Effectiveness of vibrotactile displays of patient vital signs under low and high perceptual-motor task load

Sarah Fouhy, Chiara Santomauro, Mia McLanders, Jimmy Tran, & Penelope Sanderson

The University of Queensland, Brisbane, Queensland, AUSTRALIA

1. Introduction

In clinical settings, patient information is usually communicated through visual and auditory channels, which can overload the visual and auditory senses. In this research we explore the sense of touch as an alternative method for conveying patient information. Vibrotactile technology offers a discreet form of patient monitoring, which could be useful under noisy and stressful conditions. Previous research (McLanders, Santomauro, Tran, & Sanderson, 2014) found that a novel vibrotactile display located on the upper arm could convey pulse oximetry information – levels of heart rate (HR) and oxygen saturation (SpO₂) – with accuracy significantly above 90%. Further research found that the vibrotactile display was equally effective (>90%) even when extraneous visual and auditory cues were removed (Fouhy, 2014). However, one concern is that participants were relatively motionless and had no other task to attend to than identifying the vibrations.

The aim of the current study is to investigate whether arm motion diffuses the sensation of the tactors, and whether perceptual-motor task distracts participants, making it harder to identify changes. In accordance with multiple resource theory (Wickens, 2008), we hypothesised that accuracy would worsen with a perceptual-motor task involving high visuo-spatial load, because both vibrotactile monitoring and the perceptual-motor task would be competing for spatial resources. The findings could reveal important information about the vibrotactile display under conditions more closely representing those in a clinical setting.

2. Method

A repeated measures design was employed, with task load (low vs. high) as the principal within-groups variable, counterbalanced across blocks. Participants were recruited from the general university population (N = 37). The vibrotactile device consisted of three 12-mm circular vibrating tactors attached to the participant’s right upper arm. The tactors were spaced vertically along the upper arm, with one tacto near the shoulder, one near the elbow, and one in between. HR was communicated spatially by the location of the pulses, whereas SpO₂ was communicated temporally by the number of pulses the participant felt (see Figure 1). There were five levels of HR (very high, high, normal, low, very low) and three levels of SpO₂ (normal, low, very low), which were conveyed simultaneously (see Figure 2).

In each of two blocks of trials, the display would convey pulse patterns of selected levels of HR and SpO₂ in a continuous fashion, with changes on one or both parameters occurring 12 times at unpredictable intervals. When participants detected a change, they pressed a foot pedal and vocally communicated the new HR and SpO₂ levels to the experimenter. In the low task load condition, participants moved small pellets individually from one tray to another with their right hand. In the high task load condition, participants used laparoscopic graspers to move pellets from one box to one of two alternating boxes, and viewed their progress from a video screen rather than through unaided vision.

3. Results

Accuracy in the low task load condition remained significantly above 90% for both HR (Mdn = 90%, CI [92%, 96%]) and SpO₂ (Mdn = 92%, CI [92%, 96%]), similar to prior findings. In contrast, accuracy in the high task load condition was not significantly above 90% for either HR (Mdn = 88%, CI [79%, 92%]) or SpO₂ (Mdn = 92%, CI [75%, 96%]) but neither was it significantly lower than 90%.
4. Discussion

Motion alone did not affect participants’ accuracy at interpreting the vibrotactile display. However, as predicted, the laparoscopic task worsened participants’ accuracy. As multiple resource theory suggests, this may be because the laparoscopic task shared spatial resources with the vibrotactile display as well as imposing high perceptual-motor load. However, given participants’ relatively short exposure to the vibrotactile displays, their level of performance remains very good. Overall, the findings indicate that vibrotactile displays may be viable. In present work we are testing whether performance worsens when changes in vital sign are less frequent. We are also exploring how vibrotactile displays could be used for multi-patient monitoring, and how they can be used in conjunction with visual and auditory displays to form a multi-modal approach to patient monitoring.

![Heart Rate (HR)](image1)

![Oxygen Saturation (SpO2)](image2)

Figure 1: Visual representations of tactor location on arm (left), HR pulse pattern (top) and SpO2 pulse pattern (bottom) (from McLanders et al., 2014).

Figure 2: Example of how HR and SpO2 values were combined to display the pulse oximetry value “HR High, SpO2 Very Low” in a pulse pattern of vibrotactile stimulation (from McLanders et al., 2014).

References

