

## Risk Prediction Education Using Presentations on Evaluating the Processing of Visual Information

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### Abstract

The aim of the present study was to clarify how an educational presentation on risk prediction affected the ability to process visual information. A randomized controlled experiment was conducted with 34 nursing students, who were divided into a visual-only group and an audio-visual group. The informational presentation used images obtained using an eye mark recorder, which recorded the gaze trajectory and gaze point actually observed by the individual, and the educational strategy was evaluated using the eye mark recorder. A Wilcoxon test was conducted to compare performances before and after the presentation for each group, and a Mann-Whitney test was used to compare the visual-only and audio-visual groups. We found that four items changed between the first and second experiment: (1) shorter duration of observation, (2) prolonged mean duration of gaze pauses, (3) an increase in the number of eye marks, and (4) an increase in the number of eye marks coinciding with gaze points. Results suggest that the difference in style of informational presentation didn't have a large impact on eye movement, audio-visual stimulation helped subjects make judgement during their subsequent observations and visual reflection helped to retain the risk factors in long term memory.

**Keywords:** Nurse; Risk prediction; Information presentations; Eye movement

### Introduction

To provide a pleasant environment for patients, it is important to create an environment that is experienced as safe and comfortable, as well as free from medical dangers [1]. By continuously evaluating their patients, nurses play an important role in predicting errors and risks, thereby preventing accidents. Therefore, nurses must be able to assess risks accurately. Establishing effective teaching methods to improve this ability can be an educational challenge [2,3].

Because risk prediction education has often been evaluated by subjective indices [4], very little objective or quantitative data are available on what acquisition of information enables subjects to predict risks. Furthermore, problems regarding the sustainability of effective education have also been identified [5]. As a consequence, the development of efficient teaching methods in risk identification is greatly needed so that learners will not only acquire but retain the requisite skills and make a positive long-term contribution to clinical practice.

Recent studies [6] on risk prediction using an eye mark recorder (EMR) have reported on the use of this tool to acquire information [7,8] to assess the relationship with visual information processing [9,10] and to observe the eye movements of both the medical professional [11] and the patient; therefore, we can surmise that the EMR can also be utilized in nursing education.

In the present study, we used images obtained from the EMR as nursing education materials for predicting risks in the hospital environment. In addition, objective evaluations using the EMR were

performed to clarify how the presentation of information using images obtained from the EMR affected the ability to process visual information. Furthermore, we compared visual-only and audio-visual processing of the educational information to clarify how different methods of presenting image information obtained from the EMR affected the subjects' processing of the information.

### Materials and Methods

#### Study subjects and duration

The subjects in the study were nursing students who had completed their basic coursework and thus had a general understanding of risk factors in the hospital environment. The inclusion criteria were the absence of visual abnormalities, a visual acuity of at least 20/40 with both eyes open, not requiring either hard contact lenses or an intraocular lens, and availability to participate in a non-fatigued state on the day of the experiment (as represented by having obtained at least half of that person's normal length of sleep the day prior to the experiment) [12]. We publicly advertised the study on the university's website and in campus presentations. Among the 54 students majoring in nursing science at a university in Tokyo, Japan, 35 submitted applications; one was excluded for not meeting the inclusion criteria.

The remaining 34 participants were divided into a visual-only group and an audio-visual group according to the method of information presentation that each participant received. Subjects were assigned randomly to the two groups. Those assigned to the visual-only group learned the information visually by reading textual data on established risk factors and also viewed images of their gaze trajectories and gaze points as recorded on the EMR after the first of the two experiments. The information pertains to the presentation of the specific examples

and reasons, and the basis of risk factor items of the surrounding environment in this experiment. The visual-only group received teach the information only in the text. And, they watched the images obtained from the EMR of the person on their own.

In the audio-visual group, the researcher read the text aloud while participants were able to view it as well, along with looking at the gaze points from the images. In other words, they viewed the images obtained from the EMR of the person together with the researchers and they received it for teaching through auditory and visual images.

The experiment was performed twice with each subject between January 21 and March 10, 2011. To avoid explicit memory of the experimental environment from the first measurement [13] and to examine the sustained effect of information presentation, the second experiment was performed four weeks after the first one with each participant.

### Study methods

**Study design:** The study was designed to permit two comparative analyses: a comparison of the subjects' behaviours before and after risk presentation education and a randomized controlled study comparing the visual-only and audio-visual groups.

### Experimental environment

The experimental space was 6.6 m<sup>2</sup> in area, or similar to a standard-sized individual hospital room (≥ 6.3 m<sup>2</sup>) as established by the Medical Care Law in Japan. A mock hospital room was created, containing 23 items that could be considered risk factors, in addition to the bed and the table hanging over the bed. Within the room, the temperature

ranged from 23°C to 26°C, the relative humidity was 40% to 70%, and the illumination over the bed was 500-600 lx.

### Measurement content and methods

The participants were asked to state their age, mean sleep duration, sleep duration for the preceding day and perceived fatigue levels on the self-administered questionnaire.

Eye movement was measured using the EMR-9 for both eyes (NAC Image Technology, Inc.). The EMR used the pupil–corneal reflection method to detect eye movement based on the relative distance of the reflected corneal image position using the LED and the pupillary central position. In the present experiment, the gaze was defined as a vector that connected the eye and an eye mark on the EMR forward-view camera (lens 62o) with an eye movement speed ≤ 11 deg/s, t<sub>min</sub> ≥ 0.165 and R<sub>max</sub> = 2.0 deg (± 1.0 deg) [14].

Additionally, in the present study, we used a sampling frequency of 60 Hz and parallax correction marks. The EMR-d factory (NAC Image Technology, Inc.), which is analysis software, was used for statistical analysis. Following the measurement of their eye movements, the participants were asked to mark, on pictures taken in the experimental environment, the locations of potential risk factors that they considered to be present in the room.

### Experimental protocol

In experiment 1, after explaining the experimental procedure and having participants execute the consent form, we used the questionnaire to verify that the participation criteria were satisfied and then presented experimental examples and observations (Figure 1).

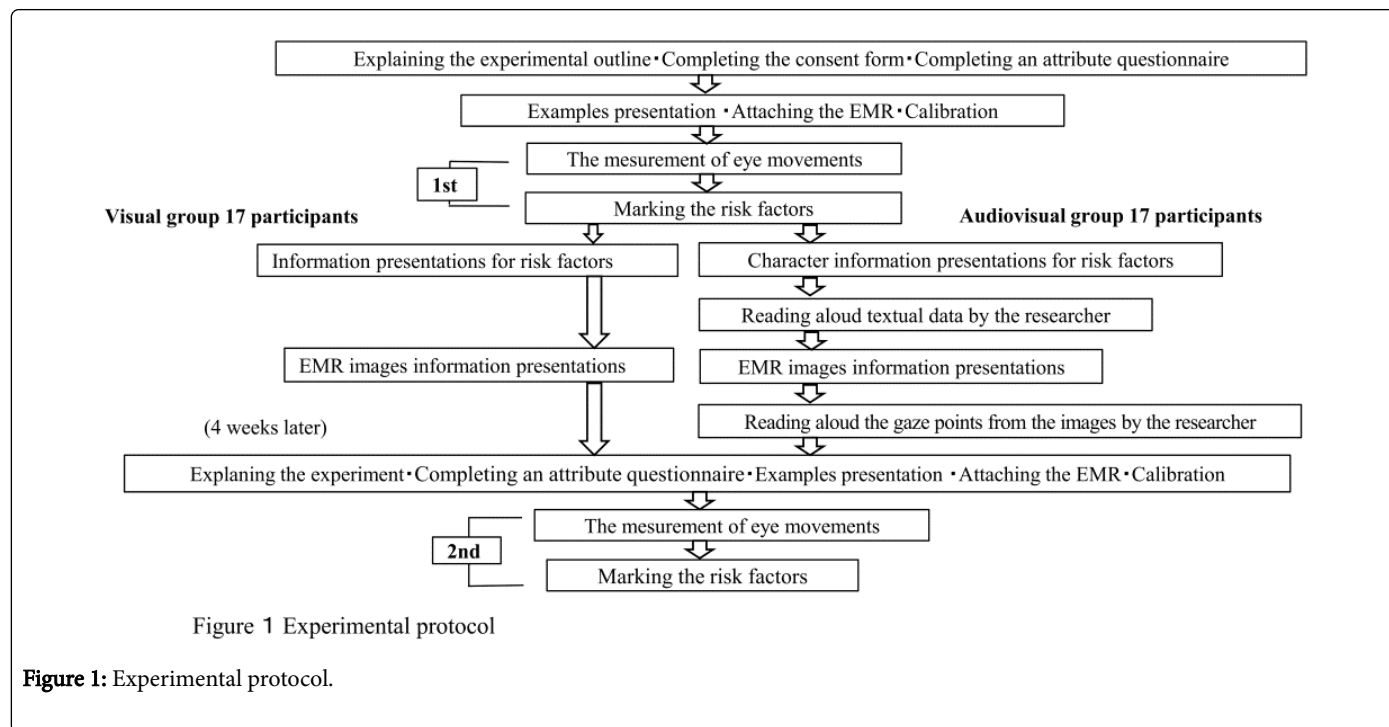


Figure 1 Experimental protocol

Figure 1: Experimental protocol.

The instruction included the following information: “A 98-year-old man called Mr. A was fasting and receiving intravenous drip therapy for pneumonia. The environment was to be prepared for Mr. A to have a safe hospital stay. Please check for dangerous objects around the bed

and for anything that could cause an accident. Consider the reasons supporting your belief that each item could present a danger”.

In the experimental space, the participants were instructed not to move their head or neck. The EMR was attached on a chin support so

that the forward camera images were consistent between participants; after showing the example again, we began taking measurements of the subject's eye movements. Once the eye movements were measured, we marked the risk factors. Thereafter, visual information was presented to the visual-only group and audio-visual information was presented to the audio-visual group, completing the first experiment.

To avoid information crossover between the two groups, the experiments were performed at different times and places. Each participant was examined individually. Furthermore, we asked participants not to describe details of the experiment to anyone after completing the first experiment. The measurements and questions for the second experiment were performed four weeks after and in the same manner as those for experiment 1. All experimental measurements and informational presentations were conducted by one researcher, who consistently followed the same protocol to improve reliability of the results.

### Indices measured

Four indices of eye movement were measured: duration of observation, gaze point, number of risk factor items and mean duration of gaze pause. The observation duration was defined as the time required to observe risk factors in the hospital environment, and it was calculated as the time that elapsed from the beginning to the completion of the observation, as reported by the participant. Each gaze point was defined as an occasion when the participant viewed a particular object in the mock hospital room for 0.165 s or longer during the observation. The gaze points were classified into two categories, based on whether the subject was looking at a risk factor item or another item. We counted the total number of gazes that paused on a specific item and the gaze duration for each item. We then

calculated the mean duration per gaze as an indicator of the average time that elapsed from focusing on a point until a change of gaze point occurred. The number of risk factor items was calculated as the number of times that the subject's gaze paused on one of the 23 risk factors. The number of eye marks was calculated as the number of marked risk factor items on the images that had been taken in the experimental environment.

### Analysis methods

The statistical analyses performed were a Wilcoxon test, to compare the results for each group before and after the informational presentation, and a Mann-Whitney test to compare the results between the visual-only and audio-visual groups. Prior to these tests, the Shapiro-Wilk test was used to verify that not all the data fell under the normal distribution curve. All statistical analyses were performed using IBM SPSS Statistics 19, and the level of significance was set at 5%.

### Ethical considerations

The study was performed with the approval of the Tokyo Medical and Dental University ethical review board. Prior to the experiment, we explained the study's purpose to the participants verbally and in writing and subsequently obtained informed consent. The participants were informed that they would be placed at no disadvantage whether or not they participated, the experimental results would not affect their academic grades, their privacy would be protected, the information obtained would not be used for any purpose other than the study, their personal identity would be protected and not specified in publications and they could withdraw from participation during the experiment.

	n=17				Audio-visual group n=17			
	First measurements		Second measurements		First measurements		Second measurements	
	Medan	Quartile deviation	Medan	Quartile deviation	Medan	Quartile deviation	Medan	Quartile deviation
Observation duration(seconds)	56.36	24.21	50.65	21.65	52.54	32.75	45.01	16.1
Total gaze counts(times)	85	36.5	89	26.5	86	53.5	72	23.75
Gaze counts for risk factor items(times)	73	36.5	81	26.5	85	40	*59.00	16.75
Other items(times)	6	2.5	8	4	2	7	6	12
Gaze duration(seconds)	41.49	17.19	44.06	21.16	43.76	22.07	31.71	12.92
Risk factor duration(seconds)	39.94	18.2	41.51	21.31	42.79	20.05	31.22	10.69
Other duration(seconds)	1.85	0.88	2.55	1.34	0.6	2.49	2.44	2.37
Mean gaze pause duration(seconds)	0.47	0.08	*0.54	0.1	0.45	0.04	0.46	0.05
Number of risk factor items(items)	19	2.5	18	3	19	3	18	1.5
Wilcoxon signed-rank test								
*p<0.05								

**Table 1:** Changes in eye movement incites using information presentations.

## Results

### Participant attributes

All participants were female (age  $21.4 \pm 4.2$  years), with a mean sleep duration of  $6.4 \pm 0.7$  h. No participants indicated having slept less than half her normal amount on the previous day. Change in eye movement indices according to mode of information presentation (Table 1).

For the visual-only group, the median observation duration was 56.36 s (quartile deviation [Q] 24.21) for the first measurement and 50.65 s (Q 27.65) for the second measurement, with no statistically significant difference between the two. Furthermore, the median total number of gaze counts was 85 (Q 36.50) for the first measurement, including 73 (Q 36.50) times for risk factor items and 6 (Q 2.5) times for other items, and 89 (Q 26.50) times for the second measurement, including 81 (Q 26.50) times for risk factor items and 8 (Q 4) times for other items, again representing no significant change.

However, the mean gaze pause duration was 0.47 s (Q 0.08) during the first measurement and 0.54 s (Q 0.10) during the second measurement, showing a significant increase ( $p = 0.044$ ). In other

words, the visual-only group spent significantly more time on each gaze during the second measurement than during the first measurement.

Turning to the audio-visual group, the observation duration was 52.54 s (Q 32.75) during the first measurement and 45.01 s (Q 16.10) during the second measurement ( $p = 0.100$ ); the gazes in the second experiment tended to be shorter, although the difference was not significant at the 5% level. Furthermore, the median total number of gaze counts was 86 (Q 53.5) in the first measurement and 72 (Q 23.75) in the second measurement, with no significant difference.

However, the median number of gaze counts for risk factor items was 85 (Q 40) during the first measurement and 59 (Q 16.75) during the second measurement, showing a significant decrease ( $p = 0.047$ ). There were fewer repeated gaze points for risk factors.

Moreover, there was no significant difference between the visual-only and audio-visual groups with regard to their change from the first to the second measurement, suggesting that the difference in style of informational presentation did not have a large impact on eye movement.

Changes in gaze count for risk factor items (Table 2).

	Visual group n=17								Audio-visual group n=17							
	First measurements				Second measurements				First measurements				Second measurements			
1:5 sk factor items	Median	Qua-tile deviation Min	Min	Max	Median	Quartile deviation	Min	Max	Median	Quartile deviation	Min	Max	Median	Quartile deviation	Min	Max
Bed rail (front side)	12	4	4	54	10	13	4	13	13	8	4	86	10	8	1	41
Drinking glass	8.5	8	1	18	7	8	1	27	7	8	0	48	4	6	0	23
Newspaper	8	8	0	21	5	6	1	23	8	7	0	36	*4	7	0	21
Oral medication	4.5	6	1	15	3	6	0	12	5	7	1	16	**2	3	0	5
Slippers	4	5	0	10	4	3	0	10	3	3	0	17	3	1	0	14
Cord	4	4	0	9	2	4	0	8	2	4	0	11	2	2	0	5
Spectacles	3.5	2	0	6	3	6	0	18	3	8	0	20	2	3	0	7
Urinal	3	6	0	12	2	5	0	20	3	3	0	21	3	4	0	16
Shelf	3	5	0	19	1	4	0	32	1	5	0	9	1	4	0	9
Intravenous drip	3	6	0	15	4	11	0	22	3	9	0	49	2	5	0	19
Tissue	3	3	0	11	2	2	0	7	3	6	0	18	2	3	0	9
Bed rail (foot)	2	4	0	13	1	4	0	15	2	4	0	25	2	4	0	6
Carriage	2	4	0	18	2	7	0	25	3	5	0	90	3	6	0	14
Castor	2	2	0	7	1	3	0	4	1	4	0	12	1	3	0	19
Plastic bottle	2	5	0	46	1	8	0	16	2	8	0	12	2	4	0	12
Bed remote control	2	4	0	20	3	5	0	12	3	8	0	25	3	4	0	18
Paper bag	2	4	0	9	2	6	0	9	3	5	0	28	3	3	0	9
Overbed table	1.5	3	0	11	2	5	0	12	1	4	0	8	0	3	0	4

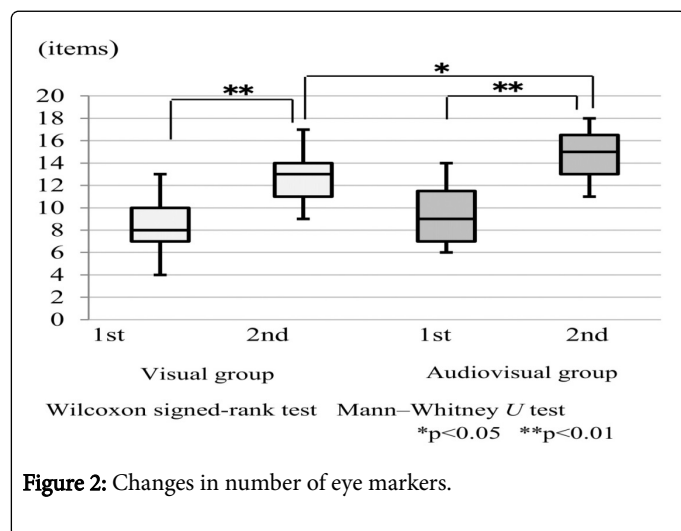
Disinfection	1	4	0	22	2	3	0	9	4	7	0	15	3	7	0	11
Scissors	1	6	0	15	2	6	0	21	2	4	0	9	2	3	0	10
Blanket	0.5	2	0	6	1	2	0	2	0	2	0	8	1	3	0	19
Nameplate	0	2	0	9	0	2	0	8	0	2	0	6	0	1	0	6
Bed rail(to the wall)	0	1	0	14	0	2	0	11	1	2	0	5	0	2	0	5

**Table 2:** Changes in gaze counts for risk factor items.

The visual-only group showed no significant change on any item between the first and second measurements. Similarly, there were no significant differences between the results of the two groups on either the first or the second measurement.

However, when the first and second measurements of the audio visual group were compared, a significant difference was observed for two risk factor items, namely “oral medication” and “newspaper” ( $p = 0.009$  and  $0.050$ , respectively). Moreover, gaze counts for several other risk factor items, i.e., “bed rail height,” “drinking glass,” and “spectacles” tended to decrease ( $p = 0.090$ ,  $0.100$  and  $0.082$ , respectively).

Changes in the number of eye marks according to information presentation (Figure 2).

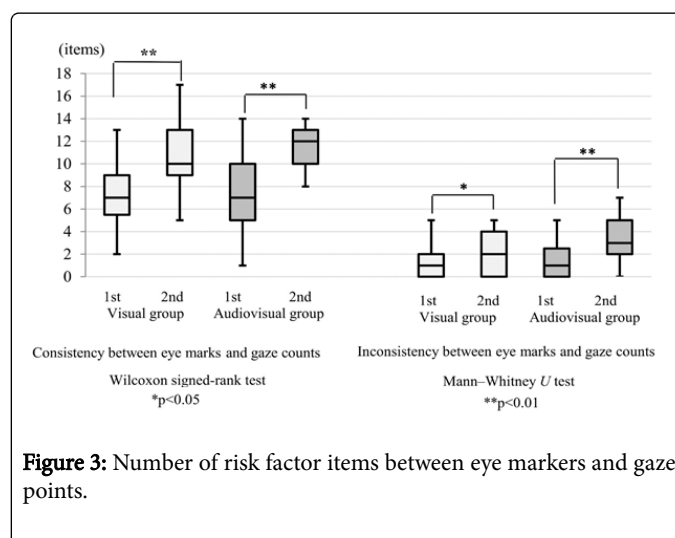


**Figure 2:** Changes in number of eye markers.

The number of eye marks increased significantly for the visual-only group, from 8 (Q 1.5) items during the first measurement to 13 (Q 1.5) items during the second measurement ( $p = 0.000$ ).

Similarly, a significant increase was observed in the audio-visual group, from 9 (Q 2.5) items in the first measurement to 15 (Q 2.0) items on the second measurement ( $p = 0.000$ ).

In the comparison between the two groups, although there were no significant differences between the first measurements, the audio-visual group had a significantly higher performance on the second measurement ( $p = 0.013$ ), indicating that the presentation of audio-visual information was beneficial.



**Figure 3:** Number of risk factor items between eye markers and gaze points.

Changes in the number of risk factor items according to the relationship between the eye marks and gaze points (Figure 3).

The number of items for which the eye marks and gaze points were consistent in the visual-only group was 7 (Q 2) for the first measurement and 10 (Q 2) items for the second measurement, indicating a significant increase ( $p = 0.001$ ).

Similarly, for the audio-visual group, the means were 7 (Q 2.5) items in the first measurement and 12 (Q 1.5) items in the second measurement, representing a significant increase ( $p = 0.001$ ).

Moreover, the number of inconsistent items for which there were eye marks but no gaze points was 1 (Q 1) in the first measurement and 2 (Q 2) in the second measurement for the visual-only group ( $p = 0.044$ ), and 1 (Q 1.5) for the first measurement and 3 (Q 1.5) items for the second measurement for the audio-visual group ( $p = 0.003$ ); there was a significant increase for both groups.

There were no significant differences between groups on either the first or the second measurement.

## Discussion

### The effect of an informational presentation on the ability to process visual information

In the present study, we found that the informational presentation resulted in four effects between the first and the second experiment: (1) shorter duration of observations, (2) longer mean duration of gaze



pause, (3) an increased number of eye marks, and (4) an increased number of coinciding eye marks and gaze points.

The observation duration represented the total time spent, including the gaze duration [15], until an item was judged to be a risk factor. In the present study, although the gaze duration did not decrease, we found that the overall observation duration tended to be shorter; therefore, it can be inferred that the presentation of information affected the judgement more than the gaze.

This finding is supported by the fact that the audio-visual group gazed at risk factors a fewer number of times and that the mean gaze pause duration was longer in the visual-only group. Specifically, in the second experiment (following the informational presentation), the participant's gaze was not repeatedly drawn to the same item, and the risk factors were determined by gazing closely at each item considered a risk; this led to a shorter average overall observation duration.

Furthermore, the effect on observation efficiency was verified by the total gaze counts on the risk factor items and by gaze duration. Five items generally identified as risk factors during the first measurements, including "bed rail height," "oral medication," "drinking glass," "spectacles," and "newspaper," were looked at fewer times following the informational presentation, whereas newly learned items that had been overlooked during the first measurements, including "blanket" and "bed remote control," received more gazes. We can deduce that not all risk factors were equally perceived, but that in the second experiment, the items most easily judged as risk factors were gazed upon fewer times, efficient observation involved repeatedly gazing at those items that were easily overlooked, and participants became aware of previously unnoticed items through the informational presentation.

In addition, based on the consistency between eye marks and gaze points, it can be inferred that the informational presentation helped to remind the participants of the significance of various dangers. In the first measurement, the consistency between the eye marks and gaze points was significantly lower, and the participants were aware of having made relatively few gazes. However, following the presentation, there was an increase in the number of eye marks, an increase in the number of items that the participants were aware of having gazed at consistently. Thus, we can surmise that information presentation did not simply promote learning memory and mechanical observation; rather, it promoted observation that took into account the significance of various dangers.

It has been shown that with the current methods used to teach about risk prediction, the educational effect does not last for more than four weeks [5], and many reports have indicated that the effect of informational presentations has been generally limited to short-term memory and would not be retained in long-term memory unless repeated [16]. Our presentations resulted in an increase in the number of eye marks during measurements conducted four weeks later. This result suggests that drawing attention to appropriate objects promoted the students' selective attention [17] and visual reflection, which helped them to retain the risk factors in their long-term memory.

### **Effective methods of informational presentation**

Verbal instruction has been found to be effective for inexperienced students [18]. Also, compared with visual or audio stimulation alone, the simple reaction time to audio-visual stimulation is shorter, demonstrating inter sensory facilitation in information processing [19]. Edgar Dale divided audio-visual media content into 11 stages from concrete to abstract, and he arranged these stages in a model that

he called the "Cone of Experience"; the audio-visual teaching material was placed in the process from experience to conception into 11 stages [20].

As shown by the visual-only group in the present study, even with the same informational presentation, which involved viewing one's own gaze trajectory and the EMR images taken of gaze points, the degree of influence was still heavily dependent on personal interests and concerns, as well as the ability to utilize the apparatus; thus, considerable individual differences were found in the effects. On the other hand, the audio-visual group gazed at the risk factors for a shorter time than the visual group, had a greater number of eye marks and identified more items that were consistent with the gaze points; therefore, the educational effect was greater. We believe that this improvement can be attributed, first, to the fact that the verbal information helped to guide participants in their use of the EMR, improving their interest, engagement and adaptability; therefore, a certain quality of information could be provided and the educational impact was not as dependent on the characteristics of each individual. Second, we believe that the stimulation of both the visual and auditory senses facilitated the interpretation of risk factors and provided knowledge to help the subjects make judgements during their subsequent observations.

### **Study limitations and future tasks**

In the present study, observational factors regarding the informational presentation and the relatively small sample size of 34 individuals could have had a strong influence on the results. As there was little variation in the population, the results could have been substantially affected by individual differences in experience and the ability to adapt to learning. Furthermore, fatigue may have been a factor. The experimental design was constructed to minimize participant fatigue, any artificial and unnatural behaviour caused by the apparatus and the mock room, and any changes in retinal scanning caused by a rotation of the head. However, the experimental requirements of positioning and wearing a bulky apparatus and the subjects' residual memory of the mock room scene could have had various effects on the observational gaze. Furthermore, during situations when the prioritizing of one's own judgements in accordance with that of expert nurses is required, the informational presentation used here would not be appropriate.

In the future, to examine the relationship between risk prediction and gaze points in the hospital environment at different educational stages in nursing, studies should include a larger population, and educational methods for observational skills should be used to examine the differences in risk prediction gaze points and the advantages and disadvantages of gazing at a particular object for at least 0.165 s.

### **Conclusions**

The present study clarified how an educational presentation on risk prediction affected the ability to process visual information. A randomized controlled experiment was conducted with 34 nursing students, who were divided into a visual-only group and an audio-visual group. We found that four items changed between the first and second experiment: (1) shorter duration of observation, (2) prolonged mean duration of gaze pauses, (3) an increase in the number of eye marks, and (4) an increase in the number of eye marks coinciding with gaze points.

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