Respiration Regulation via Different Modes of Haptic Feedback Tested through the Playing Experience of Stressful Games

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ABSTRACT

Nowadays, increasing numbers of individuals are suffering from excessive stress. An effective measure of stress relief without causing undesired distraction is active respiration regulation on smart wearables, which can be achieved by using haptic feedbacks to inform users when and how to change their breath patterns. We aim to evaluate the efficacy of different haptic feedback at stress relief with varying durations and intensities. Till now, we have performed a formative evaluation tested through the playing experience of stressful games to obtain implications for our haptic design such as how to synchronize breath patterns using vibrations.

CCS CONCEPTS

• Human-centered computing → Ubiquitous and mobile computing systems and tools.

KEYWORDS

Mobile computing, stress relieving, respiration regulation

ACM Reference format:

Panyu Zhang, Tiejun Ma, Eunho Lee and Uichin Lee. 2021. Respiration regulation via different modes of haptic feedback tested through the playing experience of stressful games. *UbiComp/ISWC 2020 Adjun. - Proc. 2021 ACM Int. Jt. Conf. Pervasive Ubiquitous Comput. Proc. 2021 ACM Int. Symp. Wearable Comput.* (2021)

1 Introduction & Related Work

In the modern society, different kinds of stress are overwhelming most of us. Hence, concern is growing vis-a-vis relieving stress. As is well acknowledged, HRV is a good predictor of stress [1]. It is not a novel topic to leverage HRV to measure people's stress level, and the research gap is how to reduce the stress level. In particular, we explore respiration regulation that is believed to be helpful to relieve the stress. For example, Tabor et al. tried different types of feedback including audio melody, on-screen bar, on-screen brightness, haptic vibration and phone desk-widget which are all proved to be effective to regulate breath [2].

Among the different types of feedback, we will explore design choices of the haptic feedback with smart wearables since they are portable and implicit compared with other types of feedback. Several studies examined haptic feedback. For example, Paredes et al. designed a haptic feedback system installed on the seat of car to regulate driver's respiration via vibrations on the driver's back and suggested offering customization of the duration and strength of the vibration patterns [3]. Costa et al. recently developed an application called BoostMeUp which regulates people's HRV via haptic feedback on Apple Watch [4]. This work used a smart watch, but respiration control with different modes of haptic feedback such as different intensities and durations is not covered. Besides, in most evaluation experiments in the previous literature, the tasks are limited to information work such as reading articles and answering the questions or solving math questions.

By developing this prototype, we aim to explore the effects of different modes of haptic feedback given by Samsung Galaxy Watch 3 and evaluate the efficacy of haptic feedback in real world settings, specifically, when people are playing stressful games, as it is the case in eSports competitions. We choose the scenario of playing stressful games aimed to relive gamers' stress level via implicit haptic feedback without distracting the gamers.

2 Respiration Regulation Via Haptic Feedback

To evaluate the efficacy of the haptic feedback, we need to measure HRV which is a predictor of stress level and check respiration

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adherence to the feedback. We use Polar H10 to measure the HRV. When the prototype gives haptic feedback, we may calculate the HRV data from ECG sensor data in polar H10. According to Tabor et al. [2], SDNN based HRV is a more direct measure of physiological benefit. The problem is how to estimate the respiration rate from Polar H10. To explore different modes of feedback, we need to well design the different modes of haptic feedback.

2.1 Respiration Estimation

Estimate respiration from ECG According to Varon et al.'s work [5], we may estimate the respiration rate from ECG data. We first standardize the ECG data and then remove the baseline wander noise. The respiration wave could be derived from the QRS area in the ECG signal from Polar H10. The respiration frequency can be calculated based on the derived respiration wave.

Estimate respiration from Acc According to Liu et al.'s work [6], the respiration may also be derived from accelerometer data. We first filter background noise and try to find peak values in frequency domain.

2.2 Haptic Design

Synchronizing breath In previous literature, researchers tried to synchronize the inhale, exhale and even hold of breath with the vibration given by the device. Once vibration is given, the user should inhale, exhale or hold breath. The breathing should be synchronized with vibration. In our prototype, we try three ways including synchronizing inhale only, synchronize both inhale and exhale and synchronize inhale, exhale and hold of breath.

Different modes of feedback We may have long/short duration and high/low intensity haptic feedback. Overall, there are 4 modes (2 duration x 2 intensity).

Figure 1: Prototype with four different modes of haptic feedback (generated by Tizen studio emulator)

3 Formative Evaluation

To compare the two ways of respiration estimation and three ways of synchronizing breath mentioned in section 2.1 and 2.2, we did formative evaluation. Two evaluators played the game F1 2014 which was believed to increase the gamers' stress level. There are four modes with different durations and intensities of vibration in this formative evaluation, serving as the independent variable. Each mode is consisted of two components, namely a baseline component followed by a treatment component. The baseline component allows us to measure the untreated reference values to which the after-treatment values can later be compared. The baseline and the treatment components were completely identical, except that no vibration was given to enable haptic feedback in the baseline. Users' work performance is quantified as the mileage and the number of collisions in each driving race, and users' stress level is quantified as heart rate and HRV. These are the dependent variables. The flow chart of the formative evaluation is shown below. Detailed description of it has been included in Attachment.

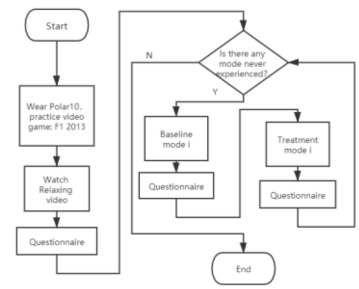

Figure 2: Flow Chart of the Formative Evaluation

4 Conclusion and Future Work

We did a formative evaluation and got the following implications. First, it is very difficult to synchronize inhale, exhale and hold of breath; instead, it is possible to synchronize only inhale or exhale with vibration. Second, to estimate the respiration rate from Polar H10, we found no peak value in the accelerometer data in frequency domain. Instead, we did successfully estimate the respiration rate from QRS complex in ECG data. For future work, we need to conduct the summative evaluation to evaluate the efficacy of 4 different modes of haptic feedback such as long/short duration and high/low intensity haptic feedback. .

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