Cognitive Load/flow and Performance in Virtual Reality Simulation Training of Laparoscopic Surgery

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Abstract

VR based laparoscopic surgical simulators (VRLS) are increasingly popular in training surgeons. However, they are validated by subjective methods in most research. In this paper, we resort to physiological approaches to objectively research quantitative influence and performance analysis of VRLS training system. The results show that the VRLS could highly improve medical students' performance (p<0.01) and enable the participants to obtain flow experience with a lower cognitive load. The performance of participants is negatively correlated with cognitive load through quantitatively physiological analysis.

Introduction

A. The VR surgical simulator has changed the surgeons learning mode by simulating the surgery from the visual, auditory, and tactile aspects[1].
B. The main cognitive load measurement methods are subjective measu-res such as NASA-TLS scale or interviews[4].
C. The psychophysiological measurement of cognitive load are its objective, the sensitivity to different cognitive processes, the noninterferen-ce of the program, and their implicitness and continuity.
D. We resort to physiological approaches to objectively and quantitatively measure the influence of VRLS on medical students from the aspect of cognitive load and flow.
E. EEG is considered a physiological indicator, which can be used as an online and continuous cognitive load measurement method to detect subtle fluctuations in instantaneous load.

Materials and Methods

Participants

41 medical students:
Age [17, 27] (21.10±2.79), gender(15 male and 26 female)

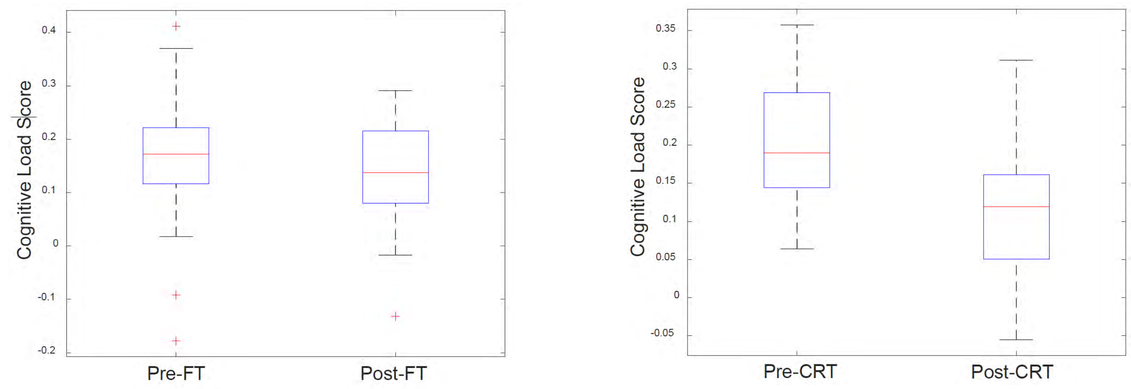
Procedures

Step 1:
Pre-test on training box: 4 fundamental skills, 1 colon resection.
Record EEG, heart rate and operation videos.
Step 2:
Training on VRLS
Step 3:
Pos-test on training box: 4 fundamental skills, 1 colon resection.
Record EEG, heart rate and operation videos.

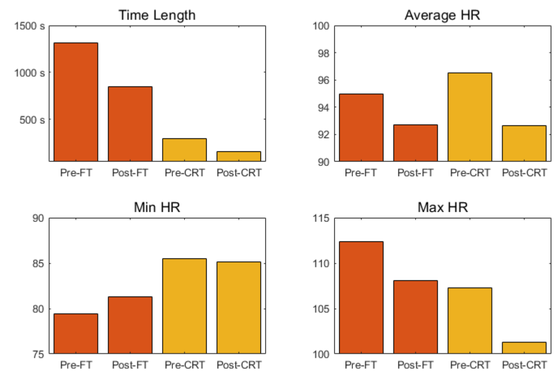
Data Processing

Step 1: EEG and heart rate data filtering and washing
Step 2: Compute cognitive load[1] and flow experience
Step 3: Anonymous grading according to GOALs etc.
Step 4: Self-report grading cognitive load and flow experice
Step 5: Statistical analysis using SPSS

Results



The post cognitive load is significantly lower than cognitive load.
Pre-FT vs Post-FT (p=0.04 < 0.05)
Pre-CRT vs Post-CRT (p<0.01)



The completion time drop sharply (p<0.01).
The average heart rate decrease significantly (p<0.05).
The maximum heart rate decrease significantly (p<0.05).
The minmum heart rate did not decrase significantly.

	Pre-test Performance	Post-test Performance
Pre-FT	↓ *	NA
Pre-CRT	↓ **	NA
Post-FT	NA	↓
Post-CRT	NA	↓ *

**: 0.01 level significant, *: 0.05 level significant, NA: Not Available

- The cognitive load has negative relation with the performance scores.
- The cognitive scores extracted from scales and cognitive load scores computedfrom EEG (CLE) has positive relations.
- There is no significant correlation between self-reported flow experience score (p=0.34>0.05).
- The most needed ablility in laparoscopic surgery skills is depth percepti-on from according to flow experience scale[2].

Conclusion

In this paper, we quantitatively investigate the influence of VRLSon medical students from three aspects: performance evaluation,physiology (heart rate and EEG) and self-reported cognitive loadand flow experience. The experimental results demonstrate thatthe VRLS could highly improve medical students' performanceand enable the participants to obtain flow experience with a lowercognitive load.

References

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