Title

Comparison of procedure time among types of endotracheal suctioning methods preparing for disaster situations

Abstract

Introduction: In disaster, the types of endotracheal suctioning methods available vary depending on the situation. Therefore, the aim of this prospective research is to measure the prolongation of procedure time by commodity/tool change.

Methods: Expert nurse group and nursing student group were participated. The participants conducted five open suctioning systems and closed suctioning system twice to measure the influence of commodity changes on the procedure time.

Results: The procedure time was not prolonged by the change of commodity among five open suctioning systems.

Conclusions: All nurses may be capable of functioning with limited medical resources without prolonging their usual procedure time. The result also implied that the procedure time could be used to measure the level of skill acquisition as well as to measure the possibility of simplifying some procedures. Further research is required to identify skill-facilitating factors and obstacles using procedure time as evaluation criteria to prepare for disaster situations.

Keywords: procedure change, procedure time, emergency management, staff education, pedagogical evaluation

1. Introduction

There are currently several methods available for endotracheal suctioning, such as the open suctioning system (OSS) and the closed suctioning system (CSS). These systems can either be electrically powered or mechanical, including a foot-operated bellows pump or foot pedal. Both the OSS and the CSS have been well described and compared in terms of parameters such as vital signs, costs, and rate of infection, among others[1-5)]. The CSS is recognized for low risk of infection compared with the OSS[6)]. Reportedly, the reason for the low infection risk is that the catheter used in CSS is covered by a protective film to avoid contamination by contact with the operator. Previously, the suctioning catheter was sterilized in disinfectant and reused, but single-use catheter is now widely recommended to prevent infection[7,8)]. In a previous study, there was no significant difference between replacing the catheter every 24 hours or storing in its paper sheath and hanging it at the patient's bedside between suctioning episodes[9)].

Recently, the OSS dry method, in which the catheters dry after being wiped with alcohol and reused every 24 hours, is used for mechanical ventilation at home because of its cost-effectiveness. Given an increase in the number of mechanically ventilated patients, both adults and children, cared for at home, the need for equipment such as home respirators, tracheotomy and tube feeding as well as gaining endotracheal suctioning skill are unavoidable[10,11)]. Development of an effective instruction method for caregivers without medical background is an issue of great urgency.

However, the same suctioning method is not always available at the time of an emergency situation, such as disaster. Maggiore et.al indicated that suctioning method, frequency and higher PEEP are risk factors for complications during endotracheal suctioning[12]. Procedure changes could be a cause of complications not only for caregivers at home, but for healthcare professionals as well. Little is known about the risk of procedure changes in emergent situations. The aim of this research, therefore, is to determine the risk of procedure changes, focusing on the influence of these changes on the time to perform endotracheal suctioning.

2. Methods

2.1 Selection of Participants

Internet and face-to-face invitations were sent to recruit participants currently working at healthcare institutions. Although participants were selected by convenient sampling, the years of clinical experience and type of wards where the participants worked were considered to reflect a real-world population. Inclusion criteria were as follows: registered nurses experienced in endotracheal suctioning at any institution, with at least 3 years of clinical experience. In total, 13 participants were recruited from three institutions. Two participants were excluded because of lack of technical expertise.

2.2 Study Protocol

The study was conducted at a single research laboratory. Nine participants were from an acute care hospital that routinely used the OSS with single-use catheter for endotracheal suctioning. The remaining two nurses routinely applied the OSS dry method at their institutions, which were long-term care facilities. Only one participant had experience with the CSS (N4). None of the nurses had experience with the use of all the six suctioning methods. Therefore, simple individual instruction was provided from a researcher before each procedure. The time was measured upon the confirmation from the participants, that they were ready to begin the procedure on the training model for endotracheal suctioning (M85 11229-000, KYOTO KAGAKU CO.,LTD). The protocol was approved by the Ethical Committee of the Faculty of Health Sciences, Hokkaido University (no.13-2). Written agreement forms from all participants were obtained before commencing the study.

2.3 Data Collection and Processing

In this study, the participants were tested using six types of endotracheal suctioning methods: 1) the OSS dry catheter method that keeps a catheter in a vacant container and is replaced every 24 hours, 2) the OSS with single-use catheter, 3) the OSS soak catheter method that keeps the catheter in the disinfectant, 4) the CSS, 5) the OSS that includes a foot-suction pump (FP-300, BLUE CROSS EMERGENCY CO.,LTD), and 6) the mechanically operated OSS that requires plantar flexion to exert pressure on a foot pedal (M002-00054927, SHIN-EI INDUSTRIES,INC.. The methods listed as 5) and 6) required maintaining the body weight and balance mainly on one leg as one foot has to operate the bellows pump or foot pedal, while suctioning. Hyperinflation, hyperoxygenation and saline lavage prior to suctioning were not used for any suctioning procedure.

Procedure time was measured from the time the participant put on the gloves until the gloves were disposed of. Each nurse performed suctioning twice by the six suctioning methods on a suctioning simulator model, resulting in a total of 132 time measurements. To avoid the repetitive use of t-test, we used Dunnett's test for data analysis. The CSS was chosen as the control group. Before statistical analysis, equality of variance was verified with an F-test. With the use of G*Power version 3.1 [13)], statistical power and degree of freedom (Df) were calculated by effect-size ($r = 0.75$) and total sample size ($n = 11$), which were $1-\beta = 0.95$ and $Df = 11$.

3. Results

A total of 11 nurses were enrolled in this study. All nurses were female, registered nurses from the same prefecture. Overall, participants were from three different healthcare institutions. Participants ranged between 25 and 40 years of age. One nurse was working as a nurse manager (N1). The clinical experience of participants ranged from 3 to 17 years (Table 1), with a mean clinical experience of 11.9 years.

The shortest mean procedure time was found in the CSS with 57.63 seconds (Table 2). The result indicated that the CSS method required a shorter time compared with the five OSS methods tested. The maximum performance time was almost two-fold the minimum time among these six suctioning methods, respectively. Only the CSS was statistically significant by t-test with the OSS open method as a comparison group: p=0.66(soak), 0.48(disposable), 9.46E-10(CSS), 0.37(foot pump), 0.61(foot pedal). There was no time difference in each suctioning method except the CSS method.

To analyze in detail, procedure time among the six different suctioning types is shown in Figure 1. As for the participants' advanced skill, one of the participants (N1) was a senior manager of the ward. As this nurse (N1) was previously employed in a ward that requires frequent suctioning practices, she achieved a shorter time of endotracheal suctioning compared with the other nurses. However, the longer clinical experience year of nurses was not reflected on the endotracheal suctioning procedure time as N3 N6 N9 and N10 performed with extended procedure time compared to other participants'. Therefore, the data were divided into two by the average procedure time, 120 seconds as the cut-off level, instead of their years of clinical experience. Hereafter, N3 N6 N9 and N10 were referred to as non-expert nurses and the remaining seven participants as expert nurses.

The mean procedure time for expert and non-expert nurses among the six methods was compared

(Figure 2). These expert nurses performed one series of suctioning within a range of 50 to 90 seconds with a mean of 77.4 seconds, while non-experts performed the same procedures in approximately 70 to 120 seconds with a mean of 107.9 seconds. After the equality of variance was verified using the F-test, the statistical significance was assessed by Dunnett's test in five pairs as the CSS a control group. Procedure time between experts and non-experts were statistically significant in the OSS dry method, the OSS soak method, the OSS single-use method, the OSS foot pump method, and OSS foot pedal method (p = 3.8E-8, 1.1E-8, 2.5E-6, 4.6E-7, and 1.2E-6, with effect size of r = 0.77, 0.79, 0.68, 0.77, and 0.66, respectively). The procedure time for CSS was significantly shorter compared with the remaining five OSS suctioning methods.

Using a paired t-test, the mean procedure time of the first and second trials was then compared for the six methods to account for the learning effects of performing the suctioning procedure twice. Only the CSS method ($P=0.001$) was significantly associated with a decrease in procedure time for the second round of suctioning (Figure 3). However, there was no significant decrease in the procedure time with the other five methods.

4. Discussion

There was a dramatic difference of procedure time for the five open methods between expert and non-expert groups. However, procedure time was not extended by each suctioning methods. These results imply that despite the different environments and scenarios, such as disaster, all nurses may indeed be capable of functioning with limited medical resources without prolonging “their usual procedure time” with the OSS methods. Furthermore, the CSS method was performed in the quickest by both experts and non-experts in endotracheal suctioning. There was relatively small difference between the two groups of nurses for the CSS method, whereas the remaining five OSS methods were significantly different in terms of skill acquisition. This indicates that the CSS method can be performed quickly regardless of the level of expertise of the operator. In other words, there may be a margin to simplify the five OSS procedures or to improve equipment considering emergent situation where there are limitation of resources.

As for the five OSS methods, there were significant differences between experts and non-experts. The result suggested that a greater clinical experience could be an important indicator of the expertise for endotracheal suctioning; however, the place of practice, that is the necessity of repetitive suctioning, may exert a greater influence on the procedure time. Work experience at ICUs or emergency rooms, which requires frequent suctioning, might be an expeditious track to improve endotracheal suctioning skills. In this research, one of the nurses enrolled was a nurse manager. The procedure time achieved by this nurse continued to be that of an expert, despite relocating to an area of work where there was no need for suctioning practices. Consequently, this finding indicates that once the skill of suctioning is acquired, it may remain as part of the long-term memory for many years. McGaghie, Issenberg, Petrusa, and Scalese (2010) determined that simulation-based education is superior to traditional clinical education in achieving specific clinical skill acquisition goals[14)]. The mechanisms of skill acquisition in terms of long-term memory could be studied further with the use of simulators. The use of simulators early in a healthcare professionals' career could lead to the achievement of high-quality skills for patient care in an emergency setting. Moreover, this approach has two major advantages, continuing professional education and human resources development[15)], that are important for the preparation for emergency situations.

Very few papers deal with the relationships between the skill acquisition and the procedure time in endotracheal suctioning. Time to perform a procedure is essential to assess skill acquisition as well as not make our patients to wait long. According to the description of the typology of learning trajectories at the early stage of professional development by Eraut (2011), he pointed out the context of task performance development, which consists of "speed and fluency", "complexity of tasks and problems", "range of skill required", "communication with a wide range of people", and "collaborative work" [15-18)]. Hence, time to perform the procedure was the only measurement in this study. Other educational validations, such as decision-making [19-21)] in emergency scenarios, obtaining respiratory/circulatory data during suctioning [22)], and hand maneuver, such as catheter control [23,24)] must be evaluated with the performance time in the future. Further research is required to find out the prolongation of performance time under the condition of adverse events, e.g. hemorrhage, bradycardia, and vomiting reaction, or the pedagogical evaluation of repetition to identify skill-facilitating factors and obstacles to prepare for disaster situations which occurs anywhere and anytime.

5. Conclusions

The prolongation of endotracheal suctioning time by changing techniques was not observed in this study; however, the difference in procedure time was confirmed between experts and non-experts in endotracheal suctioning and it was not related to their years of clinical experience. Among the six endotracheal methods, the shortest mean procedure time was for the CSS. The fact that procedure time for the CSS method was relatively similar between expert and non-expert groups indicated the expertise of participants had relatively small effect on time to perform the CSS method. The results also support the view that nurses might be able to perform any suctioning methods within their usual procedure time even in emergency. In addition, the procedure time could be used to measure the expertise of professionals as well as to determine which procedures could potentially be simplified.

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References

1） Deepu, D., Prasanna, S., Thambu, D., Nidugala, K.S., Aparna, I., Victor, P.J. : An open-labelled randomized controlled trial comparing costs and clinical outcomes of open endotracheal suctioning with closed endotracheal suctioning in mechanically ventilated medical intensive care patients. Journal of Critical Care 2011; 26: 482-488.

2） Evans, J., Syddall, S., Warwick, B., Kinney, S. : Comparison of open and closed suction on safety, efficacy and nursing time in a paediatric intensive care unit. Australian Critical Care 2014; 27: 70-74.

3） Giakoumidakis, K., Kostaki, Z., Patelarou, E., Baltopoulos, G., Brokalaki, H. : Oxygen saturation and secretion weight after endotracheal suctioning. British Journal of Nursing 2011; 20: 1344-1351.

4） Jongerden, I.P., Kesecioglu, J., Speelberg, B., Buiting, A.G., Leverstein-van, H., Maurine, A., Bonten, M.J. : Changes in heart rate, mean arterial pressure, and oxygen saturation after open and closed endotracheal suctioning: A prospective observational study. Journal of Critical Care 2012; 27: 647-654.

5） Oleci, P.F., Loureiro, D.R.M., Adriano, M.F. : Open system endotracheal suctioning: practices of intensive care nursing professionals. Anna Nery School Journal of Nursing 2014; 18: 296-302.

6） Jongerden, I.P., Buiting, A.G., Leverstein-van, H.M.A., Speelberg, B., Zeidler, S., Kesecioglu, J., Bonten, M.J. : Effect of open and closed endotracheal suctioning on cross-transmission with Gram-negative bacteria: A prospective crossover study. Critical Care Medicine 2011; 39: 1313-1321.

7） Day, T., Farnell, S., Wilson-Barnett, J. : Suctioning: A review of current research recommendations. Intensive Critical Care Nursing 2002; 18: 79-89.

8） Celik, S.S., Elbas, N.O. : The standard of suction for patients undergoing endotracheal intubation. Intensive Critical Care Nursing 2000; 16: 191-8.

9） Scoble, M.K., Copnell, B., Taylor, A., Kinney, S., Shann, F. : Effect of reusing suction catheters on the occurrence of pneumonia in children. Heart & Lung 2001; 30: 225-233.

10） McCroy, M.C., Lee, L.J., Scanlon, M.C., Wakeham, M.K. : Predictors of need for mechanical ventilation at discharge after tracheostomy in the PICU. Pediatric Pulmonology 2016; 51: 53-59.

11） McCormik, M.E., Ward, E., Robertson, D.W., Shah, R.K., Stachler, R.J., Brenner, M.J. : Life after tracheostomy: Patient and family perspectives on teaching, transitions, and multidisciplinary teams. Otolaryngology Head and Neck Surgery 2015; 153: 914-920.

12） Maggiore, S.M., Lellouche, F., Pignataro, C., Girou, E., Maitre, B., Richard, J.C., Lemaire, F., Brun-Buisson, C., Brochard, L. : Decreasing the adverse effects of endotracheal suctioning during mechanical ventilation by changing practice. Respiratory Care 2013; 58: 1588-1597.

13） Faul, F., Erdfelder, E., Buchner, A., Lang, A.G. : Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods 2009; 41: 1149-1160.

14） McGaghie, W., Issenberg, S., Petrusa, E., Scalese, R. : A critical review of simulation-based medical education research: 2003–2009. Medical Education 2010; 44: 50-63.

15） Eraut, M. : Developing a broader approach to professional learning, learning trajectories, innovation and identity for professional development. In: Innovation and Change in Professional Education (Mc Kee, A, Eraut, M., eds), pp.21-45, Springer, The Netherlands, 2012.

16） Eraut, M. : How professionals learn through work. pp.1-29, Surrey Centre for Excellence in Professional Training and Education(SCEPTrE), Surrey, 2011 http://www.mofet.macam.ac.il/amitim/forums/Documents/2010-2011/pds-2010-2011.pdf Accessed June 27, 2016.

17） Eraut, M., Hirsh, W. : The significance of workplace learning for individuals, groups, and organizations, pp.1-97, ESRC center on skills, knowledge and organizational performance, Swindon, 2014. http://www.skope.ox.ac.uk/wordpress/wp-content/uploads/2014/12/Monogrpah-09.pdf Accessed June 27, 2016.

18） Mochan, E., Nash, D.V. : Weaving quality improvement and patient safety skills into all levels of medical training: An annotated bibliography. American Journal of Medical Quality 2015; 30: 232-47.

19） Owen, E.B., Woods, C.R., O'Flynn, J.A., Boone, M.C., Calhoun, A.W., Montgomery, V.L. : A bedside decision tree for use of saline with endotracheal tube suctioning in children. Critical Care Nurse 2016; 36: e1-e10.

20） Arnold, J., Johnson, L., Tucker, S., Malec, J., Henrickson, S., Dunn, W. : Evaluation tools in simulation learning: performance and self-efficacy in emergency response. Clinical Simulation in Nursing 2009; 5: e35–e43. http://www.nursingsimulation.org/article/S1876-1399(08)00059-5/pdf Accessed June 27, 2016.

21） American Association for Respiratory Care, : AARC Clinical Practice Guidelines. Endotracheal suctioning of mechanically ventilated patients with artificial airways 2010. Respiratory Care 2010; 55: 758-764.

22） Day, T., Iles, N., Griffiths, P. : Effect of performance feedback on tracheal suctioning knowledge and skills: Randomized controlled trial. Journal of Advanced Nursing 2009; 65: 1423-1431.

23） Ahn, Y., Hwang, T. : The effects of shallow versus deep endotracheal suctioning on the cytological components of respiratory aspirates in high-risk infants. Respiration 2003; 70: 172-178.

24） Gillies, D., Spence, K. : Deep versus shallow suction of endotracheal tubes in ventilated neonates and young infants. Cochrane Database Systematic Review 2011; 6: CD003309.

Table 1. Background of Participants

	Clinical Experience (Years)	Experienced Ward(s)
N1	17	Brain surgery, Psychiatry
N2	12	NICU, GCU
N3	17	Internal medicine, Gynecology, Radiology
N4	17	ICU, NICU, Severe intellectual/physical disability
N5	11	Severe intellectual/physical disability, Community Healthcare
N6	6	Urology
N7	14	Psychiatry, Neurology
N8	13	Psychiatry, Emergency room
N9	4	Urology
N10	3	Urology
N11	17	Internal medicine, Urology

Mean clinical experience = 11.9 years

Table 2. Overall of procedure time for the six suctioning methods

Sec.

	Dry	Soak	Disposable	Closed	Foot pump	Foot pedal
Min.	70.07	74.61	66.07	36.44	70.37	64.73
Mean	99.23	102.18	93.99	57.63	93.69	95.25
Max.	147.26	146.05	155.50	81.85	151.93	174.02
SD	21.22	21.98	25.50	11.27	17.90	28.27

** （α=0.01）

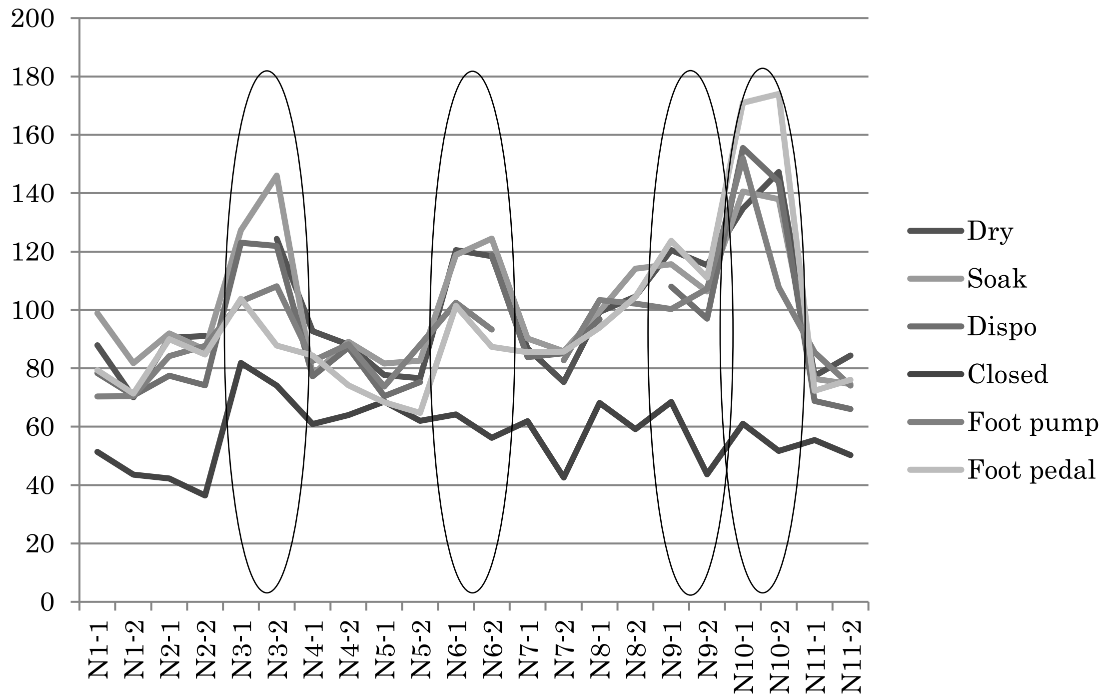

Figure 1. Procedure time among six different types of endotracheal suctioning

Sec.

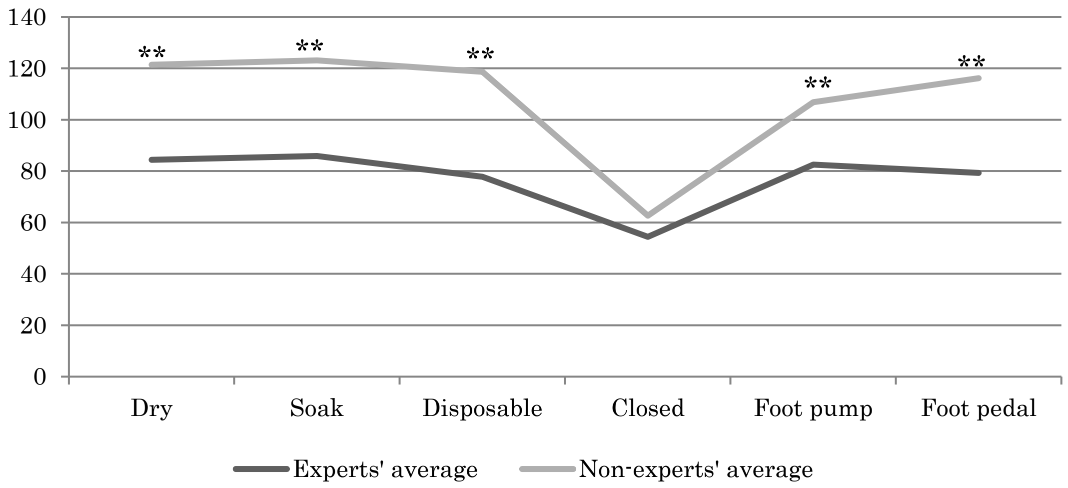

Figure 2. Mean procedure time for endotracheal suctioning methods by groups

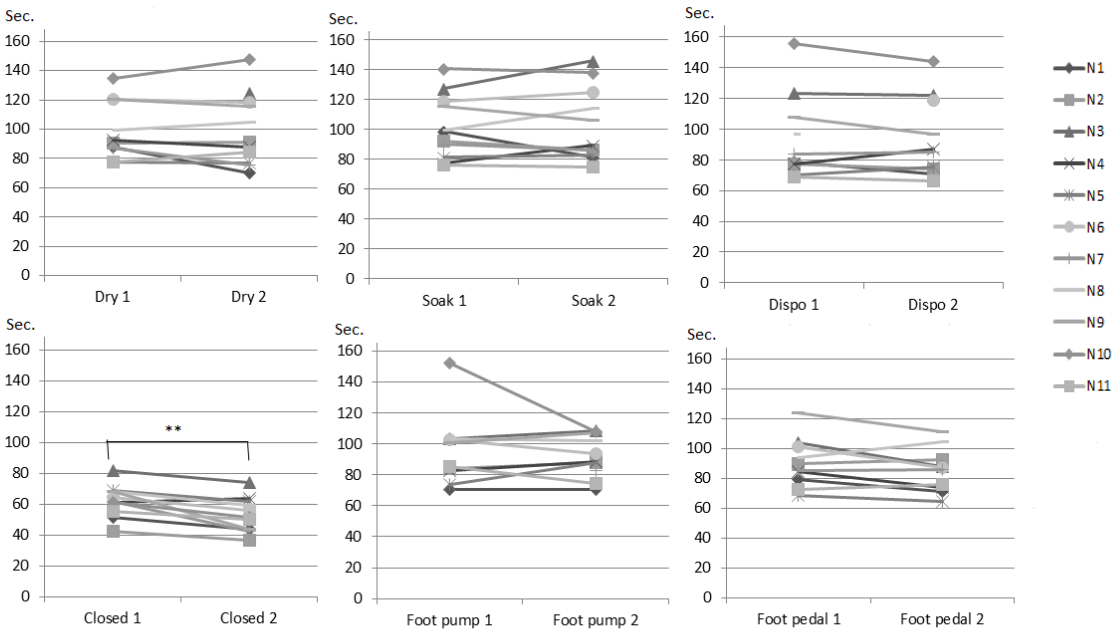

Figure 3. Comparison between first and second trials