BREATHING SPACE: BIOFEEDBACK SONIFICATION FOR MEDITATION IN AUTONOMOUS VEHICLES

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ABSTRACT

The collective, c*almspaces,* sets out to create spaces for relaxation and contemplation through traditional architectural approach combined with modern digital technology.

The ongoing project of the collective, *breathing space* (*ademruimte* in Dutch), uses unobtrusive sensing technology to monitor one's breathing, and through designed light and sonic guides, the project tries to enhance the breathing exercise beneficial to regulating one's emotion.

The paper illustrates the project and its relevance to and potential for in-vehicle development. We then discuss the details of our implementations, along with video documentations of the early prototype, and a recently completed installation work.

1. BACKGROUND

Calmspaces gathered individual specialists for the project *breathing space* – a composer designing ambient public sonic spaces, interaction designers working with attention disorder children, a psychologist, meditation therapists, an architect, and an urban planner – those who share concerns regarding the increasing anxiety issues of present day life.

In 2018 the project received the Dutch national grant for creative industry and the collective is currently working on prototypes of space design for augmented breathing exercise as a possible intervention to counter such issues.

2. BREATHING AS MEDITATION

The effects and its underlying neural mechanism of attention-to-breath as a basic mindfulness practice has been studied through fMRI viewing [1] and self-regulation of breathing is proposed as first-line treatments for stress, anxiety, depression, and some emotional disorders [2][3]. As the practice of attentive breathing merely requires one's conscious action, it can be performed inside a fully autonomous automobile without much hassle and may become a fulfilling in-vehicle experience connected to one's well-being.

3. IN-VEHICLE BREATHING SPACE

As sonification for emotion regulation/meditation of drivers in autonomous vehicles, we propose an in-vehicle adaptation of our breathing space project. Such breathing exercise does not require extensive duration (typically 10-15 minutes with measurable beneficial effect [1]) and can be performed by the driver of an autonomous vehicle as well as by other passengers on a daily routine (e.g., during commuting).

To avoid safety risks we propose the use of auditory display as the primal guide for the exercise (perhaps with optional ambient light feedback for an enhanced cue). The exercise can be immediately terminated upon unexpected traffic situations or takeover requests because it does not require any manual or feet operation, posture change or the involvement of sight. In the following paragraphs we detail the implementations of the realized installation work which we propose for the adaptation for autonomous vehicles.

3.1. Sensing

Ballistocardiography (BCG), the measure of ballistic forces on the heart, allows for noninvasive cardiac monitoring without direct contact to the skin [4]. BCG sensor technology thus integrates well into car seats. By adding a frequency analysis algorithm we create a user feedback parameter useful for realtime ambient sound synthesis and lighting control.

In the current standalone installation version completed in early May this year, the user is provided with a knob to adjust and set the pace of the breathing exercise, guided with sound, image projection and lighting [5]. The BCG sensor has also been installed at the bench (the sheet seen shortly at around 8 seconds into the video).We use frequency analysis algorithm to observe if the user's breathing (measured through BCG) matches that of the guiding pace. When the user's breathing pace matches closely to that of the guiding pace, the system gives feedback with brightened image and light as well as with a more resonant sound.

3.2. Sonification

The author has developed a library for in-vehicle auditory display using the sound synthesis programming environment SuperCollider [6]. The early prototype of realtime sonification of BCG is demonstrated in the video [7].

For the sake of demonstration only, we used a GUI slider to show how the overall sound structure follows the difference in speed setting (Fig. 1). The expanding and contracting circle corresponds to the breathing pace, which, in case of the installation work, is adjusted by the participant, but can also be directly controlled by the BCG data for sonification purpose.

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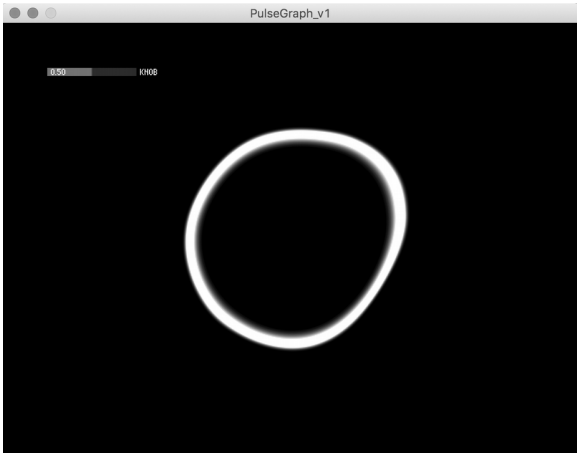

Figure 1: prototype demonstration GUI and visualization.

The overall sonic contour represents the inhale/exhale of breathing with the aim to support the exercise and provide a relaxing and meditative atmosphere. There are other bell-like sounds which tick different number of breathing cycles.

4. DISCUSSION

The exercise demonstrated in the current installation work can well be adapted for fully autonomous cars. As is seen in demonstration video, the BCG sensor system can relatively easily be installed in the car seats. The lighting and image can also be adapted as an ambient light effect to complement the primal auditory guide of the exercise. We are therefore in search of partners of researchers and automobile industry to develop prototypes of the in-vehicle breathing exercise.

The current installation work only provides instantaneous feedback to the participant (whether his/her breathing pace matches with the guide). For future work we consider implementing analysis of heart rate variability to follow a longer period of change the user causes through the exercise. We also plan to create more variations of sound so that the users can choose what they favor.

5. ACKNOWLEDGMENT

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