Comparing auditory and tactile cues to inform clinicians of patients' vital signs

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INTRODUCTION

The Intensive Care Unit (ICU) is a complex work environment, known for its high cognitive and physical workload (Carayon & Alvarado, 2007). The work of ICU nurses involves two forms of actions: initiated actions and responses to events, and is characterized by frequent interruptions (Bitan, Meyer, Shinar, & Zmora, 2004). Medical device alarms were found to account for over 20% of these interruptions (Drews, Markewitz, Stoddard, & Samore, 2019). Based on Wickens' (2008) Multiple Resources Theory (MRT) and the fact that the tactile modality remains almost unused in the current work environment, the concept of delivering alarm information via tactile cues has been examined. Our previous work showed over 80% correct identification rates of complex tactile cues when tested on undergraduate students (Katzman et al., 2019). This study aimed to compare clinicians' accuracy and response time to alarm information represented as tactile cues and auditory alarms. Furthermore, it expands knowledge regarding multimodal dual-tasking involving the tactile modality, and tactile complex cues in particular.

METHOD

The experiment consisted of two simultaneously performed activities—a continuous N-back task, which simulated the nurses' regular work, and an interfering alarm task, which presented frequent interruptions. The alarms consisted of three components: patient number (1 or 2), medical device (vital signs monitor / ventilator) and urgency (high / low), resulting in eight possible combinations. Alarms were presented via either *auditory* or *tactile* modality condition for each session, and all participants were tested under both conditions in counter-balanced order. Auditory alarms were delivered via SR850 SAMSON headphones. Tactile alarms were delivered via a tactile system consisting of an Engineering Acoustics Inc. (EAI) tactor controller Eval2.0 regulating two EAI-C2 tactors sewed into straps and positioned at two locations of the lower leg—lower tactor above the ankle and upper tactor below the knee. Participants were 12 registered ICU nurses from a large tertiary hospital. For each task, two performance aspects were examined—*accuracy rate* and *response time*. *Accuracy rate* was represented by the correct identification / correct response rate, and *response time* was the time in millisecond between the appearance of the stimulus and its response.

RESULTS

Alarm task

No significant differences were found for correct identification rates between auditory (55%) and tactile (45%) alarms ($z = -1.640,\ p = .101$). Response time was longer for tactile alarms than for auditory alarms ($z = -3.74, p < .001$).

N-Back task

A lower correct response rate and longer response time were observed under the tactile alarm condition than the auditory alarm condition ($z = 2.816,\ p \leq .005; \mathrm{z} = -1.94, \mathrm{p} \leq .052,$ respectively).

DISCUSSION

No significant differences were found between correct identification rates of the auditory and tactile alarms, while response time for tactile alarms was longer. As for the performance in the continuous task, both alarms modalities decreased performance for both measures, with the tactile condition having a stronger effect.

It is worth noting that unlike the auditory alarms, to which the nurses are regularly exposed, the tactile alarms were unfamiliar to them and were first encountered only during the present experiment. Also, these findings might have been affected by relatively short instructions and practicing sessions, due to time limitations. The instructions and explanations regarding the tactile alarms lasted approximately 3 minutes, followed by a one-minute practice session with the continuous task. Results from our previous experiments also support this idea, as identification rates for similar complex tactile alarms were significantly higher when the practice session was longer (approximately 5 minutes) (Katzman et al., 2019). Additionally, personality and perceived workload differences found in the nursing cohort, which might have also affect task performance (Deb & Claudio, 2015).

To take into account the effects of nurses' experience, performance should be compared between inexperienced

participants and those benefiting from longer training and practice sessions. Moreover, as nurses' routine work involves additional modalities beyond the visual, it is important to examine the effects of different alarm conditions on task performance involving these other modalities.

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