Mediated Meditation: Cultivating Mindfulness with Sonic Cradle

Abstract
Sonic Cradle enables users to shape sound with their breath while suspended in a completely dark chamber. We conducted a qualitative investigation to understand 39 naïve participants’ subjective responses to this design artifact. Systematic analysis with 3 independent data coders produced 11 findings which richly describe the Sonic Cradle experience as clearly comparable to mindfulness meditation (e.g. clarity of mind, loss of intention). This paper shows how persuasive media have the potential to promote long-term psychological health by experientially introducing a stress-relieving, contemplative practice to non-practitioners.

Author Keywords
Jay Vidyarthi
Simon Fraser University
Vancouver, Canada
kvidyart@sfu.ca

Author Keywords
Bernhard E. Riecke
Simon Fraser University
Vancouver, Canada
ber1@sfu.ca

Abstract
Sonic Cradle enables users to shape sound with their breath while suspended in a completely dark chamber. We conducted a qualitative investigation to understand 39 naïve participants’ subjective responses to this design artifact. Systematic analysis with 3 independent data coders produced 11 findings which richly describe the Sonic Cradle experience as clearly comparable to mindfulness meditation (e.g. clarity of mind, loss of intention). This paper shows how persuasive media have the potential to promote long-term psychological health by experientially introducing a stress-relieving, contemplative practice to non-practitioners.

Author Keywords
Biofeedback; mindfulness; meditation; sound; music; stress; deprivation; persuasive; qualitative; respiration.

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User Interfaces: user-centered design, auditory feedback, evaluation/methodology.

Introduction
Most of us no longer confront threatening circumstances on the regular basis for which our stress response has evolved. While stress – a “cognitive perception of uncontrollability and/or unpredictability that is expressed in a physiological and behavioural response” [17] – can be positive or negative, too much stress has a negative impact on the immune system [10], brain [18], and behaviour (i.e. loss of sleep, unhealthy eating, drug use, etc.) [21]. Proponents of self-regulation in healthcare would agree that encouraging people to learn how to curb unnecessary stress is essential for a healthy body and mind [2].

Persuasive technologies can help one self-regulate exercise, nutrition, and more [5, 7, 11]. However, there are fewer systems specifically designed to provide psychological support for problems like stress. Such technologies would be critical to help those suffering
from mental disorders (prevalence is 30% in USA, with other countries not far behind [3, 15]), and also help regulate the psychology of non-clinical populations.

Biofeedback can be therapeutic [9], but inadequate mobile biofeedback sensing limits stress management technology to systems for short-term physiological self-monitoring, evaluation, and reflection [24]. However, persuasive technologies can have a lasting effect by triggering changes in behaviour and attitude [7]. To this end, we designed a musical biofeedback chamber called Sonic Cradle to experientially introduce mindfulness meditation to non-practitioners [29]. This paper presents a qualitative study of subjective experiences in Sonic Cradle, a prerequisite for future work in this new and ambitious application area.

Mindfulness, Stress and Technology
Mindfulness meditation has been described as an intentional and non-judgmental experience of the present [1, 13]. The practice revolves around cultivating a focused attention on the present, often using breathing or other internal, bodily sensations [19]. When one’s mind inevitably wanders, attention is gently and pleasantly guided back to the initial focus point. In the words of Jon Kabat-Zinn (a proponent of the practice in the medical field) "mindfulness can be thought of as moment-to-moment, non-judgmental awareness, cultivated by paying attention in a specific way, that is, in the present moment, and as non-reactively, as non-judgmentally, and as openheartedly as possible" [13].

Jon Kabat-Zinn refers directly to stress in the title of his clinical intervention rooted in meditation: Mindfulness-Based Stress Reduction or MBSR [12]. Ongoing research depicts MBSR as a promising non-pharmacological tool to inhibit stress and improve the psychological state of those suffering from chronic clinical problems including anxiety, chronic pain, panic disorders, and depression [1, 4, 6, 12]. A persuasive medium which demystifies and introduces non-practitioners to mindfulness-based practices through vicarious experience and cause-effect exploration could help broader audiences experience its vital benefits [7].

Sonic Cradle is a "calming technology" [23] which aims to catalyze transitions to a restful clarity. While existing therapeutic technologies distract users [20, 30] or provide feedback on internal processes [23, 25, 26, 31], Sonic Cradle aims to introduce non-practitioners to an intimate and relatively effortless experience of mindfulness meditation (in contrast to the difficulties often encountered by new students - unintentional distractions, mindless boredom, and feelings of failure [13]). The training wheels of a children’s bicycle serve as an apt metaphor for our approach; if an interactive medium were to help non-practitioners experience mindfulness meditation for the first time, might it also have the potential to persuade them to independently learn and benefit from this self-regulatory practice?

What is Sonic Cradle?
Sonic Cradle comfortably suspends users in complete darkness, enabling them to shape a peaceful soundscape using only their breathing (figure 1). The system was designed to covertly mimic mindfulness meditation, cycling attention between awareness of breath, mental distractions, and a calm return to focus.

Readers can consult a previous paper for: theory behind the Sonic Cradle design concept; related work;
a framework for media immersion underlying Sonic Cradle’s bodily suspension and visual deprivation; detailed explanation of the Sonic Cradle paradigm and how it fosters mindful attention patterns; why and how sounds were crowdsourced; and several iterations to the system based on 15 co-design sessions [29].

Figure 1. Sonic Cradle photograph (lit for clarity) and diagram. User is surrounded by a 4.1 speaker system. The latest Sonic Cradle prototype involves a hammock-chair from Island Chairs suspended in a completely dark and quiet room. Four Mackie MR5mk2 speakers surround the chair and a large subwoofer is installed below it. Two breathing sensors are attached to participants’ abdomen and thorax to measure chest expansion (Thought Technology’s SA9311M and ProComp2 encoder: 32 Hz). Sonic Cradle’s software (implemented in Max/MSP) manipulates sound using breathing data collected in real-time. Essentially, Sonic Cradle users experience a heightened and compelling breath awareness which enables them to add, remove, and shape (reverb effects, notch equalization between 50Hz and 1950Hz, and volume) crowd-sourced sounds which come from different spatial directions. Audio recordings are available at soniccradle.bandcamp.com.

Methods and Research Question
Questionnaires and biosensors could measure Sonic Cradle’s acute effects on stress. However, the system was designed as a persuasive medium to provide an experience of mindfulness meditation which influences users in the long-term [7, 29]. Evidence of acute stress reduction would not necessarily suggest that Sonic Cradle is achieving this goal. A more valid investigation would explore how users’ attitudes and behavior toward meditation are influenced longitudinally. In order to justify such intensive long-term research and more design iteration, we conducted a preliminary qualitative investigation in the short-term.

The present study aims to motivate and guide future research by first answering the following question: can users’ experiences in a carefully designed human-computer interaction paradigm be subjectively similar to the intimate, contemplative practice of mindfulness meditation? In pursuit of rich, valid description, we avoided questionnaires as they are typically suggestive, asking for agreement with leading statements (e.g. [8]). We chose to answer our research question by adapting basic interpretive qualitative methods [22] to the validation of a design artifact with an explicitly subjective goal. The rest of this paper summarizes a systematic, inductive analysis of interview data involving strict, numeric criteria and multiple independent coders to maximize validity. The goal was to extract subjective consensus in response to Sonic Cradle in order to explore the feasibility of persuasive media for mindfulness meditation.
Purposive Participant Sampling

Qualitative research is typically most effective with a purposive participant sample [22]. While random sampling emphasizes external validity, purposive sampling selects those participants most likely to provide articulate, valid and useful insight. In the context of human-computer interaction, participants uniquely suited to respond to a forward-thinking design artifact can guide and justify further research by providing an early glimpse into future possibilities.

We recruited at the TEDActive 2012 conference for two reasons. First, the busy conference and its progressive subject matter suggested participants would likely be mentally active, optimistic, and primed for novelty. Second, an essay-based screening process ensured attendees were proactive leaders in their communities (likely with busy schedules). As the reader will soon find out, the depth of participant responses in this study confirms the success of our recruitment strategy. While purposive sampling does not provide externally generalizable claims, findings reveal that – at least in one population – Sonic Cradle’s seemingly ambitious goal of mediating mindfulness meditation is feasible.

Sessions took place with 24 men and 15 women. We removed 5 participants due to evident biases (alcohol, prior knowledge, system malfunction). Participants were also classified based on whether they claimed to have previous informal experience related to meditation (e.g. yoga, individual classes; n=20) or not (n=14).

Procedure

Individual Sessions at the Conference

Participants were fitted with sensors, seated in the hammock, and briefed. Based on our iterative design process [29], the briefing included a vague description of the control paradigm: “...if you want to add more sound to your environment and increase its complexity, you simply have to stop breathing ... if you feel like you’ve lost control of the system or are overwhelmed, you can simplify your sound environment by breathing as quickly as possible.” Participants were then left alone for 15 minutes before being subjected to a semi-structured interview (see sidebar for questions).

Qualitative Data Analysis

Interview transcripts were distilled into granular bullet points and coded. The first author was considered data coder A; two external data coders worked in parallel to maximize the reliability and validity of the analysis (data coders B and C). In the end, we had six datasheets: coders A, B and C each provided codes for those with no meditation experience and those with some meditation experience. All codes were subjected to three criteria before being declared as ‘findings’:

1. any codes which did not include comments from at least 3 individual participants were removed;
2. any codes which did not satisfy the first criterion above in all 3 independent analyses (provided by coders A, B and C) were removed; and
3. any codes which did not meet the first and second criteria above in both groups (no meditation experience & some meditation experience) were removed.

Qualitative Findings

The fact that 11 unique findings met our strict criteria for consensus across participants, data coders, and groups suggests a level of validity. The table in figure 2 shows how many participants were included in each finding by each data coder (our first and second criteria guarantee no number below 3). The bar graph on the
right side of figure 2 presents the average number of participants included in each finding (our third criterion guarantees no number below 6). We do not have space here to present everything in rich descriptive detail, so we chose to supplement figure 2 with the next sections: brief summaries of 7 key findings using indicative participant quotes. We can provide a more complete description of all 11 findings upon request.

A Relaxing, Refreshing Experience (1)
Many participants described the experience as relaxing and/or refreshing (P15: “My muscles have relaxed, I don’t know if I could stand up. I feel extremely relaxed and I like the feeling that I have. I feel it in my face. ... When I came in here I was really tired, [now] I feel oddly energetic. I thought I’d be sleepy, [but] I feel very awake. It’s very odd ’cause I feel like I just took a nap, but I was very aware of stuff.”).

A Feeling of Floating (2)
Many participants compared Sonic Cradle to floating, often in water/space (P12: “Jumping in a pool of water, and you just sit there for a moment in the water, you know you have to go back up to the surface but you’re just like I can hang out here for a while’, not moving or anything, just sitting still in there. It felt a lot like that.” / P25: “...like floating in space. In outer space, that’s how I imagine it would feel.” / P30: “I would describe it as entering and floating with sound. To me, that is the most compelling thing about the whole experience.”).

<table>
<thead>
<tr>
<th>Qualitative Findings</th>
<th>No Meditation Experience Group (n = 14)</th>
<th>Some Meditation Experience Group (n = 20)</th>
<th>Average # of Individual Participants Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  A Relaxing, Refreshing Experience</td>
<td>(A9-B14-C9)</td>
<td>(A15-B9-C14)</td>
<td>22.33</td>
</tr>
<tr>
<td>2  A Feeling of Floating</td>
<td>(A7-B8-C6)</td>
<td>(A11-B4-C9)</td>
<td>14.33</td>
</tr>
<tr>
<td>3  An Initial Tendency to Explore the Control Paradigm</td>
<td>(A13-B10-C10)</td>
<td>(A12-B14-C14)</td>
<td>24.53</td>
</tr>
<tr>
<td>4  An Eventual Transition to Less Intentional Control</td>
<td>(A13-B4-C8)</td>
<td>(A15-B12-C8)</td>
<td>20.00</td>
</tr>
<tr>
<td>5  Imagery and Visual Experiences</td>
<td>(A4-B3-C3)</td>
<td>(A5-B5-C5)</td>
<td>6.33</td>
</tr>
<tr>
<td>6  An Expressed Desire for More</td>
<td>(A5-B3-C3)</td>
<td>(A6-B5-C3)</td>
<td>9.00</td>
</tr>
<tr>
<td>7  Bodily Sensations</td>
<td>(A9-B5-C6)</td>
<td>(A6-B4-C7)</td>
<td>14.33</td>
</tr>
<tr>
<td>8  Clarity of Mind, Reduced Thinking, and Emptiness</td>
<td>(A9-B4-C9)</td>
<td>(A9-B7-C8)</td>
<td>15.33</td>
</tr>
<tr>
<td>9  A Distorted Sense of Time</td>
<td>(A4-B5-C4)</td>
<td>(A7-B4-C8)</td>
<td>10.66</td>
</tr>
<tr>
<td>10 Positive and Emotional Responses</td>
<td>(A11-B10-C5)</td>
<td>(A13-B11-C12)</td>
<td>20.66</td>
</tr>
<tr>
<td>11 A Semi-Conscious, Sleep-like State</td>
<td>(A9-B4-C3)</td>
<td>(A4-B3-C8)</td>
<td>10.33</td>
</tr>
</tbody>
</table>

Figure 2. Qualitative findings: number of participants included by each coder and average number of participants in each finding.
An Eventual Transition to Less Intentional Control (4)
The majority of participants eventually stopped trying to intentionally control the system (P4: “I found myself at the beginning wanting to use it, but at the middle and end I was just going along for the ride.” / P24: “I just sort of surrendered to it ... first figuring out the mechanics of it, then ultimately disappearing into a place where I wasn’t fully conscious.” / P32: “Right at the end ... I got to an equilibrium place where I wasn’t thinking about controlling it.” / P34: “At the beginning I was ... trying to assess how it was working ... the middle ... [I was] going with whatever was going on.”).

Imagery and Visual Experiences (5)
Some participants reported visual experiences (P5: “It's not like flashes, but everything around is a little bit brighter, it's not like you're actually seeing but it's the feeling of seeing something.” / P15: “I kept seeing a blue stencil through grey, imagery of grey almost mist. Closer to the end I was able to see more of this very subtle green pattern that was almost like a stenciling ... [but] every time ... I wanted to move the grey out of the way, the green went away.” / P25: “I was seeing waves, light waves on the back of my eyelids but then later towards the end they turned into more like, almost, the stars in the sky.”).

Bodily Sensations (7)
All 3 data coders grouped diverse participant reports of bodily sensations together (P12: “It was a whole-body sensation, a sense of euphoria ... the body started vibrating and I started floating.” / P23: “I felt like I was actually moving back and forth ... [an] illusion of motion [which] kind of dissipated away when the music changed” / P36: “I also sort of felt this body high, very pleasurable ... like right before or after an orgasm.”).

Clarity of Mind, Reduced Thinking, and Emptiness (8)
Participants often described their experience as involving a reduction in thought (P5: “My thoughts were blank ... I felt myself thinking less and less as the whole thing progressed.” / P9: “[the system] lends a positive hand to making the mind chatter quiet ... I think this almost overpowers the chatter at points, and the mind just gives up.” / P13: “I'd say that it essentially let me empty my mind ... what I felt was almost a state of emptiness. I wasn't perceiving or thinking about anything, not even about how relaxed I was ... it would just be this state of being like an empty vessel almost.” / P14: “I spent a lot of time with a clear mind ... I guess the sounds that were going on kept other thoughts from entering my mind ... you got to take a break from the everyday noise in your head.” / P18: “I had no sense of time or space and I was in harmony with breathing ... It relates to you in a way that helps you remove thinking, focusing your own thoughts.” / P20: “I think it [was] generally about getting to a point where you turn off the internal narrative, which is kind of amazing because I have this constant internal narrative going on. I felt like the experience was really about transcending that.”).

Positive and Emotional Responses (10)
Many comments communicated an intense enjoyment of the experience (P27: “First word would be amazing, second word would be surprising. It was just really unbelievable. It was hard to describe.” / P36: “I think it was just amazing to feel, to have sound go through you in a very pleasurable way.”). A few participants communicated a deeper, emotional response to the system (P4: “[The system] brought me to a place in my childhood out of nowhere, and I felt like it was good. I felt like I was going to an extreme comfort zone where
I wanted to hear more, and I was enjoying it.” / P13: “I’m really interested to see over the rest of the day if ... I perceive any change. I almost feel a little emotional right now. Thanks for doing this.”

**Limitations and Potential Sources of Bias**

Any basic interpretive qualitative study which relies on interview data inherently comes with potential biases (moderator demographics / tone, pre-determined interview content, subjective aggregation / reporting, inaccurate participant self-reports). Although atypical for qualitative methods, a lack of control could also have influenced data and been a source of bias in our more systematic analysis tailored for human-computer interaction research; we did not control for time of day or direct context (sessions ranged from being in the early morning, between talks, before dinner, or during an event). Finally, participants vaguely understood that Sonic Cradle was somehow related to meditation in advance; this may have influenced their responses.

**Discussion**

Previous work has shown that respiratory biofeedback can reduce arousal in the context of music [31], respiratory control of music can reduce blood pressure [25], sensory deprived floatation tanks can have psychological benefits [16], and visual deprivation can improve self-reported pain scores in back-pain sufferers [27]. Considering Sonic Cradle’s direct relationship to all of these apparatuses, it is no surprise that participants reported relaxation [finding 1]. However, semi-conscious, sleep-like states [finding 11] suggest that Sonic Cradle may have been too relaxing for mindfulness meditation: “[If] relaxation techniques are overused, they are likely to propel the practitioner into dullness and hence hinder the meditation.” [19] The clarity of mind reported by participants [finding 8] suggests that the relaxation felt in Sonic Cradle more likely reflects a mindful balance than any kind of dullness. Reduced thinking is directly related to descriptions of mindfulness as “non-judgmental” [13]. In the words of Kang & Whittingham [14], who contextualize the psychology of mindfulness with its Buddhist origins: mindfulness “is often described as nonjudgmental, or not making value judgments on experienced content.” These authors go on to claim that the “simple awareness” which characterizes mindfulness “is non-elaborative and relatively unencumbered by language or conception, giving it a directness of access to experiential content.” Sonic Cradle was successful in generating this clear-minded experiential focus which seems to directly characterize mindfulness. Taken in context with participants’ positive responses to the system [finding 10], it seems interactive media do have the potential to accurately portray (or “simulate”) qualities of mindfulness in a desirable way, a key attribute of persuasive media [7].

Previous work used a questionnaire targeting hypnosis, meditation, and imaging to measure experiential differences between mindfulness practitioners engaged in a 2-day retreat, a 2-week retreat, and a 3-month retreat [8]. The questionnaire was leading, but differences between groups remain valid. Subjects in progressively longer retreats were more able to maintain attentional focus with less semantic thinking and planning. This aligns directly with Sonic Cradle participant reports of a heightened clarity of mind [finding 8]. Subjects in the 2-week retreat were most likely to share other experiences with Sonic Cradle participants: visual imagery [finding 5], perceived changes in bodily state [finding 7], and distortions of
time ([finding 9]; although in the opposite direction). This suggests that Sonic Cradle might indeed be able to provide novices with an experience of mindfulness most comparable to those with a bit more experience.

Stoyva & Carlson [28] describe mindfulness meditation as facilitating stress management transitions by applying behavioural tendencies of an active coping mode (e.g. focused attention) toward a resting state. Such a transition was reflected directly in Sonic Cradle participants’ switching from an initial tendency to explore the control paradigm [finding 3] to less intentional control [finding 4]. This is important, as stress management transitions are critical for managing clinical problems; we are already planning to investigate Sonic Cradle with chronic pain patients.

Before drawing conclusions, note that our findings are based on 15-minute sessions which seemed too short to many participants who stated a desire for more and longer sessions [finding 6]. This is important because it suggests that studying extended use could add valuable insight to findings. Future work in this area should involve longer sessions and repeated exposure to investigate longitudinal depth and consistency.

**Conclusion**

Sonic Cradle is a design artifact where user experience is not some secondary attribute to a main task, but instead it is the primary goal. This persuasive medium was designed to subjectively introduce mindfulness meditation to non-practitioners. We adapted basic interpretive qualitative methods and purposive participant sampling to reveal the potential of this new application area for persuasive media. Instead of relying solely on an open-ended subjective presentation of findings, strict criteria systematically ensured that our findings and conclusions represent a strong consensus between participants as independently judged by 3 data coders.

The main contribution of this paper is evidence that **inducing experiences comparable to mindfulness meditation is not only possible, but a realistic goal for stress management technology.** Systematic analysis of interviews conducted after the Sonic Cradle experience revealed clear subjective elements of mindfulness meditation as described in relevant literature [8, 13, 14, 19, 28]. Participants consistently reported starting their session by exploring the control paradigm before transitioning to a loss of intention and clarity of mind. Participants also reported imagery, bodily sensations, and time distortions, paralleling mindfulness meditators on a 2-week retreat.

Participants’ sessions in Sonic Cradle were also described as relaxing and desirable, suggesting that the system may be able to significantly promote the self-regulation of psychological health by persuading behaviour/attitude change. For instance, any participant who particularly enjoyed Sonic Cradle could learn how their experience was similar to that which is experienced by practitioners of mindfulness meditation. Such vicarious experiences have been shown to change attitudes and behaviour [7]; Sonic Cradle could motivate users to independently pursue and develop an interest in this therapeutic contemplative practice.

The sheer quantity of findings which exhibited enough consensus to satisfy our analytic criteria suggests a certain level of validity. However, the present study was not without its limitations. We invite the research...
community to help us clarify, reproduce, iterate, and expand on this new type of stress intervention which does not rely on self-monitoring or technological dependency; instead, persuasive human-computer interaction paradigms can cultivate experiences which educate people about the self-regulatory capabilities intrinsic to their own body and mind. Diverse specialists and community resources are needed to help us confirm whether this ‘training wheels’ approach can promote continued psychological health through long-term engagement with known, beneficial practices.

Cultivating Mindfulness

We did not follow-up with participants, but Sonic Cradle’s longitudinal potential was best exemplified by a spontaneous e-mail from P13 after the study: “Your research project has certainly made trying meditation a priority as I seek to find calm in the midst of the storms in which I live ... it was a real eye-opener for me ... Based on my very positive experience in the Sonic Cradle, I've been actively looking into mindfulness meditation ... and am committed to [my first attempt] tomorrow morning.”

If an interactive medium could consistently elicit such a response, it could potentially impact stress and related clinical problems. The present study demonstrates how technology can subjectively introduce people to self-regulatory practices which do not actually depend on that technology for continued use in the long-term. Sonic Cradle may seem like a paradox in this regard, but it is actually a contextually-appropriate interaction design born from deep contemplation about the immersive quality of today’s media saturation. Our society’s technological obsession may lead to stress, but perhaps it can also be exploited to regulate stress.

Acknowledgements

Interactive Arts + Technology at Simon Fraser University, NCE-GRAND, NSERC, TED, participants, sound contributors, Dr. Diane Gromala, and CHI.

References