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Training the operating room staff in a virtual multiplayer and real-time environment to prevent adverse events: study of team situation awareness and decision making using the learning game 3D virtual operating room

Catherine Pons Lelardeux^{*1,6}, David Panzoli^{1,6}, Vincent Lubrano^{2,6}, Vincent Minville^{3,6}, Pierre Lagarrigue^{4,6} and Jean-Pierre Jessel^{5,6}

¹IRIT – University of Toulouse, INU Champollion, Albi, France

²INSERM - Toulouse University Hospital, Toulouse, France

³MATN- Toulouse University Hospital, Toulouse, France

⁴ICA - University of Toulouse, INU Champollion, Toulouse, France

⁵IRIT – University of Toulouse, UT3 Paul Sabatier, France

⁶Serious Game Research Network

*e-mail: catherine.leardeux@univ-jfc.fr

Abstract:

Many studies show that communication defaults are the most current contributive factor of adverse events in the operating room. A successful surgery depends on how accurately a dynamically evolving situation can be assessed on the basis of the information exchanged. First, this paper describes the use of 3D Virtual Operating Room, an innovative virtual multiplayer and real time environment which features a communication system designed to be used in a training context. A voting system is available to debate and make decisions on predefined topics. An experiment took place with anesthetist-nurse students and their trainer in order to analyze their behavior when they have to manage a non-standardized but real-life situation. We study different variables to analyze how information flows between the members of a team, how they make decisions and how much they are aware of the situation when they make a decision.

Keywords:

Team situation awareness, decision making, operating room, learning game, training situation

1. Introduction

In healthcare, 65% of adverse events in healthcare are related to surgery (Zegers et al., 2011). 54% of surgical adverse events occurring in industrialized countries are considered as avoidable events (Gawande, Thomas, Zinner, & Brennan, 1999). Many studies show that human factors are most often listed among the multiple causes of an accident or a near-miss. They also point that the most current root causes of adverse events in the operating room is due to a communication problem (Halverson et al., 2011; Kohn, Corrigan, & Donaldson, 2000; Lingard et al., 2004). The composition of the team is heterogeneous and each team member has their own technical skills and responsibilities. There are multiple interactions that influence the evolution of the system but a successful surgery depends on what information is dynamically exchanged to understand what is going on (Hempel et al., 2013; Plasters, Seagull, & Xiao, 2003).

2. State of the art

Flin et al (Flin, Patey, Glavin, & Maran, 2010) point the importance of non-technical skills that are not directly linked to anaesthetist's technical expertise. Non-technical skills are divided in two categories : interpersonal skills and cognitive skills (Neyns, 2011). Interpersonal skills as

communication, leadership and coordination... are skills that make teamwork effective to reach a common goal. Cognitive skills are composed of task management, situation awareness (Endsley, 1995; Kaber & Endsley, 1998) and decision making.

Situation awareness is based on pieces of information that can be seen during the situation. From all the information collected, each one makes their own mental representation according to what they have collected, memorized and understood.

Decision making skills consist in assessing the situation, listing the possibilities, identifying their costs and benefits and then decide the most suitable action to do or make a diagnostic on what's happening (Gaba, 1989).

Keyton & Beck (Keyton & Beck, 2010; Keyton, Beck, & Asbury, 2010) stress the difference between the macro-cognitive framework and the communication framework. "The two approaches differ in the role of communication: as information exchange in macro-cognition as compared with verbal and nonverbal symbols composing messages for which senders and receivers co-construct meaning" (Keyton & Beck, 2010). Here, the word "communication" refers to macro-cognition framework. The team members make their decisions based on their own representation of the situation. The lack of communication can lead the team to build a restricted mental and erroneous representation which could breed inadequate decision-making regarding the real living situation.

Team situation awareness is one of the critical factors in effective teamwork (Salas, Prince, Baker David, & Shrestha, 1995) and can impact the success of the final achievement. Mathieu et al (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000) showed the influence of shared mental models on team process and performance.

Sharing information could allow the team to build a common and more realistic representation of the situation. Therefore, decisions are likely to be more suitable. The collaborative decision making problems (Serman, 1989) can be addressed through argumentation and collaboration between the users involved.

On the basis of video clips recorded during real-life surgery operations, Devreux (Devreux, 2015) studied how professionals communicate according to the level of experience they have¹. His findings highlight how experts adapt their strategies by collecting the same information from different sources in order to check their coherence.

Some researches focus on the risk management in healthcare and highlight the importance to develop habits of action (Norros & Klemola, 1999).

Learning is a process which is constantly modified by experience (Kolb, 1984). So, involving the teams to investigate inter-professional collaboration in a virtual environment should enable them to experiment risky conditions, to identify errors, adapt their behavior, make suitable decision and then evaluate miscellaneous causes of near-miss.

3. Objectives and Methods

This paper describes the use of 3D Virtual Operating Room (3DVOR), an innovative virtual multiplayer and real time environment which features a communication system designed to be used in a training context. 3DVOR represents with great fidelity the structure and complexity of an operating room. It allows controlled manipulations of the decision context and controlled information available to the subjects. It is composed of an operating room (medical equipment, patient record, drugs...) and avatars for the patient, the surgeon, the anesthetist and the nursing staff. It aims to train them on non-technical skills. They need to communicate, act, share information and make the most suitable decision with respect to the situation. The individuals,

¹ For further details, see the poster named "The impact of operators' profession and experience and informational uncertainty during an advert event occurring in a surgical operation: A combined evaluation of situation awareness using SAGAT and eye tracking" presented at HEPS 2016. This study is part of a PhD work, supervised by J. Cegarra et A. Chevalier and financed by the 3D VOR project.

grouped in a virtual team, play the role of professionals in the virtual scene of the operating room system.

The team can experiment educational situations based on real-life situation of Surgery Theater. These situations are designed to train them to manage these situations, anticipate failures, identify and correct errors. The communication system is neither based on voice-chat nor branching dialogues but features graphical tags representing pieces of information and that can be manipulated as tangible objects in the virtual operating room.

Graphical interactions allow users to act, collect, memorize, listen and broadcast pieces of information. The Users can also ask questions and give answers thanks to information tags stored in a graphical panel representing their virtual memory. A voting system is available to debate and vote on predefined topics. Each participant can argue with pieces of information that have already been collected in the universe.

First, we check the usability of the application and then study some variables to analyze if teams are aware of the situation when they make a decision. The variables explored are:

- Pieces of information exchanged inside the virtual environment,
- Piece of information used as argument during the collaborative discussion,
- Anomalies found and exchanged,
- Decisions made by the leader after each collaborative discussion,
- Anomalies discovered and naturally spoken out during the debriefing with the trainer after the game session.

The scenario used in this experimentation focused on two adverse events: wrong patient and wrong site surgery which should be avoided using the Surgical Safety Checklist recommended by the World Healthcare Organization. The two first checklist's items concerned are: "Is the patient's identity confirmed?" and "Is the patient's operating site confirmed?"

The scenario is divided into 3 steps: (i) Verifying patient's identity (ii) Verifying patient's surgical site (iii) Move the patient to the operating room. The scene takes place when the patient has been transferred from their room to the operating room. The mission shown to the team of students consists in preparing the patient from his arrival in pre-operating room until the end of the anaesthesia procedure.

The students are unaware of the hidden educational objectives which are: "Reducing the wrong patient risk applying the checklist", "Reducing the wrong patient risk applying the checklist" and "Adapting the security procedure to the context". A briefing was shown at the beginning to explain the main visible objective. The scenario embeds some hidden anomalies as patient's bracelet is unreadable, patient can't say his name because of his disease, pieces of information relative to operating site mentioned under the different medical and nurse files are incoherent...

Pieces of information are dispersed throughout the environment and available depending on the character's role so as to encourage players to communicate.

This paper aims to analyze teamwork inside this virtual environment. We analyze how subjects interact with each other's, collect and ask information to build their own representation of the situation. Finally, we analyze if the team succeeds to share a common representation of the situation by exchanging information and then, how they make the final decisions. The method consists in using this virtual environment in a real training session with a trainer and their students.

The 18 students involved were in their last year of Anesthetist Nurse School and they already worked in the operating room. Trainer splits the students into 3 teams. The experiment was planned at the end of their grade and had no impact on it. They were not allowed to talk but to use the communication system provided by the virtual universe. Sessions were video-recorded and logged computer data were stored.

4. Results & Discussion

The learners are expected to follow or adapt clinical and paramedical tasks from the admission of the patient to the operating room. During the experiment, the teacher supervises in real time the team's activity by means of a specific graphical interface. At the end, the trainer discusses with the students in a debriefing period to make them verbally express the anomalies found, their own representation of the situation and the risks they have been faced to.

4.1 Usability

The system was designed with advanced user-friendly features, including interactive broadcasting, listening, announcement, request and answer systems. The first step consists in observing the teamwork timeline to make sure that the communication system is operating and readily useable. Checking this point, individual representations of the situation should be built during the session.

Figure 1 and Figure 2 show the global activity grouped by character's role and communication features for team 1 and 2. On average, 562 events were recorded by the tracking system during the a session and every communication features (except voting) was used during the first five minutes of the training sessions. For every session, the communication started between the team members during the first minute of game session. The dialogue is initiated between 2 players most often by a request. During the first minutes of the game session, students discover that triggering an action makes a sound and they have fun with it.

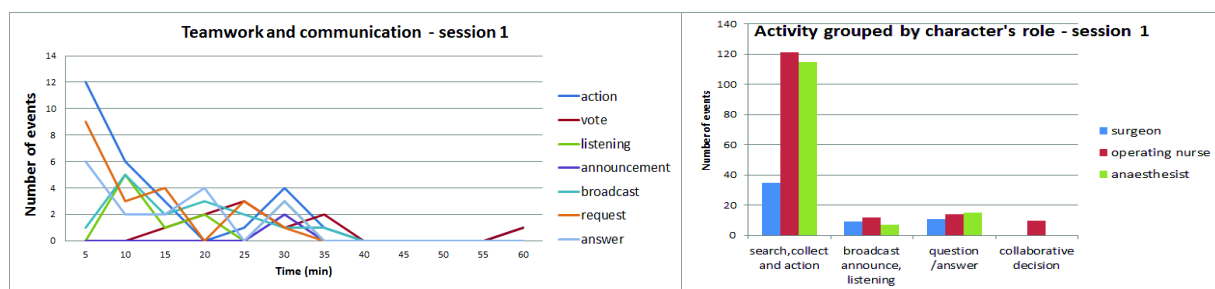


Figure 1: teamwork activity: team 1

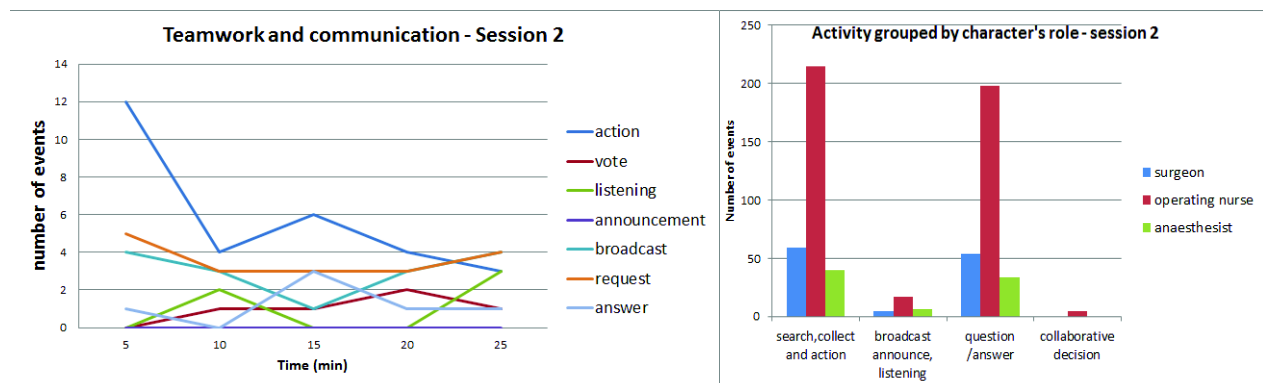


Figure 2: Teamwork activity: team 2

On average, the checklist form has been read 6,2 times, the anesthetist form had been read 1,3 times, surgical planning 2,5 times, MRI 0,8 times, doctor's letter 1 time and clinical department nurse form 1 time. Each character's role can access to a limited number of documents. Figure 3 shows how many times each character reads a document according to his access rights.

The quantity of information collected from objects is significantly higher than other related interactions like transmissions or requests. The global activity during the game and the behaviors observed as gestures, postures, facial expressions... points out that teams were engaged in the scenario and succeed to operate a dialogue and collect information reading documents.

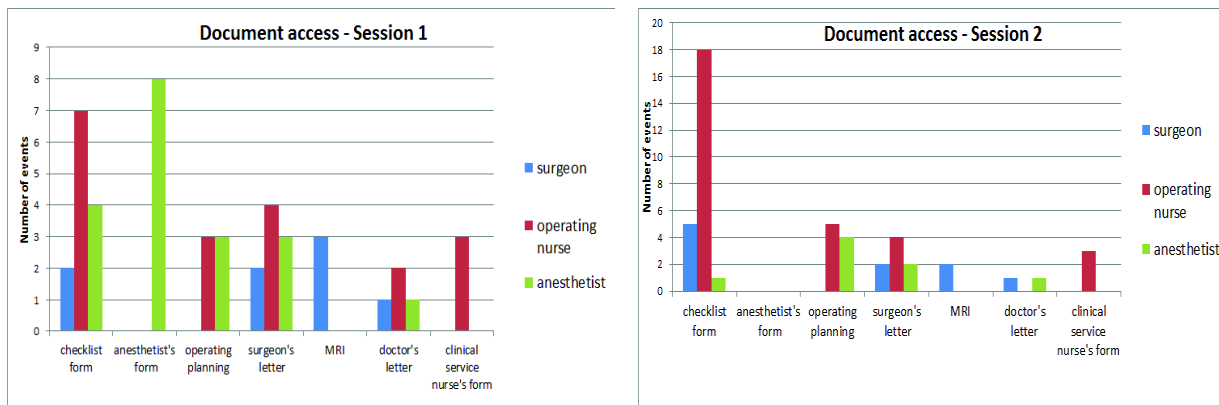


Figure 3: Distribution of document access according to the character's role

4.2 Situation awareness and decision making

Analyzing the topics of dialogue, the patient's identity was the first topic of discussion or collected information (158 for team 1, 163 for team 2) and the operating surgery site was the second one (89 for team 1 and 78 for team 2). Different strategies were observed: the first one consists in collecting pieces of information from documents whereas the second one consists in collecting information asking questions to teammates. For all teams, every anomaly hidden was found and exchanged them between the team members. The surgeon's character used the most relevant piece of information to help the leader to make the most suitable decision but 2 team leaders out of 3 decided not to trust the surgeon when he confirmed it was their patient during the voting period. During the debriefing, they expressed verbally all the anomalies found and the leaders explained that the surgeon are not used to be present during this step in real-life. They all expressed that if a similar situation (i.e. if the patient can't say their name and the identity bracelet is unreadable) was to happen in real life, they would rather ask a nurse outside the operating theater to confirm the patient's identity than trusting the surgeon.

5. Conclusion & perspectives

We have presented an innovative virtual environment designed to be used in fully digital educational context. It aims to control the conversation topics and facilitate the conversation by implementing some implicit conversation rules and proposing decision making features. Experiments were conducted in a healthcare training context, using a collaborative scenario taking place in a virtual operating room and dealing with risks related to the wrong patient or the wrong site surgery. It reveals the team situation awareness and their behavior. It may stress their disagreements managing a near-miss situation that could be discussed with the trainer on the debriefing session, based on tangible recorded events. Future work will enhance the collaborative learning environment with new features to improve the virtual experience of collaborative teamwork with students from different medical and nurse schools.

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