Simulator evaluation of head-mounted displays for patient monitoring

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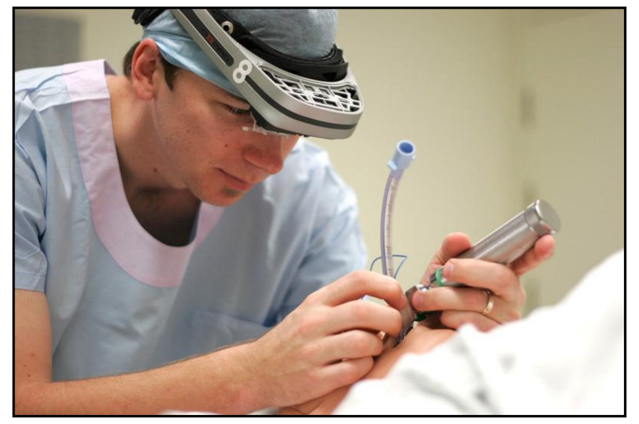
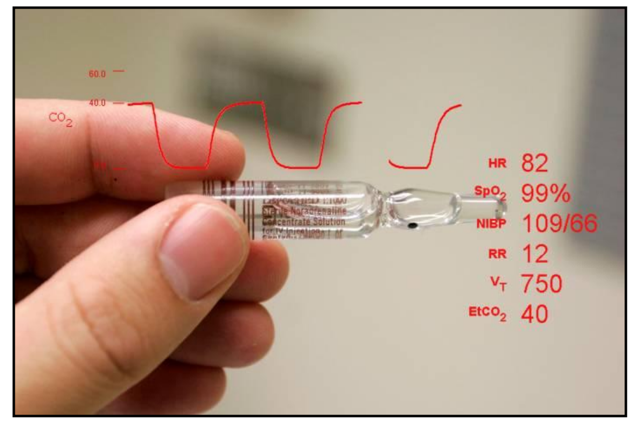
Aims

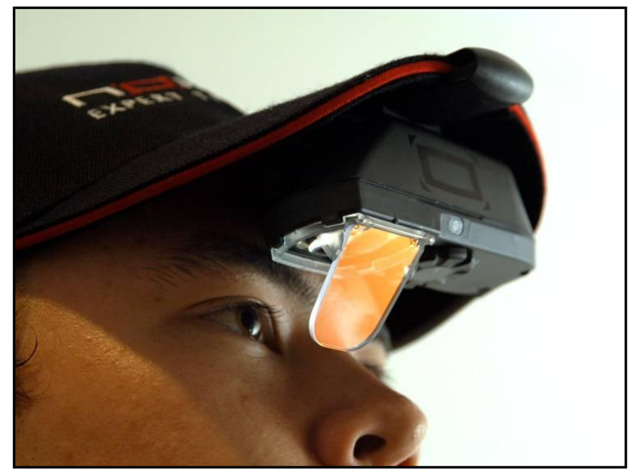
We evaluated the effect of head-mounted displays (HMDs) on anesthesiologist detection of moderately unexpected intraoperative events. We tested whether unexpected events are detected later or are more likely to be missed (1) with HMD plus standard monitoring vs. with standard monitoring alone and (2) with specific combinations of HMD depth of focus, ongoing task location and event location.

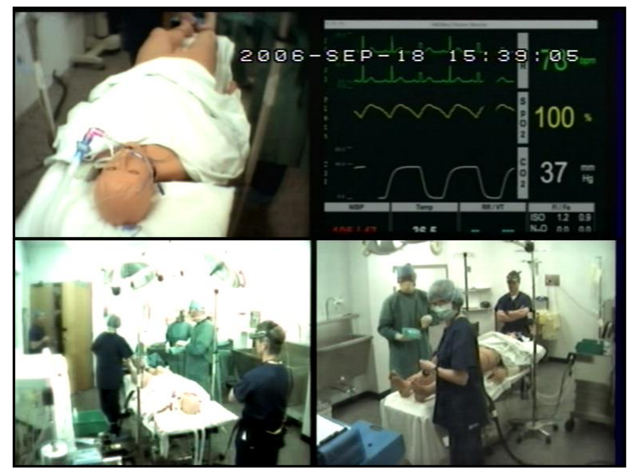




Background

Simulator studies have found that HMDs speed detection of dramatic incidents[1], reduce the need for anesthesiologists to look back towards the monitor[2], and lead to greater confidence of detecting events[3]. However, these studies have not investigated the potential disadvantages of HMDs reported in the aviation literature: reduced unexpected event detection[4] and eye mis-accommodation[5].





Methods

Twelve anesthesiologists from the Royal Adelaide Hospital provided anesthesia in a METI ECS™ simulator with custom extensions[6] while wearing a Microvision Nomad™ HMD. Participants experienced three 35-40 minute scenarios: standard monitoring (control condition), HMD with near focus, HMD with far focus. Eight events per scenario were constructed from combining distance of the anesthesiologist's ongoing task (close, distant) with the location of the event (HMD, anesthesia machine, patient, elsewhere in the OR). Participants' direction of gaze was coded from video data and the proportion of time spent looking towards either the patient or anesthesia machine was calculated. Differences in event detections and head turning were tested for significance using repeated-measures ANOVAs with α=0.05.

Event Description	Distractor Task Description	Event Location	Distractor Location
Scenario 1 – Left fem-pop bypass			
Patient's arms falls off support	Intubation	Patient	Near
ECG flat lines	Chatting with surgeon	Machine	Far
Surgeon preps wrong leg	Giving lunch orders to nurse	Patient	Far
Light anaesthesia	Charting	HMD	Near
Temperature display incorrect	Checks local for scrub nurse	Machine	Near
Patient bleeding	DA asks estimated finishing time	OR	Far
Wrong patient name on form	Signing transfusion request form	OR	Near
Severe arrhythmia	Taking a phone message	HMD	Far
Scenario 2 – Anterior resection			
Surgeon leaves operating room	Drawing up drugs from the cart	OR	Near
Patient opens eyes	Intubation	Patient	Near
Breathing circuit leak (APL valve)	Teaching med student	Machine	Near
Bronchospasm	Circulating nurse asks for ASA status	HMD	Far
Volatile too high	Med student or nurse asks question	Machine	Far
IV line falls out	Nurse displays interesting book	Patient	Far
Minor arrhythmia (AF)	Book handed to participant	HMD	Near
Med student faints on the floor	Taking a phone message (pre-meds)	OR	Far
Scenario 3 – Left knee replacement (no tourniquet used)			
Incorrect knee joint implant	Drawing up drugs	OR	Near
Laryngoscope left on patient	Surgeon asks for antibiotics	Patient	Far
ST segment depression on ECG	PACU nurses requests antiemetic	Machine	Near
Hypovolaemia	Phone message through circ nurse	HMD	Far
IV stops	Signing transfusion request form	Patient	Near
Volatile empty	Discussion with nurse at the door	Machine	Far
Circuit disconnection	Drawing up gentamicin	HMD	Near
Failure to check blood	Surgeon discusses transfer options	OR	Far

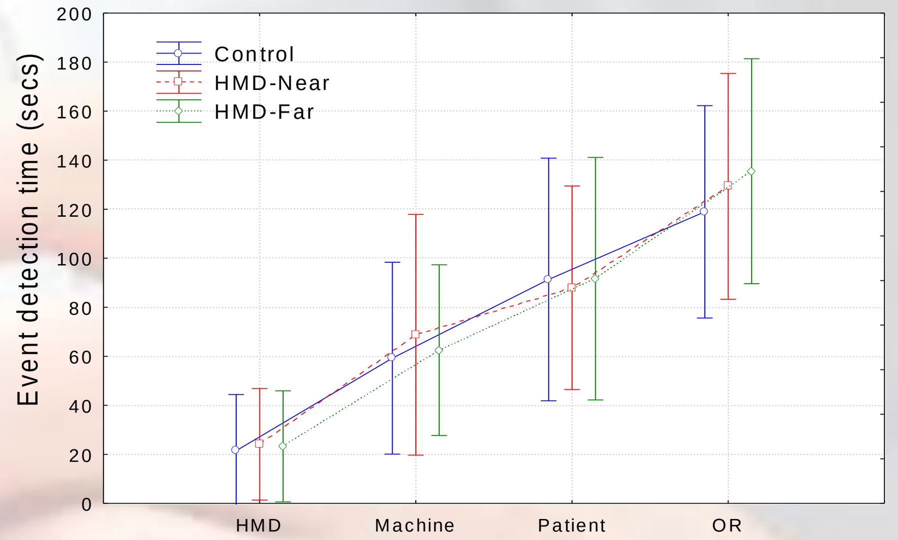
Results

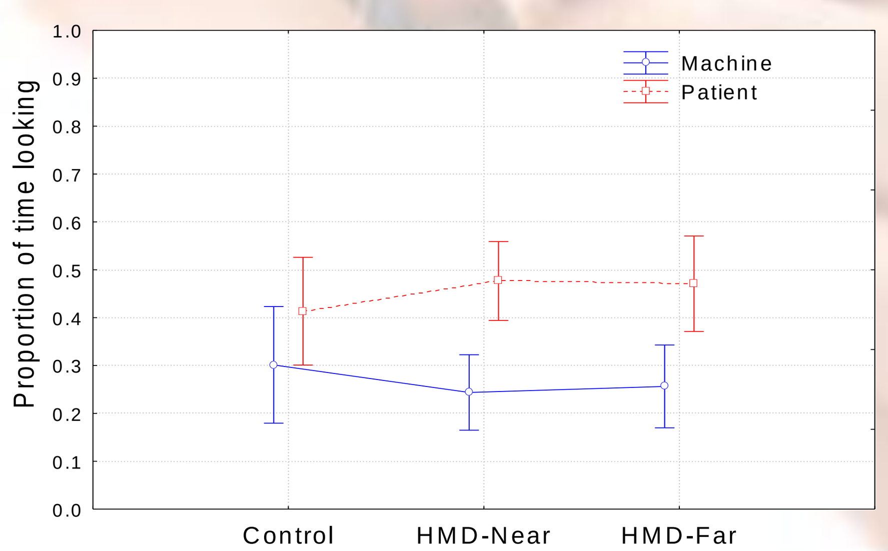
Neither HMD usage nor depth of focus affected event detection (p=0.664) or speed (p=0.769). However, event location had a significant effect on event detection (p<0.001) and speed (p<0.001). Participants using the HMD spent more time looking towards the patient and less towards the machine compared to using standard monitoring only (p<0.001). Differences between the near and far focus settings of the HMD were not significant, but 8/12 participants reported preferring the near over the far focus.

Event Location	# Events Detected	Detection Time
HMD	5.8 / 6.0	23.0 s
Machine	4.9 / 6.0	63.5 s
Patient	4.0 / 6.0	90.3 s
OR	3.3 / 6.0	127.9 s

Monitoring Condition	# Events Detected	Detection Time	Proportion of time looking		
			Patient	Machine	Other
Control	6.1 / 8.0	72.8 s	41.3%	30.1%	28.6%
HMD-Near	5.8 / 8.0	77.6 s	47.7%	24.4%	27.9%
HMD-Far	6.2 / 8.0	78.3 s	47.1%	25.6%	27.3%

Event detection times are affected by the event location, but not by HMD usage or HMD focus.





Participants wearing the HMD spend more time looking towards the patient, and less towards the monitor.

Conclusions

Event detection times were not reduced by the HMD as in prior studies[1] but were affected by the location of events. We reproduced earlier findings that the HMD allowed participants' to direct their visual attention towards the patient more often[2]. We did not reproduce the disadvantages of HMDs found in aviation[4,5] and found no difference between near and far focus settings. Overall, in the simulated OR there was no clear benefit with the HMD, but also no evidence that deficiencies seen in aviation will occur.

References

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