Nurse Education Today 50 (2017) 104–108

Contents lists available at ScienceDirect

Nurse Education Today

journal homepage: www.elsevier.com/nedt

Cognitive control level of action for analyzing verbal reports in educative clinical simulation situations

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A R T I C L E I N F O

Article history:
Received 20 July 2016
Received in revised form 5 December 2016
Accepted 13 December 2016
Available online xxxx

Keywords:
Simulation
Education
Nurse
Cognitive control
Debriefing

A B S T R A C T

Background: Several methods and theoretical frameworks have been proposed for efficient debriefing after clinical simulation sessions. In these studies, however, the cognitive processes underlying the debriefing stage are not directly addressed. Cognitive control constitutes a conceptual link between behavior and reflection on behavior to apprehend debriefing cognitively.
Objectives: Our goal was to analyze cognitive control from verbal reports using the Skill-Rule-Knowledge model. This model considers different cognitive control levels from skill-based to rule-based and knowledge-based control.
Design: An experiment was conducted with teams of nursing students who were confronted with emergency scenarios during high-fidelity simulation sessions.
Settings: Participants' descriptions of their actions were asked in the course of the simulation scenarios or during the debriefing stage.
Participants: 52 nursing students working in 26 pairs participated in this study.
Methods: Participants were divided into two groups: an “in situ” group in which they had to describe their actions at different moments of a deteriorating patient scenario, and a “debriefing” group, in which, at the same moments, they had to describe their actions displayed on a video recording. In addition to a cognitive analysis, the teams' clinical performance was measured.
Results: The cognitive control level in the debriefing group was generally higher than in the in situ group. Good team performance was associated with a high level of cognitive control after a patient's significant state deterioration.
Conclusions: These findings are in conformity with the “Skill-Rule-Knowledge” model. The debriefing stage allows a deeper reflection on action compared with the in situ condition. If an abnormal event occurs as an adverse event, then participants' mental processes tend to migrate towards knowledge-based control. This migration particularly concerns students with the best clinical performance. Thus, this cognitive framework can help to strengthen the analysis of verbal reports.

1. Introduction

Today, debriefing is considered as a critical component of learning in healthcare simulation. In an educative perspective, the main purpose assigned to debriefing is to translate the experience of simulated events into actionable knowledge. To meet this purpose, the debriefing stage closes the learning loop by bringing reflection on the actions performed by participants during the simulation (Fanning and Gaba, 2007). The paramount importance of the debriefing stage is also related to the considerable costs associated with high-fidelity simulation (see Lapkin and Levett-Jones, 2011, for a cost/utility analysis). The return on investment strongly depends on what participants have assimilated from the simulation session, and this assimilation occurs particularly during the debriefing stage (Shinnick et al., 2011; Kuznar, 2007).

To ensure effective debriefing, different educative methods have been proposed, and various debriefing conditions have been implemented and sometimes – but rarely – assessed (Cantrell, 2008; Dufrene and Young, 2014; Mariani et al., 2013). These proposals are generally based on educative theoretical backgrounds, like Dewey's theory of experiential learning, Kolb's cycle of learning, or on a general educational approach, such as constructivism or behaviorism (Parker and Myrick, 2009). These frameworks offer a rationale to examine the learning process expected from events experienced by participants during simulation (Chambers et al., 2013).

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http://dx.doi.org/10.1016/j.nedt.2016.12.016

Nevertheless, in all these studies, the cognitive processes underlying the debriefing stage are not directly addressed (Regan and Onello, 2013). Yet, evidence-based knowledge of the cognitive processes involved in students' verbal reports is required before proposing educative solutions based on these reports, so as to ensure that the verbal reports produced during debriefing effectively reveal and create changes in the participants' reflection. This evidence-based knowledge of cognitive processes would help define relevant cognitive cues and consequently best practices to ensure efficient debriefing (Neill and Witton, 2011).

In the next section, the notion of cognitive control is presented as a major conceptual candidate to apprehend the relationships between behavior and reflection on behavior. To capture this individual cognitive control processing, we used Rasmussen's (1983) Skill-Rule-Knowledge (SRK) model as a relevant psychological framework, given its fruitful use in previous human factors studies investigating cognition at work (Flach, 2015; Vicente and Rasmussen, 1992; Woods, 2009). Based on this framework, an experiment was conducted with teams of nursing students who were confronted with high-fidelity simulation scenarios. During this experiment, participants' cognitive control levels, in terms of the SRK model, were assessed at different moments of the scenario. This assessment took place during the simulation stage for one group of students, and during the debriefing stage for another group.

2. Background: Cognitive Control of Action and the Skill-Rule-Knowledge Model

Cognitive control is a process particularly involved in relating action to reflection. Cognitive control ensures that reflection drives the course of action. Through top-down processes, intention and action preparation processes specify the conditions of motor program implementation (Hommel, 2009). Reciprocally, bottom-up processes monitor the achievement of intentions. They enable the detection of possible errors, or more generally mismatches between intention and actual action effects (Fernandez-Duque et al., 2000). Action monitoring is also requested for acquiring skills. It is a prerequisite to allow experiential learning (Gollwitzer and Schaal, 1998).

In human factors/cognitive ergonomics studies, expertise acquisition often constitutes a central topic of research. In this sphere, studies have highlighted the need to model cognitive control modalities to apprehend skill acquisition at work and agents' adaptation when facing abnormal or unfamiliar work conditions (Holden et al., 1999; Hollnagel, 1997; Woods and Branlat, 2010). One major theoretical framework used in these studies is the SRK model proposed by Rasmussen (1983). The SRK model posits that individuals at work initiate goals that drive their behavior at different levels of cognitive control. Three forms of behavioral control are identified: skill-based, rule-based, and knowledge-based behaviors.

Skill-based behaviors concern intentional activities relying on sensory-motor programs that generally take place without conscious control. This kind of behavior involves smooth, automated and highly integrated patterns of sensory-motor programs, and consequently rapid coordinated movements. The environment-governed constraints on which these patterns of behavior are based are physical time-space signals that directly guide the behavior. Conscious processes can modulate skill-based control by allocating attentional resources to cues that serve as signals for the sensory-motor programs. Skill-based behaviors correspond to routines engaged in the activity.

Rule-based behaviors are behaviors controlled by rules or procedures that can be derived from previous personal experiences or from information communicated by other persons or information systems (e.g., instructions). These rules are based on environmental signs that represent functional constraints experienced in the past that individuals must cope with. Rule-based behaviors are used to match the work conditions experienced by the agents with possible decisions or actions.

Knowledge-based behaviors are controlled by explicit mental models shaped by individuals. This level of cognitive control involves concepts, goals, and plans that can be tested physically during actual trial and error in the environment or conceptually through mental simulation. Relevant information for this level is represented through symbols that allow an abstract and deep understanding of the functional properties of the environment and the prediction of the plan effects at different levels of the temporal horizon. Whereas skill-based behaviors are activated during familiar situations, knowledge-based control is particularly required when people need to face less well-defined situations. Consequently, in front of an unfamiliar situation, behavior control moves to a higher level for greater understanding of the situation. For Rasmussen (1983), this cognitive migration process is a specific trait of work expertise. Experts are assumed to be particularly able to leave their usual routine to keep control on the current changing and challenging environment.

In a study on decision making and surgical operative planning by neurosurgeons, Morineau et al. (2009) showed that it was possible to determine the SRK control levels that the surgeons refer to during their planning elicitation through verbal report coding. In that study, a sample of neurosurgeons (two board-certified neurosurgeons, two chief residents, and two residents) described the operative procedures envisaged on a set of surgical cases of increasing surgical complexity. To solve potential problems detected in their surgical procedures, the experts activated a higher proportion of knowledge-based control, as compared to intermediates and residents. Thus, Rasmussen's (1983) insight that migration towards knowledge-based behavior during complex events applies to experts rather than novices was verified. Additionally, psychological studies have confirmed that people are able to give explicit meanings to daily activities, and that these meanings can be analyzed as referring to different control levels (Vallacher and Wegner, 1987; Meineri and Morineau, 2014).

Consequently, in the context of the high-fidelity simulation of clinical events for nursing education, we posed the following hypotheses: (i) students who participate in the simulation session are able to provide information on the cognitive control levels that govern their actions during an "in-simulation" questioning or later, during "post-simulation" questioning; (ii) if abnormal events occur during the simulation session in the form of rapid patient's deterioration, participants' mental processes migrate towards knowledge-based control; (iii) this cognitive migration to knowledge-based behavior particularly concerns students who show the best clinical performance.

3. Method

3.1. Participants

The participants were 52 nursing students (working in 26 pairs), 7 men and 45 women, between 22 and 45 years of age, in the final year of their Bachelor of Nursing studies (3rd year). Their recruitment was based on a voluntary process engaged by a contact through email. They were placed in randomized pairs that constituted paramedical teams.

The experimental setting consisted in a classical educational simulation room containing a high-fidelity mannequin. Physiological cues, like heart rate, blood pressure, breathing, and verbalizations were simulated through this mannequin. Standard medical equipment was also available in the room (emergency trolley with medicine, physiological monitor, and infusion pump). Each student wore an earpiece enabling them to receive messages coming from an experimenter.

The experimental procedure involved three stages: a briefing on the clinical case, a simulation session, and a debriefing managed by an experimenter. After a first test with the audio device, each team was confronted with one of two comparable simulation scenarios. To ensure confidentiality about the scenario contents, they were used alternately, even though confidentiality for such kind of exercise is a well-integrated