Encouraging Meditative Experiences through Respiratory-Musical Interaction

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ABSTRACT
We have designed and implemented a chamber of complete darkness where users shape a peaceful soundscape using only their respiration. This interactive system was designed to foster a meditative experience by facilitating users' sense of immersion while following a specific attentional pattern characteristic of *mindfulness*. The goal of *Sonic Cradle* is twofold: first, to trigger the proven effects of mindfulness on stress, and second, to help teach and demystify the concept of meditation for users' long-term benefit. This short research note situates and presents this interaction design concept and its first implementation. We conclude by touching upon ongoing co-design sessions and our long-term plans for mixed methods validation.

Keywords
Design, biofeedback, mindfulness, sound, music, self-regulation, stress, psychology, therapy, human-computer interaction.

1. Introduction
As clinicians embrace pro-active and preventative approaches, patients' ability to promote and manage their own health is becoming critical. Researchers are actively pursuing an applicable model to equip clinicians and patients with the insight needed to improve behavioural *self-regulation* in a health context [2]. A new crop of technologies are also being designed to support the self-regulation of exercise, eating habits, work breaks, cigarette smoking and more [4, 8]. While these tools join a large family of medical technologies designed to prevent and treat physiological problems, there are relatively fewer systems specifically geared toward psychological health promotion.

Biological and physiological sensors have been used to externally manifest one's internal states in biofeedback: a technology which has been shown to be therapeutic [6]. A previous study drew from divergent trends in interactive systems in an attempt to create a mobile biofeedback system for stress management called *Affective Health* [15]. The authors claimed that, until we develop improved biofeedback sensors, future directions for stress management technology are limited to systems which allow for interpretive self-reflection on bodily states in short-term sessions as opposed to real-time, continuous use. In this research note, we propose an interactive medium designed to motivate and teach non-technological practices known to help manage stress, sidestepping the documented ineffectiveness of systems which rely on continuous engagement with physiological sensors in daily life.

Contemporary evidence points to *mindfulness meditation* as an effective therapeutic tool for psychological self-regulation which requires no technology at all. This rapidly spreading eastern spiritual practice has been described as an intentional and non-judgmental focusing of attention to the present [1]. The advent of *calming technologies*, that *"induce cognitive, physiological, or affective states"* of *"restful alertness"* [14], demonstrates that interaction designers are already beginning to incorporate meditative principles in stress management applications. While other therapeutic technologies distract users from negative experiences [7, 19], these systems often borrow concepts from meditation to support the self-regulation of stress through heightened awareness of internal processes [13, 16, 20].

In this research note, we report on an initial attempt to design a new form of stress management system which intentionally promotes specific patterns of awareness and attention characteristic of mindfulness practice. The goal is to continue onward from this initial concept to iteratively design and validate an interactive system which helps users achieve a holistically meditative user experience. If successful in achieving this first goal, we will have established a foundation for continued technological research focused not only on stress reduction in the short-term, but also on demystifying meditation, experientially educating non-practitioners about mindfulness and its benefits.

2. Interactively Mediating Mindfulness
In order to design an interactive system to promote meditation, we must recognize the existence of diverse forms of this practice. In surveying common themes of a wide range of meditative practices, Lutz et. al. [11] created a paradigmatic framework which depicts the core of this family of practice as a balance between *"one-pointed concentration on a specific object"* and insight into one's own *"habits and assumptions about identity and emotions"*. The authors proceed to discuss a growing contemporary movement known as *Vipassana* as *"especially emblematic"* of this balance because it represents a *"simplified and regularized set of meditation instructions available to a wide population"*. This practice has also been a focus in medical and psychological literature under the name of *mindfulness meditation*. The key element of mindfulness is the cultivation of a focused attention; whenever attention wanders, one is to gently return attention to some focus point without being discouraged or punitive towards the self.

Ongoing research depicts mindfulness as a promising non-pharmacological tool to improve the psychological state of those suffering from chronic clinical problems, including anxiety (**figure 1**), chronic pain, panic disorders, and depression [reviews: 1, 3, 5, 10]. One of the most ubiquitous elements of this research is the mention of direct effects on stress: a major factor in all the aforementioned conditions. Stress is known to trigger a complex cascade between the hypothalamus, pituitary gland and adrenal gland (the *HPA axis*) which can affect gene expression,

generating severe negative effects on the human brain at all stages of life, from prenatal babies to the elderly [12]. The experiential focus promoted by mindfulness practice seems to have an inhibitory effect on the stress response. In fact so much so that Jon Kabat-Zinn, the major proponent of mindfulness meditation in therapy, sees this effect as central enough to refer to it directly in the title of his treatment intervention: *Mindfulness-Based Stress Reduction* or *MBSR* [10]. This growing practice and its ongoing validation suggest that an interactive system which could encourage, motivate, help people experience, or teach mindfulness meditation is at *least* a promising direction for stress management technology (if not an instigator of more profound, lasting benefits).

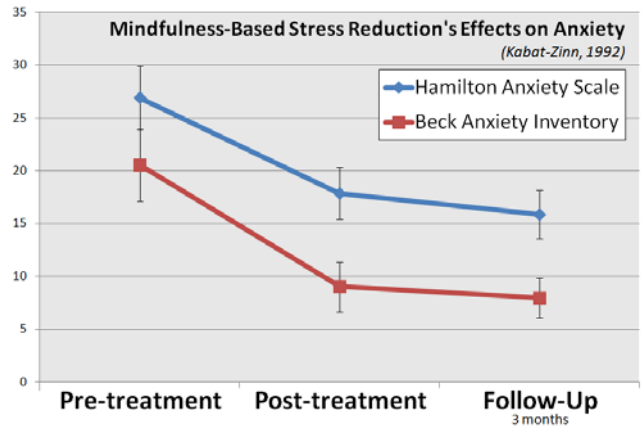

Figure 1. A simplified re-plot of data from Kabat-Zinn's 1992 study of *Mindfulness-Based Stress Reduction* created to clearly portray its persistent effects on anxiety; an addendum states that effects persisted in a 3-year follow-up as well [9].

An instrumental element of Kabat-Zinn's approach to optimizing the delivery of therapeutic mindfulness is its attempt to somehow translate the eastern practice for a western audience: *"the intervention needed to be free of the cultural, religious, and ideological factors associated with the Buddhist origins of mindfulness"* [10]. In the present work, we aim to build upon this approach by designing an interactive system focused on promoting a meditative experience which not only minimizes spiritual dogma as MBSR does, but also minimizes meditation's learning curve by reinforcing the attention patterns of mindfulness practice through interaction design. This system – *Sonic Cradle* – aims to afford the basic characteristics of mindfulness with the goal of providing non-meditators with intimate knowledge of the experience and benefits of meditation. Not only does technology have the potential to reduce the need for an expert trainer, but more importantly, an interactive approach may be able to guide one toward critical experiential knowledge of mindfulness without complex instruction or initial feelings of failure.

3. Mindfulness and Stress Management

In managing stress, overarching organizational principles of our skeletal muscle system, autonomic nervous system, and neuroendocrine system suggest *"the individual's reaction to stress … as consisting of two major phases: an active coping phase and a rest phase"* [18]. While meditation can certainly benefit everyone, it is of particular interest to chronic disease sufferers who tend to have a hard time transitioning from the active coping mode to a relaxed state. In the case of anxiety and panic disorder, the inability to make this transition is a defining characteristic of the condition itself. Other conditions like chronic pain and depression generate perpetual stressors which consistently interrupt transitions to the rest phase. Mindfulness seems to support exactly such transitions by *"bridging the gap between rest and coping"*.

Contrary to popular assumptions about meditation, the goal of mindfulness is not simply to relax; the practice essentially aims to catalyze state change by applying the behavioural tendencies of the overdriven coping mode (focused attention, mental effort, etc.) directly to properties of the relaxed mode (tranquility, an absence of striving, etc.). When stressful distractions inevitably disrupt the process of establishing an active tranquility, a knowledgeable practitioner knows to calmly regain an internal focus, and the cycle repeats. We aim to design an interaction paradigm which generates this same cycle of attention between a focused internal attention, an external awareness, inevitable distractions and a calm return to internal focus (without a feeling of failure). A positive outcome of such a system would be consistent transitions from active, coping phases to more passive, restful mental states in diverse non-meditators without extensive time spent on instruction, preparation, training or usage.

We are not blind to the apparent redundancy of introducing an interactive system to combat stress: a phenomenon often associated with technology itself. However, note that the majority of technologies created in the past century have held goals of productivity, efficiency, and organization. We feel it is not necessarily some fundamental property of technology which acts as stressor; systems designed with different goals, such as relaxation, focus, awareness, a sense of calm, and self-exploration, may have completely different effects on the human mind. Further, a system designed to promote self-regulation does not necessarily require continued use to have a lasting effect. If our interactive system were somehow truly able to generate a state of mindfulness, participants would not only receive proximal stress reduction, but potentially an experience which may encourage them to establish their own self-regulatory practice afterward. Before validating such bold claims, we must first establish whether it is possible to design a human-computer interface which can actually generate an experience of mindfulness in a naïve user.

4. Design Concept: *Sonic Cradle*

Integrating the presented research on mindfulness and stress management, we developed a design concept aimed at mimicking meditation in order to promote psychological self-regulation. *Sonic Cradle* provides a non-traditional, non-visual immersive experience where a participant is suspended in darkness, controlling sound through the exploration of their own respiration (**figure 2**). The system suspends one's body in a dark chamber where two respiratory biofeedback sensors (*Thought Technology*'s *SA9311M* sensors which measure respiration through chest expansion) connect to a 4.1 speaker system through custom software written in *Max/MSP*. Instead of passively listening to specific sounds touted as having healing properties, *Sonic Cradle* aims to foster a creative experience. It is not some specific property of the sound itself that is to help ease stress, but instead the patterns of attention stimulated by immersion into the system's creative interaction paradigm. We chose to use the aural

modality because of sound's natural potential to envelop the listener without demanding clear, directed attentional focus.

In general, participants interact with the system by exploring different breathing patterns which actively shape a soundscape. Participants hold their breath to summon a new sound, and then shape that sound in real-time by breathing in different ways. Attributes of participants' respiration (rate, depth, thoracic/abdominal ratio) control audio parameters of that recently-added sound (respectively: reverberation effects, equalization filters, volume). If participants hold their breath a second time, the first sound continues to play with its attributes locked, and another sound is added to the environment and shaped in the same way. When ready to move on, participants can lock the second sound and summon a third sound to the mix in the same way, and the process continues. Based on some initial exploratory design sessions, the latest version also allows participants to remove sounds with rapid breathing. Essentially, participants use their breath to progressively shape and mix pre-recorded sounds together in unique ways.

Figure 2. A user suspended in the *Sonic Cradle*. A light is turned on for documentation purposes; normally the room would be completely dark. Sensors detect the user's respiration and use this data to progressively shape a peaceful soundscape.
Video: *http://www.jayvidyarthi.com/cradle*

Sonic Cradle enables participants to construct a sound environment through respiratory biofeedback. Not only has biofeedback been generally successful in therapeutic contexts [6], but connecting respiration and sound/music to generate relaxation and positive health effects has shown its potential in studies which use simpler implementations [20]. Further, previous evidence suggests that sensory deprivation can be independently therapeutic [17]. *Sonic Cradle*'s complete lack of visual input prevents visual distractions from stealing attention away from the breath-based interaction paradigm. Not only does darkness and isolation prevent external distractions, but suspension in a comfortable hammock greatly reduces the potential for interoceptive distractions (orientation, discomfort, pain, etc). In this regard, *Sonic Cradle* is theoretically similar to sensory deprivation tanks which shut out all light and suspend participants in saltwater (also known as isolation tanks or *Flotation REST*). The relationship between individual elements of *Sonic Cradle* and mechanisms underlying mindfulness meditation remains unclear, but the potential certainly exists for an informed combination of sensory deprivation, biofeedback, respiratory interactivity, and sound to generate positive psychological effects in the short-term. A less obvious question is whether this interactive system will lead to subjective reports which align with the practice of mindfulness meditation, suggesting the potential for an educational tool.

In essence, *Sonic Cradle* participants can either focus on exploring the respiratory control paradigm or be in a state of internal distraction. Even when distracted, participants have no choice but to breathe and influence their sound environment; their only choice is whether to do so intentionally or not. This is because healthy human respiration proceeds autonomously and automatically unless we re-orient our attention and assume control. As they explore the system, participants will achieve a calm focus on their breathing and a general awareness of their sound environment. Just as in mindfulness practice, participants will eventually be distracted by other thoughts. When in a distracted state, the sound environment continues to respond to the participant's autonomous breathing. Changes in the sound environment will trigger a curious re-orientation of attention toward breathing. Astute readers will notice a critical difference from typical meditative instruction: as participants are not initially instructed to willfully focus or orient their attention in any way, they will loop through this process without any expectations, negativity or punitive thoughts. Whereas typical attempts to learn meditation inevitably lead to punitive thoughts upon realization that one has failed to maintain focus, distractions hold no negative valence in *Sonic Cradle* as participants are not instructed to focus. This should enable the calm refocusing of attention characteristic of experienced mindfulness practitioners to proceed unencumbered as a natural response to the interaction paradigm.

5. Ongoing and Future Directions

We are in the process of running co-design sessions with naïve participants. These informal sessions are being used to discuss the system openly, gathering ideas and inspiration for reflective design of the human-computer interface. Participants are being asked to express their subjective experience freely. Follow-up questions probe temporal elements of the system, ratios of focus/distraction, ratios of relaxation/excitement, interpretations of the system, feelings of control and the user experience in general. These sessions aim to help us iteratively tweak and refine *Sonic Cradle*'s interaction paradigm.

Exploratory co-design sessions have already led to several iterations and we expect more improvements to come. As an example, the latest iteration of the system has sounds emerge from new spatial directions: a direct result of our first few participant reports. We are also beginning to see comments which align directly with our theoretical directions. For example, a few of our early participants had comments which depicted *Sonic Cradle* as generating similar experiential transitions as mindfulness: from active coping to rest (i.e. "*at first I was playing around with the controls ... but then after a while I just kind of realized that I had stopped doing that and was just breathing... in a way that I don't normally breathe*"). This work is setting the stage for more in-depth investigations to articulate the mechanisms underlying *Sonic Cradle*'s effects on people. After co-design sessions are completed, the next step will likely involve subjecting a newly iterated implementation to mixed methods investigation using a purposive sample of potential meditators.

This proposed study will systematically analyze qualitative data for evidence of an immersive, meditative experience while reinforcing any findings through physiological indicators of arousal. If the technological mediation of mindfulness seems feasible after this study, our results would not only fuel further design optimization, but also inform the controlled study of *Sonic Cradle*'s effects on stress response and potential as a persuasive design artifact (detecting if the system can help experientially motivate/teach mindfulness meditation).

6. Conclusion

After synthesizing relevant research surrounding mindfulness meditation and stress management, we conceptualized a novel interactive medium designed to promote meditative experiences: *Sonic Cradle*. After constructing an initial prototype, we are in process of iteratively improving and informally validating it through co-design. Our next step is to systematically gauge the implementation's ability to generate meditative experiences in non-practitioners, setting the stage for a more formal validation of its potential to serve as a new vehicle for stress management.

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