Towards Interactive Mindfulness Training Using Breathing Based Feedback

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Abstract
Although regular meditation practice is linked to numerous mental health and cognitive benefits, it is often difficult for beginners to maintain focus during practice and persevere with the activity over time. To tackle this issue, we externalised the ability of self reporting loss of focus by developing a feedback loop that helps the user track and maintain their concentration levels in a non-invasive manner. We hypothesise that the change in breathing pattern can indicate a loss of concentration and the act of audibly amplifying a person's breathing sounds during meditation can help them regain and maintain focus on their breathing, leading to a more effective meditation session. We present experimental designs and findings towards this end.

Author Keywords
Meditation; Breathing Feedback; Attention; Focus; Self-regulation process; Interactivity; Mindfulness; Biosignals

ACM Classification Keywords
H.5.2 [User Interfaces]: User-centered design

Motivation
Meditation has been proven to have numerous mental health benefits, including increasing a person's self regulation of attention, reducing the rate of gray matter deterioration amongst elderly and improving mental health [5, 8,

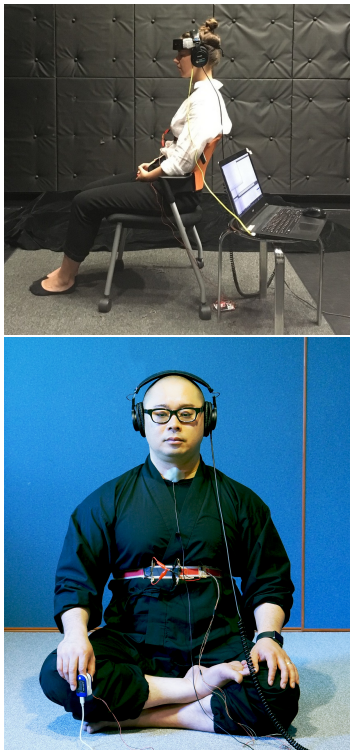

Figure 1: Experimental setup.

9]. The benefits of meditation on sustained attention have been confirmed from earlier studies [7] although results are based on regular and focused practice. Novice practitioners tend to struggle to gain focus and remain focused during meditation [6]. As a result, the activity may become frustrating and ineffective.

This paper presents first steps towards a system capable of tracking user's concentration during meditation and providing real-time feedback to help maintain the concentration throughout the meditation session. Since one of the most important aspects of meditation is the control of one's own breathing, the system uses breathing as its main input. For the output, the sound of the user's breathing is played back to the user in real-time. Audio feedback was chosen as it is reported to be the most effective means of feedback in meditation[2].

We hypothesise that audibly amplifying a person's breathing as they lose focus will help bring their attention back to their breathing and thus help them regain focus. The system is triggered when the user's breathing patterns signal loss of concentration, meaning that it will support the user only when it is needed, metaphorically scaffolding and supporting the meditation learning process and being inactive most of the time for experienced meditation practitioners.

The contributions of the paper are (1) a novel approach for facilitating meditation by artificially amplifying the user's breathing sounds, (2) indication that a user's loss of focus can be detected based on their breathing pattern and (3) user feedback on breathing sound amplification.

Approach

We chose to focus on Zazen meditation, a type of meditation practiced in Zen Buddhism, as it promotes focus on the breath which is a measurement that can be monitored non-invasively. During Zazen meditation, a practitioner is seated whilst maintaining a lowered gaze pointing 2-3 feet in front of them.

The aim was to develop an aid for people to use whilst meditating. Current applications and devices use guided meditation where users follow instructions from a meditation teacher [10, 11]. This technique may not always be effective as the users have to follow the pace of the instructions as well as self evaluate their performance, a complicated task particularly for novices.

The approach is based on the attention regulation process [1] which describes the cycle of self-regulation, supported by technology-mediated detection and feedback mechanisms. The augmentation of a person's breathing sounds was used to help them achieve and maintain a state of focus. We hypothesise that gradual amplification of a person's breathing sound will help them regain and maintain their focus.

Experimental Design

In order to conduct the experiment we identified the need of a pilot study that would help us form a baseline for detecting loss of concentration, identify the necessary data to be collected and the equipment best suited to complete this task.

In the pilot set-up, 7 individuals took part (3 men and 4 women) aged 23-30. One participant reported doing daily meditation whilst the rest were novice. The participants were asked to complete a Psychomotor Vigilance Task (PVT) test followed by a short introduction on how to conduct Zazen meditation. The participant had 3 min of rest, followed by 10 minutes of continuous meditation. During the experiment, participants were asked to sit on the floor in a crossed legged position or on a chair according to their per-

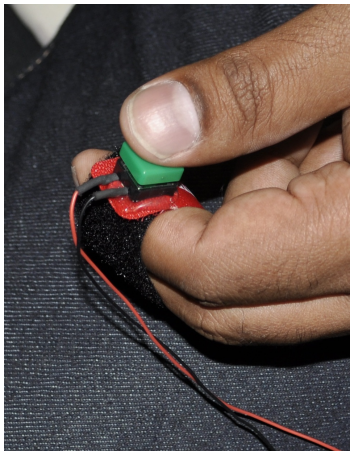

Figure 2: Concentration loss acknowledgement button

sonal preference. After the end of the meditation they had 3 minutes of rest before completing a second PVT test. The PVT tests enable comparison of alertness before and after the rest and meditation sequences [4]. A change in alertness would indicate that the participant had experienced some change in their cognitive state during the session. During the rest and meditation periods, participants were asked to wear a microphone attached to the base of their throat and headphones in order for their breathing to be recorded and replayed in real-time when their breathing rate exceeded a certain threshold. After the meditation and rest sequence, a semi structured interview was conducted with each participant. Participants were split into two groups, first group experienced the intervention and the second group served as a control group. All participants wore the same equipment throughout the session.

We attached a respiration detection strap with a stretch sensor around their chests to measure the rate, phase and depth of respiration. The amplification of the breathing sound was triggered when the breathing rate exceeded 10-11 breaths per minute [3]. Using this breathing rate as an indicator of focus loss was intended to be a starting point for the initial study with the aim to be adjusted for later experiments. The participants also had a button attached to their index finger and were asked to press it as an acknowledgment of loss of focus before returning to their breath. The button presses were recorded together with the data from plethismograph for further analysis. The use of a button was intended to replicate a common practice in Zazen meditation, whereby practitioners follow a specific ritual when they detect loss of focus before they return their focus to their breathing. Our aim was to examine whether the physiological data (number of breaths/min) synchronise with the individual's self reporting of loss of focus.

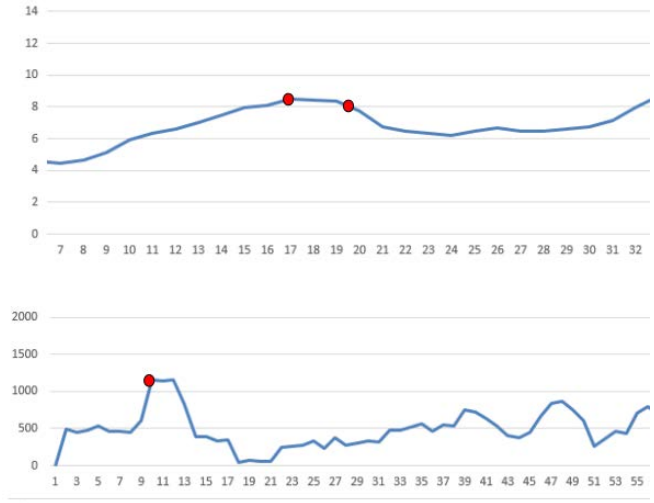

Figure 3: Upper: Breaths per minute(Y) and number of breath (X). The rate is the average of the last three breaths. Lower: Standard Deviation of the breathing cycle length of the last three breaths in milliseconds (Y), number of the breath (X). Red dots represent the button clicks, as an acknowledgement of the lost of concentration.

Discussion and and Future Work

The data show less concentration losses for the group with interventions, however not statistically significant in this small study.

This initial study shows clear changes in breathing patterns, such as a change in frequency or irregularity in breathing rate before the participants report loss of focus by clicking the button. The fragments of recordings presented in the Fig.3 show an example of typical abnormalities that precede the loss of concentration report.

The average breathing rate oscillated around 10-12 breaths per minute, with two outliers of 6-7 and 15-17 breaths per minute. Breathing patterns varied between participants, which means that a constant threshold is not applicable as a universal solution. In a future experiment, dynamic breathing characteristics analysis and user-dependent thresholding will be implemented to verify the feasibility of a universal system that is able to adjust to different breathing rates and patterns of different people.

The interviews conducted after the study showed that the participants who experienced the intervention found the sound of their own breathing to be non-diverting and suitable for the cause.

Conclusions

In this paper we introduce initial work towards helping practitioners maintain focus during meditation. The approach of recording the breathing characteristics such as rate, depth and regularity and amplifying the sound of breathing as the breathing rate exceeded a certain threshold seems promising based on initial findings. Loss of focus can be detected as a change in breathing pattern prior to a participant's self-reporting of loss of focus. A study with a larger participant group is planned with user-dependent calibration to establish the normal breathing pattern. This study will further explore the efficacy of using breathing amplification to help the practitioner regain focus after experiencing loss of focus.

Acknowledgments

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