Interactively mediating experiences of mindfulness meditation ☆

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ABSTRACT

Sonic Cradle is a human–computer interaction paradigm designed to foster meditative attentional patterns. A user's body is suspended comfortably in a completely dark sound chamber while the interaction paradigm subtly encourages them to focus on their breathing to summon and progressively shape an abstract immersive sound experience. Basic interpretive qualitative methods with a purposive sample of 39 participants were used to systematically analyze interview data after a 15-min experience of the system. Results suggest that this persuasive medium can pleasantly encourage an experience comparable to mindfulness by consistently inducing a calm mental clarity and loss of intention. Surprisingly, participants also reported perceptual illusions, feelings of floating, and emotional responses. Mounting evidence implies mindfulness meditation as an effective practice for self-regulation; this study represents a first step toward realizing technology's potential to increase wellbeing by introducing people to this psychologically beneficial contemplative practice.

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1. Introduction

"I cease thinking any thoughts about sources and give myself over to hearing. It is very much a bathing in sound, a sensuous luxuriating in pure sound and the spaces between them, in layer upon layer of sounds. Now they are simply what they are, no longer identified, no longer listened for in a straining, reaching sort of way." – Kabat-Zinn (2005)

For decades, the persuasive power of technology has been exploited for sales and corporate marketing. Recently, we have seen a new crop of persuasive technologies which aim to support their users, helping them exercise, eat healthy, take breaks, quit smoking and more (Chi et al., 2008; Consolvo et al., 2009; IJsselsteijn et al., 2006). While these persuasive tools join a large family of healthcare technologies designed primarily to prevent and treat physiological problems, there are relatively fewer systems specifically designed to provide psychological support. Such technologies would not only be critical to help those suffering from mental disorders (prevalence has been observed to be as high as 30% in the United States, with other countries approaching this number; Bijl et al., 2003; Kessler

et al., 2005), but also to help anyone identify and self-regulate unhealthy excesses in life (a key virtue in positive psychology; Peterson and Seligman, 2004).

BJ Fogg describes "computers as persuasive media" (juxtaposing them with "computers as persuasive tools" and "computers as social actors") as systems which provide "a compelling experience that will persuade people to change their attitudes or behaviours" (Fogg, 2003). This is a powerful idea for psychological health and wellbeing, an area where patients suffering from problems like depression, anxiety, and chronic pain need solutions which can fuel lasting changes. If a persuasive medium could offer a compelling experience which influences people's general outlook, it could potentially trigger long-term changes in behaviour and routine toward a healthier lifestyle. Since a growing body of evidence suggests that the practices related to mindfulness meditation can have profound effects on stress and psychological problems (Baer, 2003; Bohlmeijer et al., 2010; Fjorback et al., 2011; Kabat-Zinn, 2003), persuasive media for the adoption of contemplative practices have the potential to impact wellbeing.

We have previously published the underlying theory and iterative design process of the *Sonic Cradle* concept (Vidyarthi et al., 2012). To summarize, the system was designed to experientially motivate and teach mindfulness meditation, a practice known to be effective for stress reduction. The hope was for *Sonic Cradle* to be a persuasive medium which catalyzes interest and engagement with this vital contemplative practice. In the present

article, we will start with a brief recap on theoretical foundations for our work. Next, we will discuss the *Sonic Cradle* concept with specifics about its intention to promote patterns of awareness and attention characteristic of mindfulness meditation. This will set the stage for a comprehensive investigation of whether subjective experiences in *Sonic Cradle* align with contemporary literature on mindfulness meditation. We will conclude by discussing future directions for persuasive media aimed at wellbeing with emphasis on orienting this new research agenda towards a positive influence in people's lives.

2. Theory and apparatus

2.1. Stress management through mindfulness meditation

As many interactions with technology rely on attention, memory, executive functions, language, problem-solving, perception and decision making, the study of human psychology made – and continues to make – a major impact in the design of new technologies. However, the majority of interaction between psychology and human–computer interaction design is one-directional; most projects exploit an understanding of psychology to improve design. Only recently are we beginning to see research moving in the opposite direction: using design to improve people's psychological state (a rare example can be found in Thieme et al. (2013). *Sonic Cradle* represents an instantiation of human–computer interaction design and validation which not only draws from psychology, but also aims to benefit users' psychological state by promoting self-regulation of stress through mindfulness meditation. If an interaction design artifact can mediate longitudinal changes in behaviour and attitude which lead to improved mental health, it would help substantiate the argument for applying human–computer interaction design to promote wellbeing.

Stress is a "cognitive perception of uncontrollability and/or unpredictability that is expressed in a physiological and behavioural response" (Koolhaas et al., 2011). Too much stress can have negative impacts on the immune system (Herbert and Cohen, 1993) and the brain (Lupien et al., 2009; McEwen, 2006). Excessive activation of the stress response has also been associated with behavioural responses which can have disastrous consequences on the body (McEwen, 2006). Along with well-accepted forms of self-regulation like diet and exercise, encouraging individuals to learn how to regulate stress is absolutely essential for wellbeing. Psychological self-regulation can be especially critical for those suffering from chronic diseases which have negative effects through prolonged activation of the stress response: "prolonged physiological arousal and activation of neural and hormonal processes associated with the stress response, whether initiated by pain or anxiety, act as stressors… that can have detrimental effects on various body systems" (Asmundson and Katz, 2009).

Mindfulness meditation represents an attempt to discourage our minds' tendency to think in abstractions while simultaneously encouraging a pure experience of the present moment. In the words of Kabat-Zinn (2005), the major academic proponent of mindfulness meditation in the medical community:

> "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."

Ongoing research depicts mindfulness-based practices as promising for stress management, especially for those suffering from chronic clinical problems like anxiety, chronic pain, panic disorders, and depression (Baer, 2003; Bohlmeijer et al., 2010;

Fjorback et al., 2011; Kabat-Zinn, 2003). Jon Kabat-Zinn sees this effect as central enough to refer to it directly in the title of his clinical treatment intervention rooted in meditation: *Mindfulness-Based Stress Reduction* or *MBSR* (Kabat-Zinn, 2003). This MBSR intervention and its ongoing validation suggest that designing interactive systems which can help generate, encourage, motivate or teach mindfulness meditation can help engage broader audiences to experience its vital benefits. At least, such interactive systems suitable for broader audiences could help demystify meditation practice for secular audiences who are unaware of its growing status as a proven psychological phenomenon.

2.2. Sonic Cradle: externally simulating meta-awareness

Sonic Cradle aims to cultivate an experience of mindfulness meditation without the complex instruction and initial effort demanded by typical meditative practices. The goal of the system is to experientially educate users about a process intrinsic to their own mind. Mindfulness meditation is already known for its positive influence on our lives (Kabat-Zinn, 2005); there is little reason to replace the practice with a permanent technological implementation. Instead, we aim to inspire new practitioners. The training wheels of a bicycle serve as a clear metaphor; an interactive medium may be able to motivate and introduce an experience of mindfulness meditation in critical early stages of engagement with the practice.

Sonic Cradle is a non-traditional interactive medium where users are suspended in darkness, controlling sound through the exploration of their own respiration (Fig. 1). The system's interaction paradigm has been intentionally designed to encourage users to focus on a familiar internal sensation – breathing – in order to control and progressively shape an abstract sound experience for themselves. *Sonic Cradle* also involves a complete lack of visual input which aims to prevent visual distractions from stealing attention while encouraging users to actively co-create the experience. Further, comfortable suspension removes direct connection with the ground while greatly reducing somatic distractions like discomfort and pain, deemphasizing irrelevant aspects of physicality. While this concept seems similar to ExoBuilding, a breath-controlled external architectural structure (Schnadelbach et al., 2012), *Sonic Cradle* is unique in its aim to draw attention inward. Its respiratory biofeedback sensors are used to help root users' experience in the subtle, internal sensation of breathing and its influence on sound, as opposed to a visible external stimulus. *Sonic Cradle's* physical manifestation provides minimized distractions and a lack of competing input from the physical world.

A typical mindfulness meditation session starts with a focused attention (commonly directed at breathing or other internal sensations). After some time, one's attention inevitably wanders. Through extensive practice, mindfulness practitioners have developed some kind of *meta-awareness* which gently guides their attention back to the initial focus point, without feeling discouraged or punitive. *Sonic Cradle's* interaction paradigm was designed to guide users' attention in a similar way (Fig. 2). Users should naturally start by focusing on their respiration as they attempt to discover how to influence their sound environment. Inevitably, users will be distracted by other thoughts which steal attention away from the interaction between respiration and sound. However, since human respiration proceeds autonomously and automatically without attention, users will have no choice but to continue to influence their sound environment despite their distraction. *Sonic Cradle* intends ongoing changes in the sound environment to eventually trigger the users' curiosity and thus elicit a re-orientation of their attention toward how the sound is being shaped by their breathing, effectively restoring their inward attention. In this way, *Sonic Cradle* serves as an externally-driven
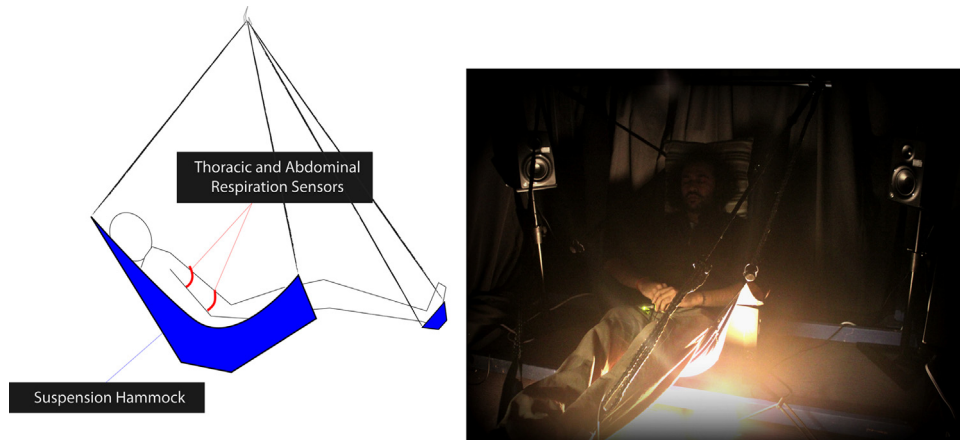
Fig. 1. Diagram/photograph of a participant suspended in Sonic Cradle. The photograph is lit for documentation purposes – the experience normally takes place in complete darkness. See http://www.jayvidyarthi.com/cradle for a video explanation of the system.
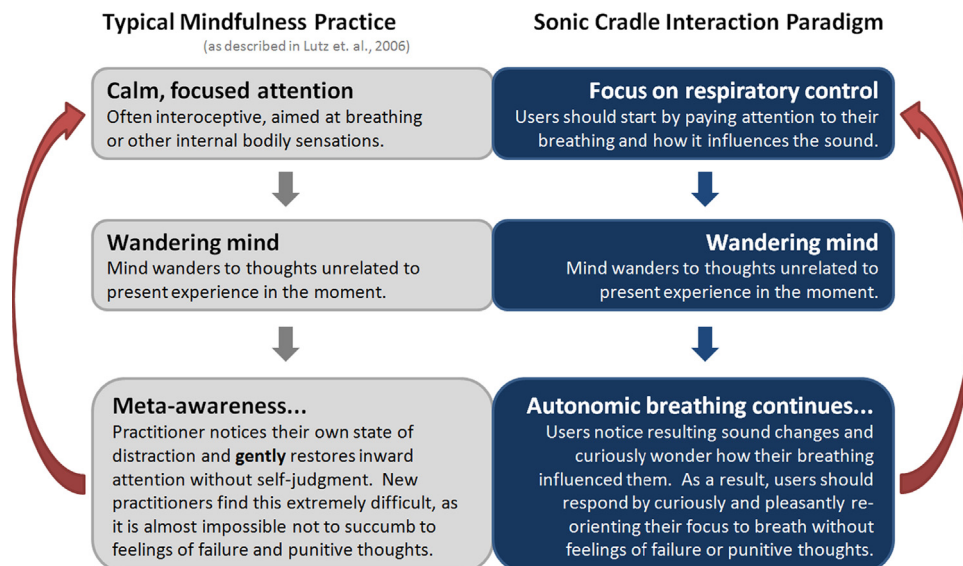

Fig. 2. Attentional comparison of mindfulness meditation and Sonic Cradle.

simulation of *meta-awareness* for non-practitioners who have not yet developed this faculty. That is, by subtly supporting users in re-directing their attention to their breathing, the system not only aims to help users re-gain focus while using the system, but also aims to implicitly and playfully teach them how to re-gain focus in daily life.

In practical terms, an externally-driven *meta-awareness* would need to draw only the attention of mentally wandering users and guide them back toward respiration; a user who is already focused should not be distracted. It was this demand which inspired us to use the aural modality, as sound has a natural potential to envelop the listener without demanding the clear, directed, attentional focus which could become a distraction:

"The ear favors no particular 'point of view.' We are enveloped by sound. It forms a seamless web around us… We hear sounds from everywhere, without ever having to focus… We can not shut out sound automatically. We simply are not equipped with earlids. Where a visual space is an organized continuum of a uniformed connected kind, the ear world is a world of simultaneous relationships." (Mcluhan et al., 1967)

Sonic Cradle aims to foster an audio experience which does not demand too much attention away from an intense focus on respiration, but does reclaim attention from mental distractions. Although we crowd-sourced sound submissions using a dedicated website where sound artists could contribute their own interpretation of peaceful sounds (see Vidyarthi et al., 2012), we only used those sound submissions which had no sharp changes to avoid forceful capture of attention. Further, we requested sounds with some rhythmic and tonal consistency (loosely related to the key of *E* and 60 beats-per-minute). Other than these dimensions, sound submissions were relatively unconstrained, as it is not some specific property of the sound itself that is to foster an experience of mindfulness, but instead the patterns of attention stimulated by the system's interaction paradigm. Submissions included recordings of musical instruments, natural phenomena, abstract sound art, synthesized tones, human voices, and more. We did not use

any specific sounds touted to have healing properties (binaural beats, chanting, specific frequencies, etc.).

For a non-practitioner learning mindfulness meditation, avoiding a feeling of failure can be especially tricky in the first few attempts. Maintaining focus is very difficult as our minds are quite prone to distraction. *Sonic Cradle* holds a critical difference from typical meditative instruction in this regard: as users are not initially instructed to willfully focus or orient their attention in any way, they should loop through this process without any expectations, negativity or punitive thoughts. Typical meditative instruction directly asks one to focus on breathing, implicitly attaching both an intentional conscious effort to the task and a feeling of failure to the inevitable realization that one has been distracted. Distractions hold no negative valence in *Sonic Cradle* as users are not explicitly instructed to focus. The *Sonic Cradle* interaction paradigm aims to enable the calm refocusing of attention to proceed unencumbered as a natural response to the interaction paradigm, potentially providing an experience which parallels more advanced mindfulness practitioners.

Readers can consult our previous paper (Vidyarthi et al., 2012) for more theory behind the *Sonic Cradle* design concept, related work, a framework for media 'immersion' underlying *Sonic Cradle's* suspension and visual deprivation, why and how sounds were crowd-sourced, and several iterations to the design concept based on 15 co-design sessions.

2.3. Implementation and algorithm

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. *Sonic Cradle's* software (implemented in Max/MSP) manipulates sound using breathing data collected in real-time from a proprietary software package called *Biograph Infiniti* (*Thought Technology*) connected to two breathing sensors which measure thoracic/abdominal expansion (Thought Technology's SA9311M and ProComp2 encoder: 32 Hz). Custom algorithms were created to extract parameters from the data: respiratory depth, respiratory length, and thoracic-to-abdominal ratio. Where applicable, the software was designed to measure each parameter as a ratio of its own maximum and minimum. In other words, a participant's current breathing depth is calculated as a percentage of that participant's deepest breathing depth so far. If a user takes a deeper breath than the current maximum, that breath would be considered the new maximum for all other breaths to be measured against. In this way, every participant was able to explore the full range of sound controls no matter how tightly the sensors were attached or how deeply the participant was able to breathe. Respiratory parameters controlled the 4.1 speaker system surrounding participants as follows:

- When participants stop breathing for 4 full seconds, a first sound is summoned. For each sound that has already been summoned by the participant, the time required to suspend breathing increases by 0.5 s, making it progressively more difficult to summon new sounds (i.e. if 3 sounds have already been summoned, lungs must be suspended for 5.5 s to summon a 4th sound). Whenever lungs are successfully being suspended, a low rumble gradually increases in volume until the time limit is reached, at which point a subtle high-pitched chime pre-empts a new sound, both of which are played from the next available speaker counter-clockwise from the speaker playing the most recently added sound.
- If 4 breaths which last less than 2.5 s each are taken in direct succession, the most recently added sound is silenced and all controls are restored to the sound added previous to that

sound. For every 3 sounds that have already been summoned, it takes one less breath to remove the most recently added sound (i.e. if 7 sounds have already been summoned, it will only take 2 breaths which last less than 2.5 s to remove the 7th sound). This makes it progressively easier to remove sounds as the soundscape gets more crowded.
- A participant's current state of breath (which is reflected by adding together thoracic and abdominal torso size as measured by the respiratory strain gauges) linearly shifts a narrow band-pass filter between 50 Hz and 1950 Hz on the most recently added sound. States of maximum inhale hit the lowest end of this frequency spectrum, while states of maximum exhale push the sound to the highest end.
- The length of the most recently recorded breath (inhale + exhale) influences the *room size* parameter of reverberation effects on the most recently added sound, where prolonged breaths lead to thicker reverberation effects (which mimic a larger room).
- The volume of the most recently added sound is influenced by the participant's respiratory thoracic-to-abdominal ratio, where predominantly abdominal breaths lead to louder sound.
- When 15 min have elapsed, the system engages in a slow, progressive fade-out to silence.

3. Methods

One way to investigate *Sonic Cradle* would be to explore its ability to provide acute stress therapy. Investigating acute effects of the system on stress would involve a combination of psychological questionnaires and physiological measures to determine the system's acute effects on stress through parasympathetic nervous system activity and hormone levels. However, findings from such a study could simply be attributable to the combination of music, suspension, and sensory deprivation; there would be no way to tell if the interaction paradigm was actually encouraging mindfulness. One might argue that the underlying mechanism is irrelevant, as evidence for acute stress relief would suggest a clear practical application for our work. However, testing *Sonic Cradle* as a short-term relaxation tool would be limiting the scope of an interactive medium with the potential to experientially motivate and demystify the practice of mindfulness meditation for long-term psychological self-regulation. While one would expect such a medium to also cause acute stress reduction, evidence of acute stress reduction alone would not be enough to suggest that *Sonic Cradle* is providing any sort of meditative experience.

In attempting to formulate an initial investigation which would be useful in determining potential avenues forward with this project, we decided to pursue the following research question: *can participants' experiences in a carefully designed human–computer interaction paradigm be subjectively similar to documented effects of the intimate, contemplative practice of mindfulness meditation*? To address this question, we analyzed interview data about participants' experiences in *Sonic Cradle* and compared it to the literature on mindfulness meditation and other relevant topics. If *Sonic Cradle* consistently generates subjective experiences which align with contemporary academic understanding of mindfulness, we can confidently proceed to more in-depth studies on technology's potential as a persuasive catalyst for psychological self-regulation and as an educational tool for mindfulness meditation. Based on the specific nature of participant testimonies, we can determine whether further study should focus on improving the design or continuing validation, where to invest in terms of collecting quantitative data for triangulation (respiratory analysis, other biosensors, interaction patterns, etc.), and whether to focus on acute or longitudinal studies.

In pursuit of conclusive evidence regarding the subjective experience of *Sonic Cradle* participants, qualitative methods are

an obvious choice. By systematically analyzing interviews conducted with people directly after experiencing a session, resulting descriptive conclusions will address common subjective trends being induced. While psychological questionnaires could target meditative aspects of participants' subjective experience in a quantitative way (as in Forte et al., 1987), we would argue that a lack of well-developed and accepted instruments suggests that rich qualitative interview data is better suited to first capture how experiences in *Sonic Cradle* might reflect the complex, nuanced phenomenon of mindfulness. We used our specific research goals to adapt a basic interpretive qualitative methodology as defined by Merriam (2002):

"In conducting a basic qualitative study, you seek to discover and understand a phenomenon, a process, the perspectives and worldviews of the people involved, or a combination of these. Data are collected through interviews, observations, or document analysis. These data are inductively analyzed to identify the recurring patterns or common themes that cut across the data. A rich descriptive account of the findings is presented and discussed, using references to the literature that framed the study in the first place."

We adapted this methodology to include a numeric element which pursues inter-rater reliability and consensus among participants. By using independent coders and a systematic, numeric analysis of qualitative data, we can extract subjective trends of participants' experiences in *Sonic Cradle*.

3.1. Participants

Qualitative research is typically most effective with a *purposive* participant sample (Merriam, 2002). 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, and system malfunction). Participants were also classified based on whether they claimed to have previous experience related to meditation (e.g. yoga, individual meditation classes; $n=20$) or not ($n=14$).

3.2. Procedure

Participants were first asked if they had any knowledge or expectations with respect to *Sonic Cradle* in order to determine if previous participants had biased them through conversation at the conference; most participants had no clear idea what to expect other than vague ideas surrounding music and meditation as advertised. Participants were then told that they would be controlling sound with their breathing, at which point they provided

their informed consent to the study and were subsequently fitted with both respiration sensors and seated in the hammock. Based on findings from co-design sessions reported in an earlier publication (Vidyarthi et al., 2012), participants were then briefed on the system's control paradigm in a way which was suggestive yet vague:

Participant briefing: "As you know, you will be controlling sound with your breathing. There are three things you need to know before you get started. First, if you want to add more sound to your environment and increase its complexity, you simply have to stop breathing and remain still. You can hold your breath in, out, or anywhere between. Second, 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. If you breathe quickly for long enough, you will eventually return to complete silence. Finally, the session will end in approximately 15 min, at which point simply sit and wait for me – I will return and instruct you further. If you wish to end the session early for any reason, feel free to ring the bell sitting beside you. Before we get started, could you please repeat these three points back to me so I can be sure that you understand them?"

Once participants confirmed that they understood their instructions, the system was initiated, the lights were turned off, and participants were left alone in the room for 15 min while they explored the system. When the session was over, the system was deactivated and the lights were turned back on. Before a final debriefing and thank you, participants remained in the hammock while participating in a semi-structured interview based on the following core questions:

(1) How did you find the experience?
(2) How would you describe your thoughts and behaviour throughout the experience?
(3) If we divide the experience into a beginning, middle and end, how would you say your thoughts and experiences changed over time?
(4) If you went halfway around the world and were hanging out with someone who has never heard of this thing, and probably will never get to try it, how would you describe the experience to them in your own words? (to clarify if needed: "Imagine you did not want to tell them what the system actually is, but more what the experience was like.")
(5) What percentage of the time would you say your attention was focused on distractive, completely unrelated, everyday thoughts? (to clarify if needed: "For example, work, friends, the conference, what's for dinner, etc.")
(6) Would you compare this experience to any other experiences you've had? If so, what?
(7) (If participant has not mentioned spontaneously) Can you describe any experiences you've had related to meditation? (follow-up questions about frequency of practice if necessary)
(8) As you know, this interview is designed to help me understand what your experience was like. Is there anything else you personally experienced in here that you want to share before we end the interview?

3.3. Data collection and analysis

The 39 audio recordings of the participants' interviews were transcribed manually to facilitate further analysis. On an initial review of qualitative interview data, five participants were removed from the study due to evident biases. P2 was removed because she clearly had drunk enough alcohol to influence her judgement and

ability to communicate. P19 and P33 were removed because they had helped to set-up the implementation and were well aware of speaker locations and system architecture. P21 was removed due to a respiratory sensor breaking during his experience, leading to system malfunction. P37 was removed due to his having in-depth knowledge and expectations with respect to the system from conversations with previous participants at the conference.

Subsequently, the remaining 34 participants were grouped based on their description of their own previous meditation experience: 19 participants claimed to have no experience with meditative practices whatsoever, 14 participants seemed to have had a few informal experiences with meditative practices (individual sessions, occasional classes, etc.), and 1 participant claimed to be a regular practitioner. For the purposes of our study, we included the regular practitioner in with the second group, such that we had two distinct groups: those with *no meditation experience* and those with *some meditation experience*.

Interview transcripts were distilled into granular bullet points and coded. Attempts to create meaningful data codes inspired much deliberation on reflexivity: how were our experiences with music, meditation and the creation of this project itself influencing qualitative data codes? To address this concern, we recruited two external data coders who were naive to the purpose of the experiment to maximize the reliability and internal validity of the study. For reference, the first author was considered data coder A. One external data coder, who we refer to as data coder B, had no experience with qualitative methods. Including a novice coder was an explicit decision in an attempt to ensure that we focused on patterns that were clearly visible in the participants' statements even to a non-expert. This novice coder was provided with a basic (non-theoretical) explanation of the artifact and participant procedure, a datasheet for each group organized by participant, and instructions on how to code data. Data coder C was a second external data coder who had extensive experience with qualitative methods and was provided with a datasheet for each group organized by participant and basic formatting instructions. She was also given an opportunity to have her own 15-min session in *Sonic Cradle*. No coders received any codes in advance. Instead, they developed their own codes in the process of analysis. Both external data coders were financially compensated 300 Canadian dollars for their time.

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 (Fig. 3). The first thing we did

was remove any codes which did not include comments from at least 3 individual participants to ensure that our findings represented a consensus between at least three participants and did not overly focus on topics specific to individuals. While individual experiences recounted by our participants were quite interesting, focusing on consensus among multiple participants is more productive for our aim to generally characterize the experience of *Sonic Cradle*.

Data codes which were agreed upon by all three coders were termed *primary themes*, whereas *secondary themes* refer to codes which were agreed upon by two coders, and *tertiary themes* to those which were only identified by one coder (which might reflect coders' personal analytical biases). It is important to note that, since each coder defined cluster titles themselves, the alignment of common clusters into themes involved some shuffling on our part; we made every attempt to maintain an objective stance in this process. Table 1 shows comprehensive results of this analysis including primary, secondary, and tertiary themes for each group. As can be seen in both Table 1 and in the next section, 11 out of 14 *primary themes* were present across both analytic groups, confirming our methodology to a certain extent; after dividing all qualitative data into two mutually exclusive groups, the fact that the majority of findings arose from both groups suggests a level of validity in our approach.

With consensus from at least 3 individual participants and all 3 independent coders, *primary themes* represent the clearest and most valid findings of this systematic qualitative data analysis. In the rest of this paper (including Fig. 4 and Table 2), we will present and discuss only the *primary themes* as findings of this study. While the experiences represented by *secondary themes* and *tertiary themes* are interesting in their own right as unique experiences, they are not as relevant for this paper's aim: to determine subjective consensus on the *Sonic Cradle* experience across many participants.

4. Qualitative findings (primary themes)

The majority of primary themes produced in analysis of qualitative interview data were common in both those with no meditation experience and those with some meditation experience. This is a striking result, as it implies that these themes were not only identified by all three independent coders, but also that they were strong enough to be revealed twice when data was separated into two

Fig. 3. An example data code contributed by data coder C. The external coders were given a large document of individual bullet points organized by participant and instructed to group and title clusters; this is an example of what they delivered.

Table 1
Primary, secondary and tertiary themes from qualitative data analysis.

Participants with no meditation experience	Participants with some meditation experience
Primary themes (included by all 3 data coders independently)	
Relaxing/regenerative	Relaxing, refreshing, revitalizing
Compared to floating in air/space	Compared to floating: water/space
Exploring the control paradigm	Exploration of control/mental models
Transition to less intentional control	Transition to less intentional control
Visual illusions/imagery	Visualizations/visual illusion/patterns of light
Desire for more/longer session	Want for longer/more sessions
Body: numbness/motion illusion	Body: displacement/motion illusion
Removing thought/clear focus	Presence in moment/reduced thinking
Time distortion illusion	Distorted temporality
Positive response	Positive response
Emotional feelings/Affect	Emotional response
	Intense engagement with sound/deep layers
	Comparison with meditative practices
Sleep-like state	Semi-conscious like sleep
Personal development/epiphanies	
Secondary themes (included by any 2 data coders independently)	
Compared to sensory deprivation tank	Lack of control/ambiguity
Compared to *Shivassana* (Yoga)	Altered thought patterns/Influencing Thought
	Focusing on Breathing
Tertiary themes (included by 1 data coder)	
Focus on breathing	Incomparable, A Unique Experience
Sonic Illusion	Meta-Awareness
Compared to massage	Epiphany about life outside cradle
Dealing with distractions	Heightened understanding of self
Comparison with meditation	Centered in your own head
Body control	Taken back to childhood/old memories
Focus on the music	Audio layering
Immersive and encapsulating	Embodied immersive experience
	A needed addition to our routine

Note: We horizontally aligned similar themes; there are a striking number of aligned primary themes across these mutually exclusive groups, making them more compelling.

mutually exclusive groups. In other words, the majority of our primary themes involve all three independent coders including a minimum of 6 individual participants, and often much more (Fig. 4 provides a visual glimpse of findings while Table 2 provides numeric detail).

In the following sections, we will quickly present each of these primary themes and a few participant quotes to capture the nuance of participants' reports of their *Sonic Cradle* experience. For clarity, we separated this presentation of findings from our discussion (Section 5), which refers to these primary themes by section number. Readers should feel free to contact the authors for a more comprehensive collection of quotes to further see the striking uniformity in experience reports across participants.

4.1. A relaxing, refreshing experience

Sonic Cradle involves a very comfortable suspended hammock, gentle music, elements of sensory deprivation, and a respiratory biofeedback paradigm which motivates deep breaths. It should come as no surprise that many participants described the experience as relaxing. P1 and P13 both used the phrase "*super relaxing*", P14 described the experience as "*womb-like*", and both P24 and P29 referred to it as "*soothing*". Some participants expressed their relaxation in bodily terms:

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. My face is just lax."

Those with previous meditation experience were likely to also describe it as refreshing. For example, P3 claimed that the

experience makes "*you feel like you've just had a whole night's sleep,*" while P15 expressed surprise at this element: "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."

4.2. A feeling of floating

Asking participants to compare *Sonic Cradle* to other experiences they have had led to a wide range of responses, including looking up at the stars, long bike rides, other installations, hallucinogenic drug use, sensory deprivation tanks, and massages. P6 even claimed the experience was "*unlike anything I've done before.*" Surprisingly, these unique, personal accounts were the exception; 17 participants compared the experience to floating, with a majority specifying to flotation in water:

P30: "I would really describe it as sort of this entering and floating with sound. To me, that is the most compelling thing about the whole experience."

P17: "It's sort of like bathing in sound. A bath [where you're] able to push the water around… It feels like [the sounds] don't have hard surfaces, but some kind of mass and weight, some very crude methods to move them … You're sort of suggesting where the water's gonna go, where the sound's gonna go, really feeling like you have some control over it."

4.3. An initial tendency to explore the control paradigm

When placed into the *Sonic Cradle* with instructions to control sound through respiration sensors tied around their torso,
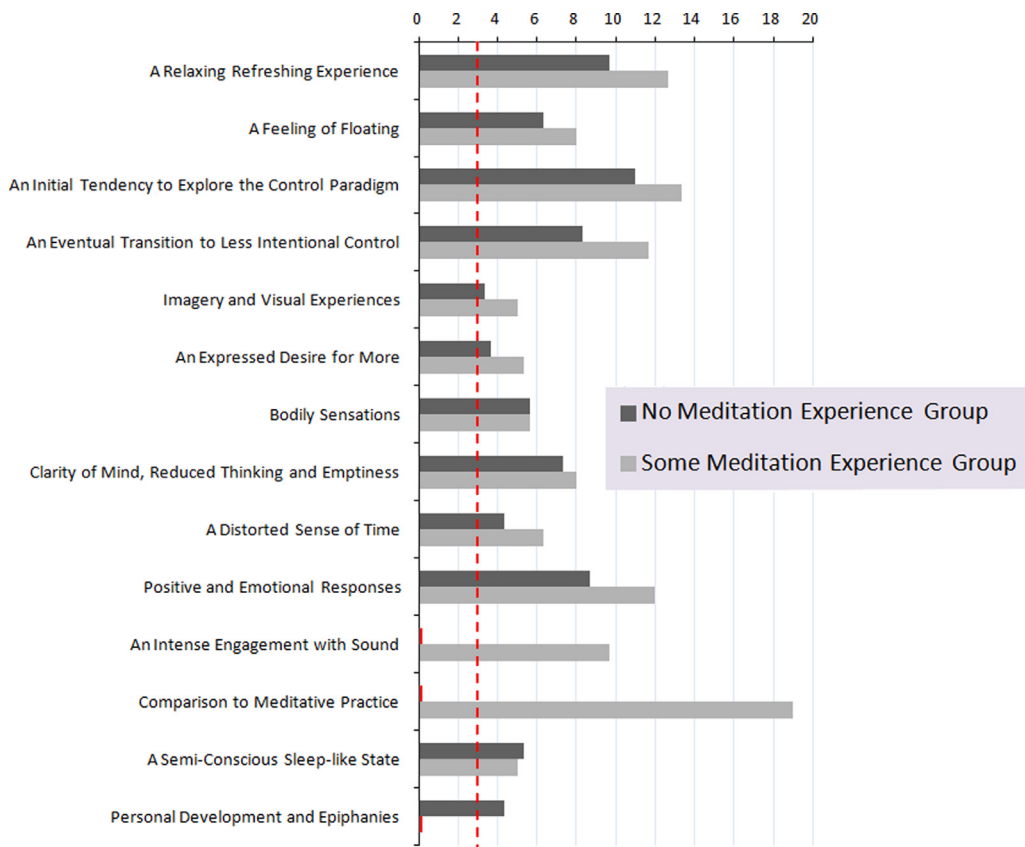
Fig. 4. Average number of participants coded within findings by group. The red dashed line indicates the threshold for data codes to be included; data which does not reach the threshold is not depicted (a small red dash is placed in these circumstances as a reminder). The subjectivity of qualitative data implies that this figure should not be used to interpret any kind of effect size.

Table 2
Number of participants included by coders by primary theme/group.

Primary themes	No meditation experience group (n=14)	Some meditation experience group (n=20)
A relaxing, refreshing experience	(A9–B11–C9)	(A15–B9–C14)
A feeling of floating	(A7–B6–C6)	(A11–B4–C9)
An initial tendency to explore the control paradigm	(A13–B10–C10)	(A12–B14–C14)
An eventual transition to less intentional control	(A13–B4–C8)	(A15–B12–C8)
Imagery and visual experiences	(A4–B3–C3)	(A5–B5–C5)
An expressed desire for more	(A5–B3–C3)	(A8–B5–C3)
Bodily sensations	(A6–B5–C6)	(A6–B4–C7)
Clarity of mind, reduced thinking, and emptiness	(A9–B4–C9)	(A9–B7–C8)
A distorted sense of time	(A4–B5–C4)	(A7–B4–C8)
Positive and emotional responses	(A11–B10–C5)	(A13–B11–C12)
An intense engagement with sound	X	(A10–B6–C13)
Comparison to meditative practice	X	(A19–B19–C19)
A semi-conscious, sleep-like state	(A9–B4–C3)	(A4–B3–C8)
Personal development and epiphanies	(A5–B4–C4)	X

Note: Each field includes the number of participants included in relevant clusters by each data coder A, B and C (e.g. B included 11 participants with no meditation experience and 9 with some meditation experience under "A Relaxing, Refreshing Experience"). The red "X" represents fields where at least one coder included less than 3 individual participants. Again, no effect size can be claimed her due to the subjective nature of qualitative data

participants typically started by exploring and playing with the system's controls:

P7: "At first I was curious about the instructions and what the system would do… I liked how you could add different layers and that it was surrounding you. It was fun to see what it became as a whole."

Interestingly, not a single participant described themselves as exploring the control paradigm closer to the end, although a few

participants had a different initial response to the system which pushed their exploration of its controls toward the middle of their session:

P20: "The beginning was conscious thought: how am I going to use this time? What's this for? What am I trying to get out of it? What am I trying to focus on? Intellectualizing what I wanted to get out of it. Then it became playing with it a little bit: what does it mean if I stop doing this? How far can I push it?… then I started playing with… the… parameters."

4.4. An eventual transition to less intentional control

Although expressed differently by different participants, a majority of participants articulated a clear transition away intentional control. P32 was especially articulate in communicating his loss of intention:

P32: "I got to an equilibrium place where I wasn't thinking about controlling it … I was in some middle space that I wasn't even intellectually controlling. And at that point, I felt a marginal experience of ego-loss… I didn't have to think about thinking."

P9 described a similar transition to "a holy moment of more pure being," which is much more dramatic than P5, who "let everything come naturally." P24 described how she "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." Even in response to an interview question referring to the beginning, middle, and end, a few participants expressed the experience as consisting of two phases, implying a single transition:

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."

4.5. Imagery and visual experiences

One of the most surprising primary themes was *Sonic Cradle's* propensity to induce visual experience in an almost synaesthesic way, often with an unexpected level of detail.

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, and I could see through it to another lighter green, and then there was a little bit of orange."

A few participants also reported visual experiences which were less abstract, related to real experiences, but still unique, detailed, and unexpected:

P18: "I was visualizing a lot of moments in my mind that were just like from the last couple of months that were just kind of coming to me, all positive, like, very positive things… it seemed to evoke very visual memories or moments related to … things that rest on your mind that you don't often think about day to day."

4.6. An expressed desire for more

After the experience, many participants claimed that they would have appreciated a longer session:

P5: "Wished it was longer, I felt like I was going somewhere but I didn't quite reach there."

Some participants expressed a desire for more sessions and home installations:

P35: "What would it be like to have this in a designated space in my house?… Just like, I discipline everything else in my life, [I could] schedule this into my day. It's like this is on the [to-do] list. But no, this is the list. That is a piece that probably would be unique to me."

4.7. Bodily sensations

A small but clear group reported bodily sensations while experiencing *Sonic Cradle*. While there was neither an overarching consensus on the nature of the sensation, all three coders grouped comments referring to the body together. The major effect seemed to be illusions of motion and displacement:

P15: "I felt like I sunk down, at the end, I felt like I sunk down, I don't know. Physically I felt like I was below the floor level… there was sort of a weird impression of me lower than I could be. It felt like [my body] from [the waist] down was lower than the ground."
P23: "I felt like I was actually moving back and forth… [an] illusion of motion [which] kind of dissipated away when the music changed."

Interestingly, a few participants described forms of numbness and a pleasing loss of embodiment:

P12: "My body was numb… it's like a subtle lightness around my skin, and totally a soft touch… It was a whole-body sensation, a sense of euphoria… as I got further into this… the body started vibrating and I started floating."

4.8. Clarity of mind, reduced thinking, and emptiness

A majority of participants described their experience with reference to a reduction of thought, in general. P20 perhaps most clearly articulated this element:

P20: "It quickly became all about the experience of being here in the chair, instead of reflecting on whatever thoughts… Just experiencing without even judging. At the beginning I was judging the sound… I was totally intellectualizing, and at the end I just lost it, and then you came in. 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, getting to a point where you're no longer dealing with the verbal side of your brain, you're just kind of released from that."

When talking about this element of their experience, some participants tried to articulate their interpretation of the mechanism through which *Sonic Cradle* was inducing this clarity of mind:

P9: "[The system] lends a positive hand to making the mind chatter quiet… sometimes I don't succeed, you know, and the mind wins, the chatter wins. I think this almost overpowers the chatter at points, and the mind just gives up."

These articulations of a clear-minded mental state align with low self-reported levels of distraction: the average of all participants' responses was 18%, which translates to only 2:42 out of a 15 min session.

4.9. A distorted sense of time

A few participants in each group communicated a feeling that time sped while they were in the system. Participants were surprised to hear how long it had been since the experience started:

P6: "The first 2 minutes felt like 2 minutes, and the next 13 minutes also felt like the first 2 minutes… [like when] you have a dream, but you're taking a catnap… in the dream you're only out for a few minutes instead of 8 hours."
P14: "The time went by really quick."
P20: "I don't know how long it took, 'cause the whole thing felt like it went pretty quick… Honestly, I have no idea how long that lasted… I know it must have been pretty long, but it didn't feel that long."

4.10. Positive and emotional responses

Spontaneous, positive comments suggested that people very much enjoyed the experience; the sheer quantity and enthusiasm of such comments overshadowed the idea that they may have been the result of politeness alone. 4 participants even communicated a deeper emotional response to the system which hints at a rather profound experience of the system extending beyond superficial enjoyment:

P3: "I loved it, I could do this all day."
P27: "First word would be amazing, second word would be surprising. It was just really unbelievable. It was hard to describe."
P4: "It brought me to a place in my childhood out of nowhere, and I felt like it was good. I felt I was going to an extreme comfort zone where I wanted to hear more, and I was enjoying it."

This overwhelmingly positive response was further evidenced by participants voluntarily recommending the experience to others during the week-long conference.

4.11. An intense engagement with sound (some meditation experience group only)

While participants with no meditation experience occasionally referred to the sound as a constituent element of a larger experience, those with previous meditation experience were much more likely to reflect on their engagement with the sound, attempting to describe its aesthetic and interactivity:

P5: "As the sounds kept piling up, I stopped hearing them separately, in the middle, they became like one unit… Towards the end there were massive sounds crashing down on me."
P31: "Imagine [one] sound slowly fading down with another [breath] coming up, and it all turns into this beautiful intricate music. It's very hard to explain but that's how I felt. It's more beautiful, it's not mechanical, and you have something with your breathing in and out, it's different… like a journey."
P30: "The most profound thing to me was that feeling that the sound would respond to my focus… actually feeling that when I would go off somewhere that some sound or some arrangement would kind of bring me back to the present again"

4.12. Comparison to meditative practices (some meditation experience group only)

Almost every participant with meditation experience compared the system to existing meditative practices, which was not too unexpected, especially since participants were forewarned of the system having something to do with meditation. However, we were surprised by the amount of participants who described the system as an augmentation of their previous meditations:

P20: "I do guided meditation… a few times a year, and even in that I don't get to this space … I just let it go. It's really just about letting go of that conscious self, it was really cool."

While these participants compared the experience to meditation by name, P4 articulated Sonic Cradle as a metaphor for dealing with life in a very meditative way:

P4: "Once you start … realizing that you want to try to change things or slow things down, you just kind of listen to this music and you start to relax and get over everything, and just be… Some of the sounds were annoying, sometimes it got too loud … but after a while you start to get over it, and be one with it, and experience it for what it's worth. I think that's probably like a lesson for everyone, to just take what's happening and just be with it; don't try to change too much but just try to be one with it so you don't want to have to change it. Slow things down so that you just go with the flow and experience it for what it is."

4.13. A semi-conscious, sleep-like state

Many participants reported semi-conscious, dreamy, or sleep-like experiences in the system:

P24: "I kind of found myself in that hazy dreamlike place, like, not full asleep, but that second tier of thinking."

During their interview, a couple of participants engaged in a clearly confused dialogue with themselves as they tried to figure out whether they were actually sleeping or in some alternative state:

P14: "I don't think I fell asleep… time sped up, I may have fallen asleep, but I spent a lot of time with a clear mind, so I wasn't sleeping… At a couple points I came back to the sound and I thought maybe 'did I just wake up?'… and with how quickly the time went, I think it's hard to tell if I fell asleep or if I just, disappeared somehow."

4.14. Personal development and Epiphanies (no meditation experience group only)

Among those with no meditation experience, several participants expressed personal experiences:

P12: "I think there's a level of confidence that I'm always searching for, and there is this disappointment that always kept me from feeling happy about myself which makes me feel less confident… and [in here] you feel accepted by that, you know that, and you feel okay with it."
P39: "It was like a shamanic journey, I was going down into something which wasn't always pleasant, it was confrontational at times, but I came out at the other side peaceful and serene."

For two participants in particular, the system influenced them to actually engage with contemplative practices after their session. Consider the e-mail P13 sent us a few days after the conference:

P13 (via e-mail): "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. Please post… any insights you get – 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. I came across [a video of a] talk that Jon Kabat-Zinn gave at Google, and am committed to trying my first mindfulness meditation tomorrow morning."

5. Discussion of qualitative findings

5.1. Relaxation does not directly imply mindfulness

In an attempt to systematically study the influence of respiratory guidance on people, Zeier (1984) showed that a rudimentary respiratory biofeedback paradigm in the context of background music could generate a reduction in arousal. Schein et al. (2001) showed that respiratory-controlled music which simply matched the rhythm of the current breath directly was able to reduce blood pressure after an 8-week daily program. Further, work studying pain patients' use of sensory deprivation tanks which float the body in saltwater in a context of complete darkness and silence

(*Flotation REST*) has shown positive psychological effects, including improved optimism, reduced anxiety and improved sleep (Kjellgren et al., 2001). Even without flotation, a complete deprivation of light has been shown to improve self-reported pain scores in back-pain sufferers (Shea et al., 1991). Considering that *Sonic Cradle* involves similar elements to all of these apparatuses, it is no surprise that participants reported their session as a relaxing and refreshing experience (Section 4.1). This relaxation may be a result of induced mindfulness, but it could just as easily be a result of other mechanisms; perhaps the same as those fueling the effects of the aforementioned studies. With this finding in mind, we can describe *Sonic Cradle* as a relaxing experience according to the vast majority of participants in our study, but we cannot yet tie it directly to mindfulness.

In fact, participants' reported relaxation during the experience (Section 4.1) does not necessarily align with theoretical interpretations of mindfulness. When Lutz et al. (2006) reviewed a wide range of traditions in a reasoned discussion of theoretical alignment surrounding the concept of meditation, the consensus seemed to be a state of balance: "*In most practices, the ideal meditative state – one beyond the novice stage – is a state in which neither dullness nor excitement occurs; in short, stability and clarity are balanced perfectly.*" These authors proceed to distinguish meditation from relaxation:

"It would be incorrect to interpret Buddhist meditation as 'relaxation'. This is not to deny the importance of mental and physical techniques that help the practitioner relax. Without such techniques, an excess of physical or mental tension may develop, and when such tension occurs, excitement will almost certainly arise. If, however, such relaxation techniques are overused, they are likely to propel the practitioner into dullness and hence hinder the meditation."

The authors clearly state the importance of relaxation techniques in meditative practice; however, they also suggest that experiences which are too relaxing can also prevent effective meditation. Seeing as participants were highly likely to report a semi-conscious, sleep-like state (Section 4.13), it seems that the current prototype of *Sonic Cradle* may have a tendency to lean a little too far toward relaxation. While many participants reported relaxation in the context of a balanced awareness, many also reported a semi-consciousness which suggests that *Sonic Cradle* may have induced the "*dullness*" discussed in Lutz et al.'s warning. Future iterations would be wise to explore a reduction in induced relaxation, perhaps through slightly less comfortable suspension, slightly more aggressive sonic elements, or changes to the interaction paradigm. The goal of such a design iteration would mirror Buddhist tradition in its pursuit of balance between excitement and dullness: "*just as the tradition contains techniques to ease mental or physical tension, it also espouses methods to counteract an excess of relaxation or dullness*" (Lutz et al., 2006). Similarly, this matches the notion of *flow* as an enjoyable "optimal experience" that can occur when balance is reached between boredom and anxiety, when the challenge of a task matches the skill of the user (Csíkszentmihályi, 1991).

Contrary to the idea that *Sonic Cradle* overused relaxation techniques, one might interpret participants' feelings of intense relaxation not as an imbalance, but instead as a perceived change toward balance. Among others, Kabat-Zinn (2005) has addressed a heightened normative state of distraction as generally ubiquitous in contemporary society:

"We drive ourselves to distraction and the human world drives us to distraction in ways the natural world in which we grew up as a species never did. The human world, for all its wonders and profound gifts, also bombards us with more and more

useless things to entice us, seduce us, pique our fancy, appeal to our endless desire for becoming. It erodes the chances of being satisfied with being in any moment, with actually appreciating this moment without having to fill it with anything or move on to the next one. It robs us of time even as we complain we don't have any. It has given rise to a dance of inattention and instability of mind."

Especially in the context of an engaging conference, participants' perceived relaxation was relative to a generally wandering mental state. We might interpret their reported semi-conscious, sleep-like state as somehow related to the mental clarity which our qualitative analysis also revealed across participants (Section 4.8). In many cases, participants took special care to mention that they were not actually sleeping, only in a state comparable to sleep. It is feasible that a non-practitioner artificially experiencing a heightened clarity of mind may somehow interpret their experience as semi-conscious and dreamlike. The notion that subjective experiences of meditation can be perceived as similar to dreams is not novel: "*In some cases… after a meditation in which one cultivates the experience of phenomenal content as seeming dreamlike, one's perceptions in the post-meditative state are also said to have a dreamlike quality for at least some period after arising out of meditation*" (Lutz et al., 2006).

In summary, participants' reported relaxation and semi-consciousness may suggest that the *Sonic Cradle* prototype may have induced a little too much relaxation. However, given the generally high level of distracting information and continually shifting attention of contemporary society – particular those of the busybodies in our purposeful participant sample – it could also be that participants were experiencing a relatively relaxing state of clarity and mindfulness which was simply interpreted as sleep-like due to its stark contrast with daily life. Further exploration is required to determine which of these is the case. At this point in our discussion, it is still possible that *Sonic Cradle* induced participants with an experience related to mindfulness, but it is equally likely that the experience was simply a pleasant relaxation.

5.2. Clear-minded loss of intention suggests mindfulness

The clarity of mind participants reported as part of the *Sonic Cradle* experience (Section 4.8) is directly related to well-documented understanding of mindfulness. Mindfulness has been generally defined as "*the awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment.*" (Kabat-Zinn et al., 2003). In the words of Kang and Whittingham (2010), who contextualize contemporary psychological understandings of mindfulness with their Buddhist origins:

"This kind of awareness is often described as nonjudgmental, or not making value judgments on experienced content and present-focused, or centered on the present occurrence of experience without interference from past or anticipated images. Also, simple awareness is non-elaborative and relatively unencumbered by language or conception, giving it a directness of access to experiential content. It is free from identification with experienced content by virtue of its intentional witnessing stance."

The fact that *Sonic Cradle* led to participants consistently reporting reduced thought and a clear mind aligns with initial stages of mindfulness meditation: "*In the early stages, the aim of the [Vipassana or mindfulness] meditation is to keep the attention focused on the breath without distraction – that is, without the attention wandering to some other object, such as a sensation or a memory*" (Lutz et al., 2006). This initial practice is designed to clear

the novice practitioners' minds in order to catalyze the emergence of two faculties associated with mindfulness: "*a meta-awareness that recognizes when one's attention is no longer on the breath and an ability to redirect the attention without allowing the meta-awareness to become a new source of distraction*" (Lutz et al., 2006). *Sonic Cradle* was successful in generating an experience of clear-minded thinking which pre-empts such faculties, and can be described as the "*directness of access to experiential content*" which characterizes mindfulness. Such states of experiential focus which lack internal narrative have been shown to be neurally distinct (Farb et al., 2007). *Sonic Cradle's* ability to reduce thought and generate some form of clear-mindedness suggests that the system may be approaching its goal of introducing experiential elements of mindfulness.

30 years before the present writing, Brown et al. (1983) designed a questionnaire specifically aimed at measuring elements of hypnosis, meditation and imaging. As the instrument's questions were based on interviews about the subjective experience of these three practices, the fact that many topics discussed in their paper align with subjective reports of *Sonic Cradle* is mildly interesting. While the resulting questionnaire may be leading, it produced very interesting findings when used to measure differences between mindfulness practitioners engaged in a 2-day retreat, those engaged in a 2-week retreat, and those engaged in a 3-month retreat (Forte et al., 1987). While those subjects in the 2-day retreat had difficulty sustaining attention, subjects in progressively longer retreats were more able to maintain attentional focus with less semantic thinking and planning. This element aligns directly with *Sonic Cradle* participant reports of a heightened clarity of mind (Section 4.8). Interestingly, compared to subjects in the 2-day retreat, results from those in the 2-week retreat share other characteristics with the experience of *Sonic Cradle*: simple imagery effects (Section 4.5), perceived changes in bodily state (Section 4.7), and distortions of time (Section 4.9; although in the opposite direction). This suggests that *Sonic Cradle* might indeed be able to cultivate an advanced experience of mindfulness specifically for beginners, as it seems to provide novices with an experience most comparable to those in the 2-week retreat. Our systematic qualitative analysis did not produce any finding which aligns with the key subjective characteristic of Forte et al. 3-month group: "*the decreased identification of the contents of experience as belonging to an enduring self, and use of a self-image as a frame of reference for orienting to internal or external experience*".

The long-term goal of *Sonic Cradle* is to experientially educate people about mindful self-regulation in a way which will motivate independent stress management. Stoyva and Carlson (1993) posit that effective stress management should be about mediating a transition from coping to rest. In fact, these authors directly portray mindfulness meditation as a useful mediator of such transitions through a reverberation between paying attention to breath and paying attention to environment. While future studies should include physiological correlates for confirmation, such a transition was reflected directly in *Sonic Cradle*: participants started with an initial tendency to explore the control paradigm (Section 4.3) and eventually moved into a state of reduced intentional control (Section 4.4). Just as in Stoyva and Carlson's direct descriptions of stress management practices, *Sonic Cradle* seems to induce a transition from coping to rest; across all participants, there was an overwhelming tendency to let go of initial intentions to intellectually explore the system. Judging from participants' comments, this is not to be read as an eventual boredom with the system; on the contrary, participants reported low levels of distraction. This finding was described more as an abandoning of the desire and need to explore the system semantically. Considering the importance of facilitating transitions from

coping to rest in helping those with chronic problems where stress plays a major role (anxiety, chronic pain, panic disorders, depression, etc.), another clear direction forward lies in the investigation of *Sonic Cradle* as a potential treatment intervention.

5.3. Multimodal construction of an 'immersive' experience

All participants seemed generally engaged with the system based on the richness of their articulated experience and minimal self-reported distraction levels. Further, qualitative data from those with meditation experience revealed a primary theme directly describing an intense engagement with sound (Section 4.11). Only a few participants articulated a deep engagement with respiration; there was not enough consensus on this point for our methodology to consider it a finding (though it was present in secondary/tertiary themes). However, there were three other findings which strongly align with the perceptually constructive quality of engagement which characterizes the concept of media 'immersion' (Vidyarthi et al., 2012): visual sensations (Section 4.5), bodily sensations (Section 4.7), and comparisons to floating (Section 4.2).

These three themes are particularly striking in their inherent psychological complexity when compared to the relative technical and sensory simplicity of *Sonic Cradle*. Through interaction design fueled by a framework of media 'immersion' grounded in studies of literature, art and technology, a rather simple control paradigm involving a suspension hammock, visual deprivation, two respiratory sensors, and a few loudspeakers was able to generate profound illusions. A few participants saw abstract patterns of light which they struggled to articulate into words while others claimed to see specific moments from memory (Section 4.5). Physically, participants felt everything from illusions of swinging back and forth, illusions of rotating slowly, feelings of vibration/buzzing, full-body numbness, disorientation, vertical motion and tingling (Section 4.7). Without further experimentation, it is impossible to determine exactly which elements of *Sonic Cradle* contributed to these complex experiences (sensory deprivation, hyperventilation, sound quality, suspension or biofeedback could all play a role). In any case, the combination of physical and visual illusions in the context of relatively little sensory input suggests that participants' were not simply sensing the stimuli provided by *Sonic Cradle*, but also attempting to integrate these stimuli into what appeared to be the perceptual construction of a consistent, multimodal experience which aligns with interdisciplinary notions of media 'immersion' (Vidyarthi et al., 2012). Further, the abundance of participants reporting a feeling of floating (Section 4.2) – often in the context of water – aligns with the fact that the word 'immersion' shares etymology with 'merge'; both derive from the Latin word *mergere* which has been directly translated to words with aqueous connotations like 'plunge' and 'to dip' (Seo, 2007).

5.4. A desirable experience

Participants' strong positive responses to *Sonic Cradle* (Section 4.10) would align with a claim that the system induces mindfulness, as Lutz et al. (2006) have shown that mindfulness-based stress reduction activates the left prefrontal lobe of the brain; a region associated with positive emotion. However, these positive responses are hardly evidence for an experience of mindfulness; participants could have simply reacted positively to pleasant music, technological novelty, comfortable seating, and much more. However, positive responses to *Sonic Cradle* do suggest that the system has the potential to draw prolonged use. In fact, another primary theme of the study was an explicitly stated desire for more and longer sessions (Section 4.6). This desire for extended use implies that the findings presented here could be

strengthened by participants' intrinsic motivation to engage with more than a single 15 min session. Positive responses to the system also imply that *Sonic Cradle* has the potential to bring positive associations to mindfulness, a critical element for its potential role as a persuasive medium.

5.5. Potential for long-term effects

Interestingly, while those participants who had some prior meditation experience were likely to compare *Sonic Cradle* to meditation and related practices (Section 4.12), there were several novices who articulated the system as a reflective, liberating experience, expressing personal developments and epiphanies (Section 4.14). Some participants described their session as introspective and thought-provoking while others explicitly described feelings of personal growth. A few participants even explained coming to realizations with actual significance in their lives. These findings position Sonic Cradle as an answer to recent calls for reflective and slow technologies which *"use slow design expression as an instrument to make room for and invite reflection"* (Hallnas and Redstrom, 2001). A 15 min session in Sonic Cradle is relatively short in terms of contemplative and meditative practices, but it is an eternity for human–computer interaction. Most interactions with technology strive to be quick and effortless. Seeing such dramatic effects in response to a slow technology should serve as validation for reflective HCI and its ability to invite personal reflection.

One participant in particular contacted us a few days after the experience to explain how *Sonic Cradle* inspired him to pursue mindfulness independently. This particular anecdote suggests the potential for technology to intentionally encourage behaviour change for psychological self-regulation, even if only in one participant. In the language of the Fogg behaviour Model for persuasive design (Fogg, 2009), we can say that *Sonic Cradle* somehow provided that participant with the 'motivation' and 'ability' required to successfully 'trigger' a change in behaviour. This interactive medium somehow persuaded a non-practitioner to attempt to take up mindfulness meditation.

6. Conclusions

As a persuasive medium, *Sonic Cradle* was designed to provide an experience which introduces mindfulness meditation to non-practitioners. In the present study, we adapted basic interpretive qualitative methods and purposive participant sampling as an early investigation into 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 independent data coders.

6.1. A mediated experience comparable to mindfulness

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. 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 (Forte et al., 1987; Stoyva and Carlson, 1993; Kabat-Zinn et al., 1992; Lutz et al., 2006; Kang and Whittingham, 2010). 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 (Forte et al., 1987). Those participants with previous experiences relevant to meditation consistently compared *Sonic Cradle* to their prior experiences, with many suggesting it was somehow easier to engage with. A few participants even reported personal developments and emotional responses to the system.

Almost every single participant described their experience in *Sonic Cradle* 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. Any participant who particularly enjoyed *Sonic Cradle* could learn how their pleasant experience was theoretically similar to that which is experienced by practitioners of mindfulness meditation. Such experiences have been shown to change attitudes and behaviour (Fogg, 2003). *Sonic Cradle* may motivate users to independently pursue and develop an interest in this therapeutic contemplative practice.

The fact that participants had a vague notion of the system's association with meditation in advance could play a role in these conclusions; however, meditation is a notably difficult skill and it would be difficult to argue that a simple design intention, experimental demand, and 15 min alone could give rise to the findings we have seen in this investigation. It is with limitations in mind that we conclude on this design artifact's pleasant provocation of subjective elements of mindfulness. Further study is required to directly validate whether *Sonic Cradle* provides the same acute stress relief associated with mindfulness meditation, whether it can directly motivate long-term adoption of this psychologically self-regulating practice, and whether it has these same striking effects on a randomized sample population.

6.2. Future research directions

Findings and results from the present investigation have raised a wide range of new academic questions worthy of pursuit. First of all, the idea that *Sonic Cradle* seems to be encouraging elements of mindfulness also sheds a new light on research aimed at understanding the psychological and physiological mechanisms underlying this meditative practice. Future investigations could consider randomized controlled studies which compare an interactive system like *Sonic Cradle* with guided meditation tapes, Mindfulness-Based Stress Reduction courses, and expert mindfulness practitioners in pursuit of similarities and differences. Controlled studies could also be used to separate out the individual factors of *Sonic Cradle* in an attempt to determine which findings are resulting from which constituent elements of the system design. Control groups could compare a full *Sonic Cradle* implementation with partial versions in a lit room, versions without bodily suspension, and versions with varied interaction paradigms. These studies could use robust physiological indicators in a randomized participant sample (i.e. heart rate variability, salivary stress hormones, electroencephalogram, etc.) to get more insight into how *Sonic Cradle* affects users in comparison to control conditions.

Other directions forward can specifically aim to tweak and optimize practical versions of the system. Some qualitative results suggested that the system may have been too relaxing for an optimized experience of mindfulness. It would be useful to run design-based research to explore less comfortable suspension or even more aggressive sound in pursuit of even stronger user experiences. In fact, the topic of sound quality was left relatively unexplored in the present study: audio was crowd-sourced for diversity with very little curation. Future design sessions could

also explore intentionally defined collections of sound and altered sound parameters in pursuit of optimizing new iterations.

Whether exploring academic or practical directions forward, further investigations should try 30-min sessions or even hour-long sessions to help determine how far an individual *Sonic Cradle* session could go toward strengthening the acute experiential effects revealed in the present study. Future studies could also explore the effects of repeated exposure to the system and include follow-ups which investigate for changes in attitude and behaviour towards contemplative practices and stress. The authors are willing to divulge all resources, software, and information to any potential collaborators.

6.3. Persuasive media for long-term wellbeing

The stress relief associated with mindfulness meditation can significantly improve people's wellbeing and quality of life; not only because stress is a subjectively unpleasant phenomenon, but also because it negatively influences the brain, reduces immune system function, and causes/exacerbates a wide range of clinical problems (anxiety, depression, etc.). In the context of stress management technology, *Sonic Cradle* represents a new approach; instead of only focusing on continuous engagement for self-quantification and reflection, biofeedback-based systems can also be persuasive, serving as 'training wheels' in one's independent establishment of non-technological practices which manage stress. We believe the results presented in this investigation call for more research on persuasive media which aim to teach and demystify the vital practice of mindfulness meditation. Instead of creating stress-reduction applications which counter-intuitively encourage users to evaluate themselves and force them to depend on yet another technology, the possibility exists for interactive media to play a role in empowering people to manage their own stress independent of any external tool.

While many of us have lived through the advent of new technologies and can perhaps regulate the stress they bring into our lives to some degree, younger generations are simply born into this environment:

"Today's adolescents have no less need than those of previous generations to learn empathic skills, to think about their values and identity, and to manage and express feelings. They need time to discover themselves, time to think. But technology, put in the service of always-on communication and telegraphic speed and brevity, has changed the rules of engagement with all of this. When is downtime, when is stillness?" (Turkle 2011)

Sonic Cradle paradoxically demonstrates how interactive systems might be designed specifically to provide the moments of stillness and self-reflection needed to maintain wellbeing in saturated media environments. We have shown how technology can introduce non-practitioners to the subjective clarity of mind and loss of intention characteristic of mindfulness meditation.

To summarize, mounting evidence implies mindfulness meditation as an effective practice for psychological self-regulation; the human mind appears to be already well-equipped with tools to manage its own stress. If most technologies distract us from these mental faculties in favour of stressful, constant productivity, *Sonic Cradle* represents a step in the opposite direction. Instead of forcefully resisting today's exponentially growing technophilic information society, maybe an alternative solution lies in building bridges directly to the restful clarity it has obscured.

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