Training situation awareness through error recognition in an immersive virtual operating room

Marie-Stéphanie Bracq, Marie Le Duff, Estelle Michinov, Bruno Arnaldi, Valérie Gouranton, Jeanne Descamps, Pierre Jannin

TRAINING SITUATION AWARENESS THROUGH ERROR RECOGNITION IN AN IMMERSIVE VIRTUAL OPERATING ROOM

Marie-Stéphanie Bracq[1,2], Marie Le Duff[2], Estelle Michinov[1], Bruno Arnaldi [3], Valérie Gouranton[3], Jeanne Descamps[4], Pierre Jannin[3].

1. Univ Rennes, LP3C (EA 1285), F-35000 Rennes, France
2. Univ Rennes, Inserm, LTSI - UMR 1099, F-35000 Rennes, France
3. Univ Rennes, INSA Rennes, Inria, CNRS, IRISA, F-35000 Rennes, France
4. Ecole d'Infirmier(e)s de Bloc Opératoire – Pôle de formation des professionnels de santé du CHU de Rennes, France

Contact: marie-stephanie.bracq@univ-rennes2.fr

INTRODUCTION

Training healthcare professionals in non-technical skills is crucial for patient safety and quality of care. Simulation offers good opportunities to achieve that goal. Simulation technologies are emerging, including virtual reality (VR). However, few simulation training scenarios using VR simulators focus on non-technical skills (NTS) (Bracq, Michinov, & Jannin, 2018). The "Error Recognition in an immersive Virtual Operating Room (OR)" scenario aims to develop situation awareness (SA) in a VR environment.

SA is the ability to gather information, recognize and understand information, as well as anticipate its future status (Flin, O'Connor, & Crichton, 2008). It is a crucial NTS in the OR as it has a direct impact on communication, decision making, leadership and teamwork (Flin, Youngson, & Yule, 2015), other key NTS. "Error recognition in an OR" is a simulation scenario involving real-life situations in a mock-up OR in order to sensitize healthcare professionals to quality and safety standards as well as hygiene rules (Mirek & Prétot, 2019). Our goal in using this simulation scenario in a VR environment was to extend its pedagogical interest to situation awareness training, in particular for scrub nurses who are responsible for hygiene and security and for whom SA is a major NTS (Mitchell et al., 2012).

MATERIALS AND METHODS

Virtual Reality Simulator

Participants were immersed in a virtual OR, and were not guided during the simulation; they could move freely between 5 different places: equipment, colleagues, instrumentation tables, patient and tactile screen (see Figure 1). The scenario included 19 errors, divided into five categories: identity monitoring, hygiene and risk of infection, wrong-site surgery, patient safety, and flow disruptions. The VR equipment used was an HTC Vive system, composed of a Head Mounted Display and two hand-controllers.

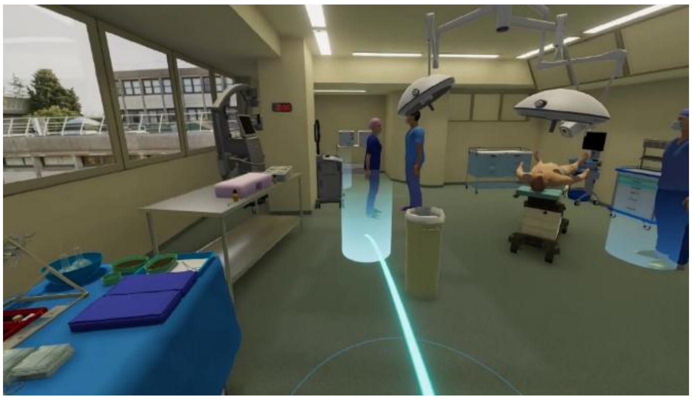

Fig 1. Scenario of "Error recognition in the virtual operating room (OR)"

Participants and setting

The scenario was pretested by three second-year students at the School for Scrub Nurses in Rennes in December 2018. The simulation sessions for the pilot study took place on 22nd and 23rd January 2019 with 18 first-year student nurses. Participation was individual and was followed by a short collective debriefing with scrub nurse teachers. The study was approved by the Ethics Committee of the University Hospital of Rennes.

Tasks

Participants had to check that quality standards, safety and hygiene rules were respected in the virtual OR. They had 14 minutes to report any surgical error they observed. Before entering the virtual environment, participants read a paper version of the patient file. The case was a craniotomy for Mr Jean Dupond, born on July 12th 1955, who had a left frontal meningioma (brain tumor).

Assessment metrics

Data were gathered from self-report post-simulation questionnaires about SA (SART; Taylor, 1990) and workload (NASA TLX; Hart & Staveland, 1988), from the number of errors detected and from the log files (head and hand position, pattern of movements in the OR). Participants also assessed the simulator for ease of use, immersion and efficiency on a 5-point Likert scale. We did not measure participants' fatigue because we feared it would be too general and not specifically due to the simulation.

Hypotheses

H1: Participants detecting few errors (group 1) would have a higher workload than participants detecting a large number of errors (group 2).

H2: Participants detecting a large number of errors (group 2) would have a higher level of SA than participants detecting few errors (group 1).

H3: Participants detecting a large number of errors (group 2) would rate the simulator's ease of use, immersion and efficiency higher than participants detecting few errors (group 1).

H4: Participants detecting a large number of errors (group 2) and those detecting few errors (group 1) would visit a different number of places in the virtual OR.

RESULTS

Statistical analyses were conducted with JASP (JASP Team, 2018). The median number of detected errors was 9. We median-split participants into two groups in order to compare their results using unilateral Student's T- tests, after checking the normality hypothesis, as we assumed level of SA would be better for participants who had a better error detection, and workload would be higher for those with a lower error detection. Group 1 members detected fewer than 9 errors (n_1=7), and group 2 members detected 9 errors or more (n_2=11).

Mean value for Workload was 56.96 (min=30.83, max=69.17, *SD*=13.04) for group 1, and 44.06 (min=20, max=58.83, *SD*=13.87) for group 2. The difference between the two groups was significant $t(16) = 1.967$, p =.033, validating H1 (see Figure 2).

Mean value for SA was 12.14 (min=-8, max=25, *SD*=12.18) for group 1, and 22.27 (min=10, max=33, *SD*=7.31) for group 2. The difference between the two groups was significant $t(16) = -2.22$, p =.021, validating H2 (see Figure 3).

There was no statistically significant difference between groups for ease of use and efficiency. For immersion, mean values were 3.32 (min = 1.25, max = 5, *SD* =1.31) for group 1 and 4.36 (min= 3, max= 5, *SD*= 0.69) for group 2. The difference between the two groups for Immersion was significant $t(16) = -2.216$, p =.021, partially validating H3 (see Figure 4).

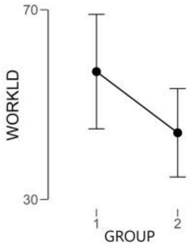

Fig 2. Workload

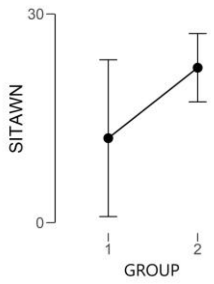

Fig 3. Situation Awareness (SA)

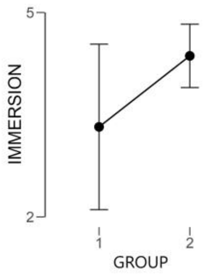

Fig 4. Immersion

The number of locations visited by each participant was analyzed. The mean number of places visited by group 1 was 11.29 (min=9, max=16, *SD*= 2.29), and the mean number visited by group 2 was 12.91 (min=8, max=29, *SD*= 5.97). Group 2 visited slightly more places than group 1, but the difference was not statistically significant, invalidating H4. Patterns of movement were also analyzed, focusing on the first place visited; 10 participants checked the tactile screen first, 6 the instrumentation table, 1 the equipment, and 1 the patient. None checked their colleagues first. A complementary analysis of movements is being conducted, to see whether any pattern emerges, as in VR training for laparoscopic surgery (Gallagher & Satava, 2002) (see Figure 5).

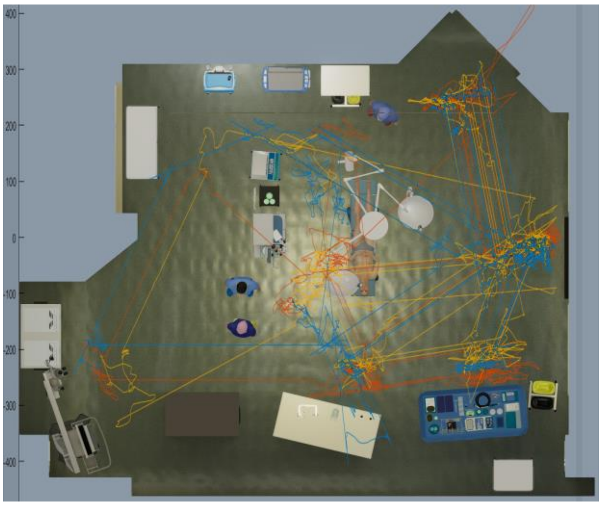

Fig 5. Aerial view of the operating room (OR) showing the movements of 3 participants

DISCUSSION AND CONCLUSION

In this study, we analyzed the workload and SA of participants immersed in a virtual surgical simulation. Although error recognition, workload and SA might be interdependent processes, the results confirm two of our main hypotheses: participants detecting few errors had a higher level of workload, and participants detecting a large number of errors had a higher level of SA. The latter also felt more immersed in the environment. The number of places visited does not seem to predict error detection. However, it would be interesting to analyze participants' strategies in the virtual OR through the first place they visited and their movements in the OR.

Although the scenario was only tested on a small sample, it enables SA to be assessed and seems to be a suitable training tool for this NTS, especially when it is followed by debriefing.

Participants were not asked about their previous experience of video games or VR, as the acceptability study of the environment demonstrated that it had no impact[10], but it could have been interesting to check that this was still valid.

At the request of the nursing students at the end of the collective debriefing, a second session with the same participants and the same scenario is scheduled for August 2019. This will allow us to analyze any progression in students' behavior and attitude towards both the simulator and the scenario. It will also give us an opportunity to observe any changes in their movements in the OR, and see if any profiles emerge.

Future studies, such as expanding and diversifying the sample and the specialty of participants, will be considered. Future studies should test the external validity of "Error Recognition in the Virtual OR" and see whether its use can be extended to other professions.

REFERENCES

Bracq, M. S., Michinov, E., & Jannin, P. (2018). Virtual Reality Simulation in Nontechnical Skills Training for Healthcare Professionals : A Systematic Review. *Simulation in Healthcare : Journal of the Society for Simulation in Healthcare*. https://doi.org/10.1097/SIH.0000000000000347

Flin, R., O'Connor, P., & Crichton, M. (2008). *Safety at the sharp end, a guide to non-technical skills*. Farnham: Ashgate Publishing Limited.

Flin, R., Youngson, G. G., & Yule, S. (2015). *Enhancing Surgical Performance : A Primer in Non-technical Skills*. CRC Press.

Gallagher, A. G., & Satava, R. M. (2002). Virtual reality as a metric for the assessment of laparoscopic psychomotor skills. *Surgical Endoscopy*, *16*(12), 1746-1752. https://doi.org/10.1007/s00464-001-8215-6

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index) : Results of Empirical and Theoretical Research. In *Advances in Psychology* (Vol. 52, p. 139-183). https://doi.org/10.1016/S0166-4115(08)62386-9

JASP Team. (2018). *JASP (Version 0.9)[Computer software]*. Consulté à l'adresse https://jasp-stats.org/

Mirek, S., & Prétot, R. (2019). Le "bloc des erreurs" en simulation, apprendre autrement. *Inter bloc*, *6502*(1), 28-31. http://dx.doi.org/10.1016/j.bloc.2019.01.004

Mitchell, L., Flin, R., Yule, S., Mitchell, J., Coutts, K., & Youngson, G. (2012). Evaluation of the Scrub Practitioners' List of Intraoperative Non-Technical Skills (SPLINTS) system. *International Journal of Nursing Studies*, *49*(2), 201-211. https://doi.org/10.1016/j.ijnurstu.2011.08.012

Taylor, R. M. (1990). Situation awareness rating technique (SART) : The development of a tool for aircrew systems design. *Situational Awareness in Aerospace Operations (Chapter 3).* Présenté à France: Neuilly sur-Seine. France: Neuilly sur-Seine: NATO-AGARD-CP-478.