Team J - Proposal Biofeedback

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Research question

If a player hears a sonification of their heart rate, does this improve their ability to control their heart rate in a heart rate variability (HRV) impacted biofeedback video game?

Introduction

We will do an experiment with 2 groups: A study group playing a HRV game with the sonification of their own heartbeat, and a control group who hears the sonification of a steady heartbeat that is not related to their own. Both groups will play the same HRV impacted game, which is designed so that having control over HRV improves their score. We hypothesise that those who hear their own heartbeat will be more aware of their heartbeat, and therefore perform better in the game.

Our study is strongly inspired by the research of Kosunen et al. (2018), which suggests that poker players who had their heart rate sonified performed better at poker. In this study, the participants' HRV did not directly influence the outcome of the game. We are curious to see if we will have a similar outcome when participants play a game in which HRV directly influences the game.

As an example, in the biofeedback-enhanced video game *Nevermind*, the psychological state of the player directly affects the gameplay. Lobel et al. (2016) showed that the game encourages players to regulate their emotions in stressful scenarios. The use of HRV biofeedback can have beneficial effects on emotion regulation in games (Schumann et al., 2018). However, the measured heart rate is not communicated back to the player. So, we wondered how the overall gameplay experience would be impacted if we made the player more aware of their heartbeat.

The game

We will design a new game or modify an existing game, in which the difficulty rate is linked and thus, influenced by the heart rate variability (HRV). The game will be designed so that the player only receives support or certain advantages by managing to control their heart rate (reducing their HRV). Some options which we are considering include: A shoot 'em up game in which more enemies spawn over time, and more enemies appear if the HRV is higher, and your score is determined by how long you survive. Another option could be a racing game where the HRV controls your speed; more variability leads to a slower speed.

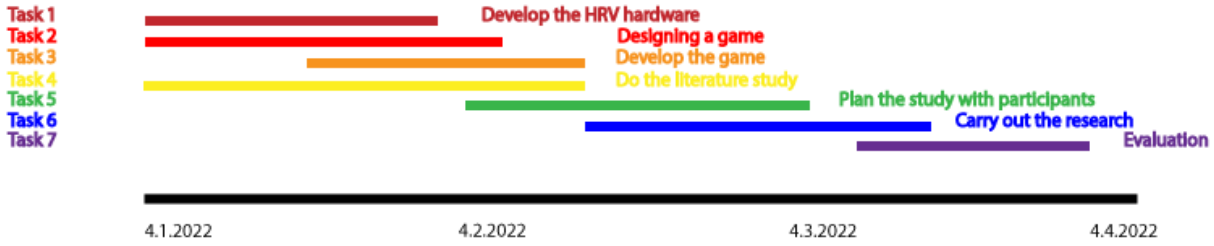
Tasks

1. Develop the HRV hardware
2. Designing a game suitable to the experiment
3. Develop the game, find possible base or engine, source graphics.

4. Do the literature study
5. Plan the study with participants
6. Carry out the research on small scale
7. Evaluation, discussing the results in a research paper

Roman will look into task 1 (hardware). If it turns out we need to build our own hardware, Daniel will join this task. Tudor, Marinus and Jan will work on task 2, and decide what kind of game design is required for the project. Daniel will then do research on finding a suitable game codebase or engine.Once a game design is made, we will divide tasks regarding the development of the game.The literature study is carried out by Marinus. Task 5, 6 and 7 will be processed in collaboration.

Preliminary timeline



Materials

We will need a device to measure heart rate, and calculate the HRV from that. Generally, HRV is considered a good proxy for physiological stress (Kim et al., 2018). Our first step is to find hardware for this, possibly we are able to borrow EmWave HeartMath equipment.

Graphics and sounds can be either sourced online or be made bespoke, there are researchers on this project with the ability to make or modify anything we might need.

Relevant research

Kosunen, I., Palomäki, J., Laakasuo, M., Kuikkaniemi, K., Ravaja, N., & Jacucci, G. (2018). Heart-rate sonification biofeedback for poker. *International Journal of Human-Computer Studies*, 120, 14–21. https://doi.org/10.1016/j.ijhcs.2018.07.001

Kim, H. G., Cheon, E. J., Bai, D. S., Lee, Y. H., & Koo, B. H. (2018). Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. *Psychiatry Investigation*, 15(3), 235–245. https://doi.org/10.30773/pi.2017.08.17

Schumann A, de la Cruz F, Köhler S, Brotte L and Bär K-J (2021) The Influence of Heart Rate Variability Biofeedback on Cardiac Regulation and Functional Brain Connectivity. *Front. Neurosci.* 15:691988. http://doi:10.3389/fnins.2021.691988

Lobel, A., Gotsis, M., Reynolds, E., Annetta, M., Engels, R. C., & Granic, I. (2016). Designing and Utilizing Biofeedback Games for Emotion Regulation. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems.* https://doi.org/10.1145/2851581.2892521