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Quantifying Eye Tracking between Skilled Nurses and Nursing Students in Intravenous Injection

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Abstract. In nursing education, it is important that nursing students acquire the appropriate nursing knowledge and skills which include the empirical tacit knowledge of the skilled nurses. Verbalizing them is difficult. We paid attention to the eye tracking at the time of the skill enforcement of expert nurses and the nursing students. It is said that the sight accounts for 70% higher than of all sense information. For the purpose of the learning support of the tacit nursing skill, we analyzed the difference of both including the gaze from an actual measured value with the eye mark recorder. In the results the nurses particularly address the part related to inserting a needle among the other actions, they should move their eyes safely, surely, and economically along with the purposes of their tasks.

Keywords. Nursing skill, Eye Tracking, Tacit Knowledge, Learning support, Intravenous Injection

1. Introduction

In nursing education, it is important that nursing students acquire the appropriate nursing knowledge and skills which include the empirical tacit knowledge of the skilled nurses. Verbalizing them is difficult, so the passing down them are our big tasks. In this study, we paid attention to the eye tracking at the time of the intravenous injection skill enforcement of expert nurses and the nursing students. It is said that the sight accounts for 70% higher than of all sense information [1]. For the purpose of the learning support of the tacit nursing skill, we analyzed the difference of both including the gaze number of times for eyes trend, a gaze part and gaze duration from an actual measured value with the eye mark recorder. Based on these results, we will suggest the self-learning support system of tacit nursing skills.

2. Methods

The participants were 31 nurses who consented to participation in the present research (with over five years of clinical experience and able to conduct intravenous injections

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alone) and 30 nursing students (who had acquired credits of nursing skills 6 or more months prior).

2.1. Experiment method

Experiments were conducted in the following order:
(1)Before the intravenous injection experiment, students were asked to review lecture materials and skill videos so that they would be able to imagine conducting the procedure by themselves.
(2)Each participant wore an eye mark recorder (EMR-8B; nac Image Technology Inc.) for calibration.
(3)The patients, actually an infusion and a blood col-lection trainer (Adam Rouilly), were in a sitting position. Intravenous injection was conducted after two tests to let the participants get used to tools, procedures, and models. The whole scene during the experiment was recorded (Figure.1).

Figure 1. Scene of the experiment.

2.2. Analytical method

For analysis of eye tracking data obtained from the eye mark recorder and processed by eye tracking analytical software, we used EMR-dFactory (hereinafter "dFactory") (nac Image Technology Inc.), which enables observations of every frame (about 33 ms) of the data (Figure 2).

The analysis covered the basic actions of intravenous injection process: from having a patient wear a tourniquet, selecting the vessel to insert the needle, sterilizing the skin, inserting the needle, confirming that there is no blood reverse flow, releasing the tourniquet from its clip, injecting liquid medicine, pulling out the needle, to cleaning up. In terms of the six sites, the patient's arm, puncture point, the tourniquet, patient's face, articles, and the syringe were the main sites attracting the gaze of participants (the starting points from which a participant's eyes were tracked), we confirmed and categorized which site the eyes were placed on every frame, visualizing the nurses' and nursing students' eyes behaviors in chronological order for comparison. Additionally, calculating the total gaze time of the nurses and students, the average of ratio of each site's gaze time to the total gaze time, and average of ratio of each site's number of gaze times to the total number of gaze times, we examined the difference between both groups using Student's *t*-test.

Regarding data at locations other than the six sites, such actions as wearing rubber gloves for medical treatment and removing a cap from a syringe, which were not directly related to injecting skills and for which the action (gaze) time varied depending among participants, we regarded them as gaze points "others (between each task)" and

excluded them from the present analytical targets of gaze time and number of gaze times.

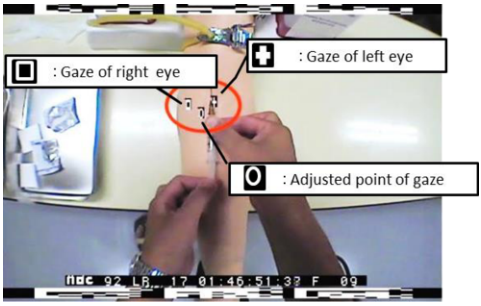

Figure 2. Field of vision of the eye mark recorder and the point of gaze.

2.3. Ethical considerations

This study was approved by the university to which the authors belong. We explained to participants the following in writing and obtained their consent: participation is based on free intentions of participants; non-participation is not disadvantageous for non-participants; anonymity is guaranteed; this experiment was not conducted to evaluate any participant; withdrawal from the study is possible at any time.

3. Results

From the results, participants with incomplete gaze point eye mark recorder data were excluded from analysis. Results show that the targets for eye tracking analysis consisted of 18 nurses and 17 nursing students.

3.1. Gaze movement of nurses and nursing students

Regarding the movement of gaze parts from tying a tourniquet to taking needle and cleaning up, figure 3 and figure 4 respectively portray one case of nurses and nurse students. The vertical axis represents gaze sites and the horizontal axis, time, showing the time-series change of gaze locations of participants as gaze movement. The gaze time of each part of a nursing student was longer than that of a nurse. Generally, students took more time to work on anything. Especially, the gaze time "Others (between each task)," which was not related directly to intravenous injection, was longer, and also the time spent before inserting a needle (the time taken while the gaze point moved to the "puncture point") was longer.

3.2. Ratios of each part gaze time to the total gaze time of nurses and students

The averages of total gaze time of the nurses and students were, respectively, 77.2±23.5 s and 92.2±30.9 s. The gaze time of the former was shorter by about 15 s. The ratios of each part gaze time to the total gaze time of the nurses and students are shown in Table 1. Among the nurses, the ratio of gaze time of the "puncture point" was more than that of the students (p<0.05). Among the students, the ratio of gaze time of

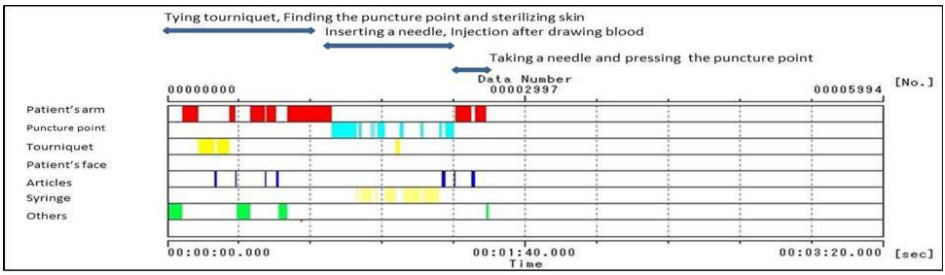

Figure 3. Example of the time-series gaze part of a nurse.

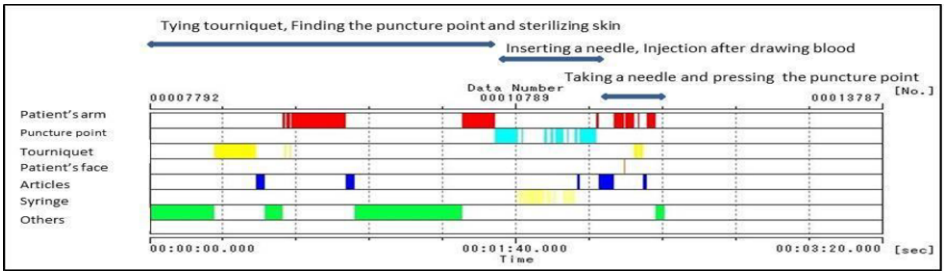

Figure 4. Example of the time-series gaze part of a nursing student.

"article" and "tourniquet" was more (p<0.05).

3.3. Number of gazes by part

The averages of total number of gaze time of the nurses and students were, respectively, 36.2±10.8 times and 40.4±13.4 times. The numbers of gazes by part are presented in Table 2. Compared with the nurses, the students tended to take more glances of each part, significantly more of the "patient's arm" and the "patient's face" (p<0.05). Although no significant difference was found, the students tended to take more glances at "article" and "tourniquet"; the nurses tended to take more glances at the "puncture point."

4. Discussion

With gaze movement, although the nurses had a longer gaze time on the "patient's arm" before inserting a needle, the students had longer gaze time on "articles" and "others" (Figure 3, Figure 4). Additionally, the results of the mean gaze number of times in each part for the whole practice (Table 2) shows that the students took more glances at the "patient's arm" and "articles" than the nurses did, suggesting that their eyes were not fixed; they were frequently diverted. Kawai[2] reports that when nursing students had not completed their own pattern for patient observation yet, their eyes were dispersed and their viewpoint for observation was not fixed. In the present study, students who had not mastered the movement image of intravenous injection sufficiently also moved their eyes repetitively from the patient's arm to the articles, which required them to move their eyes with every movement.

In contrast, the nurses' gaze time on the "puncture point" was significantly longer than the students' (Table 1), and the number of gaze times tended to be more only on the

Table 1. Mean of ratio of each part gaze duration for the whole practice

		Ave.gaze ratio		Standard deviation
Patient's arm	Nurse	39.2%	±	9.8%
	Student	43.1%	±	8.7%
Puncture point	Nurse	25.4%	* ±	8.3%
	Student	17.7%	±	6.9%
Syringe	Nurse	13.9%	±	6.1%
	Student	11.2%	±	7.1%
Articles	Nurse	8.5%	* ±	3.4%
	Student	11.8%	±	4.7%
Tourniquet	Nurse	13.0%	* ±	4.4%
	Student	15.4%	±	4.8%
Patient's face	Nurse	0.0%	±	0.1%
	Student	0.7%	±	1.1%

(*p<0.05)

Table 2. Mean gaze number of times in each part for the whole practice

		Ave.gaze number of times		Standard deviation
Patient's arm	Nurse	9.1	* ±	2.5
	Student	11.5	±	3.6
Puncture point	Nurse	9.6	±	5.0
	Student	8.8	±	4.3
Syringe	Nurse	6.8	±	4.4
	Student	6.8	±	4.0
Articles	Nurse	5.8	±	1.9
	Student	6.5	±	3.3
Tourniquet	Nurse	4.9	±	2.3
	Student	5.8	±	2.4
Patient's face	Nurse	0.1	* ±	0.2
	Student	1.0	±	1.4

(*p<0.05)

"puncture point" (Table 2). It is presumed that the nurses' gaze time and number of gaze times on the "puncture point" should be more than those on other parts to elucidate the situation of blood vessels precisely, which varies depending on patients, even if they are accustomed to intravenous injection. In other words, particularly addressing the part related to inserting a needle among the other actions, the nurses should move their eyes safely, surely, and economically along with the purposes of their tasks.

The nursing students described "procedures and placement of articles" as keys of intravenous injection practice, which differed from the nurses [3]. Their gaze movements suggested that many useless actions were spent "others," which were not related directly to intravenous injection skills. To reduce them as priorities, it is necessary to develop a self-learning support system by which the learners can follow the gaze movement of a skilled nurse for image training and introspective learning.

To develop a self-learning support system of nursing skills, the quantification of gaze movements conducted in this research is expected to be meaningful as a method to formulate the skills and knowledge of nurses which have been tacit. Currently, we have produced a trial product of the system proposed in this paper. We are evaluating it in future studies.

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