Investigating the Role of Haptic Stimulation in Mobile Meditation Tools

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Abstract. Previous studies have shown that mindfulness meditation and paced breathing are effective tools for stress management. There are a number of mobile applications currently available that are designed to guide the breath to support mindfulness meditation and paced breathing practices. However, these focus mainly on audio/visual cues and are mostly non-interactive. Our goal is to develop a mobile meditation tool focusing on haptic cues. To investigate the effectiveness of the system, we conducted user studies. This study explores the following questions: How effective is haptic guidance on its own? And how may the addition of haptic feedback enhance audio based guidance? Preliminary analysis support the value of haptic guidance in mobile meditation tools.

Keywords: Meditation · Technology · Haptic device

1 Introduction

Stress is physical response that affects us all in varying degrees throughout our lifetime. Throughout history, people have developed various practices to cope with stress. Many of these focus on bringing awareness to the body and breath. Previous studies have supported that mindfulness meditation and paced breathing are effective tools for stress management [1]. Within the past year there have been huge strides in development and commercial interest regarding health and fitness portable tools [2]. There are a number of commercial mobile apps currently available designed to guide the breath to support mindfulness meditation and paced breathing practices; however, these focus mainly on audio and visual cues and are non-interactive. Overall, there has been limited research done towards integrating meditation with technology, especially in the realm of haptic use and interactivity in portable meditation tools. This study will focus on how effective haptic rhythm guidance is in comparison with different modalities (audio and audio-haptic).

2 Related Work

2.1 Traditional Methods of Relaxation

As stress is undeniably universal, there have been many techniques and practices previously developed to assist in stress management and the promotion of relaxation.

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The breath is one of our primary contacts with our parasympathetic nervous system. Often during bouts of stress or panic attacks, our sympathetic nervous system activates “fight or flight” mode. Breathing is the only component of the autonomic nervous system that can be controlled consciously. Control of the breath stimulates the parasympathetic nervous system, triggering a relaxation response [3]. Paced breathing has been shown to be a valid tool in managing stress and anxiety [1].

The relationship of the body to its environment can be obtained through bringing awareness to the senses. Although, tactile exploration is underexplored in this particular area, there is evidence of the sense of touch being incorporated in traditional relaxation practices. Touch is an extremely personal and intimate sense. It is used to create a personal space, only experienced to those directly exposed to the action. The use of therapeutic touch is often used to help people relax [4]. Similarly, the tactile sense has also been incorporated in meditation through the physical manipulation of objects with the hands, such as the creation of a zen garden or the handling of baoding balls and prayer beads [5].

2.2 Technology Driven Methods of Relaxation

Recently, there has been a shift in focus in technology to fitness and health related devices. In this age of technology and innovation, there exists a lot of opportunity to supplement existing practices. Breathe with the Ocean, explored various systems featuring an environment with audio (ocean wave sounds), haptic (touch blanket), and visual (light) stimuli. It was noted that most users found the synchronization between the wave-like patterns from the haptic blanket and the audio waves pleasing [6]. Another project, the Heartbeat Sphere featured a spherical object designed to assess and reflect a person’s heart rate through soft pulsing vibrations and colorful lights. This is intended to invite the user to be mindful of her heartbeat [7]. There are also numerous commercial mobile phone applications available on the market that offer meditation or paced breathing guidance. Audio utilized ranges from guided meditation voice narrative to natural sounds (e.g. water, birds) to percussive sounds (e.g. bell chimes, gongs, meditation bowls). Visual guidance often appears in the form of meters filling and emptying, objects expanding and contracting, or animated graphs. Few offer haptic components, and those that do have abrupt pulses that feel jarring. You Can’t Force Calm [8] was an exploratory study that designed and evaluated techniques to support respiratory regulation to reduce stress and increase parasympathetic tone. It incorporated breath sensor input and visual and audio feedback. Evidence from this study supported that auditory guidance was more effective than visual at creating self-reported calm. It would be interesting to further this exploration of mobile tools into the physical and subjective effects of haptic stimulation.

3 Case Study

We investigated how haptic modality in a mobile meditation system affects a user's relaxation experience. We conducted user studies comparing different modalities implemented in a mobile device.

3.1 System Design

We developed a mobile phone application in Android Studio. The application has the ability to produce haptic, audio, or audio-haptic outputs to act as a breathing guide for the user. The application has manual and biofeedback interaction mode. Biofeedback mode utilizes an external sensor, the Zephyr BioHarness 3, in order to determine the user's current breathing rate. The breathing guide is initially set to match the user's rate, slowly increasing the interval to decrease the user's breathing rate. The program continuously monitors the user's ability to match the guide and adjusts the breathing interval accordingly. Manual mode allows the user to manipulate the breathing interval in real time with a slider. Figure 1 contains a diagram of the overall system and a visual description of the various breathing guide modalities. A pillow was used to encase the mobile phone, helping to soften and amplify vibrations. This also allowed the user to relax with their hands wrapped around the pillow (Fig. 2).

3.2 User Study

We obtained 21 undergraduate and graduate university students for our user study. The study lasted three days for each participant. Users were separated into three different modality groups (haptic only, audio only, and combination audio-haptic) based on a pre-filter questionnaire. Groups contained 6 to 7 participants each. Each participant was able to control the system manually and interactively through a biofeedback sensor. In this paper, we analyzed only manual sessions. Both quantitative and qualitative data are used for analysis. Quantitative data included the following: breathing rate, heart rate variance, user preference (choice on Day 3), and the short stress surveys (before and after each sit). Qualitative data was gathered by a general feedback on-site interview at the end of each session. The recorded interview data was coded and analyzed focusing on "key theme" arising from the participants' experiences.

4 Results

The stress survey contained an analog scale that read very tense to very relaxed. Participants marked their current relaxation state on the scale before and after each meditation sit. The participant's mark was converted to a real number on a scale of 0 (very tense) to 10 (very relaxed). We calculated the user's subjective change in relaxation by the difference of the converted values. Overall, each group experienced an increase in relaxation state (Fig. 2b). The haptic group obtained the greatest average

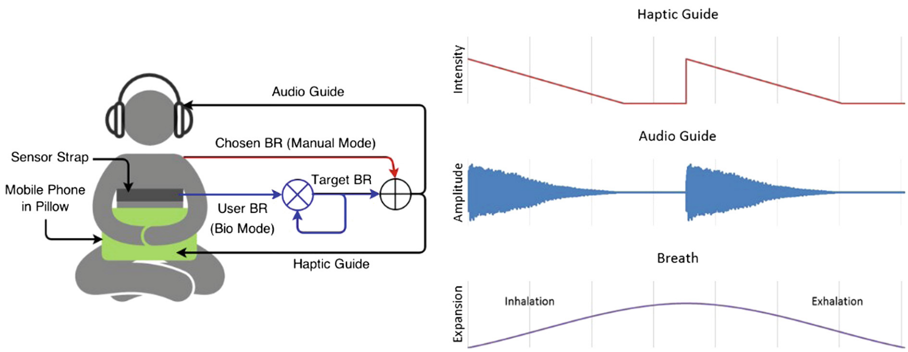

Fig. 1. (a) System diagram with interaction modes: manual and biofeedback. BR: Breathing Rate. (b) The haptic guide describes the intensity of the phone's vibration. The audio guide describes the amplitude of the gong chimes. The vibration pulse and/or gong chime marks the beginning of the inhalation/exhalation.

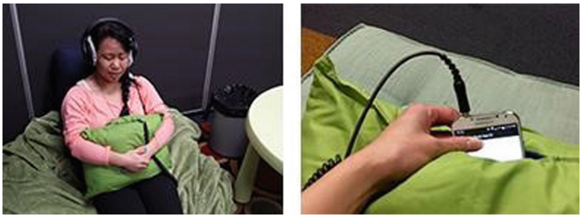

Fig. 2. (a) Participant using device. (b) Participant inserting phone into pillow pocket.

change in relaxation at a value of 4.4. The audio and audio-haptic group had average changes in relaxation with values of 4.1 and 3.4 respectively.

The stress survey also contained 5-point Likert scale items of various adjectives adopted from the Stress Arousal Checklist [9]. Stress adjectives were given a positive or negative ranking, and summed together, to quantify the user's current stress level. We calculated the user's change in stress by finding the difference before and after each meditation sit and mapped to a scale from 0 (no change) to 10 (greatest possible change). Overall, participants did experience an increase in objective relaxation, as inferred from a decrease in quantitative stress (Fig. 2a). Again, the haptic group felt the greatest decrease in quantitative stress after using the application with an average value of 2.9. The audio group followed behind with a value of 2.0. The audio-haptic group experienced the least amount of quantitative stress relief with a value of 1.6.

Difficulty of the session (Fig. 3c) indicates the observed level of difficulty the user had in following the breathing guide. Each session was described using the following adjectives: gradual, flat, and bumpy (Fig. 4). A gradual section is characterized by a steady decrease in average BR. A flat section is characterized by a stable value of average BR. A bumpy section is characterized by an unstable BR. This value was calculated by determining the fraction of time the user's breathing pattern was bumpy

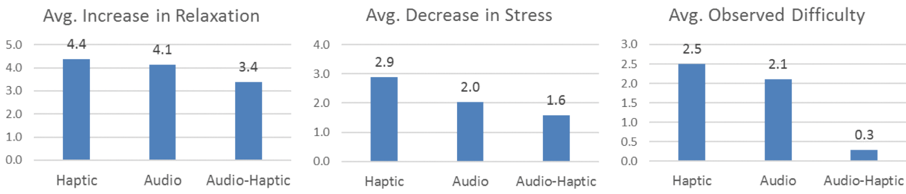

Fig. 3. Average change in (a) subjective relaxation and (b) objective stress, and (c) observed difficulty for each of the modality groups.

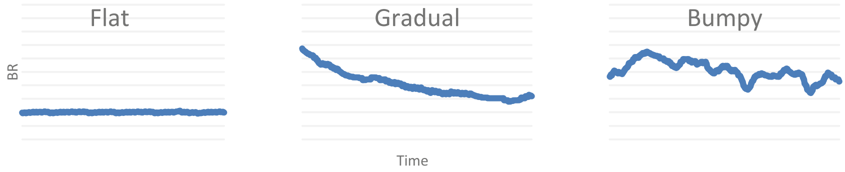

Fig. 4. Graph descriptions of breathing rate (BR) over the session duration: (a) flat, (b) gradual, and (c) bumpy.

during the session. It was then converted on a scale from 0 (completely smooth) to 10 (completely bumpy). Out of the three guidance feedback systems, the audio-haptic guide was significantly the easiest to follow. The average difficulty participants had following the audio-haptic guidance was 0.3 session versus 2.5 and 2.1 for the haptic group and audio group respectively.

To iterate, each user only experienced one type of modality for the duration of the study. However, a few users made comments directly addressing the haptic feedback they experienced. Three users commented that the vibration pulses from the pillow reminded them of a heartbeat or a cat purring. Participant A liked the subtleness of the effect, commenting, "*Normally when I try to meditate on my own I get severely distracted… But I liked how the vibrations made you aware that you were doing something. But you weren't really aware of it*". One user initially found the vibration pulses unpleasant as they were reminiscent of a phone ringing. However, by the end of the session, he was able to remove that negative association. Two people commented how they liked how the sounds and the vibrations worked together. Participant H reflected, "*I actually found the gong noise a lot more relaxing… for some reason I realized this is actually a good noise. I like this… And I felt that… had the vibrations not been there I don't know if it would have the same effect*". Overall, users tended to enjoy the addition of the haptic stimulation.

5 Discussion

Our preliminary analysis suggests the effectiveness of haptic stimulation on its own in mobile meditation tools. On average, participants in the haptic group experienced the greatest increase in subjective relaxation and decrease in objective stress of all three modality groups. Haptic stimulation may be greatly applicable to various situational use. There may be certain conditions where audio guidance is not viable (e.g. too much environmental noise or desire for silence). Many people also have a personal mobile device which contains a motor, and thus, can take advantage of the haptic guidance benefits.

Additionally, the results support the value of experiencing audio and haptic stimulation simultaneously. The participants in the audio-haptic group followed the breathing guide with more ease on average compared to participants experiencing only one type of feedback. However, our results suggest that the ease of following the guide did not necessarily lead to a greater feeling of relaxation. Multimodal audio-haptic stimulation may be beneficial in aiding focus to meet a particular task, but this may impede the user's ability to relax. Future work is necessary in order to validate the significance of our findings on a larger sample scale.

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