an echo is used. I don't pay attention to the cables of a sphygmomanometer because it is most likely that they work well without problems. I didn't mention about the ventilator because I felt that it worked well.	Examining specific information mostly in event-driven style or those which are directly related to the patient's condition in general
Ns Expert	I always look at a patient' face and a ventilator first because I know that they are very important. I don't change how to observe a patient depending on how much I know him/her. I check the power supply tap because this may interrupt for us.	Taking very rational/logical routine processes at any moment from effective medical treatment and nursing point of view

Continued

Table 5: Continued

Participant Group	Example Comments Obtained by the Eye Tracking Stimulated Retrospections	Typical Strategy Inferred Preliminarily
Senior	I always glance at a patient's face. Only when I have a patient whom I'm responsible for, I check the oxygen cylinder very carefully in my bedside rounds. I always check the patient's clothes to find issues relating to posture.	Taking rational/logical routine processes at any moment from effective medical treatment and nursing point of view, the process may differ depending on individuals
Junior	I know that the nutrient has a critical risk of pulmonary aspiration. Only when I have a patient whom I'm responsible for, I check the oxygen cylinder very carefully in my first bedside rounds. I see a patient's face first because we nurses have to communicate with a patient when entering an in-patient room.	Examining specific information mostly in event-driven style or those which are directly related to the patient's condition in general

The strategies inferred seem to be relating to the experience/expertise of the participants. As found in the table, the way of observation seems more systematic and sophisticated along with the level of expertise. The doctors/nurses having sufficient experience and knowledge seem to have very stable cognitive routines in their observations. In resident and junior nurses, their observation processes seem to be driven by events, or they follow basic knowledge related to patient safety.

CONCLUSION

This paper shows characteristics of observation strategies in ERs emulated by a simplified KYT technique. The strategies were elicited by combinations of eye tracking data analysis and retrospections stimulated by eye tracking data. We carried out a series of experiments in which doctors and nurses performed risk perceptions, and identified the tendencies of visual attention allocations, key information and possible strategies during observations for each participant group. In our plan, we will continue analyzing all data (i.e., photos) obtained in the experiment. We will identify the attention allocation processes and strategies taken for other scenes, and their relations with the levels of performance and effectiveness. In addition, we plan to deploy our approach to educational tools, especially for novice doctors and nurses, to avoid overlooking.

ACKNOWLEDGMENT

This research was supported by the Tokyo Institute of Technology-Tokyo Medical and Dental University joint research fund and the Shibaura Institute of Technology research fund. We would like to acknowledge doctors and nurses at the trauma and acute critical care medical center, Institute of Science Tokyo Hospital for their participation in our research.

REFERENCES

Aoki, H. Morishita, K. Takahashi, M. Machida, R. Kudo, A. Kishino, M. Shirai, T. (2023) "Expertise Analysis in Chest X-Rays Diagnosis based on Eye Tracking Stimulated Retrospections: Effective Diagnosis Strategies in Medical Checkup Condition", proceedings of the Twenty-Fifth International Conference on Human Computer Interaction, Copenhagen, Denmark.

Ito, K. Taguchi, H. Fujinami, K. (2014). Posing Questions during Experimental Operations for Safety Training in University Chemistry Experiments, International Journal of Multimedia and Ubiquitous Engineering Volume 9, No. 3.

Ji, H. J. (2014). A Study on Safety Culture Construction for Coal Mine, Applied Mechanics and Materials Volumes 644–650.

Rasmussen, J. (1986). Information processing and human-machine interaction: An approach to cognitive engineering, New York: Elsevier.