医工学治療　**Therapeutics and Engineering**

Title: DIFFERENCES IN VISUAL ATTENTION BETWEEN NOVICE AND EXPERT NURSES PERFORMING ENDOTRACHEAL SUCTIONING (ES) : A SIMULATION STUDY

論文様式：原著

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Keywords: endotracheal suctioning; expertise; eye movement; tacit knowledge; multitasking risk

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利益相反について：

本論文発表に関連して、開示すべきＣＯＩ関係にある企業等はございません。

Title: DIFFERENCES IN VISUAL ATTENTION BETWEEN NOVICE AND EXPERT NURSES PERFORMING ENDTRACHEAL SUCTIONING (ES) : A SIMULATION STUDY

Abstract

Background: Endotracheal suctioning was authorized to be performed by individuals after attending a training course even though they do not possess a medical/nursing qualification in 2012 in Japan, though it is still considered as an evasive medical procedure.

Objectives: This paper aims to discover experienced nurses' proficiency of endotracheal suctioning in order to discuss future solution of nursing delegation.

Methods: EMR-9® (NAC Image technology Inc.) was used for eye tracking. EMR-dFactory® version 2.7.0 was used for data analysis. ES was separated into six phases. Performance time, visual pathways, and movement speed of each participant were then analysed.

Participants: Participants were recruited by snowball method and bulletin board. Inclusion criteria for nurses were experience of endotracheal suctioning in real work at any institution, and for students no experience of endotracheal suctioning in real settings.

Results: Nurses' average time for ES was significantly shorter than students'; however, there was no significant correlation between years of experience and the time (p= -0.006). Bimodality of eye movement velocity at 0-40 and 180-220 deg./s was also observed in the nurses' group, in contrast to the unimodal distribution of the students' velocity.

Conclusion: Nurses achieved both time-efficiency and risk-avoidance by quickly gathering adequate visual information. Preparations before procedure to avoid task multiplicity are also important.

Introduction

Rapid developments in medical technology have contributed to quality of life in patients with ventilators. In 2012 in Japan, home based endotracheal suctioning was authorised to be performed by non-qualified persons, but still categorized as a medical procedure due to its multiplicity and complexity. Numerous research papers warn about the risks, such as bleeding and pain[1)], anxiety[2)], cardiac dysrhythmia by stimulation of the vagus nerve[3)], infection[4,5)], mucosal damage, tracheal stenosis or unwanted increase of tissue in the airway, and hypoxia[6,7)], loss of end-expiratory lung volume (EELV), tidal volume (VT) and lung derecruitment[8-12)], and atelectasis[13,14)]. Endo tracheal Suctioning (ES) restricts ventilator users to participate in society[15,16)], which could increase the risk of social isolation. Frequent suctioning increases the risk of alveolar derecruitment[17)], whereas lack of suctioning causes ventilator-associated pneumonia (VAP) [18]), partial endotracheal tube (ETT) occlusion[19)], or suffocation[20,21)]. Recent researchers have found that the selection of catheter size plays a more important role in protecting against derecruitment than open or closed suctioning system[22)]. Hepponstall et al. (2012) concluded that "the change of lung volume is uniform[23)]". ES is, therefore, a procedure that is unavoidable and involves a certain level of risk. However, ES is still under the debate whether it is "medical procedure" or not, for family caregivers at home settings in Japan.

Moreover, little is known about the relationship between ES-related complications and expertise, as well as how experts avoid those complications. Özden and Görgülü (2012) made a guideline for the enhancement of patient safety and the quality of nursing care[24]. Maggiore et al. (2013) conducted a prospective study before and after improving and implementing guidelines of ES to decrease adverse events[25]. Beuret et al. (2013) warned that there are discrepancies between ES guidelines and practice, with respect to adequate suction size (5.3%) and suction pressure monitoring (57.6%)[26]. The difficulty of describing expert nurses' "tacit knowledge[27]" might be a cause of those findings.

This study was conducted to discover the differences in visual attention between novices and experts performing ES, and to describe nurses' risk avoiding technique, in order to discuss future solution in delegation of suctioning as a process of demedicalization[28] . A simulation-based study was conducted, comparing nursing students to experienced nurses with respect to transitions in eye movements during ES to describe nurses' visual attention to improve suctioning techniques and training methods for safe social task shifting.

2 Method

2.1. Participants

Participants were recruited by snowball method and bulletin board at a division of nursing in a university from July 1st to August 2nd. Inclusion criteria for nurses were experience of endotracheal suctioning in real work at any institution, and for students no experience of endotracheal suctioning in real settings. Two participants who have low vision and could not put research apparatus were excluded. Overall, eleven female nurses from three institutions (with three to 17 years of experience, mean 8.67 years) and nine nursing students from one university (third-year students, 8 female and 1 male students, no work experience related to nursing) participated in this research. Sample size was determined according to previous researches[29-31]. Nine of the 11 nurses have been using the open suctioning system (OSS) single-use catheter method at their work, whereas two nurses had experience with the OSS dry method and the soak method. Only one nurse had experience with a closed suctioning system (CSS). All the nursing students had learned the OSS single-use catheter method before this research as a part of their curriculum. Single university students were chosen to uniform their background knowledge about suctioning. Simple lecture was provided individually from one of our research member. After collecting data, we showed one of researcher's eye movement video to every nursing student for their future interest. All participant received rewards for cooperation after this research.

2.2 Ethical consideration

The protocol was approved by the Ethical Committee of Faculty of Health Sciences, Hokkaido University (no. 13-2). Written permissions from all participants were obtained in advance of the research.

2.3 Variation of Suctioning Procedure

Suctioning technique is important in maintaining the patency of an artificial airway to avoid pneumonia and suffocation. There are two types of ES: OSS and CSS. OSS can be subdivided into three: dry method, soak method, and single-use method. These depend on whether the tracheal catheter is dried in a clean container, or soaked in disinfectant, those exchanged every 24 hours to maintain hygiene, or disposed after every suctioning. CSS is considered to decrease the transient loss of EELV and VT, however, it is still expensive for long-term consumption. Fernández et al. (2004) found that decreased lung volume in patients without severe lung disease was transient and rapidly reversible[32). After a meta-analysis, Jongerden et al. (2006) concluded that there is no evidence to prefer CSS to OSS[33]. Jongerden et al. (2012) stated that both systems can be considered equally safe with respect to heart rate, mean arterial pressure, and oxygen saturation[34]. More recently, Corley et al. (2012) said that EELV recovers more slowly after CSS than after OSS[35]. Therefore, the OSS dry method was selected in this research, and it is a common and financially reasonable technique for both hospital and home settings in Japan. Each participant performed a suctioning procedure twice, and the better of the two was selected for analysis.

Before analysis, the process of OSS was separated into six phases from Phase one to six. Phase one (P1) is from touching the disposable gloves to first touching the catheter. P2 is till just before insertion of the catheter into the tracheal tube. P3 is till pulling out the catheter. P4 is from reattachment of the connection onto the tracheal tube to closing of the lid of the catheter container. P5 is until the turning off of the suctioning machine. P6 is the time for the participant removes the disposable gloves.

2.4 Apparatus

EMR-9® (NAC Image Technology Inc.) version 2.61 model ST-725 was used for eye tracking. Participants wore a cap with two lenses and carried a shoulder bag while suctioning. The 60°lens field and gravity mode for the fixation algorithm were chosen.

The sampling frequency was 60Hz. Retention of eye movement was defined as more than 100ms and less than 2.00 degrees[36)]. EMR-dFactory® version 2.7.0 and Microsoft Excel 2010 was used for data analysis. Figure1 shows a snapshot of this research procedure.

3 Results

Data was collected from July 23rd to August 15th in 2013. Firstly, performance time, visual pathways, and movement speed of each participant were analysed. The nurses' average performance time was significantly shorter than that of the students (Figure 2). Most of students were still inserting catheter when nurses finished ES. However, no significant correlation was observed between years of experience and performance time by Pearson product-moment correlation coefficient (p=-0.006).

Secondly, the performance times of the six phases were compared between the nurses and the nursing students. The overall data was calculated by Fisher's exact test and Welch t-test, as its small sample size and equal variances were not assumed (Table 1). Significant differences were found in five of the six phases other than P3, which is the time for inserting the catheter into the tracheal tube. Therefore, the “less than 15 seconds rule[37)]” seems to be kept by both groups. The majority of time spent by the student group was based on the time spent for steps before and after catheter insertion and tidying up of the suctioning machine equipment. We also found that some students took 4-5 seconds of hesitation between disconnecting the tracheal tube connector and inserting the catheter.

Bimodality of eye movement velocity at 0-40 and 180-220 deg/s was also observed in the nurses' group, in contrast to the unimodal distribution of the students' velocity (Figure 3). From the result, the students' eye movement were slower than the nurses'. They consciously or unconsciously controlled their oculomotor speed to obtain visual information.

Compared to the students' eyesight and focal point, which were fixed on the ETT (Figure 4(a)), the nurses observed a wider area, such as the patient model's face around the nose, the pulse oximetry, and the tip of the catheter (Figure 4(b)).

Expert nurses were not just quickly collected visual information; their focus of their eyes was proper. The nurses' focal point shifted to the face of the human model as shown in Figure 1 or to pulse oximetry while the nurse was putting on gloves or wiping catheter by alcohol cotton. This multi-layered observational skill seemed to be part of the nurses' tacit knowledge. Expert nurses' were able to move their hands and simultaneously they could pay attention to different things.

In contrast, the majority of nursing students did not move their attention from ETT; after the procedure a student stated that she attempted to look at the patients' faces but she was unable to do so. The nurses consciously or unconsciously obtained observation skills for suctioning as necessitated by the situation. This accuracy of observing point could be another evaluation criterion for expertise in ES. Moreover, the distance between the simulator and each participant's eyes was greater for the nurses than for the students, which might involve the ability of information acquisition in multitasks like ES.

4 Discussion

From the analysis of oculomotor between the two groups, the nurses' group was found to demonstrate quicker and safer suctioning than the students' group demonstrated. The expert nurses' distribution of eye movement velocity was bimodal; nurses observed effectively to prevent adverse events, controlling their visual search in terms of speed and accuracy. Learners were slower in body and eye movement, concentrating their attention only on ETT during P3, and they were unable even to glance at the patient's face. Reductions in the time to disconnect from the ventilator could be the most effective means of preventing diminution of EELV and VT seems to require repeated practices. One reason for the longer performance time among the nursing students' was hesitation or indecisiveness about the correctness of the next task. After watching the nurses on video, several students stated that they thought it had been played in fast forward. Performance time can be a criterion for evaluating suctioning technique; because a shorter performance time reduces the patient's waiting time from when they call the nurse until when the nurse inserts the catheter.

The visual information accumulation methods differ between novices and experts; the differences appear in eye movement in the shape of anticipation and the useful field of view[38,39]. The activeness and predictability of the expert's visual information intake is due to the formation of cognitive schema and matrix by experience.

During suctioning, the field of view, including that in peripheral vision, became wider for the nurses. They are capable to handle multiple visual information that allow them to assess the risk of adverse events. According to Maggiore et al. (2013), the most frequent incidents in ES were oxygen desaturation (6.5% of 4506 suctioning procedures), haemorrhagic secretion (4.0%), blood pressure changes (1.6%), and heart rate fluctuations (1.1%)[40]. Our previous research mentioned that there were more than ten observation points during catheter insertion[41]; whereas the results showed that the nurses were only observing the patient model's face, the tip of the suctioning catheter, and the oximetry. These three observation points, however, cover the majority of the side effects from the provision of ES. For instance, in the case of haemorrhage, the sputum changes colour; the tip of suctioning catheter is the most important observation point. In the case of cyanosis, facial colour and oxygen saturation are the information that is necessary to assess. Perhaps nurses also use suctioning sound and touch to evaluate the amount or softness of secretion and to assess the patient's lung function impairment. In the case of bradycardia, facial expression and sound of pulse rate from oximetry will assist nurses' decision-making regarding whether to continue the suctioning. Although may need more in-depth research, these three observation points seem effective minimum elements for maintaining speed and safety. The nurses' observation spots in the video seemed effective at preventing such incidents for beginners.

There are two types of attention: bottom-up attention, and top-down attention[42)]. In the usual optic environment, multiple objects are simultaneously projected onto the retina. The former attention is for highlighted objects that are noticeable and that automatically trigger a person's attention. The latter attention is defined as that when objects are evenly distinctive but the person is able to pay attention to an object out of his/her own interest or from direction by others. From these findings, at least cyanosis, haemorrhage, and bradycardia must be detected by the top-down attention before the actual provision of ES for the quality of care.

Once new knowledge is acquired and repeatedly put into practice, it gradually becomes automatic and non-conscious[43)]. Experts cannot explain what they are doing if they cannot realize and verbalise it. Automated expertise results in significant but unintended omissions when experts attempt to communicate their skills to others [44)]. Therefore, there might be a large discrepancy between learners and experts in terms of skill inheritance. What kind of information is where was already embedded in their body through experience. The skills of ES, therefore, have to be recognized as tacit knowledge that requires experience, and not merely as knowledge of a technique.

As for infection risk, several students inadvertently contaminated the suctioning catheter. They touched the tip of catheter with gloved fingers or they swung the tip of catheter. Hunt and Joslyn (2000) pointed out that "Errors most likely increase in number and severity under time-pressure and anxiety-producing situations[45)]". Preparation to manage danger and unwanted situations before provision of ES is also important for quality of nursing. Some procedures, such as selecting adequate suction size or setting suction pressure, can be prepared before ES, and multiplication of tasks can be avoided.

Especially in relation to risk, the causes and effects of ES need to be elucidated by future research.

5 Conclusion

Our results show that the nurses' group performed ES significantly quicker than the students did; however, there was no significant correlation between years of experience and performing time. The nurses' observation point was reasonable to avoid main adverse events of ES and more accurate and speedy than the nursing students. These results imply that expertise is a key factor for providing safe ES. Further research is needed to reveal the skill acquisition process and the decision-making process of expert ES providers.

Preparations before ES to avoid task multiplicity are also important. These findings could be used for nursing students training, for people who care for their family members with ventilators, and for improvements of ES machines to minimize avoidable risks.

Limitations

Participants might have failed to observe some of the side effects of ES, because the model we used did not show any change. The length and the angle of endotracheal catheter insertion were not measurable from our video to assess its risks. Thus, research has to be conducted to reduce the risks of each suctioning procedures.

References

1) Rahu, Mamoona Arif; Mary Jo Grap; Jeffrey F. Cohn; Cindy L. Munro; Debra E. Lyon; and Curtis N. Sessler (2013) Facial Expression as an Indicator of Pain in Critically Ill Intubated Adults During Endotracheal Suctioning. American Journal of Critical Care 22(5):412-422

2) Pedersen, Carsten M.; Mette Rosendahl-Nielsen; Jeanette Hjermind; and Ingrid Egerod (2008) Endotracheal suctioning of the adult intubated patient: What is the evidence? Intensive and Critical Nursing 25:21-30. doi:10.1016/j.iccn.2008.05.004

3) Ashurst, S.(1992)Suction therapy in the critically ill patient. British Journal of Nursing, 1 (10), p. 485

4) Blackwood, B. and C.H. Webb (1998) Closed tracheal suctioning systems and infection control in the intensive care unit. Journal of Hospital Infection 39:315-321 doi: 0195-6701/98/080315

5) Wood, Caroline J. (1998) Endotracheal suctioning: a literature review. Intensive and Critical Care Nursing 14, 124-136.

6) Day, Tina; Steven P. Wainwright; Jenifer Wilson-Barnett(2001) An evaluation of a teaching intervention to improve the practice of endotracheal suctioning in intensive care unit. Journal of Clinical Nursing, 10: 682-696

7) Maggiore, S.M. and C. Volpe (2011) Endotracheal suctioning in hypoxemic patients. Reanimation 20:12-18 doi 10.1007/s13546-010-0211-1

8) Richard, Jean-Christophe; Salvatore M. Maggiore; Bjorn Jonson; Jordi Mancebo; Francois Lemaire; and Laurent Brochard (2001) Influence of Tidal Volume on Alveolar Recruitment: Respective Role of PEEP and a Recruitment Maneuver. American Journal of Respiratory Critical Care Medicine 163:1609-1613.

9) Richard, Jean-Christophe; Salvatore Maggiore; and Alain Mercat (2003) Where are we with recruitment maneuvers in patients with acute lung injury and acute respiratory distress syndrome? Current Opinion in Critical Care 9:22-27

10）Maggiore, Salvatore M.; François Lellouche; Jérôme Pigeot; Solenne Taille; Nicolas Deye; Xavier Durrmeyer; Jean-Christophe Richard; Jordi Mancebo; François Lemaire; and Laurent Brochard (2003) Prevention of Endotracheal Suctioning-induced Alveolar Derecruitment in Acute Lung Injury. American Journal of Respiratory and Critical Care Medicine 167(9) doi: 10.1164/rccm.200203-195OC

11)Almgren, Birgitta; Carl-Johan Wickerts; Erkki Heinonen; Marieann Högman(2004) Side Effects of Endotracheal Suction in Pressure- and Volume-Controlled Ventilation. Chest. 125(3):1077-1080. doi:10.1378/chest.125.3.1077

12）Morrow, Brenda; Merle Futter and Andrew Argent (2006) Effect of endotracheal suction on lung dynamics in mechanically-ventilated paediatric patients. Australian Journal of Physiotherapy 52: 121-126

13）Brandstater B. and Muallem M. (1969) “Atelectasis following tracheal suction in infants.” Anesthesiology 31: 468-473

14）Czarnik R.E.; Stone K.S.; Everheart C.C. Jr. and Preusser B.A. (1991) Different effects of continuous versus intermittent suction on tracheal tissue. Heart and Lung 20(2), 144-151.

15）Colley, N., Y. Yokoo, H. Shimizu, C. Honda, K. Otsuka (2013) Indication for new risk analysis tools of tracheal suctioning. Therapeutics and Engineering 25(3): 179-185 in Japanese

16）Huijzen, van S. and AnneLoes van Staa (2013) Chronic ventilation and social participation: experiences of men with neuromuscular disorders. Scandinavian Journal of Occupational Therapy 20(3) 209-216 doi: 10.3109/11038128.2013.765033

17）AARC (2010) AARC Clinical Practice Guidelines: Endotracheal Suctioning of Mechanically Ventilated Patients With Artificial Airways 2010. Respiratory Care 55(6) 758-764　http://rc.rcjournal.com/content/55/6/758.full.pdf+html

18）Lorente, Leonardo; Maria Lecuona; Maria M. Martin; Carolina Garcia; Maria L. Mora; Antonio Sierra (2005) Ventilator-associated pneumonia using a closed versus an open suction system. Critical Care Medicine 33(1):115-119:

doi: 10.1097/01.CCM.0000150267.40396.90

19) Jaber, Samir; Jerome Pigeot; Redouane Fodil; Salvatore Maggiore; Alain Harf; Daniel Isabey; Laurent Brochard and Bruno Louis (2004) Long-term Effects of Different Humidification Systems on Endotracheal Tube Patency. American Society of Anesthesiology 100(4):782-788

20) Day, Tina; Sarah Farnell; and Jenifer Wilson-Barnett (2002) Suctioning: a review of current research recommendations. Intensive and Critical Care Nursing 18, 79-89
doi: 10.1016/S0964-3397(02)00004-6

21) Maggiore, Salvatore Maurizio (2006) Endotracheal suctioning, ventilator-associated pneumonia, and costs: open or closed issue?" Intensive Care Medicine 32:485-487 doi: 10.1007/s00134-006-0093-x

22) Tingay, D.G.; Copnell, B.; Grant, C.A.; Dargaville, P.A.; Dunster, K.R.; & Schibler, A (2010) The effect of endotracheal suction on regional tidal ventilation and endo-expiratory lung volume. Intensive Care Medicine, 36:888-896.

23) Hepponstall, J. Michele; David G. Tingay; Risha Bhatia; Peter M. Loughnan; and Beverley Copnell(2012) Effect of Closed Endotracheal Tube Suction Method, Catheter Size, and Post-Suction Recruitment During High-Frequency Jet Ventilation in an Animal Model. Pediatric Pulmonology 47:749-756

24) Özden, Dilek and R. Selma Görgülü (2012) Development of standard practice guidelines for open and closed system suctioning. Journal of Clinical Nursing 21, 1327-1338, doi: 10.1111/j.1365-2702.2011.03997.x

25) Maggiore, Salvatore Maurizio; Francois Lellouche; Claudia Pignataro; Emmaniele Girou; Bernard Maitre; Jean-Christophe M. Richard; Francois Lemaire; Christian Brunbuisson; Laurent Brochard(2013) Decreasing adverse effects of endotracheal suctioning during mechanical ventilation by changing practice. Respiratory Care 58(10):1588-1597 doi: 10.4187/respcare.02265

26) Beuret, Pascal; Christophe Roux; Adrin Constan; Alain Mercat; Laurent Brochard (2013) "Discrepancy between guidelines and practice of tracheal suctioning in

mechanically ventilated patients: a French multicenter observational study." Intensive Care Medicine39:1335-1336

27) Polanyi, Michael (1966) The Tacit Dimension, University of Chicago Press: Chicago, 4.

28) Conrad, Peter (1992) Medicalization and social control. Annual Review of Sociology 18(1992):209-232.

29) Seya, Yasuhiro; Nakayasu, Hidetoshi; and Patterson, Patrick(2008) Visual search of trained and untrained drivers in a driving simulator, Japanese Psychological Research, 50(4): 242-252.

30) Ishibashi, Yukimasa; Kato, Takaaki; Nagano, Tomohisa; Ohgi, Yuji; and Sasaki, Miotsuo (2010) Visual Search behaviour of Experienced Players while Anticipating the Success of Basketball Free Throws. Japanese Journal of Sports Psychology, 37(2): 101-112.

31) Kataoka, Jun; Sasaki, Minako; and Kanda, Katsuya(2011) Effects of mental worklord on nurses' visual behaviours during infusion pump operation. Japan Journal of Nursing Science, 8: 47-56.

32) Fernández, Maria-del-Mar; Enrique Piacentini; Lluis Blanch and Rafael Fernández (2004) Changes in lung volume with three systems of endotracheal suctioning with and without pre-oxygenation in patients with mid-to-moderate lung failure. Intensive Care Medicine 30:2210-2215 doi:10.1007/s00134-004-2458-3

33) Jongerden, Irene P.; Maroeska M. Rovers; Mieke H. Grypdonck; and Marc J. Bonten (2006) Open and closed endotracheal suction systems in mechanically ventilated intensive care patients: A meta-analysis." Critical Care Medicine 35(1):260-270 doi: 10.1097/01.CCM.0000251126.45980.E8

34) Jongerden, Irene P.; Jozef Kesecioglu; Ben Speelberg; Anton G. Buiting; Maurine A. Leverstein-van Hall; and Marc J. Bonten(2012) Changes in heart rate, mean arterial pressure, and oxygen saturation after open and closed endotracheal suctioning: A prospective observational study. Journal of Critical Care 27, 647-654

35) Corley, Amanda, Spooner, Amy J.; Barnett, Adrian G.; Caruana, Lawrence R.; Hammond, Naomi E.; and Fraser, John F. (2012) Endo-expiratory lung volume recovers more slowly after closed endotracheal suctioning than after open suctioning: a randomized crossover study. Journal of Critical Care, 27(6), 742.e1-742.e7.

36) Endo Sho and Kohama Takeshi (2012) Inhibition of microsaccade rate caused by focus of visual attention. Memoirs of the Faculty of B.O.S.T. of Kinki University 29, 7-15

37) AARC(2010) op.cit.

38) Ishibashi et al. (2010) op.cit.

39) Seya et al. (2008) op.cit.

40) Maggiore, S. M. et al. (2013) op.cit.

41)Colley, N., C. Honda, T. Abe, K. Ogasawara (2010) Visualization of Tracheal suctioning by activity model. Therapeutics and Engineering 23(1): 22-33 in Japanese

42) Miura, K.; Y. Sakato; K. Kawano; T. Ogawa(2011) Mechanisms of target selection underlying saccades and smooth pursuit eye movements. IEICE technical Report NC2011-5(2011-06).pp.61-66

43) Wheatley T. and Wegner D.M. (2001) Automaticity of action, psychology of. In International Encyclopedia of the Socialand Behavioral Sciences, edited by N. J. Smelser and P. B.Baltes, pp. 991–993. Oxford: Elsevier.

44) Clark, Richard (2014) Cognitive Task Analysis for Expert-Based Instruction in Healthcare. Handbook of Research on Educational Communications and Technology. 541-551

45) Hunt, E., and S. Joslyn (2000) A functional task analysis of time-pressured decision making. In J.M. Schraagen, S.F. Chipman, & V.L. Shalin, (Eds.), Cognitive Task Analysis, 119-134.

Figure 1. The endotracheal suctioning simulation laboratory

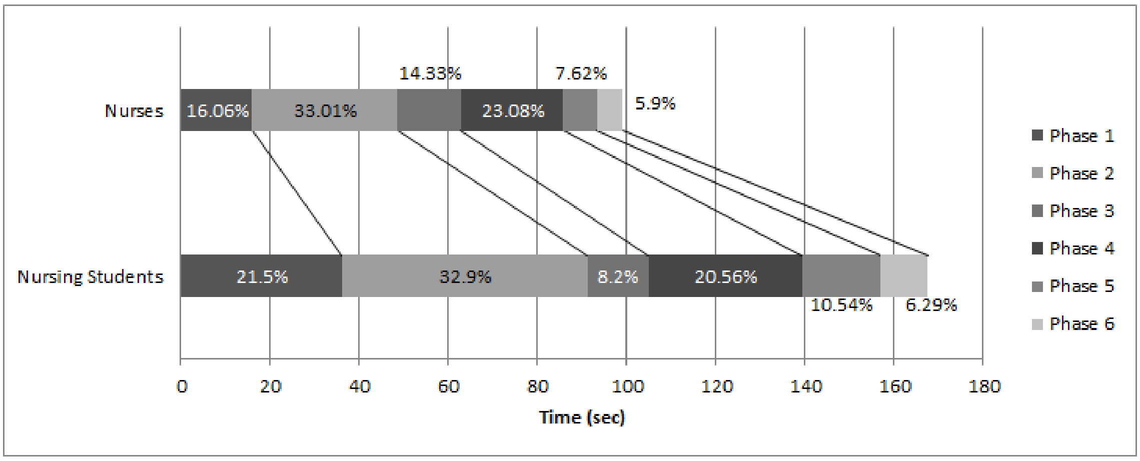


Figure 2. Percentages of performance time between nursing students and nurses

	Nurses (n=11)		Nursing Students (n=9)			
	M (SD)	CV	M (SD)	CV	F-value	p
Phase 1	15.94(4.04)	25.35	36.11(14.68)	40.65	0.00044	0.003**
Phase 2	32.76(9.90)	30.21	55.2(15.95)	28.89	0.16	0.0005*
Phase 3	14.22(5.15)	36.21	13.75(7.89)	57.38	0.21	0.876
Phase 4	22.91 (5.00)	21.82	34.48(10.13)	29.38	0.041	0.010**
Phase 5	7.56(3.12)	41.27	17.69(3.15)	17.81	0.95	0.00001*
Phase 6	5.86(1.55)	26.45	10.56(1.65)	15.63	0.84	0.00003*
Total time	99.25(18.60)	18.74	167.78(34.28)	20.43	0.074	0.00018*
*α<0.05, significant difference calculated by Student t-test						
**α<0.05 significant difference calculated by Welch t-test						

Table 1. Comparison of average performance time in the six phases

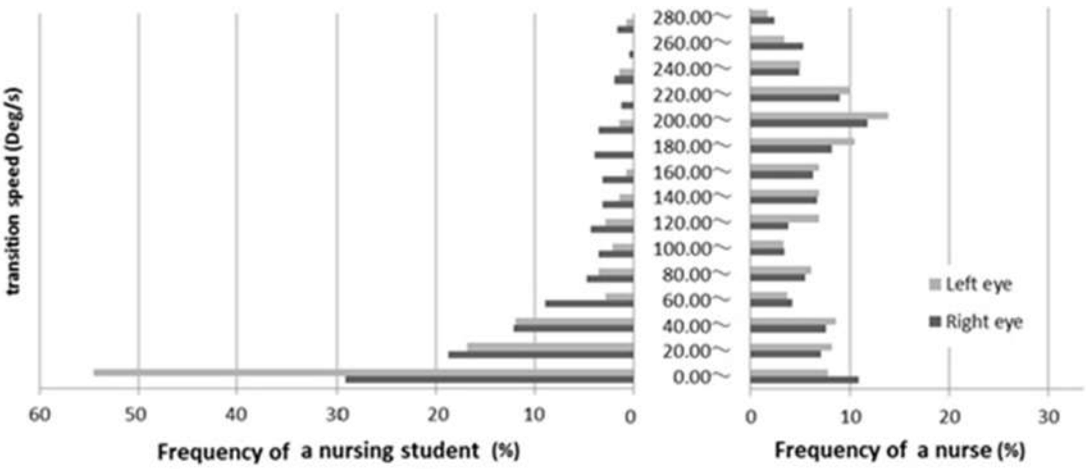
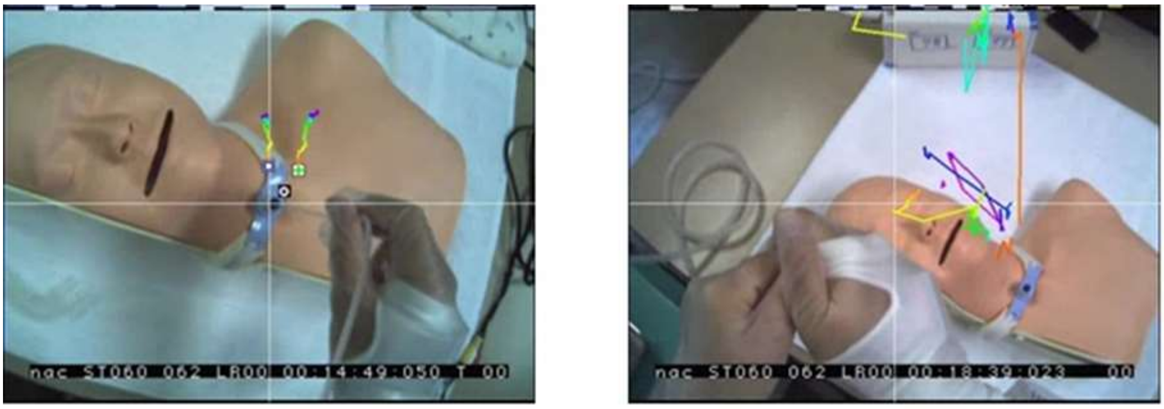


Figure 3. Eye movement speed distribution in nursing students and nurses



(a) Visual pathway of a nursing student (b) Visual pathway of a nurse

Figure 4. Typical visual pathway of a student and a nurse after inserting catheter