Physiological Response While Driving in an Immersive Virtual Environment

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1. Introduction, hypothesis and objectives

Virtual reality has extensively been used as a tool to evaluate driving behavior and its physiological correlates in the last few decades. Usually, virtual driving simulators consist of a computer running a driving simulator software displayed on one or several monitors. New, more immersive displays have been commercially produced these past years, including the HTC Vive and the Oculus Rift HMDs. Both allow for a high resolution display along with head movement tracking and a wide field of view (> 110◦) thereby increasing the sense of immersion in the simulation or presence.

In this pilot study, we aimed to explore the sense of presence and the physiological response evoked by an immersive virtual environment by using a modern head-mounted display (HMD) while performing a driving task in our simulator. We hypothesize that, (a) since modern HMDs are capable of eliciting a higher subjective sense of presence, this effect should be reflected physiologically while driving in our virtual simulator, and that (b) while driving, emergency maneuvers will evoke a stronger response while using our HMD.

2. Methods

Two conditions were created: standard driving simulation (SDS) and immersive driving simulation (IDS).

Simulation setup consisted of a PC running Windows 7 64bit with a high-performance Graphics card (GeForce GTX 970, Nvidia), a 27” LCD monitor (for SDS), an Oculus Rift CV1 (for IDS) together with a Logitech G29 driving set including the steering wheel and pedals (clutch, brake, accelerator).

5 healthy young adult males (31.2±4.6 years old) with a valid driving license and 11±6.5 years of driving experience were evaluated during 10 minutes simulations through a four-lane street, traffic flow in both directions. At least 20 random emergency events (cars driving in a very aggressive manner/pedestrians showing erratic behavior) BITalino was used to measure heart rate (HR), electromyography (EMG, tibialis anterior), right palm electrodermal activity (EDA) and 3-axis accelerometer.

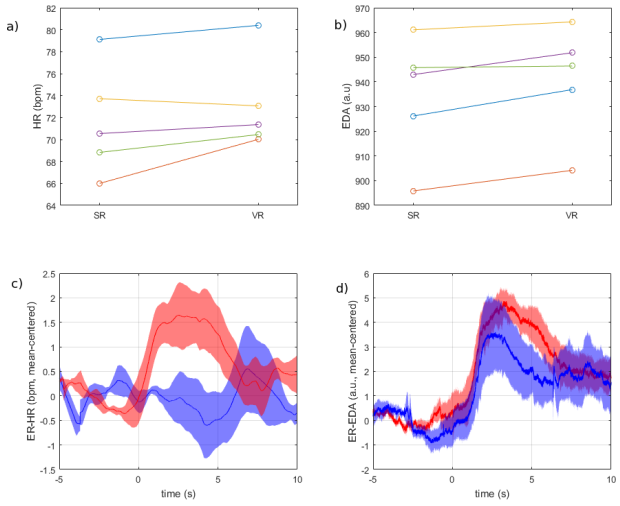

Figure 1. ***(a)*** *Mean HR and* ***(b)*** *EDA for each of the 5 subjects investigated. Event-related changes (mean ± SEM) in* ***(c)*** *HR and* ***(d)*** *EDA signals during emergency maneuvers (Blue = SDS, Red = IDS).*

3. Results and Conclusions

Two subjects had had a previous exposure to the HMD used in this study and none of them reported any cybersickness symptoms.

HR signal showed a trend towards increasing in the IDS while EDA mean signal was significantly higher in the IDS modality. Event(emergency maneuver)-related analysis detected a consistent increase in HR during IDS but not in SDS. Over EDA signals the ER analysis discovered a stronger and more extended response to the event in the IDS modality.

In this proof of concept phase of our study we were able to successfully register several physiological signals when driving in a virtual scenario with immersive Oculus Rift headset. Results suggest that this new form of technology increases the sense of presence, with larger effects in EDA and HR responses. Emergency maneuvering also resulted in an increased response in both EDA and HR, suggesting an association between a heightened sense of presence and a physiological correlate when driving in an IDS.