Chelsea Dobbins and Stephen Fairclough, "Wearable Sensors, Driving and the Visualization of Cardiovascular Stress During Everyday Life," in the *1st Neuroadaptive Technology Conference 2017 (NAT'17)*, Berlin, Germany, 19th – 21st July, 2017 [Accepted]

WEARABLE SENSORS, DRIVING AND THE VISUALIZATION OF CARDIOVASCULAR STRESS DURING EVERYDAY LIFE

Chelsea Dobbins [1] and Stephen Fairclough [2]
Department of Computer Science [1] and School of Natural Sciences and Psychology [2]
Liverpool John Moores University, Byrom Street, Liverpool, L3 3AF
E-mail address: {C.M.Dobbins, S.Fairclough}@ljmu.ac.uk

ABSTRACT: Driving is a common daily activity, where the experience of negative emotions, such as stress/anger, can frequently occur. The repeated experience of cardiovascular activation associated with negative emotions can be detrimental to long-term health. However, these physiological changes can be quantified via wearable technology to enable insight and self-reflection from the perspective of the individual. A study was conducted to explore the impact of data visualization on cardiovascular reactivity and self-regulation in response to driver stress.

INTRODUCTION

High-levels of negative emotions can have adverse implications for health, including inflammation, which can impact long-term cardiovascular health (e.g. developing coronary heart disease and hypertension) [1]–[3]. However, this cumulative damage can be reduced with the use of effective coping strategies, the development of which can be supported using wearable technology [4]–[5]. This work presents our mobile platform, which captures data during daily commuter driving. This includes psychophysiological data collected from wearable devices, including heart rate (HR), heart rate variability (HRV) and pulse transit time (PTT). This was enhanced with contextual data collected via a smartphone, including location, vehicle speed and photographs of the driving view. These data were then used to create an interactive visualization of changes in cardiovascular stress.

MATERIALS AND METHODS

Eight participants took part in the study to collect data during eight commuter journeys to/from work (four during the journey to work and four during the journey back to their residence). The initial two days of data collection were referred to as a pre-test phase. Data from all four journeys during this phase were translated into an interactive visualization of each cardiovascular measure (HR, HRV, and PTT) and mapped on the geospatial route. Participants were invited to explore their data visualization and a structured interview was performed to assess perceptions and insights into the cardiovascular data. After exposure to the interactive visualization, data were collected from participants during four subsequent commuter journeys, known as the post-test phase.

RESULTS

High journey impedance is characterized by slow vehicle speed due to high traffic density and is known to be a source of cardiovascular stress during the driving task [6]. Periods of high journey impedance were identified for both pre-test and post-test phases based on vehicle speed (i.e. <10mph). The impact of the data visualization on cardiovascular reactivity during high journey impedance was explored using a two (before vs. after visualization) x two (AM drive vs. PM drive) repeated measures ANOVA. Results indicate that heart rate significantly declined during high journey impedance during the post-test phase compared to the pre-test phase (see Fig. 1). The analyses also revealed that HRV significantly increased during the post-test phase, which was indicative of reduced inflammation during high traffic impedance (see Fig. 1). The strength of the effects found and the statistical significance is $F(1,7) = 22.2$, $p < .01$, effect size = 0.76.

DISCUSSION AND CONCLUSION

The results provide evidence that exposure to the interactive visualization had a positive effect on cardiovascular reactivity to stress during real-world driving. The impact of high journey impedance on the cardiovascular system was significantly ameliorated after participants had been exposed to the data visualization. It is questionable whether the data visualization itself or the introspective exercise was responsible for this effect and further research is required to explore this issue.

Chelsea Dobbins and Stephen Fairclough, "Wearable Sensors, Driving and the Visualization of Cardiovascular Stress During Everyday Life," in the *1st Neuroadaptive Technology Conference 2017 (NAT'17)*, Berlin, Germany, 19th – 21st July, 2017 [Accepted]

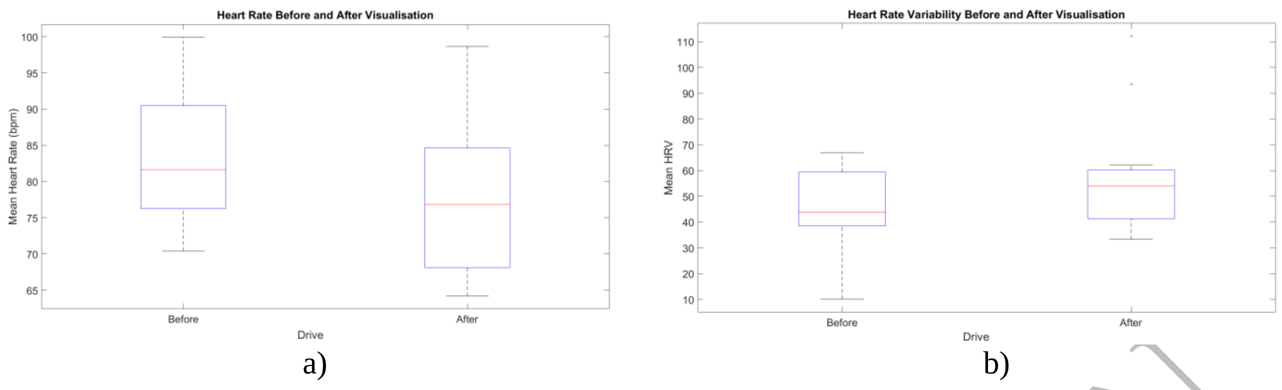

Figure 1: Boxplots that illustrate a) mean heart rate and b) mean heart rate variability before and after exposing participants to the visualizations.

REFERENCES

[1] J. Suls, “Anger and the Heart: Perspectives on Cardiac Risk, Mechanisms and Interventions,” *Prog. Cardiovasc. Dis.*, vol. 55, no. 6, pp. 538–547, 2013.

[2] M. A. Samuels, “The Brain-Heart Connection,” *Circulation*, vol. 116, no. 1, pp. 77–84, Jul. 2007.

[3] H. D. Sesso, J. E. Buring, N. Rifai, G. J. Blake, J. M. Gaziano, and P. M. Ridker, “C-Reactive Protein and the Risk of Developing Hypertension,” *J. Am. Med. Assoc.*, vol. 290, no. 22, pp. 2945–2951, Dec. 2003.

[4] B. L. Ganzel, P. A. Morris, and E. Wethington, “Allostasis and the human brain: Integrating models of stress from the social and life sciences.,” *Psychol. Rev.*, vol. 117, no. 1, pp. 134–174, Jan. 2010.

[5] J. Hernandez, D. McDuff, R. Fletcher, and R. W. Picard, “Inside-Out: Reflecting on your Inner State,” in *2013 IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)*, 2013, pp. 324–327.

[6] S. H. Fairclough, M. van der Zwaag, E. Spiridon, and J. Westerink, “Effects of mood induction via music on cardiovascular measures of negative emotion during simulated driving.,” *Physiol. Behav.*, vol. 129, pp. 173–180, Apr. 2014.