Eye-Tracking in Computer-Based Simulation in Healthcare Training

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Introduction

Patient safety is a critical area of concern within healthcare and medical errors are a well-known problem that can have fatal ramifications (Kohn et al. 2000). Lack of knowledge and skill with clinical tasks and procedures, as well as decision-making can be significant factors with many of the errors that are reported in healthcare (Zhang et al. 2002). Many healthcare tasks can be simulated using computer and web technology for training purposes and provide trainees (students and practicing) with a way to improve or maintain their knowledge and skills (Persson et al. 2014; Cant & Cooper 2014). The concept of visual attention during a task has been tested in medical and healthcare task studies (O'Meara et al. 2015; Zheng et al. 2011; Breen et al. 2014) with an aim of finding discriminative differences between competency levels. The study of this previous work led us to hypothesise that eye tracking metrics exclusively have a relationship with specific task performance and can discriminate between performance level. We found the duty of patient monitoring with interpreting vital signs monitors in nursing earmarked in the literature for improvement in available simulation-based training. We sought to use eye-tracking with the task of nurses interpreting simulated patient vital signs from a monitor. The objective was to determine if eye-tracking technology can be used to develop biometrics for automatically classifying the performance of nurses whilst they interact with computer-based simulations.

Methods

For the study a total of 47 nurses were recruited, with 36 nursing students (TG - Training Group) and 11 coronary care nurses (QG - Qualified Group). Each nurse interpreted five simulated vital signs scenarios whilst 'thinking-aloud'. We recorded the participant's visual attention (eye tracking metrics [ETMs]), verbalisation, confidence level (1-10, 10=most confident). Interpretations were given a score out of ten to measure performance. Data analysis was used to find patterns between the ETMs and performance. Multiple linear regression was used to predict performance (score) using ETMs.

The five scenarios were designed by an expert nurse with validation was provided by three colleagues of similar expertise. The scenarios were designed to be within the expected ability of the average undergraduate student but also with assessment criteria that would likely provide fully trained and qualified nurses a higher score.

The criteria assessed participants' verbal responses at three levels and scores were allocated according to:

<u>Basic</u> performance: identification of abnormalities in the presented vital signs.

<u>Mid-range</u> performance: identification of why the abnormalities occurred based on their knowledge and understanding of the presenting condition outlined in the case scenarios.

<u>High-range</u> performance: identification of and decision-making with regard to the immediate interventions required to stabilise the patient.

Performance scores were then put into classes according to expert advice:

- 0-5 = low
- 6-7 = medium
- 8-10 = high

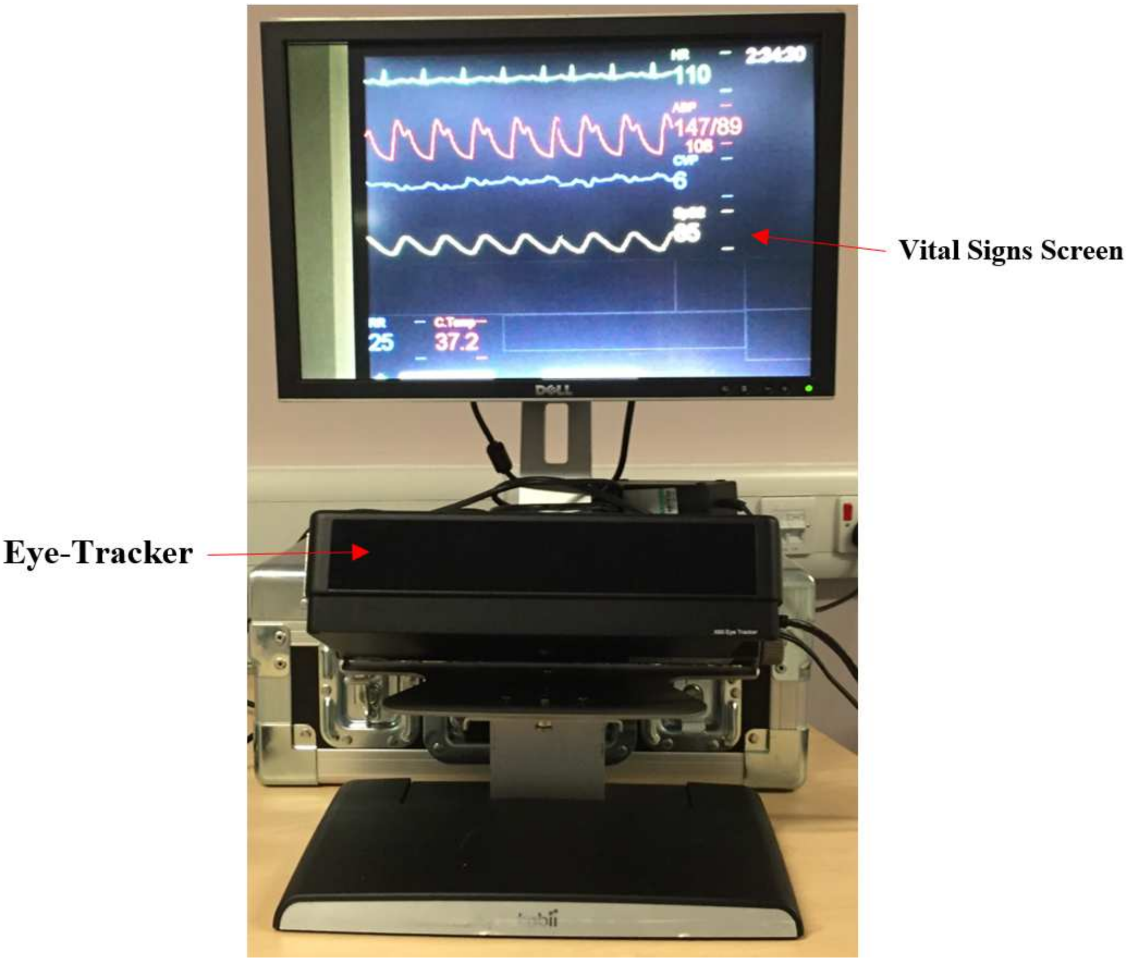

Figure 1. Participant Point of View During Interpretations

Figure 2. Simulated Vital Signs Screen with Eye Tracking Areas of Interest with Variable Names Highlighted

Results

The QG scored higher than the TG (6.85±1.5 vs. 4.59±1.61, p=<0.0001) and reported greater confidence (7.51±1.2 vs. 5.79±1.39, p=<0.0001).

Class	TG	QG	All
Low (0-5)	129 (72%)	10 (18%)	139 (59%)
Medium (6-7)	45 (25%)	25 (45%)	70 (30%)
High (8-10)	6 (3%)	20 (36%)	26 (11%)

Table 1. Interpretation Performance Results in Classes (Count and %)

20 ETMs discriminated between classes of performance (low, medium, high). Regression using ETMs (62 independent variables) was shown to adequately predict score (adjusted R2=0.80, p=<0.0001).

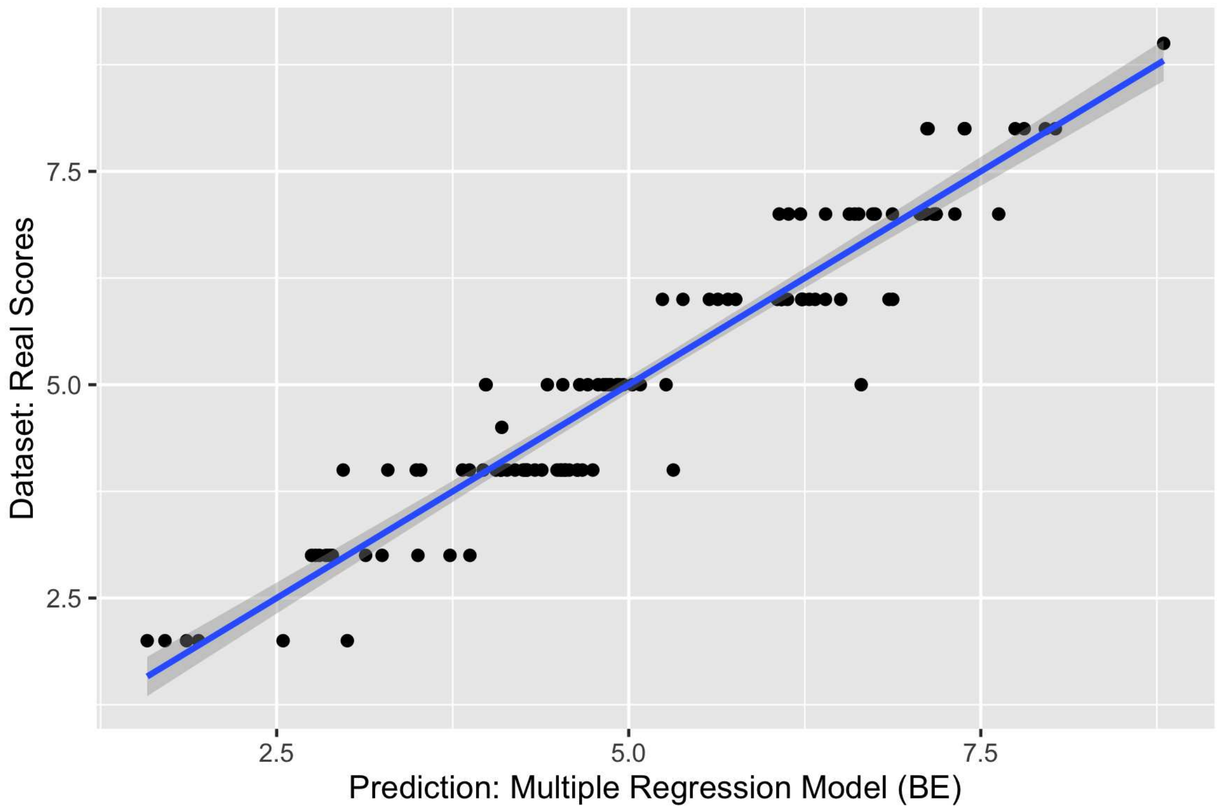

Figure 3. Participant Scores Vs Predicted Scores
Using Subset of Eye Tracking Metrics As Predictors

Conclusions and Future Work

Thedata collected, specifically the data analysis of ETMs,has shown that visual attention and the level ofperformance for this specific task (measured byperformance score) are not independent of each other. Put differently, ETMs exclusively could be used topredict a person's performance when reading vital signs. Explicitly, we can see that specific ETMs are statisticallysignificant in discriminating between classes ofperformances for interpreting vital signs. With furtherrecruitment of participants (especially high classperformances), we could potentially reveal more ETMsthat are discriminatory between low, medium and highclass performance. Further research, including statisticaltechniques like PCA are required to refine the regressionmodels and the optimal level of accuracy for predictingperformance using the ETMs. At present, we canconclude that there is a relationship between ETMs and performance that can be seen but it is unclear to what extent ETMs can predict performances.

Future newly designed studies will include:

1. Using eye-tracking during a much more complex simulated procedure, such as cardio angiography. We want to test the assumption (Zheng et al. 2011) that trainees and experts have different patterns of visual attention during surgical tasks that classify them. During this, we will also look at the link between visual attention and attentional capacity (Weaver 1949) of the task performer by provided them with added stimulus/distraction.

2. Other future work will progress the study described above, with eye-tracking to discriminate performance whilst an experimental group is presented a changed layout of on-screen vital signs. This work will look at the influence of information hierarchy on interpretation performance as the experimental group is presented the same scenarios but with the most concerning vitals emphasized on screen (positioning). We wish to test if this provides any advantage to the experimental group in their performance. If so, it could make an argument for automatic prioritizing of vital signs in accordance to the specific patient (through machine learning algorithms) in future equipment to reduce poor interpretations and patient monitoring.

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