Sonic Cradle: Evoking Mindfulness through 'Immersive' Interaction Design

by

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Abstract

The present work introduces a relaxing human-computer interaction paradigm designed to foster meditative attentional patterns. After theoretically situating the project, this thesis develops a framework for media ‘immersion’ to conceptually guide the design of *Sonic Cradle*: a darkened chamber which suspends individuals in a comfortable hammock while they progressively control sound through their own respiration. Next, 15 co-design sessions are presented along with several resulting tweaks and improvements aimed at balancing users’ perceived sense of control.

A mixed methods investigation of the iterated prototype with a purposive sample of 39 participants demonstrates how *Sonic Cradle* can pleasantly encourage mindful experiences by consistently inducing a calm mental clarity and loss of intention. Surprisingly, participants also reported perceptual illusions, feelings of floating, and emotional responses. Concluding discussions explain how this project breaks new ground toward fulfilling technology’s potential to experientially persuade people to adopt and psychologically benefit from contemplative practices like mindfulness meditation.

• **Keywords**: human-computer interaction, mindfulness, design, immersion, stress, biofeedback

Dedicated to my family for putting
up with my perpetual wandering,
and
Krista Howarth for
wandering with me.

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Table of Contents

List of Tables

List of Figures

Extended Abstract

The artifact presented in this thesis was designed to enable non-practitioners to experience mindfulness meditation. Practical applications include acute stress relief and encouraging long-term adoption of this vital stress management practice. Beyond the more obvious theoretical underpinnings on stress, mindfulness meditation, and human-computer interaction design, I conducted an ambitious literature review surrounding the concept of media 'immersion'. Upon confronting drastically different explanations of what constitutes an 'immersive' medium in the context of virtual reality, video games, literature, and art, I began to search for underlying psychological themes. The resulting cross-disciplinary framework for media 'immersion' aims to be relevant across media and its implications for interaction design are presented at the end of chapter 2. This element of the project is an example of 'research through design', as it not only inspires my own interaction design, but also provides a new understanding of media 'immersion' relevant to a wide range of researchers and theorists.

Chapter 3 begins by explaining how my newfound theoretical understanding of media 'immersion' inspired *Sonic Cradle*, an interactive system which occludes access to the physical world by comfortably suspending the body in complete darkness. The interaction paradigm – using respiratory biofeedback to enable the progressive shaping of a peaceful soundscape through breath – intends a subtle creativity while encouraging attentional patterns characteristic of mindfulness meditation. Chapter 3 continues by discussing this concept in detail, including a presentation of 15 co-design sessions where participant comments suggest balancing one's perceived sense of control as a critical element of the system design; users should feel as if they are directly controlling the system, but in a way which is vague enough to motivate continual discovery. Based on these sessions, several tweaks and improvements were made to a working prototype.

Various potential applications of the *Sonic Cradle* concept suggest many methods for validation. While physiological measurement could be used to study acute effects on stress and longitudinal studies with repeated exposure could measure lasting effects and behaviour change, both these approaches would require significant investment of time

and resources in an artifact which has not yet been validated as related to mindfulness. I decided to first conduct an initial qualitative validation study aimed at investigating how busy people subjectively experience *Sonic Cradle*. Although I used a purposive sample which limits external validity, I managed to complement qualitative findings with quantitative resting respiration data taken both before and after the experience. Major data trends generally suggest that participants:

- found the experience relaxing and refreshing, a qualitative finding which parallels significant decreases in resting respiration rate after the session;
- compared the experience to a feeling of floating, with many comments suggesting aqueous contexts;
- started by semantically exploring the control paradigm but eventually let go of such intentions;
- reported temporal, visual, and somatic illusions including patterns of light, feelings of movement, and acceleration of time;
- reported a clarity of mind where thoughts were suppressed;
- described themselves as in a semi-conscious, sleep-like state during the session;
- had overwhelmingly positive reactions to the experience; many expressed a clear desire for more and longer sessions while a few even had profound emotional responses;
- described an intense engagement with sound and compared the experience to meditative practices (participants with prior informal meditation experience);
- occasionally expressed personal development and reflexive epiphanies during the experience (participants with no prior meditation experience).

Chapter 5 concludes that *Sonic Cradle* is a human-computer interaction paradigm which seems to cultivate experiences comparable to mindfulness meditation. Further, the system provides these experiences in a desirable and relaxing context, suggesting that practical implementations of the system would likely encourage extended use and positive sentiments toward this vitally beneficial practice. Final sections of this thesis describe future directions to further validate and build upon these findings, laying out plans to explore underlying mechanisms and to inspire new design iterations which aim to bring *Sonic Cradle* out of the lab and into people's lives.

"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."

- **Jon Kabat-Zinn**
  (Coming to Our Senses, 2005)

1. Introduction

As clinicians embrace pro-active and preventative approaches to helping people, patients' ability to promote and manage their own health is becoming critical. Researchers are actively pursuing an applicable model to equip both clinicians and patients with the insight needed to improve behavioural *self-regulation* in the context of maintaining health (Bandura, 2005). A new crop of human-computer interfaces are also being created to support the self-regulation of exercise, eating habits, work breaks, cigarette smoking and more (Chi et. al., 2008; Consolvo et. al., 2009; IJsselsteijn et. al., 2006). While these persuasive tools join a large family of medical 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 regulate the psychology of the general public. To put it simply, technology could play a key role in helping people manage their own stress.

Biological and physiological sensors have been used to externally manifest one's internal states in biofeedback: a technology which has been shown to be therapeutic (Gatchel et. al., 2003). A previous study drew from divergent trends in interactive systems in an attempt to create a mobile biofeedback system for stress management called *Affective Health* (Sanches et. al., 2010). The authors claimed that, until we develop improved biofeedback sensors, future directions for stress management technology are limited to short-term use systems which allow for interpretive self-reflection on one's own physiological data. However, systems for short-term use can also have a lasting effect if they are persuasive, triggering long-term changes in behaviour and routine (Fogg, 2009). I wish to propose an interactive medium designed to experientially motivate and teach existing, non-technological practices known to help manage stress, sidestepping the documented ineffectiveness of systems which rely on continuous engagement with physiological sensors in daily life. Instead of creating permanent dependence on a new external device or gathering biological data for intellectual self-reflection, I hope to incorporate biofeedback into a technology aimed at motivating, encouraging and teaching people about meditation.

Contemporary evidence points to *mindfulness meditation* as an effective therapeutic tool for psychological self-regulation which requires no technology at all. This rapidly spreading eastern spiritual practice has been described as an intentional and non-judgmental focusing of attention to the present (Baer et. al., 2003). The advent of *calming technologies* which *"induce cognitive, physiological, or affective states"* of *"restful alertness"* (Moraveji et. al., 2011) serves to exemplify an integration of meditative principles into stress management applications. While other therapeutic technologies are designed to distract users from negative experiences (Hoffman et. al., 2000; Mahrer & Gold, 2009;

Wiederhold & Wiederhold, 2007), these systems often integrate concepts from meditation to support the self-regulation of stress not through distraction, but instead through heightened awareness of internal processes (Moraveji et. al., 2011; Shaw et. al., 2007; Schein et. al., 2001; Zeier et. al., 1984).

In this thesis, I will report on an attempt to design a human-computer interface which intentionally promotes the specific pattern of awareness and attention characteristic of mindfulness meditation. The goal is to create an interactive system which enables people to experience a feeling of mindfulness without the complex instruction and initial effort demanded by typical meditative practices. A clear potential benefit of such a system would be to offer people an easier way to trigger the proven stress management practice of mindfulness. However, my focus on the subjective experience of mindfulness as opposed to directly targeting stress reduction hints at my long-term goal of creating an interactive technology which encourages an introduction and demystification of mindfulness while simultaneously experientially educating people about its benefits. 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, I aim to use technology to offer an intimate, personal experience of mindfulness well beyond one's actual ability in a way which will inspire new practitioners of this vital practice for psychological self-regulation. The training wheels of a bicycle serve as a clear metaphor for this approach; an interactive medium may be able to motivate and help people understand mindfulness in critical, early stages of their engagement with the practice.

The present writing starts by clarifying the concept of mindfulness meditation as it applies to human-computer interaction design and stress management. Next, chapter 2 describes a detailed psychological framework for the concept of 'immersion' which was instrumental in our interaction design process. In chapter 3, I present the interactive system itself – *Sonic Cradle* – and a series of co-design sessions which helped iteratively improve its human-computer interface. Chapter 4 presents and discusses a validation study which aims to determine if subjective experiences in *Sonic Cradle* align with contemporary understanding of mindfulness meditation. Finally, chapter 5 draws conclusions and postulates future directions for investigation and practical implementation of *Sonic Cradle* which aim to maximize its potential positive influence in people's lives.

1.1. Interactively Mediating Mindfulness

In order to create an interactive system to promote meditation, we must recognize the existence of diverse forms of this practice. In surveying common themes across a wide range of meditative practices, Lutz et. al. (2006) created a paradigmatic framework which depicts the core of this family of practice as a balance between *"one-pointed concentration on a specific object"* and insight into one's own *"habits and assumptions about identity and emotions"*. The authors proceed to discuss a growing contemporary movement known as *Vipassana* as *"especially emblematic"* of this balance because it represents a *"simplified and regularized set of meditation instructions available to a wide population"*. This practice has also been a focus in medical and psychological literature under the name of *mindfulness meditation*. The first step of mindfulness practice is the cultivation of a focused attention. The focus is commonly

interoceptive: directed at breathing or other internal, bodily sensations. Next, this calm, directed focus is applied to a more general awareness. Inevitably, one's attention wanders away. When such distractions are identified in the field of awareness, one is to gently guide attention back to the initial focus point without being discouraged or punitive towards the self. Avoiding a feeling of failure at this stage can be especially tricky as the human mind is quite prone to distraction. The idea of this practice is to discourage our minds' tendency to think in abstractions while simultaneously encouraging a pure experience of the present moment. In the words of Jon 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 as an especially promising non-pharmacological tool to improve the psychological state of those suffering from chronic clinical problems, including anxiety, chronic pain, panic disorders, and depression (reviews: Baer et. al., 2003; Bohlmeijer et. al., 2010; Fjorback et. al., 2011; Kabat-Zinn, 2003). For example, one study showed participants in an 8-week meditation course attaining reduced anxiety scores which lasted for at least 3 years (Kabat-Zinn, 1992; **figure 1**). One of the most ubiquitous elements of this research is the mention of direct effects on *stress*: a major factor in all the aforementioned conditions. Stress is known to trigger a complex cascade between the hypothalamus, pituitary gland and adrenal gland (the HPA axis), which can affect gene expression, generating severe negative effects on the human brain at all stages of life, from prenatal babies to the elderly (Lupien et. al.; 2009). The neurally distinct experiential focus promoted by mindfulness practice (Farb et. al., 2007) seems to have some kind of inhibitory effect on the stress response. In fact so much so that 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 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.

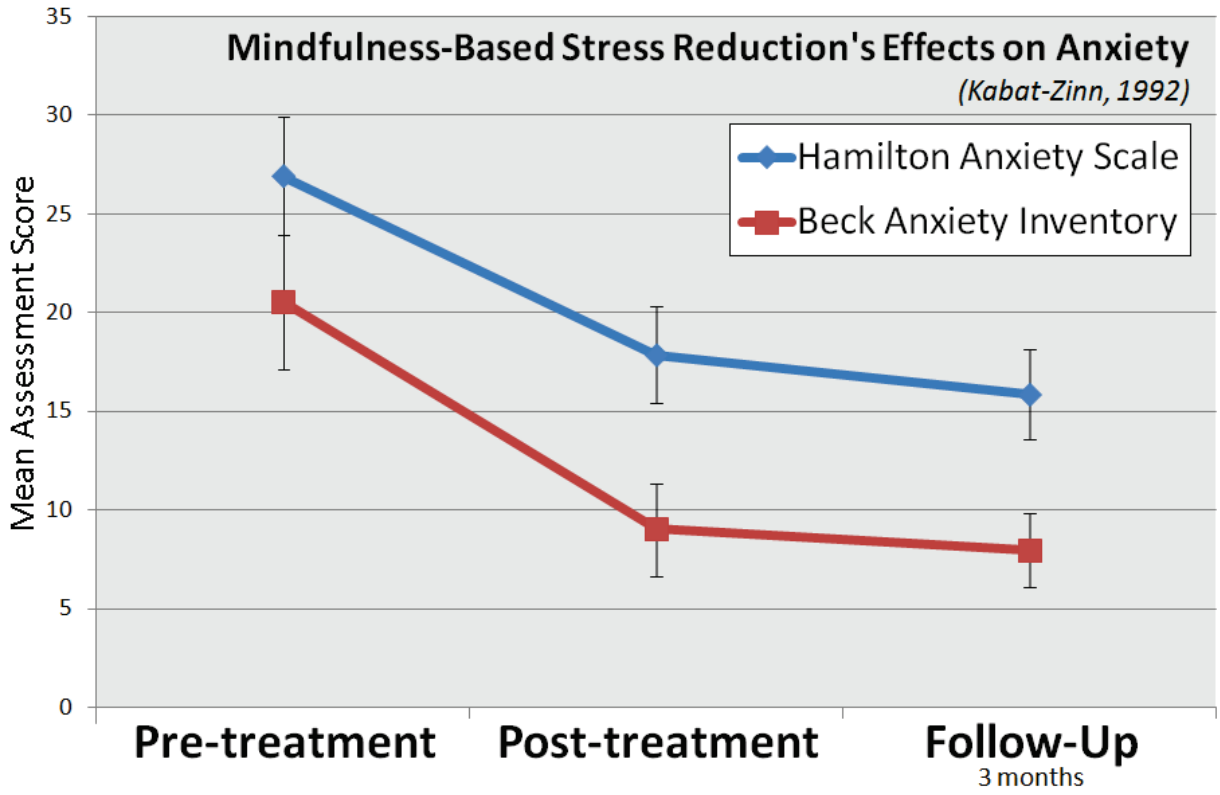

Figure 1. Re-plot of Mindfulness-Based Stress Reduction's impact on anxiety.

Note. This figure is a simplified re-plot of data from Kabat-Zinn's (1992) study of *Mindfulness-Based Stress Reduction* created to clearly portray its persistent effects on anxiety; an addendum on the paper states that effects persisted in a 3-year follow-up as well.

An instrumental element of Kabat-Zinn's (2003) approach to optimizing the delivery of therapeutic mindfulness is its attempt to somehow translate the eastern practice for a western audience: *"the intervention needed to be free of the cultural, religious, and ideological factors associated with the Buddhist origins of mindfulness"*. In the present work, I aim to build upon this approach by not only minimizing spiritual dogma as MBSR does, but also by minimizing meditation's learning curve through a human-computer interface which reinforces mindful patterns of attention. This system – *Sonic Cradle* – aims to afford the basic characteristics of mindfulness with the goal of providing non-meditators with an initial, intimate experience of the practice. If a subjective experience of mindfulness can be successfully and consistently generated through an interaction with this technology, further investigation can determine whether its documented benefits are also produced. Not only do I believe that technology has the potential to mimic mindfulness as a tool for acute stress reduction, but I also believe it can motivate interest in – and even adoption of – mindfulness meditation. An interactive approach may be able to guide one toward critical experiential knowledge without complex instruction or initial feelings of failure: a pleasant and compelling introduction to mindfulness through technology. This experiential piece is critical to exploring technology's potential to go beyond short-term relaxation tools toward playing a role in educating people about mindfulness.

1.2. Designing for Human-Computer Interactions

The nebulous term *design* has been used in a wide range of disciplines related to architecture, art and the 'industrial' design of consumer products. In 1969, Herbert Simon brought the term into a wider range of disciplines by identifying anyone *"who devises courses of action aimed at changing existing situations into preferred ones"* as a designer (Simon, 1996). When Don Norman (2002) began to consider the *"psychology of everyday things"* academically in 1988, critiquing commonplace artifacts such as doors and light switches, contemporary technologists began to consider the *usability* of artifacts. As consumer products grew more and more reliant on screen-based abstractions which were not always easy to understand, researchers and designers began to focus more specifically on the *usability* of hardware and software interfaces which stood between humans and computers. As this discipline focusing on *human-computer interaction* eventually gained traction and influence, relevant academic work from a wide range of other, relevant disciplines began to inform new approaches; among the most relevant of these cross-disciplinary approaches lay cognitive psychology. As many interactions with technology rely on attention, memory, executive functions, language, problem-solving and decision making, the study of human cognition made – and continues to make – a major impact in the development of new technologies. While these origins of human-computer interaction suggest a highly analytic approach, the burgeoning field of *interaction design* focuses more on the applied creative manifestation of this field; interaction designers aim to meet needs and satisfy desires through artifacts intentionally designed to encourage specific behaviour (Moggridge, 2006). The present work represents an instantiation of human-computer interaction design which not only draws from psychology to encourage user behaviour, but also aims to benefit users' psychology by promoting self-regulation. If an interaction design artifact can be shown to produce an experience of mindfulness, future studies might aim to determine whether acute, short-term stress reduction is taking place. However, I believe future studies should also target whether longitudinal changes in behaviour and thought can result from artificially-generated mindfulness experiences; such a finding would not only lead to practical outcomes, but it would also help substantiate an argument for interaction designers to consider every new technology's influence on daily stress levels and psychological self-regulation in the long-term.

1.3. Mindfulness and Stress Management

Stress was once a worthy investment of physiological resources toward appropriate responses to predators and adversity. In contemporary life, we no longer confront truly threatening circumstances on the regular basis for which our bodies have evolved. Stress is a *"cognitive perception of uncontrollability and/or unpredictability that is expressed in a physiological and behavioural response"* (Koolhaas et. al., 2011). Note that stress does not hold an implicit valence; it can be a response to positive or negative situations. However, too much stress of any kind can still be considered a major problem, given the direct, negative impact of long-term stress 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:

> "For example, being 'stressed out' may cause us to be anxious and or depressed, to lose sleep at night, to eat comfort foods and take in more calories than our bodies need, and to smoke or drink alcohol excessively. Being stressed out may also cause us to neglect to see friends, or to take time off or engage in regular physical activity as we, for example, sit at a computer and try to get out from under the burden of too much to do. Often we are tempted to take medications - anxiolytics, sleep-promoting agents - to help us cope, and, with time, our bodies may increase in weight." (McEwen, 2006)

Along with well-accepted forms of self-regulation like diet and exercise, individuals could benefit from awareness and management of their own stress. Encouraging individuals to learn how to identify and curb an unnecessarily active stress response is absolutely essential for long-term functioning of the systemic interactions which regulate and maintain the body. 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 & Katz, 2009).

In trying to manage stress, it is important to note that overarching organizational principles of our skeletal muscle system, autonomic nervous system, and neuroendocrine system suggest *"the individual's reaction to stress … as consisting of two major phases: an active coping phase and a rest phase"* (Stoyva & Carlson, 1993). This characterization of stress management is of particular interest to chronic disease sufferers who tend to have a hard time transitioning from the active coping mode to a relaxed state. In the case of anxiety and panic disorder, the inability to make this transition is a defining characteristic of the condition itself. Other conditions like chronic pain and depression generate perpetual stressors which consistently interrupt transitions to the rest phase. Effective stress management practices like mindfulness meditation seem to support exactly such transitions by *"bridging the gap between rest and coping"* (Stoyva & Carlson, 1993). The importance of this transition depicts mindfulness as a useful tool for psychological self-regulation not only to prevent the aforementioned long-term effects of chronic stress on the brain and body in typical populations, but also to manage pathologies which tend to imbalance the biphasic functioning of physiological systems toward stress and coping.

Contrary to popular assumptions about meditation, the goal of mindfulness is not simply to relax; the practice essentially aims to catalyze state change by applying the behavioural tendencies of the overdriven coping mode (i.e. when stressed, we tend to exert mental effort and focus our attention on problems) directly to properties of the relaxed mode which is characterized by tranquility and an absence of striving. In other words, mindfulness involves using the subtle tranquility of internal sensations as the focus of active mental effort. When stressful distractions inevitably disrupt the process of establishing an active tranquility, a knowledgeable practitioner knows to calmly and

pleasantly regain an internal focus, and the cycle repeats. I aim to design for an interaction where users parallel this same cycle between a focused internal attention, an external awareness, inevitable mental distractions, and a calm return to internal focus. A positive outcome of such a system would be evidence of mindfulness in diverse non-meditators without extensive time spent on instruction, preparation, training or usage. If successful in this aim, the foundation will be set for practical technologies to not only acutely offer the benefits of mindfulness meditation, but to increase the accessibility of this vital practice for the general public.

There exists a certain redundancy in introducing a new technology to combat stress: a phenomenon often associated with technology itself. However, note that most computer technologies have been created with goals of productivity, efficiency, and organization. It is not necessarily some fundamental property of computer technology which acts as a stressor; systems designed with different goals, such as relaxation, focus, awareness, a sense of calm, and self-exploration, may have completely different effects on the human mind. Further, as concluded by Sanches et. al. (2010) after exploring *Affective Health*, psychologically-relevant systems do not necessarily require continued use to have a lasting effect if they can lead to interpretive self-reflection. Technology can even serve as a trigger for behaviour change in the long-term (Fogg, 2009). If our interactive system were truly able to promote an experience of mindfulness, participants might not only see proximal stress reduction through a pleasant and relaxing session, but potentially a demystification of meditation which may encourage them to establish their own self-regulatory practice afterward. If not a direct motivator, a system which triggers experiences of mindfulness could also be used as an educational tool for new mindfulness practitioners. Before validating such bold claims, I must first establish how to go about designing for the attentional interaction demanded by the meditative human-computer interface I am proposing.

2. A Framework for Designing 'Immersive' Media

2.1. Can Subtler Media be 'Immersive'?

A trained practitioner engaging in mindfulness meditation has learned to engage an extreme level of focus and attention inward in the context of a supervisory meta-awareness aimed at identifying distractions. Without extensive training, non-meditators will be easily distracted without even noticing; they are simply not accustomed to heightened levels of engagement on subtle, internal sensations. Here we find the major design challenge of a system which promotes an experience of mindfulness: how could an interactive medium encourage complete engagement without simultaneously providing new sources of distraction which could dissuade meta-awareness? If a design is to guide users' attention in patterns characteristic of mindfulness practice, it must not only hold their attention, but also be able to reclaim their attention when distracted. However, typical attention-grabbing systems involve either multi-faceted narratives or complex sensory worlds. This challenge drew me to center my design process on the concept of '***immersion***': a term which seems to capture the media-driven, enveloped, attention-grabbing state I hope to instill with respect to mindfulness. I came across a series of theorists characterizing this term in different ways depending on the medium and field of study (Csíkszentmihályi, 1991; Ermi & Mäyrä, 2005; Nechtaval, 2001; Ryan, 2001; Slater, 2009).

Video games, virtual reality, and literature certainly promote 'immersion' into compelling subjective worlds; however, trying to use such media to support the subtle, internal focus characteristic of mindfulness is problematic. Bright screens, 3D environments and narrative story-worlds may capture intense attention and focus, but they shift one's perceptual context toward multi-faceted, non-actual, external realities which continue to inspire a continuously shifting focus reminiscent of the distracted mind states which are antithetical to mindfulness. This contrasts with my aim to engage such a process of media 'immersion' toward an inward, one-pointed concentration. While researchers discussing 'immersion' tend to focus on multi-faceted, external media, apparent themes across these theories raised an initial question in my attempt to theoretically ground my design process: could we develop a cross-disciplinary understanding of media 'immersion' which could be applied to the design of a subtler, internally-focused medium which inspires a single-minded attention?

If I aim to design a novel medium which holds an 'immersive' quality of engagement and absorption toward a novel medium, I must first establish a common, interdisciplinary understanding which is independent of existing media; an understanding of 'immersion' which does not rely on technical set-ups or narrative story-worlds. For this reason, I set sail on an ambitious theoretical journey to establish a framework of 'immersion' which would align with all existing media. The reasoning here is that a broader re-conceptualization of media 'immersion' which holds no attachment to any specific medium

can be used as a tool to design new and non-traditional media specifically to be 'immersive'. In other words, if whatever common ingredient of 'immersive' media in diverse contexts can be extracted and dissected, it can then be applied to the construction of non-traditional forms of 'immersive' media tailored to new requirements and goals.

By synthesizing diverse theories into a framework, I was eventually able to conceptualize a non-traditional system designed to promote 'immersive' engagement with an endogenous meditative experience without using distractive virtual environments, contemplative story-worlds, or invasive technologies. The system's first prototype, *Sonic Cradle*, was a direct result of an interdisciplinary exploration of media 'immersion' presented here in full: this chapter outlines the development of a psychologically-driven theoretical framework which attempts to characterize the concept of media 'immersion' for the explicit purpose of design.

2.2. The Cross-Disciplinary Nature of Media *'Immersion'*

While traditional media concern one's engagement with elements depicted in words, paint or even sculpture, new media introduces discussion of an integrated perceptual element: a sense of actually being within a depicted world. Questions have been raised comparing the experiences of physical reality, virtual environments, dreams, books *("the book problem"*), and more (Biocca, 2003). To compensate for this ambiguity, virtual reality theorists have been using a foundational taxonomy to facilitate discussion of virtual environments involving the terms *immersion*, *presence* and *involvement* (Slater, 1997; Slater, 2003). This taxonomical foundation was successful in its aim to *"clear up the confusion, and prevent arguments over essentially non-issues,"* (Slater, 2003) as ensuing dialogue has progressed to a deeper understanding of each term, with a sizable focus on *presence* in the context of virtual environments (Lombard & Ditton, 1997; Biocca, 2003; Witmer & Singer, 1998). However, this taxonomy runs into difficulties when discussing interactive media which combine technical aspects with literary and artistic quality. For example, video games are new media artefacts which combine virtual environments with narrative and artistic qualities; their propensity to engage spectators is impossible to discuss without ambiguity. While Slater and other VR researchers distinguish *immersion* from the multi-faceted concept of *presence* by characterizing the former as a property of technology (Slater, 1997; Slater, 2003), literary and art theorists carry an understanding of *immersion* which overlaps much more with psychological components of *presence*. This leaves the nature of media 'immersion' up for debate.

The theory presented in following sections will culminate in the establishment of a characterization of 'immersion' as a process of directed constructive perception as suggested by theories from technology, literature, art, and psychology: fields which have been implicitly growing together in the study of new media artifacts. In discussion of Slater's taxonomy, I will first suggest that the present technical conception of *immersion* as a property of the medium should be divorced from the term 'immersion', and instead be considered as 'immersiveness'. This demarcation lays a foundation for subsequent arguments that reserve the term 'immersion' for an active psychological process which applies to a variety of areas including technical media, literature and art. By focusing on an active process instead of

a passive state, and on the human mind instead of the medium, I aim to psychologically characterize 'immersion' in a way which applies across media.

It is important to note that this work assumes a cognitivist, information processing model of the mind which aims to be predictive and therefore practical for creating new media with specific intentions, an approach similar to Picard's framework for affective computing (1997). Another important element of this work is that it in no way attempts to suggest that existing theories from technology, literature or art are fundamentally misguided. On the contrary, I rely on these existing theories being not only productive for their own field of research, but also robust enough to guide cross-disciplinary dialectic. As different media use different words to refer to the human observer engaging with them (i.e. a book has a 'reader' while technology has a 'user'), I will use the word 'spectator' as a common term across media. Although this word typically has a visual connotation, I will use the term to refer to any media engagement in any modality. With this use, 'spectator' could refer to the user of a VR system, the listener of sounds and music, the reader of a book, the viewer of a movie, the audience of a performance, and more. I will detect theoretical similarities and patterns across existing media-focused theories and use them to guide my pursuit of a unifying framework which describes the psychological process of the 'immersed' human spectator, no matter the medium.

2.3. Blind Monks and the Elephant of 'Immersion'

In the study of virtual reality systems, Slater's taxonomy seems to have given rise to a dialogue which treats *immersion* as a property of media which can afford certain sensorimotor actions (Slater, 2009), *involvement* as a higher-level cognitive engagement (Slater, 2003) and *presence* as an ongoing debate somehow related to the plausibility of a robust illusion of having a virtual body within a virtual place (Slater, 2009). Slater has suggested that *"presence is a 'response' to a system of a certain level of immersion,"* while *"involvement ... [has] to do with content, not to do with form"* (Slater, 2003). While some theorists (Nechtaval, 2001; Witmer & Singer 1998) have referred to *immersion* as a psychological state or perceptual experience, Slater's taxonomy treats it as an attribute of technological interfaces (Slater and Wilbur 1997; Slater, 2003). Slater considers an interface's *immersion* as *"a property of the valid actions that are possible within the system,"* while *presence* is divided into 'place illusion' and 'plausibility illusion', which are considered *"consequences for participants of different levels of immersion embodied in different physical systems"* (Slater, 2009). The term *involvement* seems to house cognitive engagement, although the term *presence* does house some psychological components, with descriptions referring to the plausibility of illusion (Slater, 2009) and a sense of *"being there"* in a virtual space (Held & Durlach, 1992; Sheridan 1992). Interestingly, earlier work used this same notion of *"being there"* as a characterization of *immersion* instead of *presence* (Pausch et. al., 1997), an early symptom of the ensuing nebulousness surrounding both terms. These dialogues eventually developed into a media-focused position on *immersion* suggesting that a head-mounted display is more 'immersive' than a television because the former subsumes the latter; you could simulate the television-watching experience in a head-mounted display, but not vice versa (Slater, 2009).

Slater's taxonomy serves the virtual reality research community well by fuelling ongoing work on understanding the nuances of *presence* (Lombard & Ditton, 1997; Biocca, 2003; Witmer & Singer, 1998). However, this taxonomy lies in stark contrast with a collection of theories discussing the concept of *immersion* in the context of other media (Ryan, 2001 is a key example from the study of literature). Using Slater's taxonomy to describe a moment where I am distracted by thoughts while wearing a head-mounted display with spatialized audio and haptic feedback, I would be spatially *present* in a fairly *immersive* system without being *involved.* As a counterexample, a written novel or painting which has me engaged in the social structure between characters and perceptual attributes of the subjective world depicted in text or paint would be considered an exercise solely in *involvement*, as these media are a *"low level of immersive 'technology'"* (Slater, 2003) which do not activate *"perceptual, vestibular, proprioceptive, and autonomic nervous systems ... in a way similar to that of real life in similar situations"* (Slater, 2003). Being distant from the realm of virtual environments, the use of Slater's taxonomy to describe this second example is in significant disagreement with theories of *immersion* spawned from the study of literature and art (Ryan, 2001; Palmer, 2007; etc.). While it may seem tempting to suggest that this ambiguity of terminology is irrelevant as the word has simply been appropriated and redefined for use in different academic fields, my goal of creating a novel medium which fosters a level of engagement characteristic of *immersion* is limited without a consistent understanding which holds across existing media.

What we observe in these theoretical developments is not completely unexpected. Slater's taxonomy represents a position on *immersion* which has been clearly developed through the study of technology. Interestingly, the same tendency exists in other media-focused disciplines. Ryan's literature-based theory of *immersion* concerns a reduction in subjective distance between a reader and a non-actual world depicted in text, referring to the imagination required to engage with a work of fiction (Ryan, 2001). Not surprisingly, discussion of *immersion* in the context of contemporary media art surrounds contemplation and self-exploration (Palmer, 2007). This present state of understanding with respect to media *immersion* calls to mind a canonical Indian folk tale about blind monks trying to describe an elephant. The tale describes each blind man in contact with a different part of the elephant: one touching the tusk, one touching the tail, one touching the leg, etc. When asked to explain the concept of 'elephant', the blind men describe only their point of contact: the blind monk near the tusk describes an ivory spike while the monk near the elephant's leg describes a powerful tree trunk. The moral of the proverb lies in our tendency to describe overarching truths based only on our own experience, ignoring larger contexts; it seems the concept of media *immersion* is just such an elephant. It is no coincidence that theorists who study virtual reality describe *immersion* in terms of technology and sensory encapsulation while literary theorists discuss subjective, non-actual worlds; these are simply theories each rooted in the analysis of a specific medium. The question still remains as to whether these disparate theories are related, as their nomenclature would suggest: is there truly a single 'elephant' when it comes to *immersion*? I aim to overcome the blind monks' tendency in my own theoretical pursuit of an answer to this question by starting from a close inspection of relevant terminology.

2.4. A Psychological Focus: 'Immer-*sion*' vs. 'Immer-*sive*'

Water is the etymological root of an 'immersive' environment and also the *"most prevalent metaphor for environments used to create 'immersion'"* (Seo & Gromala, 2007). However, contemporary use of the term *immersion* clearly surrounds more abstract, conceptual metaphors related to one's absorption and engagement in a medium. This evolution from a physical concept toward higher-level conceptual metaphors appears to be common in the development of language and cognition (Johnson, 1990). However, while literal, physical definitions are clear, the aforementioned contemporary theoretical analyses of *immersion* are disparate. In the process of designing and analyzing a new technological artefact, using a theoretical foundation based only on contemporary media without considering theories from literature and art is tempting. However, with my goal of exploiting an understanding of *immersion* to encourage mindfulness in the psychology of the spectator, I cannot afford to create a technically-impressive feat which fails to engage or a highly engaging medium which serves as a new source of distraction. Broadening my analysis to include key theories from the study of diverse media will help maximize my novel medium's ability to inspire heightened engagement and profound psychological impact without relying on previous paradigms. In order to enable reasoned dialectic, I discovered a key terminological development needed to eliminate the many ambiguities plaguing 'immersion': a separation in meaning of the adjective 'immersive' from the noun 'immersion'.

In a response to Witmer & Singer, who challenge Slater by suggesting that *immersion* is a psychological phenomenon, Slater (1999) qualifies his definition to acknowledge this ambiguity by specifying it as *"system immersion"*. However, given the flexibility he demonstrates in the nomenclature of his conceptual delineation, and considering the aforementioned need to integrate technical discussions with literature and art theories, I postulate that Slater's concept of *immersion* would be better defined as a quality of ***immersiveness***, a term which more accurately captures a descriptive dimension referring to a given medium's propensity to generate 'immersion' in a spectator. In a sense, *immersiveness* can be defined as the degree of affordance of the phenomenon of 'immersion'. In other words, a highly ***immersive*** medium has a higher propensity to generate 'immersion' in a spectator. In virtual reality, this property may be related to which sensorimotor actions are afforded by the system as suggested by Slater (2009). However, the beauty of this nomenclature is that it also provides theorists studying other media with the freedom to have *immersiveness* individually defined in their own discipline; for example, existing theories of 'immersion' from literature can be redefined as the nature of *immersive* literature, which can be entirely different from *immersive* virtual reality without ambiguity.

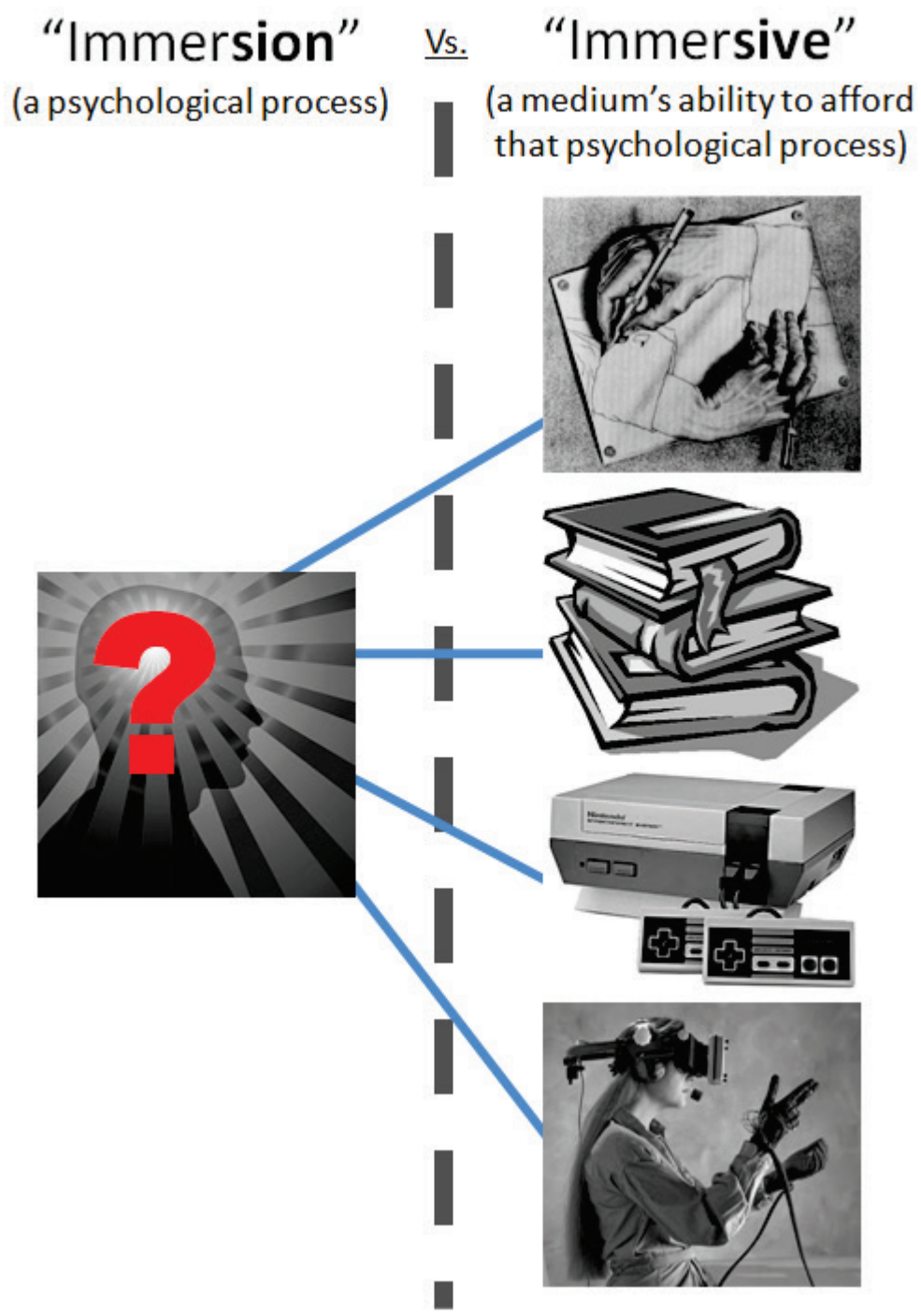

Figure 2. Separating the noun 'immersion' from the adjective 'immersive'.

Note. The images on the right-hand side of the figure represent art, literature, video games and virtual reality; I am postulating that relevant theories of *immersion* from these disciplines should instead be considered theories of what makes the medium in question *immersive*, reserving the term *immersion* for a human-centered understanding.

In summary, the only element *immersive* books, *immersive* video games, *immersive* VR systems, *immersive* art, and any novel *immersive* artifact need to share in common is their propensity to give rise to a psychologically-defined form of 'immersion' in the spectator (**figure 2**). Slater's discussions of *immersion* can be reconsidered as theories about the nature of *immersive* virtual reality, distinct from Ryan's theories describing the elements of *immersive* literature, and so on. The main constraint of this new nomenclature is that it assumes that these diverse media, each with their own characterization of *immersiveness*, all somehow engage a hypothetical common process of media 'immersion' in the spectator. This assumption sets the stage for 'immersion' itself to be analyzed as a human-centered phenomenon, a theoretical endeavour to which I will devote the rest of this chapter. By reconsidering all existing theories of 'immersion' as theories of *immersive* media instead, I leave the concept of 'immersion' open for psychological exploration. This refusal to consider any media-focused theory as a final statement on the phenomenon of 'immersion' itself lays a foundation for an attempt to draw common, human-centered elements of each media-focused theory together into a predictive framework. With this clarified terminology, I will proceed by taking a psychological perspective in my search for underlying themes across theories of 'immersion' as postulated by leading theorists studying various media.

2.5. The Path to a Unified Framework of Media 'Immersion'

One needs to look no further than the burgeoning field of video games to see systems which integrate visual art, imaginative narratives, challenging interaction, 3D environments, and multimodal displays. These interactive media represent a tangible starting question for our theoretical development: how can we appropriately discuss immersion in the context of a video game without glaring ambiguities? For example, when discussing an involved game like *Konami*'s Metal Gear Solid (1998), does immersion relate to the perceptual quality of screen resolution, graphics and audio, the strength of a player's reflexive responses to an ensuing firefight, the in-depth narrative surrounding multi-dimensional characters, or the game's role as an evocative artwork with statements about political warfare, capitalist military factions, and nanotechnology?

Ermi & Mäyrä (2005) surveyed literature and interviewed children to explore the core concept of immersion as it applies to the gameplay experience. They start with a similar problem as that of this investigation, namely the widespread use of the term immersion *"often in an unspecified and vague way without clearly stating to what kind of experiences or phenomena it actually refers to"*, and progress toward the construction of a gameplay experience model which includes three types of immersion. ***Sensory immersion*** is described as the *"audiovisual execution of games"* which *"easily overpower the sensory information coming from the real world."* ***Imaginative immersion*** is described as the type *"in which one becomes absorbed with the stories and world, or begins to feel for or identify with a game character."* Finally, ***challenge-based immersion*** is described as a balance between challenge and ability. Early in their paper, Ermi and Mäyrä draw a connection between their analyses of gameplay immersion to human experience in general: *"human experiences in virtual environments and games are made of the same elements that all other experiences consist of."* It seems the authors understand that the

concept of immersion is much larger than their taxonomy, but choose to focus on aspects relevant to their medium of study: video games. Since video games represent a well-known medium which blurs theoretical interpretations of immersion, I will use this rudimentary framework as a starting point for a psychological characterization of immersion which accounts for a wider range of disciplines, beyond gaming. I will apply deep explorations of immersion from a wide range of disciplines to broaden Ermi & Mäyrä's taxonomy into a larger theoretical context (**figure 3**).

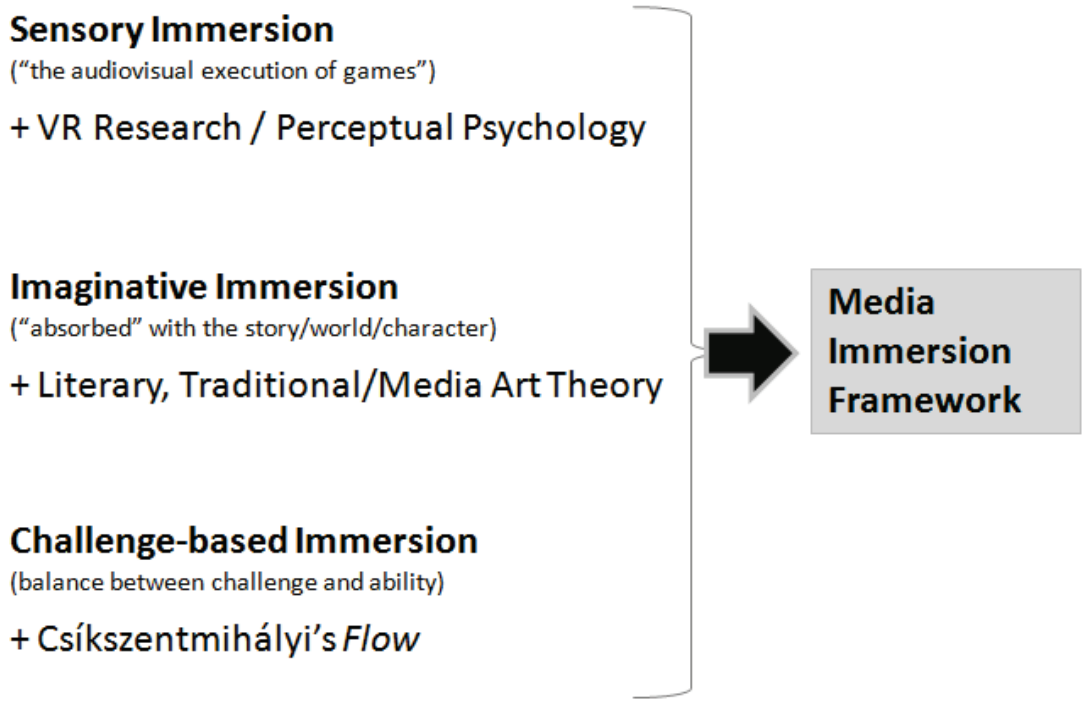

Figure 3. Theoretical approach to broadening Ermi & Mäyrä's immersion taxonomy

Note. Validation using theories from psychology and neuroscience is not depicted for clarity.

The path to a unified framework of media immersion is now clear. Common ground between ambiguous notions of immersion across technology, literature and art lies in the psychology of the spectator. The following attempts to formulate a characterization of immersion roughly manifest as the broadening of Ermi and Mäyrä's (2005) typology of immersion with a psychological lens: first, discarding *challenge-based immersion*, suggesting it as a premature oversimplification of a leading positive psychological theory surrounding the concept of 'flow' (Csíkszentmihályi, 1991); next, connecting *sensory immersion* to ideas relating to perceptual psychology and research into virtual environments; and finally, considering *imaginative immersion* in the context of theories from literature and art in an attempt to determine whether it truly is a separate component (**figure 3**). The conclusion of this chapter will be a human-centered framework which depicts immersion as an active process of perceptually constructing a consistent subjective reality based on a combination of multimodal input and prior knowledge.

2.5.1. The Prematurity of Challenge-Based Immersion

Before moving on to sensory immersion and imaginative immersion, I will first discard Ermi and Mäyrä's *challenge-based immersion* (2005). Despite no reference of the sort, this component clearly alludes to Csíkszentmihályi's (1991; 1997) theory of *flow* which generally states that when personal ability is well-matched with the challenge of a task at hand, people enter some kind of immersed state. Ermi and Mäyrä's *challenge-based immersion* only addresses *"a satisfying balance of challenges and abilities"* (2005), leaving many other elements of Csíkszentmihályi's theory unaddressed, including clear goals, immediate feedback, concentration, reduced self-awareness, a distorted sense of time, and a sense of control. While flow and immersion are certainly intertwined, it seems premature to simply lump a complex and refined psychological concept like *flow* as a form of immersion. Csíkszentmihályi seems to use the term 'immersion' to refer to deep engagement without concern for media connotations. Given the complexity of these topics, I assert that deeper theoretical exploration on the nature of media immersion needs to be done before considering comparison with a more structured and established theory like *flow*. For this reason, I intend to characterize immersion as a psychological process based on themes from literature, technology and art, leaving its juxtaposition with other psychological theories as a next step, including not only *flow*, but also relevant theories of attention.

2.5.2. Occluding Input from the Physical World Bolsters Immersion

Expanding Ermi and Mäyrä's *sensory immersion* (2005) beyond the context of video games changes its scope substantially. The first issue lies in how this definition ignores immersion's relation to systems which occlude, instead of merely overpower, input from the real world. If we view immersion as some quality related to absorption and engagement with a medium, we cannot ignore the power of occluding the physical world to maximize this quality. Just as we naturally find a quiet place to read and habitually turn off the lights to maximize our engagement with a film, virtual reality interfaces like the head-mounted display cover the eyes and ears in close proximity when delivering sensory input from a virtual world. Occluding sensory access to distractive stimuli from the physical world can increase the proportion of overall sensory input which comes from the medium. Consider the diagrams in **figure 4**; if the complete circle surrounding the spectator represents the sum total of all sensory input, these diagrams illustrate how turning off the lights when watching a screen removes distracting visual input. When the lights are off, the screen provides a higher proportion of overall sensory input to the spectator.

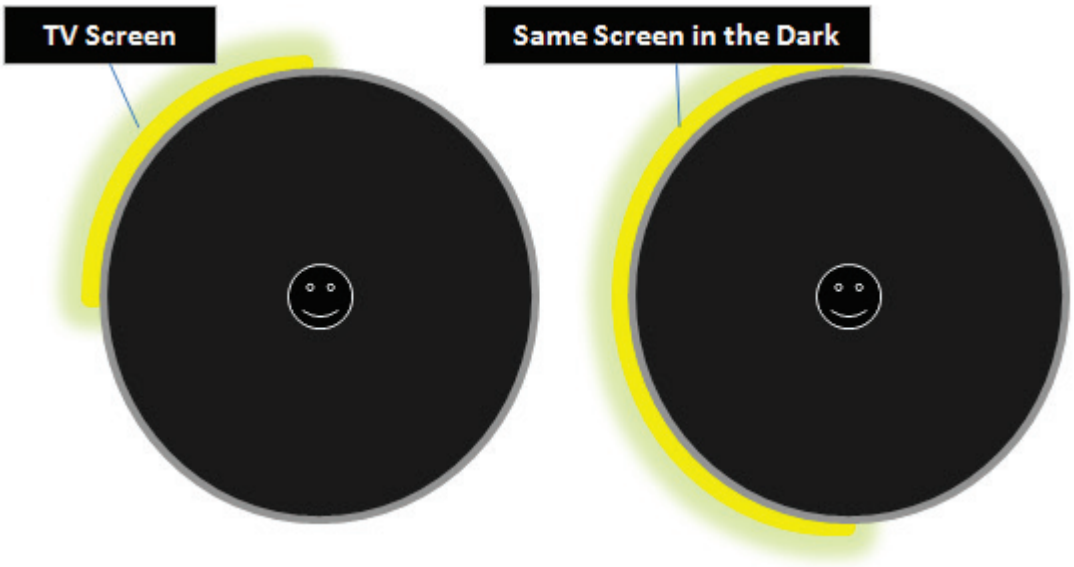

Figure 4 Occluding unrelated input gives media a higher proportion of sensory input

Note. This diagram is instructive; actual quantities are difficult to measure or even estimate, and are therefore not represented.

Cruz-Neira et. al. (1992) evaluate different displays (HMD, standard screens, projection rooms, etc.) with respect to this type of peripheral occlusion, referring to it as "*intrusion"*. In fact, it is not uncommon for contemporary research to consider Cruz-Neira et. al.'s (1992) multi-directional projection concept (the "CAVE") as inherently *"immersive"*, simply due to its three dimensional presentation and sensory encapsulation (Feng et. al., 2007; Huff et. al., 2010; Weil et. al., 2010). Virtual reality theorists clearly consider immersion to not only be a question of overpowering reality, but also occluding access to it. Even beyond the CAVE, other work using virtual reality systems often frame their attempts to maximize this type of occlusion as attempts to maximize immersion. For instance, a study depicting effective reduction of pain using an *"immersive"* virtual reality display suggests that *"the patient's inability to see [a] burn wound in VR may have contributed to [a] reduction in the patient's pain"* when compared to standard video games (Hoffman et. al., 2000; for a more comprehensive review of this area, see Wiederhold & Wiederhold, 2007). In another example, researchers studying human spatial orientation using a projection set-up to generate a virtual space attempt to *"enhance immersion"* by surrounding the projection setup with a black frame and *"light-proof black curtains on all sides"* (Riecke et. al., 2005). The presented work clearly implies that **the occlusion of sensory input from the physical world is tied to immersion in virtual worlds**. Video games do not attempt to occlude the physical world by design, explaining why this element was omitted in Ermi and Mäyrä's characterization; another example of thinkers' tendency to act as 'blind monks' when formulating theory in the context of specific media.

2.5.3. Immersion Can Involve Any Sensory Modalities

Ermi and Mäyrä's (2005) game-focused characterization of *sensory immersion* using the word *"audiovisual"* exhibits an aural and visual bias when contrasted with research in virtual environments.

Those studying virtual reality displays and media installations tend to generally characterize immersion as maximizing sensory input of stimuli which correspond to a virtual world without reference to specific modalities. For example, in their development of a presence and immersion questionnaire, Witmer & Singer (1998) suggest that "*immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences.*" Similarly, in a more artistic exploration of aesthetic implications of virtual reality, Joseph Nechtaval (2001) speaks of immersive virtual reality as *"ambiently includ[ing] everything of perceptual worth within its domain in an overall enveloping totality that is concerted and without evident frame or border."* Nechtaval later qualifies his interpretation of the concept of immersion by mentioning its focus on stimulating *"our internal perceptual circuitry through excess*". It is evident that these depictions of immersion would not limit their focus to Ermi and Mäyrä's *"audiovisual"*, and likely not even limit themselves to the classic five exteroceptive senses. Our *"internal perceptual circuitry"* also consists of internal, *interoceptive* senses like equilibrioception (orientation), proprioception (bodily awareness), and nociception (pain).

This separation of individual senses for discussion of immersion seems even more misguided given that consciousness theorists often discuss an associative sensory binding which suggests that conscious perception happens through the association of all senses simultaneously (Blackmore, 2004). Such theorists would say Ermi and Mäyrä's definition of *sensory immersion* as strictly *"audiovisual"* is not only too narrow, but also inherently problematic. In light of the broader literature, we can certainly detect Ermi and Mäyrä's *"audiovisual"* approach as another product of their focus on video games. Broadening this element of their taxonomy, it becomes evident that **immersion is at least related to any sensory modality, if not all modalities simultaneously**. In **figure 4**, I can illustrate this by pointing out that the screen would still not dominate the entire circle even if the periphery were absolutely dark. This is because other sensory modalities should also be included. If the pink triangles added to the diagram in **figure 5** represent individual sensory inputs to the spectator, they could be visual, auditory, or even nociceptive (pain). In the context of designing media to be specifically immersive, we can see clearly that occlusion in a wide range of modalities can help maximize a screen's proportional sensory input: this is an element which has manifested itself in a wide range of media already. The clearest example being a movie theatre, where lights are turned off, cellphones are silenced, people are encouraged to refrain from talking, and seats are designed to be comfortable (to remove potential distractions from bodily discomfort or pain).

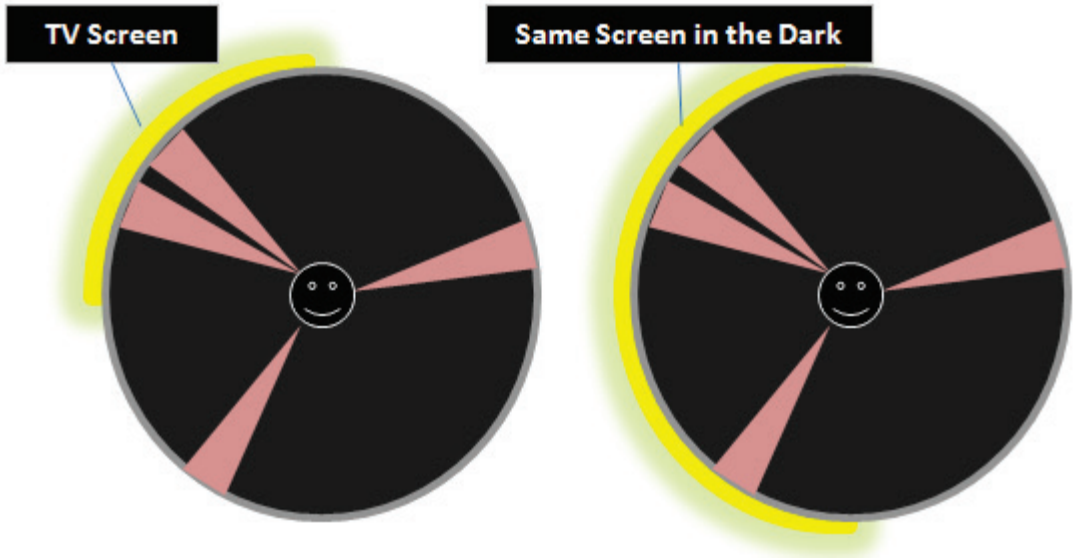

Figure 5 Sensory input can be in any modality (including interoceptive input)

Note. Pink slices represent individual sensory inputs which could present in a wide range of modalities; for example, the slice on the far right could be anything from a sound to one's internal nociceptive sense of pain from sitting in an uncomfortable position while watching the TV screen.

2.5.4. Immersion Involves 'Top-Down' and 'Bottom-Up' Factors

'Top-down' and 'bottom-up' processing are two terms used often when considering perception with an information-processing view of the mind. 'Top-down' processing refers to the influence of high-level declarative knowledge on perception, while 'bottom-up' processing refers to outside stimuli being sensed and processed more directly (Damasio, 1995). For instance, consider the optical illusion of *Rubin's Vase* in **figure 6**: this static image can be perceived either as a vase or as two faces. While the individual contours of the image are processed 'bottom-up', a spectator can control how they perceive the image by actively searching for either the vase or faces. This active cognitive influence is considered a 'top-down' process. As another example, consider visual attention: 'top-down' factors describe how our cognitive vigilance can ignore distractions while focusing our attention on the act of reading (Connor et. al., 2004), while 'bottom-up' factors describe how peripheral motion or a flashing light tends to pull our gaze almost automatically. Theories of immersion in the context of technology tend to be discussed with this same dichotomy. Not only do Ermi and Mäyrä (2005) separate a sensory form of immersion from an imaginative form, but Slater (2009) also makes a distinction between sensory and cognitive elements of engagement with virtual reality through his distinction between *immersion* (a question of how computer systems provide sensory stimulus to a spectator) and *presence* (a nuanced concept based on illusions of being in a new place and illusions of that place being consistent and plausibly related to the spectator).

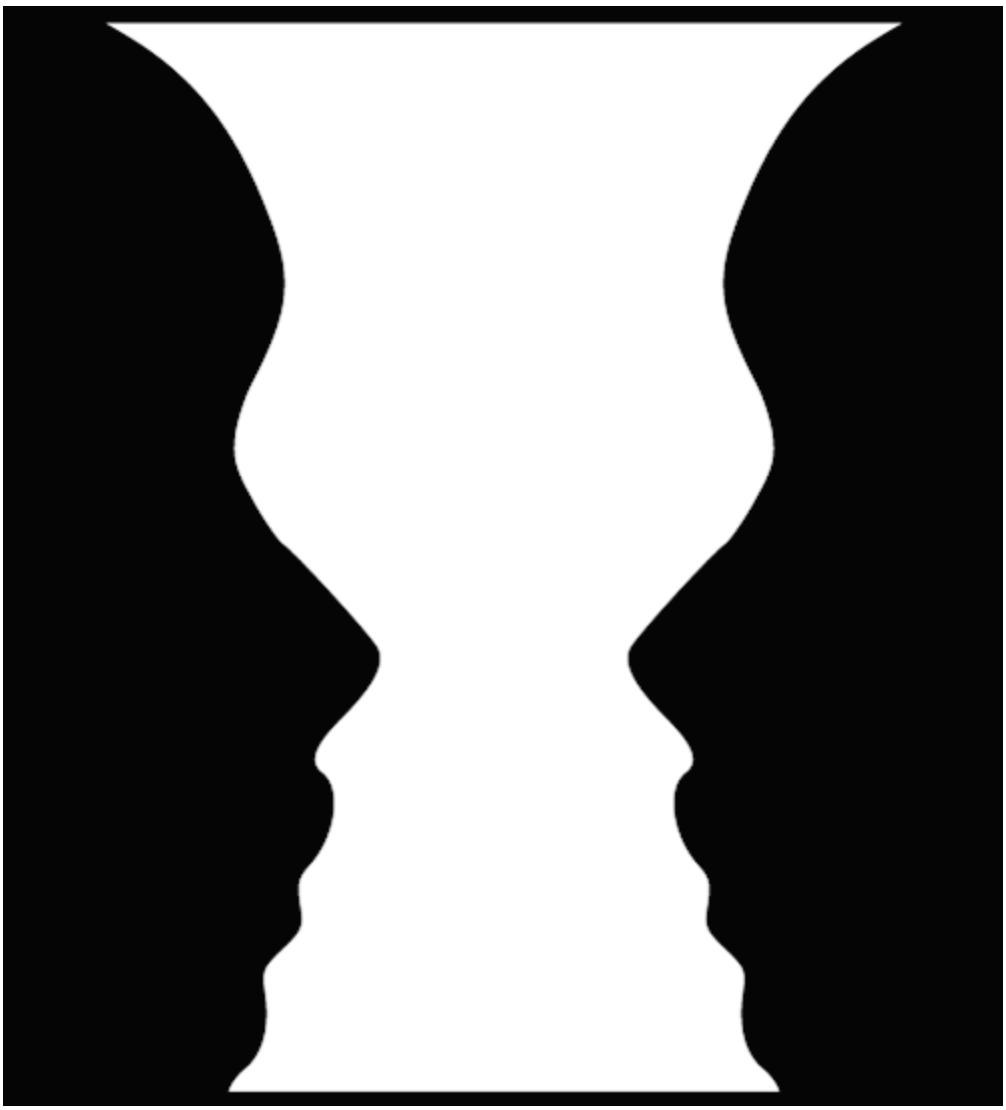

Figure 6. Rubin's Vase illusion showing a clear 'top-down' influence on perception.

While discussing the intersection of presence and immersion, Lombard & Ditton (1997) also present this same dichotomy through a distinction between *"perceptual"* and *"psychological"* components; the former are described in terms of multimodality and occlusion, while the latter are described as subjective, self-reported, and using terms like "*involved, absorbed, engaged, [and] engrossed*". However, while the term 'sensation' refers to information received by the traditional senses in a mostly 'bottom-up' fashion, use of the term 'perceptual' implies a holistic process involving both sensation and a cognitively constructive 'top-down' component. This use of terminology distinguishing "*perceptual*" and "*psychological*" components of immersion is less parallel to 'top-down' and 'bottom-up' processing, yet it is more psychologically accurate. In alluding to perception, these theorists (in addition to other theorists who refer to 'perceptual' elements of immersion – Nechtaval, 2001; Witmer & Singer, 1998) are aligning themselves with contemporary studies in psychology which depict strong 'top-down'

influences in the processing of all sensory input. For instance, consider how one's prior knowledge, attention, expectations and assumptions can directly influence vision (Summerfield and Egner, 2009). Since video games and virtual reality systems are providing sensory input like any other, our contemporary psychological understanding suggests that immersion into such systems simply must result from an interaction between sensory input and 'top-down' influence, placing it well beyond Ermi and Mäyrä's description. While sensory immersion implies only 'bottom-up' processing, it seems that the term 'perceptual' is more appropriate, as it aligns with modern psychology by alluding to both 'bottom-up' and 'top-down' factors. Put in context of **figure 6**, psychologists treat both the sensory and cognitive aspects of one's interaction with *Rubin's Vase* as elements of perception. While Gibson's ecological approach to perceptual psychology disagrees with a top-down influence on perception in favour of a more direct sense of vision (Gibson, 1986), my goal remains to develop a predictive understanding of immersion which can be used in the design of a novel artifact which influences human cognition. For this reason, I will ignore Gibson's theories and focus on applying cognitive approaches to perception. Human beings do not simply sense individual stimuli in our environments; we seem to cognitively integrate multimodal stimuli into a coherent perception of reality. Media should be no exception: **both 'bottom-up' and 'top-down' elements should be involved in any robust characterization of immersion.**

Although the notion of *perceptual immersion* includes a 'top-down' element of cognitively processing 'bottom-up' sensory input, it remains distinct from components of immersion which are primarily 'top-down' and involve relatively little sensory input: Lombard and Ditton's (1997) *"psychological"* component of presence-as-immersion, the *"plausibility illusion"* component of Slater's (2009) formulation of *presence*, and Ermi and Mäyrä's (2005) *"imaginative immersion"*. These theoretical formulations of immersion all seem to address some component of immersion which is much more cerebral than simply guiding the interpretation of sensory input. The compelling idea of immersion into dreams and literature leads some technological researchers to acknowledge that sensory-focused characterizations of immersion are too narrow (Biocca, 2003). Despite the power of multimodal human-computer interfaces to mediate virtual realities, we are also clearly able to mentally simulate compelling subjective worlds without need for sensory saturation. Dreams and literature seem to best represent the extreme cases of almost entirely 'top-down' forms of immersion which engage and absorb spectators using minimal sensory stimuli. Beyond the active process of synthesizing sensory stimuli into a cohesive experience, 'top-down' factors also seem central to a psychological component of immersion which is simply imagined. In order to better understand how this component influences our dialectic, I will now turn my attention away from technology and towards immersion theories rooted in the study of literature.

2.5.5. Is 'Imaginative Immersion' Really a Unique Form of Immersion?

As clearly evidenced in the previous section, a robust notion of immersion should take both 'bottom-up' and 'top-down' factors into account, despite existing research in technology placing emphasis on the former. In a complementary assessment of the more psychological components of mediated immersion, it is clear that both 'top-down' and 'bottom-up' factors still exist, only in a different balance. The text of a novel is still a sensory stimulus despite the complexity of immersion taking place in the

reader's mind. Even in the context of video games, Ermi and Mäyrä's *imaginative immersion* (2005) may involve imagining characters and worlds, but it does so through the perception of 'bottom-up', on-screen attributes. Given that literature involves the same 'bottom-up' and 'top-down' dichotomy – albeit with much more emphasis on the 'top-down' side when compared to newer media – it is logical to wonder whether so-called 'psychological' components of immersion are really different from perceptual components at all. **Could the only difference of immersion in different media contexts be the balance between its reliance on sensory input and its reliance on the spectator's cognitive influence?** This dimensional quality suggests the possibility of a unified psychological framework; here lies the first inkling that my overarching assumption of a common psychological characterization of immersion across media might be valid. If I am to theorize a psychological process which characterizes immersion across disciplines, it must apply to both extremes of this dimension: from media involving sensory saturation to subtle, imaginative contexts. We have already studied the psychology underlying immersion in the context of sensory encapsulation in a human-computer interface (prominently 'bottom-up'), but what are the underlying psychological themes of complete subjective involvement in a written novel (prominently 'top-down')? Are technological theorists who vaguely refer to some imaginative, fully psychological component of immersion referring to a state similar to that elicited within a reader furiously turning the pages of an engaging novel?

The written novel is a medium which is well-known to be considered immersive, despite text being relatively simple when compared to contemporary graphical environments which include visual, audio and even haptic feedback. Good novels give readers everything they need to imagine entire subjective worlds. Traditional art media such as painting and sculpture may have more of a sensory, 'bottom-up' element than the written word, but still much less than an interactive environment or video game. Not only can traditional art elicit an immersed state of deep allegorical contemplation from spectators which has been described as immersion (Palmer, 2007), but it also represents the living ancestor of contemporary interactive technology: both directly attempt to depict a virtual world, often visually (Grau, 2003). Despite seeming quite different, these traditional media share many elements with contemporary media; they all often involve virtual worlds, characters, drama, events, abstractions, and mimetic representations. However, art and literature are not dying practices and we can find the most relevant answers from these disciplines by asking how contemporary theorists discussing immersion in the context of literature and art consider new media. Just as theories from the presence and virtual reality communities helped broaden Ermi and Mäyrä's *sensory immersion* beyond video games, contemporary theories from literature and art will help broaden *imaginative immersion*.

2.5.6. Prior Knowledge Fuels Cognitive Construction

In order to effectively analyze immersion in literature and tie it to cognition, I inherently make fundamental assumptions about the human mind. First, let me restate my assumption of the mind as an information processor, one I make in pursuit of an applicable and predictive understanding of immersion which will facilitate the design and analysis of a novel immersive medium. Next, I assert what Marie-Laurie Ryan (2001), in an assessment of narrative forms of immersion in the context of new media, calls a *"textual world"* assumption: *"the idea of textual world presupposes that the reader constructs in imagination a set of language independent objects, using as a guide the textual*

declarations, but building this always incomplete image into a more vivid representation through the import of information provided by internalized cognitive models, inferential mechanisms, real-life experience, and cultural knowledge, including knowledge derived from other texts." This assumption positions me away from a school of thought called 'post-structuralism' which argues that – since our words are only defined subjectively using other words – texts are recursive in that they can only truly refer to themselves (i.e. Derrida, 1976). This idea conflicts with Ryan's description of an interaction between "*textual declarations*" and non-linguistic origins of information like experience and culture. However, I am willing to sacrifice compatibility with 'post-structuralism' as the "*textual world*" assumption suggests an active construction of mental representations based on text which directly aligns with most other theorists discussing immersion.

Just as some virtual reality researchers have equated presence to a feeling of being transported from one's actual physical location to a virtual, mediated world (Lombard & Ditton, 1997), many literary theorists also portray immersion as travelling from one world to another. The idea of literary immersion as world-travelling is thematic in a wide range of references: Ryan's *"poetics of immersion"* (2001), Gerrig's (1993) ideas of being *"transported"* into a narrative world, and Nell's (1988) ideas on the effects of familiarity and prose on being *"lost in a book"*. Transportation implies that one's active engagement with typical reality is replaced by a process of immersion into a new subjective reality. Transportation also aligns with the idea that immersion is highly dependent on the occlusion of sensory access to the physical world (see section *2.5.2*); if media attempt to convince the mind to facilitate transportation, reduced input from the physical world should lubricate the process. This idea of transportation also parallels the study of reference frames in spatial perception: when doing certain tasks - imagining another person walking, for example - we tend to reorient our mental frame of reference to a new, task-defined reference frame through the re-mapping of parameters to a new co-ordinate system (Klatsky & Wu, 2008).

Ryan presents a model for literary immersion which adds a more subjective bent to the idea of transportation by depicting immersive reading as the *"recentering"* of one's perspective. This theory states that one has a centered subjective reality which varies in distance to other conceivable realities. For instance, the model depicts your reality (or your *"center"*) as much further from the reality proposed by Shakespeare's Romeo and Juliet than an inhabitant of Verona in the late 16th century (who was not only more accustomed to physical and social attributes of the story's setting, but also conceptually closer to the values, beliefs, and general frame of mind of this time period). Based on this, Ryan's framework would suggest that your propensity for an immersive reading of Romeo and Juliet would be less than your Italian counterpart who lived in the renaissance. However, Shakespeare's masterful depiction of universally human themes (like forbidden love in Romeo and Juliet) keeps his work compelling when compared to other, less compelling historical works. This description of one's propensity for immersion based on one's previous knowledge and existing psychological attributes is Ryan's key contribution here, which she makes through an extensive review of existing literary theories of immersion. The implication is that existing knowledge and experience within one's typical subjective reality seems to influence immersion into new, mediated, subjective worlds. This should strike the

reader, as the role of prior knowledge in literary immersion aligns quite well with the importance of 'top-down' factors in more perceptual forms of immersion studied in technological contexts.

Ryan's (2001) framework seems to provide missing detail to Ermi and Mäyrä's *imaginative immersion* (2005). While the two conceptualizations align superficially in that they both depict immersion in terms of entering a new subjective reality, Ryan's model suggests that one's current subjective reality, including the influence of one's previous experience, will play a large role in the process of immersion into other realities. Ryan is not alone in this assertion. Umberto Eco (1989) considers the *"theoretical perception of contemporary aesthetics"* as the idea *"that any work of art, even if it is not passed on to the addressee in an unfinished state, demands a free, inventive response, if only because it cannot really be appreciated unless the performer somehow reinvents it in psychological collaboration with the author himself."* If Eco believes that the spectator of a work of art plays a major role in the internal reinvention of art, he would likely agree that this process is highly dependent on psychological attributes of the spectator. As another example, consider the perspective of Janet Murray, a more contemporary theorist bringing ideas on narrative and story to direct contact with new media and technology who claims that *"we bring our own cognitive, cultural and psychological templates to every story as we assess the characters and anticipate the way the story is likely to go"* (1997). Murray's view of reader response to a story generally aligns with Eco, as both authors suggest that our existing cognitive traits developed from a lifetime of experience have direct effects on our response to literature. However, as Murray studies both literature and technology, she progresses further to a direct discussion of this concept as it applies to technologically-mediated worlds. She refutes allusions to Coleridge's often-quoted depiction of immersion in film as *"the willing suspension of disbelief"* by asserting that immersion is also an active, creative process:

> "When we enter a fictional world, we do not merely suspend a critical faculty; we also exercise a creative faculty. We do not suspend disbelief so much as we actively create belief. Because of our desire to experience immersion, we focus our attention on the enveloping world and we use our intelligence to reinforce rather than to question the reality of the experience."

Murray is essentially reinterpreting Eco in the realm of interactive media by directly suggesting what Ryan's theory of *"recentering"* implies: **immersion should be characterized as an active, creative process where the spectator's psychological attributes and prior knowledge interact with the medium to generate a consistent subjective experience of reality.**

2.5.7. Immersion as Active Contemplation

The active, creative view of immersion based on prior knowledge not only ties to our previously discussed perceptual form of immersion based on the active combination of 'bottom-up' and 'top-down' factors, but also to theories of art which discuss *contemplative immersion*. The active contemplation of an art piece or novel might seem much different from the media I have discussed so far. However, a contemplative form of immersion has been thought of as the integration of mind and medium in a way which parallels the ubiquitous trends of immersion which have emerged from the present dialectic. For example, in addressing the evolution of art criticism with the advent of new media art, Daniel Palmer

(2007) contrasts Walter Benjamin and Theodor Adorno's attitudes toward film to point out two seminal views on the aesthetics of immersion: *"Adorno harshly critiqued cinema on the basis that the spectator is so absorbed that there is no space for the imagination (which can be read as a direct rebuttal of Benjamin's enthusiastic embrace of cinema's revolutionary potential)."* While both cited theorists have much broader theories, Palmer's focus on juxtaposing their specific references to *contemplative immersion* holds a loose but striking parallel to our aforementioned distinction between 'top-down' and 'bottom-up' components of immersion: Palmer depicts Adorno as essentially critiquing cinema's sensory saturation which hinders contemplative, 'top-down' influence. This is in stark contrast to Benjamin's praise of film's *"shock effect"* on the public, regardless of their attention, which seems to be an ode to its powerful 'bottom-up' elements (Benjamin, 1936). Palmer surveys these positions in the context of art criticism, where he suggests an evolution of Adorno's perspective for contemporary media, addressing both a perceptual and a contemplative component of immersion simultaneously:

> "[The immanent mode of contemplative immersion] is no longer the central critical ambition even as it might remain our individual desire as viewers. Registering the body's affects, while dissolving the space of individual self-possession, has become an equally important goal for media art criticism. Ultimately, immersive media art enables us to explore the uncertainty and instability of all perception and consciousness. In this way, such work blurs the normally clear distinctions between self and other, viewer and object."

Palmer appears to align with both technological and literary theorists in his call which appears to parallel the unification of 'top-down' and 'bottom-up' factors. This conclusion on contemplative immersion wraps up my own exploration of immersion theories by yet again reinforcing two key elements. First, this attempt to push art theory toward embracing a perceptual form of immersion is perfectly complimentary to contemporary technologists' consistent addressing of some vague psychological component of immersion, as if both disciplines were reaching toward each other. Second, Palmer depicts immersion as dependent on both the medium and the spectator's unstable conscious perception, directly aligning with even the most disparate theories of immersion in its focus on the involvement of spectator attributes in the co-creation of an immersive experience.

2.6. Summarizing Trends across Art, Literature and Technology

At the beginning of this chapter, the concept of immersion appeared as a theoretical battleground ripe for conflict between artists, literary scholars and technological researchers. It is precisely this confusion which led me to start my analysis from Ermi and Mäyrä's (2005) work on immersion in video games. While they focus on their own medium of study like most other theorists mentioned (serving the metaphor of "blind monks"), their particular medium forces a preliminary rectification of this conflict. In their analysis of video games, a medium capable of audiovisual proficiency, artistic discussion and narrative quality, they place both a sensory and imaginative component of immersion on the same descriptive plane, all under the common header of immersion. However, these theorists never answer a fundamental question: why these are considered components of immersion and not completely

separate concepts? Are all theories of immersion truly discussing the same phenomenon as their choice of language would suggest? My intensive study of immersion theories across different media reveals potential answers to these questions which lie in the realm of human psychology.

The lack of continuity in Ermi and Mäyrä's taxonomy seems to come from an apparent mind-body distinction. They seem to treat *sensory immersion* as a directional flow of information from the external medium through the exteroceptive senses ('bottom-up' only), while *imaginative immersion* is depicted in the opposite direction, originating with abstract mental properties like imagination and fantasy ('top-down' only). This dichotomy parallels that found in our cross-disciplinary literature review in suggesting two distinct sources of immersion: external media can immerse us with their sensory complexity, or we create immersion ourselves through our imagination. This distinction seems to be a false dichotomy in that it ignores constructive, cognitive influences on perception (i.e. Summerfield & Egner, 2009), and ignores the body's influence on the mind (Johnson, 1990; Wilson, 2002). In reality, even when in contact with an immersive external medium, our imagination and prior knowledge play a large role in generating consistent experiences of immersion. On the other hand, the seemingly immersive experience of imagining a world depicted in text or even dreaming is largely shaped by cognitive factors shaped by a lifetime of sensory experiences. In any medium, including encapsulating virtual reality displays and written novels, elements of sensation are met by cognitive influence in forming a subjective reality out of the medium through any modality; the only variable seems to be the relative weighting of sensory and cognitive factors. Here, our attempt to unify disciplines seems promising: the vast majority of immersion theories allude to some form of interaction between sensory input from the medium and attributes of the spectator including cognitive factors and prior knowledge.

Despite different perspectives on immersion being from completely different fields, they all seem to predict heightened immersion in media which provide cues that align with familiar sensibilities from spectators' prior knowledge. Just as a technological theorist might prize the *immersiveness* of a VR system which is realistic – that is, a system with detailed sensory input which accurately parallels the physical world – a literary theorist might presume a novel to be more immersive when its characters and settings are familiar or plausible with respect to the typical subjective reality of the reader (i.e. a high school student will engage easier with a novel which takes place in a high school). In both cases, familiar elements of the medium serve as guides for the spectator to actively construct an experience of a virtual world which parallels their previous experience with physical or imaginary worlds. Through years of experience, our minds seems to have amassed prior knowledge with respect to how inputs can be shaped into a coherent subjective world; when media integrate familiar cues, they encourage the balance of bottom-up and top-down factors characteristic of immersion by providing elements which the mind can familiarly integrate into its subjective world. A corollary implication of this emphasis on the role of prior knowledge in immersion is the fact that any given medium will be in natural competition with similarly compelling cues from a spectator's existing physical reality. This explains why media can become more immersive through occlusion of the physical world. This raises questions about the relationship between media immersion, the physical world, and the human body.

2.7. Is the Physical World an Immersive Medium?

The human mind's propensity to create a cohesive experience of subjective reality seems to be active in our conscious interpretation of a spatial environment depicted graphically, the imaginary world of a novel, or even the more abstract, contemplative realms of traditional and media art. The common theme seems to be the active application of prior knowledge to the consistent reinforcement of a coherent subjective experience through cognitive integration of relatively crude sensory stimuli. Prior knowledge fuels the use of familiar cues as immersive affordances which somehow guide us in this process, presumably due to our previous experience conceptualizing these specific elements. However, since much of one's prior experience cognitively constructing consistent subjective realities takes place through one's body which exists in the physical world, the present synthesis of existing theories of immersion seems to be lacking a discussion of physicality. Just as virtual reality researchers suggest immersion's dependence on the occlusion and overpowering of stimuli from our existing reality, literary theorists depict immersion as travelling to a new world, a treatment which implies a minimization of engagement with our typical, physical world. Seeing as the cognitive factors, sense organs, and prior knowledge which seem to be exploited by immersive media are typically engaged in our day-to-day lives, should we be considering the physical world as an immersive medium? In order to explore this, I will first identify to what extent cross-disciplinary trends of media immersion parallel academic understandings of perceptual experience in general.

Diverse perspectives of immersion all seem to align with a constructive, 'top-down' process which uses existing knowledge to synthesize sensory input into a mental simulation of a mediated subjective reality. In this respect, the day-to-day reality which we experience as an objective physical world is not much different. In our lives, we are constantly presented with crude stimuli in a range of modalities which are synthesized into a holistic experience through some form of *"binding"* (Blackmore, 2004). Presumably, this cognitive construction somehow bases itself on prior knowledge learned during a lifetime of physical, cultural, and personal experience in a hegemonic socio-political context. Not unlike an optical illusion, a phenomenon which demonstrates how *"perception depends largely on prior knowledge"* (Gregory, 1997), our general impression of reality seems to rely on prior knowledge as well. In perceiving *Rubin's Vase* (**figure 6**)**,** 'top-down' factors can influence our perception between a vase and two faces; prior knowledge explains why those two culturally significant shapes are the two options we perceive. Experimental evidence toward *inattentional blindness* corroborates the plausibility of such an active, constructive tendency by demonstrating people's ignorance of blatant changes in unattended or unexpected stimuli (Mack, 2003). Inattentional blindness should be familiar to anyone who has witnessed the well-known *"Gorilla"* demonstration (Simons & Chabris, 1999): when instructed to count the number of passes in a short video of basketball players, the intense focus required results in most participants failing to notice a person in a gorilla costume walking through the scene, blatantly posing right in front of the observer. In general, when not paying direct attention to unexpected objects or events, the mind seems to construct a contextual environment using inferences based on prior knowledge, assumptions, expectations, and intentions ('top-down' factors) from years of experience in their own subjective reality.

The constructive tendency which characterizes our engagement with day-to-day, physical reality parallels our engagement with immersive media. However, a key difference remains: we are permanently rooted in physicality. No matter how engaging or immersive a book or VR system might be, it only takes an urgent physical sensation like hunger or pain to snap us back to our embodiment in the physical world. Through our bodies, we have all spent a lifetime inhabiting this physical world. The same cannot be said of literature, video games, art, virtual reality environments, and other external media. Discussion of whether physicality can be considered a 'medium' or not is deeply philosophical; however, theoretical overlap in diverse theories of immersion suggests it is a constructive perceptual experience not unlike our day-to-day engagement with the physical world. This similarity is a result of immersive media exploiting our engagement with physical reality. Embodiment suggests that our seemingly immersive experience of physicality is primordial to our engagement with artificial media. Experiences of physicality seem to align with theories of immersion because they serve as key criteria for the *immersiveness* of the media which try to emulate them.

2.8. Incorporating the Preconscious and Embodied

When it comes to the body, there is a distinction between the conscious attention which surveys one's field of awareness and the preconscious functioning which takes place without conscious intentionality. When discussing the influence of prior knowledge in engaging a process of immersion, this distinction is important. Grounded in the philosophical writings of Merleau-Ponty, Gallagher discusses this issue in the context of distinguishing between a conscious, emotional, and perceptual *"body image"* from the *"body schema"* (Gallagher, 1995). The former concept ties closely to the majority of work in cognitive science which biases toward the phenomenological and transcendental focus on consciousness. So far in this chapter, much of my discussion on immersion has been guilty of this bias due to its basis on theories which share this guilt: especially the notion of a constructed subjective reality based on the synthesis of 'bottom-up' sensory input by 'top-down' cognitive factors. Gallagher rightfully points out that, as a researcher focused on cognition, I am likely to prioritize and even limit my investigation to conscious elements, a position which extends from a school of thought Merleau-Ponty argued against:

> "Merleau-Ponty sets out to show that the body itself is doing the perceiving, and that the operations of the body schema provide specific conditions that constrain perceptual consciousness. Meaningful perceptual structures originate in certain prenoetic performances of the body. The body operates according to a 'latent knowledge' it has of the world, a knowledge anterior to cognitive experience." (Gallagher, 1995)

This notion that latent knowledge which informs *"prenoetic performance"* – Gallagher's term for preconscious bodily actions – suggests that immersion's apparent dependency on prior knowledge should not be limited to the conscious and cognitive realms. The idea that 'top-down' influences based on prior knowledge serve to cognitively construct a consistent experience based on sensory input should include embodied knowledge. Certainly our emotions, perceptual experience, and conceptual knowledge will influence the nature of media immersion, but so will our neurophysiological structure

which implicitly holds a lifetime of experience through our adaptive development and neuroplasticity (Shaw, 2001). Further, the physiological organization of our senses dramatically constrains our perception of the world. These embodied, preconscious elements should play a role in any discussion of 'top-down', cognitive factors which contribute to immersion in order to avoid perpetuating disembodied understandings of immersion.

The latent, prior knowledge which is held implicitly by our physical structure is not the only preconscious factor which should impact immersion. Although the preconscious body schema cannot be grouped in with the conscious body image, it also cannot be reduced entirely to a physiological phenomenon. Many physiological actions are possible in any given context, but somehow the body responds to its environment with a striking immediacy which is beyond the scope of latent physiological knowledge, selecting appropriate actions without conscious intervention:

> "When, for example, in the context of a game I jump to catch a ball, that action cannot be fully explained by the physiological activity of my body. The pragmatic concern of playing the game motivates the action, while the physical environment, the effects of all my practice (or lack thereof), and even the rules of the game as they are habitually expressed in the practiced movement of my body may define how I jump to make the catch." (Gallagher, 1995).

This example demonstrates the importance of the body in a holistic understanding of human cognition. The wide range of perspectives which exist on this topic of *embodied cognition* (Wilson, 2002) suggests that a working understanding of immersion cannot lie in the mind alone. Based on psychological experiments, Gallagher goes on to make a compelling case that preconscious somatic factors go as far as *"constraining and enabling factors that limit and define the possibilities of intentional consciousness."* (Gallagher, 1995) While existing theories agree on the importance of cognitive 'top-down' factors and prior knowledge for media immersion, any unified framework of immersion must not forget the role of the human body. To avoid a disembodied characterization of immersion, I will not only incorporate this element in the framework presented in the next section, but I will also assert now that all future references to prior knowledge and previous experience should be taken to include not only conscious, explicit knowledge, but also the implicit, latent knowledge and perceptual constraints embodied in one's current state of adaptive, neurophysiological organization (quite literally, a 'body of knowledge'). As for mentions of cognitive, 'top-down' factors in the subsequent sections, they should be taken to include embodied cognition in contexts where applicable.

2.9. A Framework of Media 'Immersion'

To summarize, our lifetime of experience through an adaptive nervous system has resulted in knowledge, assumptions and expectations which lie both in the realm of conscious awareness and in latent preconscious and embodied states. Our perception of a day-to-day subjective reality somehow relies on the application of this knowledge to fuel cognitive 'top-down' construction. Media exploit this

process, generating immersive experiences of alternative realities, including literary universes, contemplative artistic constructs, and technologically-mediated worlds.

In the previous sections, key themes were elucidated from a wide range of descriptions and theories of immersion in the context of various media. To ensure compatibility with ideas from technology, literature and art, any resulting characterization of immersion should accommodate the interaction of 'top-down' and 'bottom-up' factors, the critical role of prior knowledge, and the idea that our engagement with the physical world is not unlike that with immersive media. Uniting these themes, I claim that it is an enhanced constructive interaction between person and mediated world which generally characterizes an active and continuous process of immersion. Immersive media cause us to disengage with our typical subjective reality while engaging in the ongoing perceptual reinforcement of consistent, alternate realities suggested by those media. In the case of a sensory-occluding head-mounted display, an engaging written novel, a challenging video game or even a piece of art, the psychological quality which characterizes immersion seems to be the use of prior and latent knowledge to fuel the spectator's active construction of a cohesive subjective experience of that medium. While constructivity always plays a role in perception to some degree, this characterization suggests immersion as a heightened, continuous, and proactive engagement of mental faculties to co-create a seemingly consistent mediated reality. Any medium which strongly affords such co-creation can be described as highly immersive. We can rephrase this to say that **the *immersiveness* of a given medium is indicated by its propensity to encourage a spectator to construct and reinforce a subjective world based on said medium, as opposed to based on physicality or any other medium.**

Intensive investigation of immersion led not only to the aforementioned cognitive characterization of immersion, but also to the more detailed framework depicted in **figure 7**. These four circular diagrams visually communicate a psychological process of immersion which captures and simplifies the intersection of a diverse range of relevant theory presented in this chapter. To summarize, our minds are typically in the act of synthesizing crude sensory input from our physical reality in any modality into a cohesive, subjective world. Media are elements of this physical world which suggest a second, artificially-mediated world; often these elements are explicit artifacts designed specifically for this purpose (i.e. books, video games, art, virtual reality, etc). An immersive medium seems to exploit our lifetime of experience synthesizing disparate stimuli into a coherent, consistent reality, inviting the construction of a subjective reality suggested by that medium. *Immersiveness* can be defined differently based on the type of medium being described, but all media seem to depend on familiar cues which appeal to prior (and latently embodied) knowledge, triggering a habitual process of immersion which the mind is already accustomed to (although compelling abstractions are also certainly necessary to keep that reality engaging and interesting). Sensory input consistent with a mediated world can further encourage immersion by occupying high proportions of our total sensory input, either through sensory encapsulation or through complete occlusion of irrelevant sensory inputs (go back to **figure 4** for more detail). However, when immersed in a given medium, a spectator will always remain tied to the physical world due to their embodiment; while embodied cognition and latent knowledge can play a role in defining an immersive experience, they cannot be totally occluded and therefore can also trigger re-engagement with the physical world.

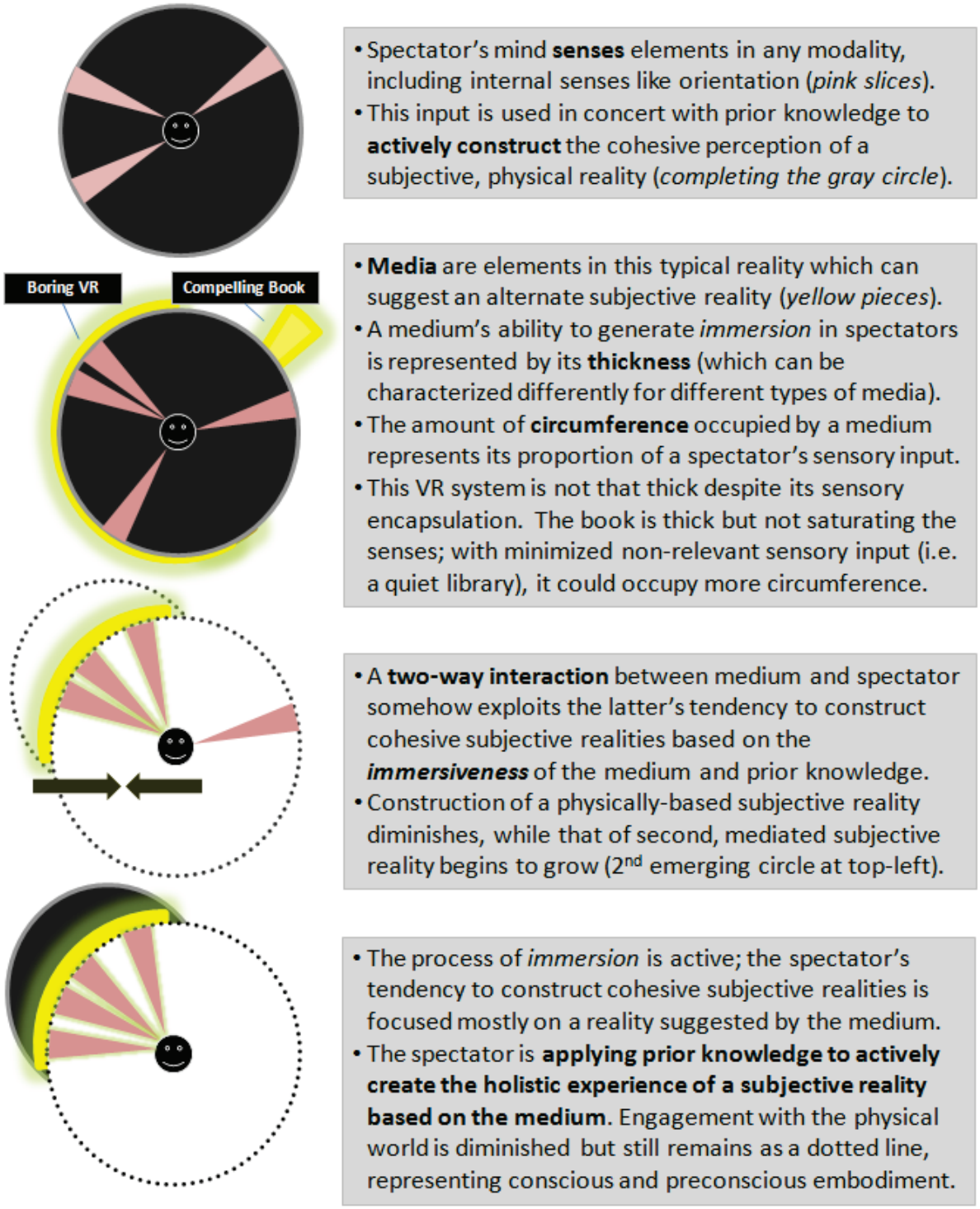

Figure 7. A proposed framework for media immersion based on diverse disciplines.

Note. 'Spectator' is being used as a blanket term to refer to the observer of any medium (reader, user, viewer, etc.); despite common use of the term which has a visual implication, I am using it to refer to any combination of modalities, including both interoceptive and exteroceptive senses.

2.10. Implications for Human-Computer Interaction Design

The psychological framework of immersion presented here has implications worth exploring in psychology, virtual reality, video game research, media theory, literature, art, and human-computer interaction design. For example, psychologists could bring depth to my work by exploring the framework's overlap with existing theories, possibly even leading to experiments in search of evidence and measurement tools. The framework could lead VR theorists to refine and improve existing methodologies being used to measure presence and immersion, perhaps even leading to new methods entirely. As for technological, media, literary, and art theorists, the framework represents new, cross-disciplinary ideas on media engagement which may inspire new dialogues. While it remains impossible to predict if and how the framework will appear to specialists in these different disciplines, my hope is that it will at least help to combat the tendency to focus on one's particular medium of study when thinking about immersion (the tendency of 'blind monks'). While further investigation is needed to validate its compatibility with each particular field, I believe this framework has the potential to become a centerpiece for interdisciplinary discussion by providing a common target worth exploring by diverse specialists. As will be elaborated in the final chapter of this thesis, these implications for theoretical development were generated in the context of a design project, positioning this work as *"research through design"* (Zimmerman, 2010).

Returning to my overarching goal of using this theoretical exploration to fuel a human-computer interaction paradigm aimed at promoting mindfulness meditation, **the framework can help generate guidelines on how to intentionally design and study systems with respect to immersion**. Based on the framework, I drew together the following short list of design hypotheses which are directly relevant to any new medium aimed at generating the heightened engagement characteristic of immersion. I am certainly not in a position to claim these guidelines to be objective absolutes, but they represent a useful source of human-computer interaction design rationale based on the theoretical exploration of immersion presented in this chapter.

1. **Occluding the physical world** can play a big role in strengthening spectators' engagement with the medium. Movie theatres are dark and comfortable; similarly, quiet places are optimal for reading. Immersive media should attempt to minimize the likelihood of physicality disturbing spectators' engagement in all modalities.
2. **Engaging the internal senses of the body** in a way which is consistent with a medium's proposed virtual world should encourage immersion; any interoceptive senses which are not relevantly engaged should be instead deprived to prevent distractions which may re-engage spectators' engagement with their typical, physically-based subjective reality.
3. Immersive media should not oversaturate the senses; instead, include just enough sensory input to suggest a virtual world while **artfully leaving enough omission** for the spectator to engage in active, continuous completion of the world (leave room for spectators to 'fill in the blanks').
4. An immersive medium which aims to invite the cognitive construction of a virtual world should **include subtle elements based on spectators' prior knowledge** as key affordances for the cognitive construction of novel, interesting subjective realities. That is, a balance between

familiarity and abstraction is critical for immersion. This guideline also applies to the inclusion of elements based on latent knowledge embodied in spectators' neurophysiology.

5. If an immersive medium can **prime spectators to be in a consciously creative mode**, it may help engage the active, construction of a subjective, mediated reality which characterizes immersion.

While traditional media use varying combinations of these approaches to lubricate immersion into mediated, external worlds, there is no reason why new media cannot encourage an active, creative form of immersion which involves internal, interoceptive elements. In fact, many flight simulators already do so when they use a rotating platform to provide a familiar sense of gravity and acceleration to pilots-in-training, exploiting their internal orientation sensors to add realism to the virtual world. Theoretically, an immersive medium can be designed to parallel mindfulness meditation through similar integration of internal, bodily sensations. Further, such a design concept could occlude the physical world, balance familiarity and abstraction, and be the basis for a creative interaction paradigm which places users in a naturally authorial role, priming them to cognitively construct their own experience. The next section describes *Sonic Cradle*: a design concept which attempts to occlude access to the typical, physically-based subjective world while simultaneously encouraging a subtle creativity based on a one-pointed internal sensation: respiration. The framework of immersion presented in this chapter informs this system which has been designed specifically to foster immersive experiences of mindfulness meditation for users' benefit.

3. Sonic Cradle: Interaction Design Phase

3.1. A Sound-Based Interaction Design for Mediated Mindfulness

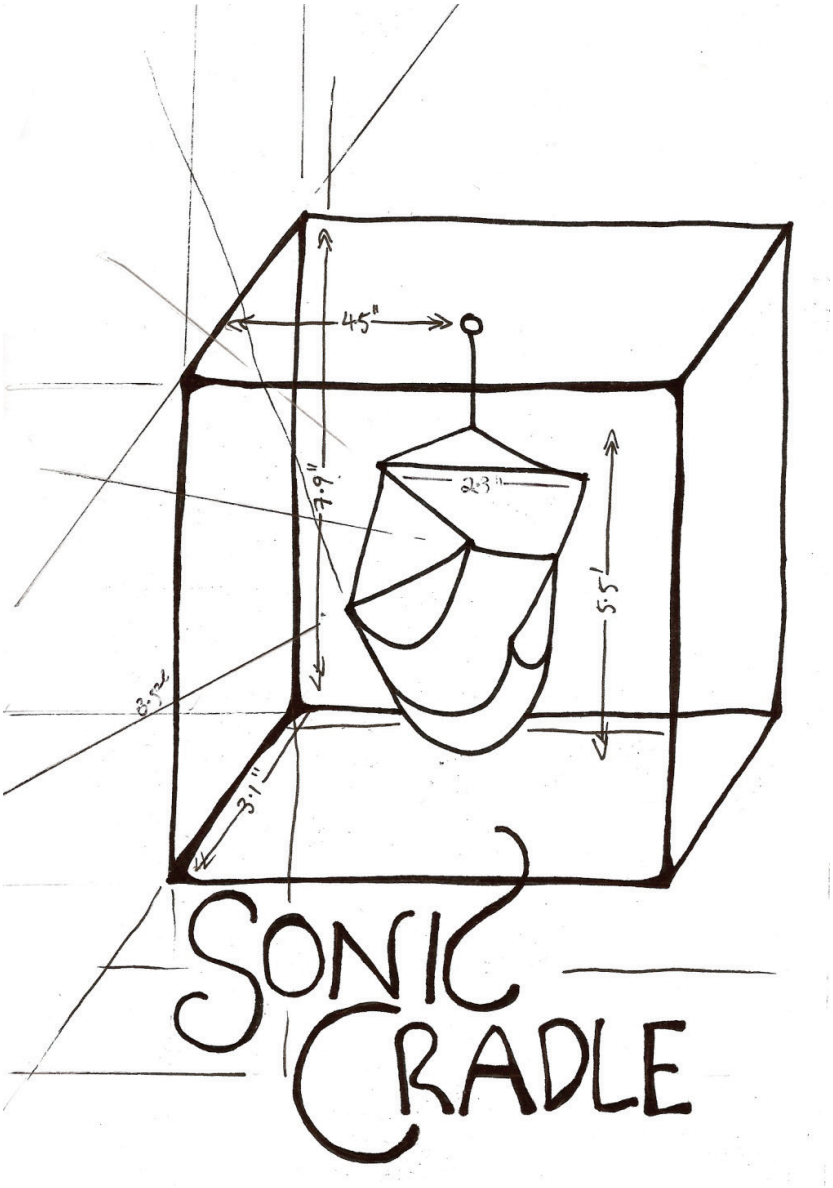

Figure 8. An artistic portrayal of the Sonic Cradle concept (artist: Jen Mahon).

Integrating the presented research on mindfulness and stress management in chapter 1 with the framework presented in chapter 2, I developed an initial design concept aimed at encouraging 'immersion' into a relatively subtle human-computer interface which encourages an attentional pattern mimicking mindfulness meditation. *Sonic Cradle* is a non-traditional interactive medium where spectators are suspended in darkness, controlling sound through the exploration of their own respiration. The system's interaction paradigm has been intentionally designed to encourage spectators 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. Further, comfortable suspension removes direct connection with the ground while greatly reducing somatic distractions like discomfort and pain, deemphasizing irrelevant aspects of physicality. These design decisions also leave the somatic and visual modalities vacant for appropriation by spectators subjectively creating their own compelling and cohesive experience. Respiratory biofeedback sensors help root that constructed experience in the subtle, internal sensation of breathing and its influence on sound (**figure 9; right**). With minimized distractions, a lack of competing input from the physical world, a balance of familiarity with abstraction, and a creative context, this design concept takes advantage of the framework presented in the previous chapter to try and foster a subtle, internally-focused process of 'immersion' (**figure 9; left**). Certainly the framework has not yet been directly validated; however, it is based on research from established experts in diverse disciplines and it remains a compelling design rationale for *Sonic Cradle*.

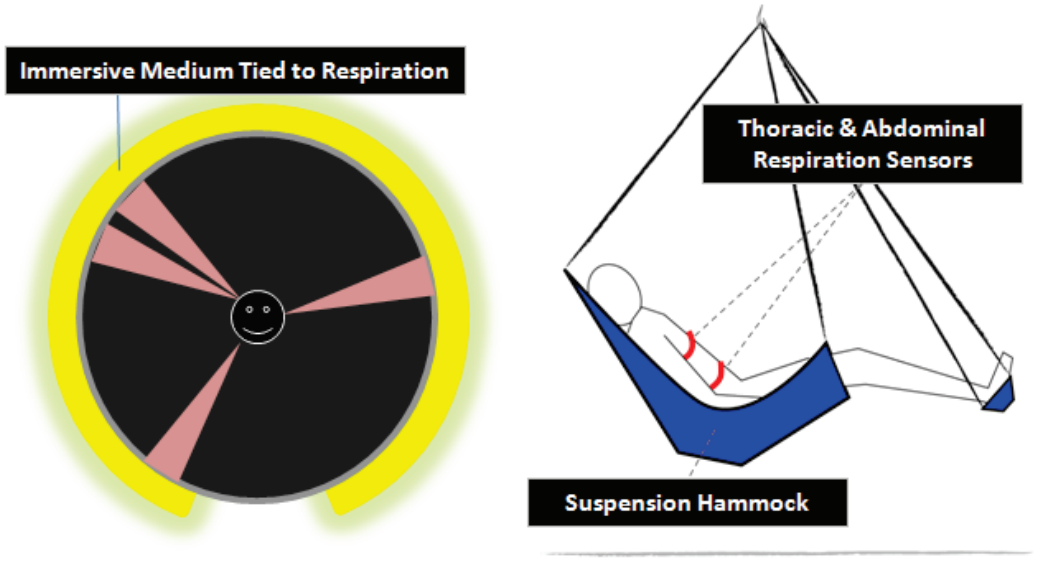

Figure 9. The Sonic Cradle concept expressed in diagrams.

Note. The left diagram expresses the *immersiveness* (thickness of the yellow medium) and proportion of sensory input (circumference) of the *Sonic Cradle* concept using circular 'immersion' diagrams from the framework in chapter 2. The diagram on the right depicts the system's bodily suspension aspect along with the respiration sensors which detect a user's breathing.

I developed the algorithm which connects respiration to the act of progressively building a soundscape reflexively while controlling it with my own respiration in real-time. The system allows spectators to hold their breath to summon a new sound, and then shape that sound in real-time by breathing in different ways. Attributes of spectators' respiration (rate, depth, thoracic/abdominal ratio) control audio parameters of that recently-added sound (respectively: reverberation effects, equalization filters, volume). If spectators hold their breath a second time, the first sound continues to play with its attributes locked, and another sound is added to the environment and shaped in the same way. When ready to move on, spectators can lock the second sound and summon a third sound to the mix in the same way, and the process continues. Essentially, spectators use their breath to progressively shape and mix pre-recorded sounds together into their own custom soundscape.

If spectators are indeed highly engaged by *Sonic Cradle* despite its subtlety and lack of depth compared to other media which are considered 'immersive', this would only be a partial success. The main goal of the interaction design is to motivate mindfulness through the reverberation of a subtle and one-pointed attention between an internal sense of breathing, *Sonic Cradle*'s external human-computer interface, and inevitable mental distractions. To appropriately serve this attentional cycle, the human-computer interface needs to draw the attention of mentally distracted spectators back toward respiration without hindering focus on breathing. It was this demand which inspired me 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't 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, 1967)

Sonic Cradle's audio element aims to foster a subtly creative sonic experience which does not demand too much attention away from an intense focus on respiration, but does reclaim attention from mental distractions. For this reason, all individual sounds were created specifically to have no sharp changes to avoid forceful capture of attention. Inspired by the 'immersion' framework's suggestion of balancing familiarities based on prior knowledge and unfamiliar yet interesting elements, the initial prototype involved a balance between sounds which were realistic and recognizable and those which were abstract and unrecognizable. Sounds were also created to have some rhythmic and tonal consistency (loosely related to the key of E and 60 beats-per-minute). Other than these dimensions, sound choices for the initial prototype were relatively arbitrary, as it is not some specific property of the sound itself that is to foster mindfulness, but instead the patterns of attention stimulated by 'immersion' into the system's creative interaction paradigm. Sounds were not selected to be intentionally meditative or stress-reducing (other than the requirement of avoiding sharp changes), though they did tend to avoid being abrasive. Instead of actively trying to employ specific sounds touted as having healing properties (binaural beats, chanting, specific frequencies, etc.), the initial prototype involved recordings of musical instruments and natural phenomena, as well as a few abstract synthesized tones.

In essence, *Sonic Cradle* spectators can either focus on exploring the respiratory-musical control paradigm or be in a state of internal distraction; however, the paradigm is designed to return spectators to inward attention. As they explore the system, spectators should naturally start by orienting their attention toward breathing as they explore the system controls. The system's audio response to respiration is designed to encourage spectators to focus on their respiration as they attempt to discover how to influence their sound environment. Inevitably, spectators 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, spectators will have no choice but to continue to influence their sound environment despite their distraction. Ongoing changes in the sound environment should eventually trigger a curious re-orientation of attention toward sound; subsequently, as spectators wonder how and why the sound changed as it did, they should reflect on their breathing, restoring their inward attention. This loop of attention is almost identical to that of mindfulness (**figure 10**). Astute readers will notice a critical difference from typical meditative instruction: as spectators 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 spectators are not explicitly instructed to focus. This 'training wheels' approach should enable the calm refocusing of attention characteristic of more experienced mindfulness practitioners to proceed unencumbered as a natural response to the interaction paradigm.

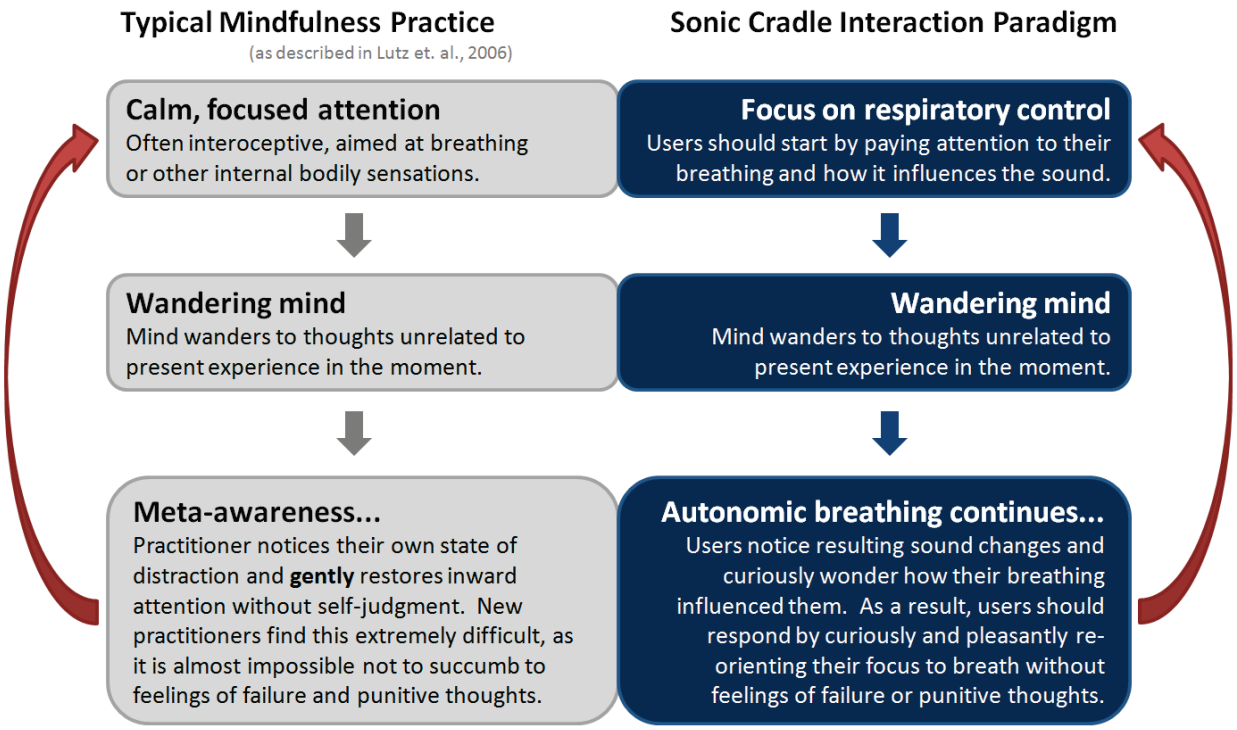

Figure 10. Attentional comparison of mindfulness meditation and Sonic Cradle.

Note. The left half of the diagram describes the common explanation of mindfulness meditation presented by Lutz et. al. (2006) after studying a wide range of traditions (see section *1.1*). The right half of the diagram depicts Sonic Cradle as attempting to generate a similar attentional pattern as a response to its interaction paradigm.

3.2. Contextualizing the Sonic Cradle Concept

Sonic Cradle enables spectators to construct a sound environment through respiratory biofeedback. Not only has biofeedback been generally successful in therapeutic contexts (Gatchel et. al., 2003; Gatchel, 2009), but connecting respiration and sound/music to generate relaxation and positive health effects is not new. Almost 3 decades ago, Hans Zeier (1984) reported ten participants' relaxation and reduced heart rate when provided with respiratory biofeedback in the context of slow, baroque music and verbal suggestion. More recently, a home-use device which uses musical patterns to guide users to slow and regular breathing patterns was shown to effectively reduce high blood pressure after 2 months of daily use (Schein et. al., 2001). Further, previous evidence suggests that sensory deprivation can be independently therapeutic (Shea, 1991). In terms of visual deprivation and bodily suspension, *Sonic Cradle* is theoretically similar to sensory deprivation tanks which shut out all light and suspend people in saltwater (see studies on *Flotation REST*: Kjellgren et. al., 2001). The relationship between these individual elements of *Sonic Cradle* and mechanisms underlying mindfulness meditation remains unclear, but the potential certainly exists for an informed combination of sensory deprivation, biofeedback, respiratory interactivity, and sound to generate positive psychological effects. However, a

less obvious question is whether this interactive system will lead to subjective reports which align with the practice of mindfulness meditation. While evidence determining whether *Sonic Cradle* can generate acute stress reduction would be useful for validation, this outcome should be expected based on the system's individual components. A bigger question surrounds whether the subjective experience of *Sonic Cradle* parallels mindfulness; can an interactive medium introduce non-practitioners to this vital practice which could profoundly improve their lives? The next chapter attempts to address this key research question using a systematic analysis of rich, descriptive data from participant interviews.

More cohesive design concepts related directly to *Sonic Cradle* also exist. Shaw et. al.'s (2007) *Meditation Chamber* is similar in its high-level objectives and combination of biofeedback and interactivity, but it differs in its use of galvanic skin response (GSR) as its main control mechanism. There are also commercial products being explored using electroencephalogram (EEG) toward meditative ends (e.g. *emotiv* applications, *BrainBot*). EEG and GSR are both bodily attributes which lie outside the field of direct conscious awareness, making them inappropriate for use toward my goal of encouraging meditative attentional patterns. *Sonic Cradle* holds much more similarity to an installation called *Osmose* (Davies, 1996). As a multi-layered experience involving suggestive virtual environments and complex soundscapes, *Osmose* allows users to freely explore abstract worlds using their breathing and physical balance. This installation not only shares *Sonic Cradle*'s breath-based interactivity, but it also implicitly relies on the user to piece together a cohesive experience based on abstract sensory input in a way which aligns with the framework of 'immersion' presented in chapter 2. Further, participant responses to *Osmose* seem to align with *Sonic Cradle*'s meditative goals: *"The experience of seeing and floating through things, along with the work's reliance on breath and balance as well as on solitary immersion, causes many participants to relinquish desire for active 'doing' in favor of contemplative 'being'"* (Davies, 1998). *Sonic Cradle* builds upon this previous work with a rigorous, systematic design approach based on the psychological sciences and media studies in pursuit of a clear goal: consistent, 'immersive', subjective experiences of mindfulness.

3.3. Refining Interactions through Co-design Sessions

In order to tweak and refine *Sonic Cradle*'s interaction paradigm, I engaged with 15 naïve participants in individual sessions that can be described as *co-design*: a term which refers *"to the creativity of designers and people not trained in design working together in the design development process"* (Sanders & Stappers, 2008). The participants were recruited haphazardly through personal contact. As the institution where recruitment took place is focused on human-computer interaction research and interactive art, the sessions included mostly graduate students, post-doctoral students and faculty who share a deep interest in art, technology and design. It is moot that this population does not represent a purposive sample of our target demographic or a random sample of an experimental population, as these co-design sessions were used to discuss the system openly, gathering ideas and inspiration for reflective iteration of the human-computer interface (a more controlled and contextually interesting investigation of a purposive sample is presented in the next chapter). After 20 minutes in *Sonic Cradle*, participants were asked to express their subjective experience freely (**figure 11**). These open-ended

interviews probed temporal elements of the system, ratios of focus/distraction, ratios of relaxation/excitement, interpretations of the system, feelings of control, and general user experience. Interviews were recorded, transcribed, informally analyzed, and used to inspire exploratory design iterations. These sessions led to several changes which all surrounded what I now understand to be a critical dimension for the interaction design of technologies aimed at prolonged engagement and general awareness in the context of subtle stimuli: participants' perceived sense of control.

Figure 11. A co-design participant discussing the initial prototype directly after use.

3.4. The Importance of Balancing Perceived Control

Much of the discussion which took place in the *Sonic Cradle* co-design sessions surrounded the topic of perceived control. The first few participants reported a decreased sense of control when using the system after several sounds had been summoned; they felt like their respiration was no longer having strong effects on the sound (i.e. "*After the third sound, I felt I had absolutely no control.*", "*I wish I could isolate the sound a bit more and control it.*"). While adding a first, second or even third sound led to a profound change which captured participants' attention, adding sounds beyond three seemed to have progressively less effect as the soundscape became much more crowded. This was critical, not only because the experience became less engaging over time, but also because stress is often associated with a perceived loss of control (Stoyva & Carlson, 1993). However, there were also comments suggesting that the lack of obvious, explicit controls helped participants focus in what seemed to be a meditative way (i.e. "*the sounds are ambiguous enough that there's no direct correlation, which helped you lose the desire to control it so much, stopping your thought.*", "*It wasn't as dramatic as I had expected, I expected*

to really be able to tell when new sounds came in but it was more subtle, I had to listen"). These testimonies suggested that too obvious a paradigm may place too much emphasis on intentional control. After a few more sessions, it became clear that systems focused on generating heightened focus on a subtle stimulus need to deliver a consistent sense of control to maximize engagement without rendering participants' perception of the mechanism too obvious. A certain level of ambiguity seems to help motivate prolonged engagement and heightened awareness through a sustained feeling of discovery. Throughout the ensuing sessions, iterative design exploration eventually led to the following improvements to the system which all relate to optimizing participants' perceived sense of control.

3.5. Specific Design Iterations

3.5.1. Spatializing Sounds

In order to help achieve a consistent sense of control no matter how many sounds are playing, I added a spatial dimension to the system: instead of playing all sounds from all speakers, the idea involved having new sounds come from new directions. Even if a few sounds are already mixing in a participant's environment, a new sound will be easier to notice and focus on individually if it comes from a new spatial direction. When several sounds are playing together, they will not all be mixed together digitally and then played on all speakers simultaneously; instead, they will come from different speakers and mix physically in the room, adding clarity and distinction to the sound quality.

3.5.2. Crowd-Sourcing Sounds for more Diversity

After co-design sessions, I felt the quality of individual sounds used in the first *Sonic Cradle* prototype also contributed to participants' decreasing sense of control. As I created all the sounds for the initial prototype myself, they were very similar in rhythm, pitch and timbre: this likely contributed to participant reports that multiple sounds seemed to blend together, making new sounds less noticeable. In response to this, I implemented a website which presented the basic concept of the system and enabled the crowd-sourcing of audio samples (**figure 12**). The website included a form which allowed contributors to directly upload their own interpretations of peaceful sound. I collected 39 sounds from a range of musicians and sound artists of different styles which ensure that stimuli remain diverse. With minor adjustments, the final prototype system enabled participants to progressively summon and shape field recordings, acoustic instruments, digital sound generators, abstract mash-ups, spoken word poetry and more.

Figure 12. Web interface used to procure crowd-sourced sounds for the system.

Note. The dark image to the right is a video which explains the basics of the project in order to provide context for sound contributors. The video included an activation code which was required to upload sounds, ensuring that all contributors had been properly briefed.

3.5.3. Enabling Sound Elimination

Most of the negative comments which were made during the co-design sessions were related to specific sounds. This should come as no surprise, as people typically hold quite diverse tastes in music (i.e. "*the very first sound, which was like a percussion instrument where you have break in between and harsh-onsets, kind of counteracted my attempts to relax*"). While there did not appear to be a pattern as to which specific sounds were annoying, the notion of being able to remove certain sounds from the system was alluded to by several co-design participants. In response, I implemented a control which enables participants to work backwards, progressively removing sounds from their environment through a series of short, rapid breaths. This not only gives participants the option to eliminate unpleasant sounds, but also enables them to manage their own perceived control in a way: they can simplify their sound environment if they feel lost and overcrowded.

3.5.4. Removing High Frequencies from the System as a Whole

Many of the negative comments related to specific sounds also pertained to loudness and abrasiveness. The common sentiment seemed to be that the system was pleasantly loud and engaging, but occasional

cacophonies became too abrasive. Several participants described the most abrasive moments as being high pitched, which translates to energy increases at higher frequencies. In my own subsequent exploration of the system, loud cacophonies involving high pitches were indeed rather unpleasant. To address this problem, I began to lower the high frequency ceiling of the system as a whole through trial and error, eventually settling on 1950 Hz as an appropriate number to maintain sufficient clarity while removing most abrasiveness. This change also aligned with many participant comments which communicated an appreciation of the deep bass and low drones of the system.

3.5.5. Biasing Control with a Central Tendency

As the system seemed to be the most sonically interesting and clear with a 4-6 sounds playing, I decided to add a variable to control parameters which subtly influences progression toward this system state. The fewer sounds that are currently playing in the system at any given time, the easier it will be to add a new sound (one must halt their breathing for less time). Conversely, when the number of sounds increases, it becomes easier to remove sounds (one must take fewer rapid breaths). In other words, the control paradigm was subtly biased with a sort of central tendency. This design decision was not only to help maintain a balanced number of sounds, but also to add a mostly unnoticeable variable which helps balance perceived control by avoiding too linear and predictable a system response.

3.5.6. Adding Feedback for Summoning Sounds

As another intervention to help foster a consistent sense of control, an audio feedback mechanism was implemented. As mentioned in the previous section, the system requires participants to hold their breath for a prolonged period of time in order to summon new sounds. However, early co-design sessions revealed that participants were often not able to remain perfectly still when holding their breath. In other words, a participant may think they are holding their breath and expect to summon a new sound, but their respiratory data reveals fluctuations and subtle exhalations taking place. Since the participant is not aware of these fluctuations, the system seemed unresponsive. I managed to correct this problem by adding feedback: when respiration is held completely still, a low rumble begins to sound, increasing in volume until the threshold for adding a new sound has been reached. When the rumble abruptly stops due to fluctuating breath, participants promptly tried again, seemingly aware that something had gone wrong in their attempt to summon a sound. A quiet meditative chime was also added to signify the exact moment when a new sound has been successfully summoned to the soundscape. The chime serves to provide feedback and also to prime a participant's attention, as it pre-empts the newly added sound from a new spatial direction.

3.5.7. Tweaking Participant Instructions

Since *Sonic Cradle* employs a novel interaction paradigm unfamiliar to participants, the way it is introduced will have a large effect on their perception and experience. Throughout the co-design sessions, I iteratively experimented with various verbal introductions to the system. I took the opportunity to explore what level of specific instruction would optimize the experience toward the goals of the system. Participants were briefed with varying levels of detail, spanning the range from no instruction at all to a comprehensive explanation of the interaction paradigm. As might be expected, a

lack of instruction led to confusion and even clear expression of a desire for more explicit instructions (i.e. "*when you attach sensors, that's telling me there is an interaction happening to some extent, and that there is some level of control … [that] could have been something that was brought more to the forefront initially*"). On the other hand, when instructions were highly specific, participants tended to think very semantically about the experience and intentionally control it; in some cases it even generated a goal orientation in usage of the system (i.e. "*I was trying to win ... I was trying to quickly initiate the sounds so I could see what it was like ... instead of trying to enjoy what was happening*", "*I would imagine you'd want to say less; explain the basic mechanism and that's it*"). The compromise turned out to be a few vague instructions surrounding the summoning and elimination of sounds. In the current protocol, participants are simply instructed that they can stop breathing to explore new sounds, and to breathe quickly when they feel lost and want to simplify their sound environment; the specifics of the interactive control paradigm are not divulged, again, to balance a vague sense of control with variations so subtle that attempts to logically decipher them quickly seem futile.

3.6. Informal Concept Validation

Throughout the 15 informal co-design sessions that were conducted there were also a lot of comments which, unbeknownst to participants, aligned directly with theoretical directions. As this was not a scientifically sound participant sample, I urge the reader not to over-interpret these trends as concrete findings; a more formal study with a purposive sample is presented in the next chapter. However, I thought it appropriate to dedicate a short, final section of this chapter to discuss a few promising trends from co-design sessions which seemed to connect *Sonic Cradle* directly to its theoretical underpinnings:

11 out of 15 co-design participants described the experience as 'relaxing' (e.g., "*I'm giving you lots of minutiae feedback, but the whole thing was overwhelmingly calming and relaxing*", "*It was pretty cool, I'd like to have one in my home, just to relax*").

9 out of 15 participants clearly alluded to a de-emphasis of intentional control and semantic thinking: (e.g., "*At first I was playing around with the controls ... but then after a while I just kind of realized that I had stopped doing that and was just breathing... in a way that I don't normally breathe*", "*At first ... I was thinking about it pretty hard and experimenting with it a lot, by the end I realized the best way to go through it was to not think about it so hard and just listen ... I kind of turned my brain off*").

10 out of 15 participants alluded to some perceptual experience akin to actively constructing an alternate world which aligns with the constructive framework of 'immersion' presented in chapter 2. *Sonic Cradle* seemed to inspire visualizations, disengagement with the physical world, and more (i.e. "*I was visualizing the ocean, the waves at dusk… it's a water-like experience … not from any specific sound, but the experience and low rumbles felt like a deep body of water*", "W*hen I was starting to get really into it, I stopped noticing the speakers and ... it just became sort of this reality that there was nothing beyond my breath and this noise... and eventually I wasn't even thinking about my breath anymore ...*

and that was where I got that floating in sound immersion feeling when I felt like I was pretty much one with the noise that I was making, I felt like it was all one thing").

Although most participants understood that the system had something to do with meditation in advance, it is interesting to note that 5 participants directly articulated why they thought the experience was meditative (i.e. "*It's an exploration using your breath, but you also start to explore the way your mind reacts to these things, and that's pretty meditative*", "*I've tried meditation briefly, but that felt like the ... best attempt ... there was this moment where I thought 'that's what meditation is all about' ... this 10 or 20 second window where my entire body was just numb and I thought 'whoa, what's happening here?'*"). Unfortunately, I did not probe co-design participants for information about their history and experience with meditative practices.

8 participants were asked what percentage of the time they felt they were entirely focused on the sound and their own breathing (as opposed to distracted in thought), and the average of participants' estimates was approximately 78% which translates to an average of 15 minutes and 36 seconds out of each 20 minute session.

4. Purposive Investigation of Sonic Cradle

4.1. Methods

After co-design sessions led to a new and improved prototype of *Sonic Cradle* (**figure 13**), I began to formulate plans for a more systematic investigation. 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 effects on perceived anxiety, parasympathetic nervous system activity, and stress hormones. However, any short-term stress relief detected through these methods 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 *Sonic Cradle*. However, my goal is not to simply create a new relaxation tool, but instead to determine whether an interactive medium has the potential to experientially motivate and demystify the practice of mindfulness meditation to promote 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. Alternatively, an attempt to instead investigate *Sonic Cradle*'s ability to influence users' thoughts and behaviour with respect to mindfulness meditation in the long-term would be a significant undertaking. Such an investigation would involve longitudinal tracking of participants' thoughts and behaviour over a timescale of months, or even years. Useful results would depend on adequate control conditions to separate different experimental factors well enough to draw robust conclusions. This type of in-depth study would require a large time commitment and a significant amount of resources devoted to studying a relatively novel artefact which has not yet been validated to have any relationship with the practice of mindfulness meditation: hardly a wise investment. I decided to first conduct an initial study aimed at exploring the subjective experience of *Sonic Cradle* as a springboard to justify and guide more in-depth analyses.

Figure 13. Photograph of myself suspended in the iterated version of Sonic Cradle.

Note. In this photograph, a light is turned on and the image is artificially brightened; normally the participant would be in complete darkness. A video explaining *Sonic Cradle* with clips from the co-design sessions described in section 3.3 is available at *http://www.jayvidyarthi.com/cradle*

4.1.1. Basic Interpretive Qualitative Study

In attempting to formulate an initial investigation which would be useful in determining potential avenues forward with this project, I decided to pursue the following research question: **could a human-computer interaction design like *Sonic Cradle* trigger subjective experiences of mindfulness?** Such evidence would not only motivate further research, but also help guide and inform methodological selection and quantitative experimental design. If *Sonic Cradle* can be shown to consistently generate subjective experiences which align with contemporary academic understanding of mindfulness, we can confidently proceed to investigate its potential as a therapeutic tool for acute stress therapy, as a 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, collecting quantitative or qualitative data, and whether to focus on acute or longitudinal studies. In pursuit of conclusive evidence regarding the subjective experience of *Sonic Cradle* users, the phenomenological philosophy underlying all qualitative methods makes them 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), I would argue that a lack of well-developed and accepted instruments suggests that rich qualitative interview data is better suited to first capture whether experiences in *Sonic Cradle* reflect the complex, nuanced phenomenon of mindfulness. Our research goals motivated the selection of a basic interpretive qualitative methodology as defined by Merriam et. al. (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."

4.1.2. Quantitative Triangulation

While a qualitative methodology will be sufficient to justify deeper investigation, it will not provide any indication of preconscious effects, physiological changes, or any other objective constructs in general. In pursuit of such findings, physiological indicators can be used for triangulation. There exist physiological measures which could be quite directly indicative of *Sonic Cradle*'s effects with respect to autonomic nervous activity, stress levels, and more (i.e. heart rate variability, salivary testing of stress hormones, skin conductivity, electroencephalogram, etc.). However, the ability to generalize findings from quantitative analysis strongly depends on a random participant sample and an appropriate control condition. While a random sample would optimize the external validity of any statistical conclusions, qualitative research tends to be most effective with a purposive sample: *"since qualitative inquiry seeks to understand the meaning of a phenomenon from the perspectives of the participants, it is important to select a sample from which the most can be learned"* (Merriam et. al., 2002).

Since my priority is the analysis of subjective descriptions of the *Sonic Cradle* experience, I ultimately chose to use a purposive sample. This decision limits the usefulness of statistical conclusions to the triangulation of the present sample: they will only be able to provide a secondary, physiological source of insight into qualitative findings with very little external validity. This limitation clearly suggests that any investment of time and resources on a complicated hardware setup for physiological measurement or meticulous control conditions should be made in a later study with a randomized sample. However, *Sonic Cradle*'s technical setup already involves physiological sensors which can provide us access to quantitative respiratory data with no additional setup. This is of particular interest since altered resting respiration rates have been correlated to the general dimensions of emotional response (discussed in the next section). Without any additional or invasive hardware, I will be able to collect data and compare each participant's resting respiration rate before and directly after their experience in *Sonic Cradle*, enabling statistical conclusions which – although tentative, specific, and lacking control – can support or refute qualitative findings on the dimensions of emotional valence and arousal. If both sources of data corroborate an account of significant and relevant effects on participants, future studies

should commit resources to the controlled investigation of physiological indicators and psychological questionnaires using a random participant sample.

4.1.3. Hypotheses

While certainly the ideas which constitute *Sonic Cradle*'s interaction design set a certain level of expectation and bias, the potential complexity of subjective experiences tends to discourage the forming of explicit hypotheses for qualitative methods. However, as Sonic Cradle pursues the specific design goal of cultivating an experience of mindfulness in non-practitioners, I feel it is appropriate to assert this as a loose design hypothesis; I will compare qualitative findings to subjective elements of mindfulness as depicted in academic literature (Forte et. al., 1987; Kabat-Zinn, 2003; Kabat-Zinn, 2006, Lutz et. al., 2006; Kang & Whittingham, 2010; etc.). As for the quantitative resting respiration data I have chosen to collect for triangulation purposes, a more traditional hypothesis is appropriate.

Boiten et. al. (1994) surveyed a wide range of literature in an attempt to validate the notion that changes in resting respiration are somehow linked to emotion. Although many studies, especially older ones, are wrought with methodological limitations, the authors present a series of tentative general conclusions which *"show an appreciable amount of consistency across studies"* (Boiten et. al., 1994). While there are more appropriate physiological measures for rigorous analysis of *Sonic Cradle*'s effects on a random participant sample, the link between resting respiration and emotion suggests that this readily-accessible respiratory data will enable some crude triangulation of qualitative findings from our purposive sample. As depicted in **table 1** (which I constructed based on Boiten et. al., 1994), fast and deep breathing at rest is associated with states of excitement characterized by *"undirected, aimless behaviour under conditions in which directed action is blocked or restrained"* and *"enhanced readiness for action."* Fast and shallow breathing is associated with *"effortful and stressful mental task performance"* and *"a range of affects varying from concentration, resolution and determination, through tension, to anxiety and fear, and maybe ultimately, panic."* Though slow and deep breathing has insufficient data *"to draw solid conclusions concerning [its] behavioural and emotional correlates,"* this respiratory pattern *"is most often encountered in relaxed resting states."* Slow and shallow breathing is associated with *"emotions like passive grief and calm happiness,"* being *"found in [non-clinical] depression, during calm pleasurable experiences and during states of relaxation."*

Table 1. Emotional Correlates of Resting Respiratory Depth and Rate

	Shallow Breathing	**Deep Breathing**
Slow Breathing	*"found in [non-clinical] depression, during calm pleasurable experiences and during states of relaxation"*	*"most often encountered in relaxed resting states"*
Fast Breathing	*"effortful and stressful mental task performance"*	*"enhanced readiness for action"*

Note. This table is based on Boiten et. al.'s (1994) review paper about resting respiration and emotion.

When depicted visually in **table 1**, Boiten et. al.'s (1994) review of previous research seems to suggest a dimensional relationship between respiration rate and emotion. Increases in breathing rate seem to reflect heightened levels of behaviour and thought, while decreases seem to correlate with reduced behaviour and thought. Changes in respiration depth seem to indicate a modulation of this effect, with deeper breaths associated with healthier psychological states of being like relaxation and readiness. In another section of their review paper, Boiten et. al. (1994) also claim that thoracic-to-abdominal ratio can help us interpret *"hedonic tone (variations along a pleasantness-unpleasantness dimension)"*: reductions of this ratio are correlated *"to pleasant emotional states or relaxation"* while increased thoracic-to-abdominal ratios are correlated with *"unpleasant affect, tenseness or anxiety."*

If *Sonic Cradle* is able to achieve its goal of encouraging experiences of mindfulness, I hypothesize that, first and foremost, participants should have a slower resting respiration rate after their session when compared to before. Further, deeper breathing would suggest a healthier psychological state, and a decreased thoracic-to-abdominal ration would imply positive affect. These findings would imply the need for more controlled study of physiological stress correlates, as the present study is only valuable to reinforce qualitative findings; our measures are severely limited in external validity due to a lack of control and use of a purposive sample.

4.2. Apparatus

The final prototype implementation of *Sonic Cradle* used for investigation was installed in a dark, quiet, and windowless room at *TEDActive 2012*, a conference which took place at the *Riviera Resort & Spa* in Palm Springs, California. The room had no windows and good ventilation, although the ventilator made an obnoxious noise which had to be muffled with insulation foam. A hammock-chair from *Island Chairs* was suspended at a comfortable height with enough room to freely rotate approximately 270° when a participant's feet were also suspended in the chair's built-in footrest. A large subwoofer was installed below the hammock chair and four *Mackie MR5mk2* studio monitor speakers were set up on stands in

the four corners of the room. The room was almost completely dark when the lights were turned off. The only source of light was under the entrance door, a problem I solved by installing a skirt to block the light when the door was closed. Finally, there was a small bell left nearby in case a participant wanted to end their session early; this bell was never rung.

The *Sonic Cradle* software implementation was a *Max/MSP* patch (**figure 14**) which collected data from a custom bridge application which retrieved respiratory biofeedback data from a proprietary software package called *Biograph Infiniti* (*Thought Technology*). This software package obtained respiratory data from two strain gauge sensors (*Thought Technology*'s *SA9311M* connected to their *ProComp2* encoder; 32 samples per second) which were attached to participants' abdomen and thorax in order to measure respiration through chest expansion. 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 lung position was calculated as a percentage of that participant's deepest lung position so far. If the participant took 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 the system no matter how tightly the sensors were attached or how deeply the participant was able to breathe.

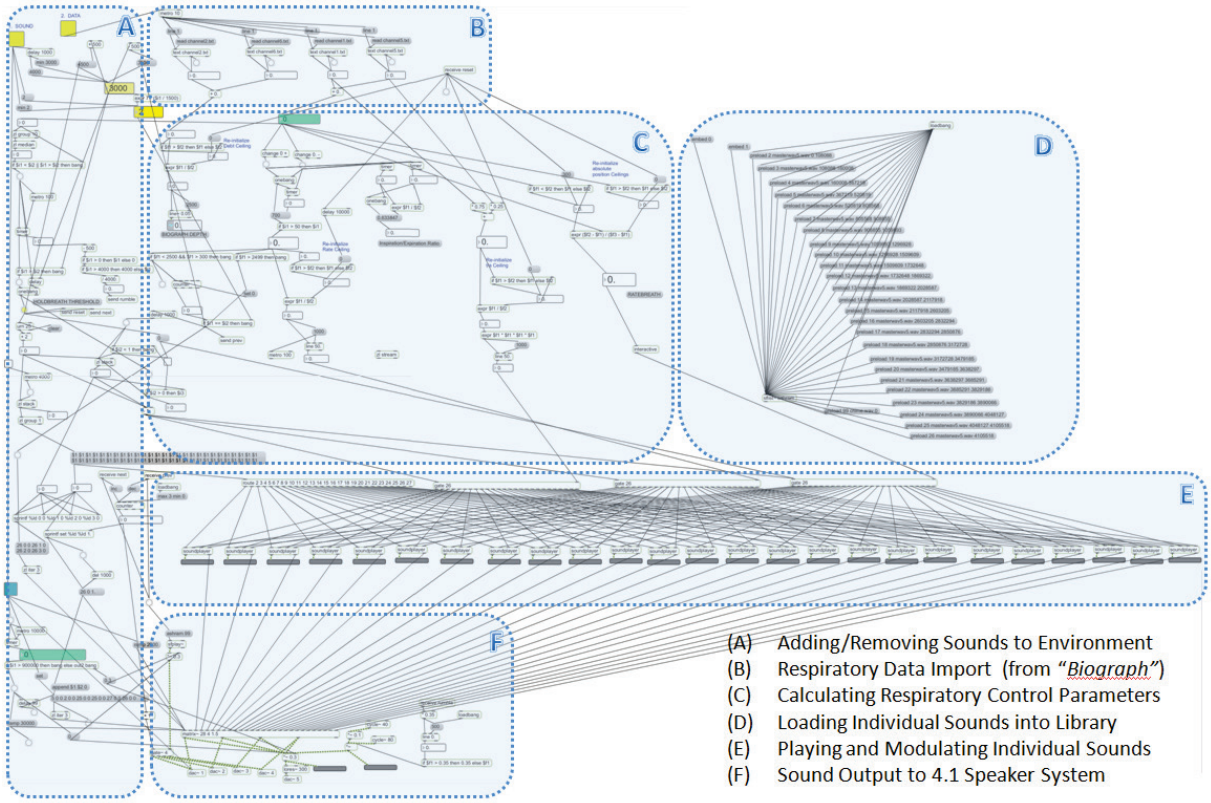

Figure 14. Annotated structural overview of Sonic Cradle prototype Max/MSP patch.

Note. Although specific elements of this code are illegible, the annotated regions of this image provide a structural overview of the main software algorithm of the prototype; there are also three external patches concerning sound output which are referred to in the code but not depicted in this figure.

Respiratory parameters pulled from the biofeedback system were used to control the 4.1 speaker system surrounding participants. After implementing the design iterations based on the co-design sessions outlined in the previous chapter, our final *Sonic Cradle* prototype had the following controls in place:

- When lungs are suspended for 4 full seconds, a new sound is summoned. For each sound that has already been summoned by the participant, the time required to suspend breathing increases by 0.5 seconds, 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 seconds to summon a 4^{th} 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 seconds 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 seconds 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 minutes have elapsed, the system engages in a slow, progressive fade-out to silence.

4.3. Participants

The progressive nature of the *TEDActive* conference's focus on technology, entertainment and design attracts people who are generally open-minded to novel interactive media. During the conference, I was able to run sessions with 39 volunteer participants – 24 males and 15 females – who were attracted through signage, sign-up sheets and word-of-mouth. I asked participants about any respiratory problems in advance to ensure they were not at risk of discomfort or pain resulting from prolonged exposure to the respiratory control paradigm. Further, the conference organizers had a rigorous screening process in place, evaluating whether attendees were proactive contributors to their communities. While this selective admittance to the conference would bias any attempt to treat our sample population as random, it makes for an excellent purposive sample for our qualitative investigation; these 39 participants represent a selection of individuals who likely have more responsibilities than average. Participants who have a lot on their mind – and thus are likely to need and value psychological self-regulation – are an appropriate source of qualitative data for an exploration of whether interactive media can encourage experiences of mindfulness. Unfortunately, since attendees' had paid to attend the conference, I was instructed to ensure that their experience in *Sonic Cradle* did not feel like a dry research study; I was not able to collect detailed demographic information. I was also unable to procure specific screening criteria used by conference organizers. However, many participants confirmed that they were busy people by spontaneously alluding to very active personal and professional lives during their follow-up interviews (i.e. different participants self-identified as CEOs, successful artists, lawyers, agency executives, professors, engineers, event planners, PR agents, and more).

4.4. 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. Participants were then misled to wait patiently while the system was supposedly being calibrated. In actuality, the respiratory sensors were using this time to actively measure resting respiratory parameters for 1 minute: duration, depth, and thoracic-to-abdominal ratio.

Based on findings from co-design sessions, participants were then briefed on the system's control paradigm in a way which was suggestive yet vague:

> "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 minutes, 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 and participants were left alone in the room for 15 minutes while they explored the system. When the session was over, participants were again misled to wait patiently for technical reasons while the system measured their respiratory parameters again for 1 minute. 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 didn't 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 hasn't 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?

4.5. Data Collection and Analysis

After the study, I was left with 39 sets of data which included audio recordings of each participant's follow-up interview and a collection of resting respiratory parameters recorded both before and after their experience in *Sonic Cradle*. This section describes how the data was collected and analyzed.

4.5.1. Qualitative Analysis

Audio recordings of the interviews were captured using the *Evernote* application on an *Android* mobile phone. These recordings were then transcribed manually to text format in *Microsoft*'s standard *Notepad* application 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 and due to prior conversations during the conference.

At this point, each of the remaining 34 participants was 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, I included the regular practitioner in with the second group and divided the data into two analytical groups: those with *no meditation experience* and those with *some meditation experience*.

Once the raw data was grouped accordingly, it was broken down into granular bullet points which each described an individual, relevant piece of information. At this point, each group's complete set of data was progressively coded and re-coded into major clusters. Throughout the process, these clusters changed shape and name, dividing and joining into a wide range of themes. Eventually, the majority of relevant data from each group was organized into main themes which seemed to lie on a very useful level of abstraction. Attempts to maximize the usefulness of these data clusters inspired much

deliberation on my own reflexivity in this study: how were my own experiences with music, meditation and the creation of this project itself influencing my qualitative data clusters? To address this concern, I recruited two external data coders to maximize the reliability and internal validity of the study.

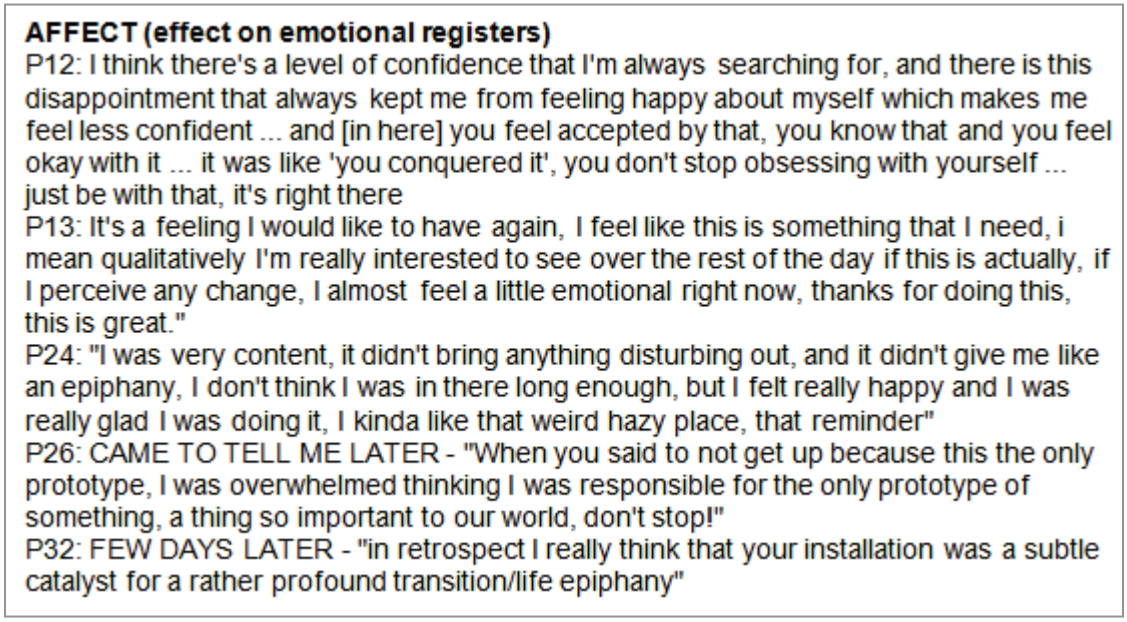

Figure 15. An example data cluster contributed by data coder C.

Note. 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.

For reference, I will consider myself as data coder A. One external data coder, who I will call data coder B, had no experience with qualitative methods or *Sonic Cradle*; she was provided with a basic (non-theoretical) explanation of the artifact and participant procedure, a datasheet for each group organized by participant, and basic instructions on how to code them into useful clusters. The second external data coder, who I will call data coder C, had extensive experience with qualitative methods and had tried an early prototype of *Sonic Cradle* as a participant in our co-design sessions. She was provided with both datasheets and instructions on what was required of her. Both external data coders were financially compensated $300 for their time.

After receiving finished data codes from both external coders (**figure 15**), I was left with six different datasheets: each of three different coders (including myself) provided data codes for those with *no meditation experience* and data codes for those with *some meditation experience*. At this point, all clusters which represented the comments of less than 3 different participants were removed in the pursuit of consistent findings, and datasheets for each group were compared and contrasted to determine overarching themes for that group. I gave the label of ***primary themes*** to those clusters which were agreed upon by all three coders, ***secondary themes*** to those which were agreed upon by two coders, and ***tertiary themes*** to those which were only identified by one coder (these can be said to 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 my part; I made every attempt to maintain an objective stance in this process. **Table 2** shows comprehensive results of this analysis including primary, secondary, and tertiary themes for each group. As can be seen in both **table 2** and **table 3**, 11 out of 14 *primary themes* were present across both analytic groups, confirming my 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 validity.

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. This is why the findings presented in section *4.6* (including **figure 16** and **table 3**) do not include secondary or tertiary themes.

Table 2. 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. I made an attempt to horizontally align similar themes across both groups; there are a striking number of aligned primary themes across these mutually exclusive groups, making them more compelling.

4.5.2. Quantitative Analysis

Respiratory parameters were collected both before and after each participant's session through an adapted version of the *Sonic Cradle* application. Instead of running for a full session and using respiratory data to control the system, this adapted application ran for only 1 minute and wrote respiratory parameters to an external file labeled in sequence. At the end of the study, I was left with a single file which contained labelled datasets for a 1 minute series of breaths both before and after each participant's session. The collection contained both temporal measurements and depth measurements of each breath during the 1 minute recording time. The amount of time spent on each inhale and exhale was used to calculate the overall respiration length for each breath. Relative measurements of depth from each independent sensor were used to calculate a thoracic-to-abdominal ratio indicating the degree with which each breath was being taken in the chest or stomach. *Biograph Infiniti* comes with a built-in algorithm for depth measurement based on chest expansion (a deceptively complex parameter to extract from a strain gauge, as different participants tighten the straps to varying degrees). The data for each parameter was compiled into an average for each participant before and after the session which was then used for statistical analysis.

Since the study did not involve a random sample of participants, the goal of this quantitative analysis was to complement qualitative findings, providing a physiological source of confirmation for participants' subjective trends. For this reason, participants who were removed from qualitative analysis due to biases were also removed from the quantitative dataset (P2, P19, P21, P33, and P37). Data capture errors resulted in the complete loss of quantitative data from P4 and P36, as well as partial data loss from P35, P38 and P39. The remaining data were transferred into *IBM*'s *SPSS*, where they were organized by participant for each respiratory parameter on a dimension of time (before vs. after). Again, since these data were being used to triangulate qualitative findings, I also added a second dimension based on participants' self-reported meditation experience: each participant was organized into either the *no meditation experience* or *some meditation experience* group. I employed a two-way mixed ANOVA for each respiratory parameter: meditation experience was treated as a between-subjects factor and time (before vs. after) was treated as a within-subjects factor. The goal of these ANOVAs was to determine any dimensional significances or interaction effects which could be interpreted through existing research on correlating resting respiration to emotional valence and arousal (Boiten et. al., 1994; as presented in *4.1.3*).

4.6. 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 mutually exclusive groups. In other words, the majority of primary themes involved all three independent coders including a minimum of 6 individual participants, and often much more (**figure 16** provides a visual glimpse of findings while **table 3** provides detail). Traditionally, qualitative researchers contextualize

findings with theory as they are presented; however, the present findings overlap in such a way that theoretical interpretation will be easiest to understand if all qualitative results are presented first. Discussion of these results is included at the end of this section (*4.6.15*). Further, I have opted to present a rather comprehensive collection of participant quotes for each theme which will help exhibit the nuance and striking uniformity of participants' reports of their *Sonic Cradle* experience.

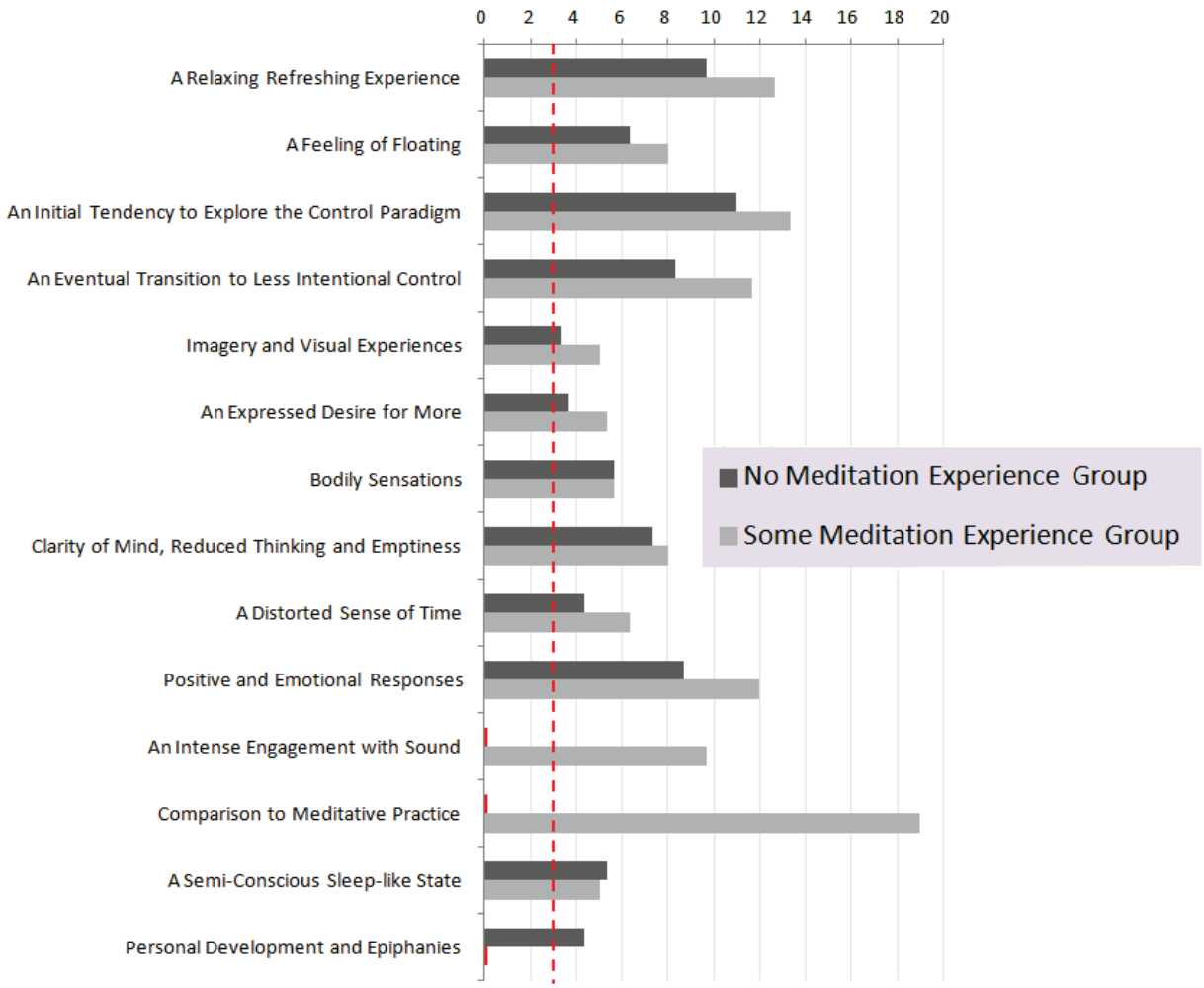

Figure 16. Average number of participants coded within primary themes by group.

Note. The red dotted line indicates the threshold for clusters 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). Just as in **table 3**, the subjective nature of qualitative data implies that numeric data should not be used to interpret any kind of effect size. Instead, they merely provide a glimpse into qualitative data and its subjective coding.

Table 3. Number of participants included by each coder in primary themes / groups

Primary Themes	**No Meditation Experience Group** (n = 14)	**Some Meditation Experience Group** (n = 20)
A Relaxing, Refreshing Experience (*4.6.1*)	(A9-B11-C9)	(A15-B9-C14)
A Feeling of Floating (*4.6.2*)	(A7-B6-C6)	(A11-B4-C9)
An Initial Tendency to Explore the Control Paradigm (*4.6.3*)	(A13-B10-C10)	(A12-B14-C14)
An Eventual Transition to Less Intentional Control (*4.6.4*)	(A13-B4-C8)	(A15-B12-C8)
Imagery and Visual Experiences (*4.6.5*)	(A4-B3-C3)	(A5-B5-C5)
An Expressed Desire for More (*4.6.6*)	(A5-B3-C3)	(A8-B5-C3)
Bodily Sensations (*4.6.7*)	(A6-B5-C6)	(A6-B4-C7)
Clarity of Mind, Reduced Thinking, and Emptiness (*4.6.8*)	(A9-B4-C9)	(A9-B7-C8)
A Distorted Sense of Time (*4.6.9*)	(A4-B5-C4)	(A7-B4-C8)
Positive and Emotional Responses (*4.6.10*)	(A11-B10-C5)	(A13-B11-C12)
An Intense Engagement with Sound (*4.6.11*)	**X**	(A10-B6-C13)
Comparison to Meditative Practice (*4.6.12*)	**X**	(A19-B19-C19)
A Semi-Conscious, Sleep-like State (*4.6.13*)	(A9-B4-C3)	(A4-B3-C8)
Personal Development and Epiphanies (*4.6.14*)	(A5-B4-C4)	**X**

Note. Each field includes the number of participants included in relevant clusters by independent data coders (A, B & C). For example, data coder B included 11 participants with no meditation experience and 9 participants with some meditation experience (a total of 20 participants) under "A Relaxing, Refreshing Experience". All active fields represent a minimum of 3 participants from each independent coder; fields which are grayed out with an "X" represent situations where there is no primary theme because at least one coder included less than 3 individual participants. Due to the subjective nature of qualitative data, they are not to be interpreted with any kind of effect size. Instead, they merely provide a glimpse into qualitative data and its subjective coding.

4.6.1. A Relaxing, Refreshing Experience

The experience of *Sonic Cradle* involves a very comfortable suspended hammock, soothing music, elements of sensory deprivation, and a respiratory biofeedback paradigm which motivates deep breaths. With these individual components, it should come as no surprise that many participants described the experience as relaxing. P1 and P13 both used the phrase *"super relaxing"*, while P14 went as far as describing the experience as not only relaxing but *"womb-like"*. 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."

P24 described the experience as *"soothing but stimulating at the same time"* and P29 referred to it as a *"soothing transcendent musical experience"*. While descriptions of the experience as relaxing were fairly ubiquitous in qualitative interview data, it is worth noting that the participants with some previous meditation experience were more 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,"* claiming that the end of the experience *"was a nice feeling"* after going *"through that middle part, that digestion"*. P10 expresses this element of the experience more directly:

> P10: "I actually have been exhausted [lately] ... but it was replenishing and revitalizing in a lot of ways."

P27 described the experience as *"a really needed checkout ... like a shot of fuel."* P15 even expressed surprise at his own refreshment:

> P15: "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, but like a super uber power nap."

Another participant gives a more intimate level of detail by comparing the experience to his personal source of revitalization:

> P8: "I swim, and after I do a couple of laps ... I [swim 50 meters completely] underwater ... and then when [I] get up, because of the lack of oxygen, [I] get this kind of rush of tranquility... when [I] resurface, people have told me that they see my body shaking. You're breathing really slowly ... and you have this kind of orgasm somehow, this rush of energy, revitalizing energy that rushes form head to toe in like 3 seconds ... here [in Sonic Cradle], let's say I was feeling at the end so comfortable that I was [similarly] revitalized at a very slow, [less intense] pace."

4.6.2. A Feeling of Floating

When participants were asked if they would compare *Sonic Cradle* to other experiences they've had, one would expect diverse life experiences to lead to a wide range of responses. This was the case to a certain extent as unique, personal comparisons were indeed shared:

> P18: "I've climbed up a mountain in the middle of the night before and [lay] down with friends and looked up into the stars, listening to nature ... that was a comparable feeling of calm and environmental response to you."

Other participants likened the session to previous experiences with long bike rides, other installations, hallucinogenic drug use, sensory deprivation tanks, and massages, while P6 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:

> 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."

A few participants explicitly placed their experience of floating as occurring in space:

> P9: "There was a cosmic moment of transcendence when I went off into a galactic thing."

> P16: "I would probably say it was like a trip to outer space. I swear to god, when it was ending I was like 'I wanna stay in outer space'!"

> P23: "This is more like floating in space then floating in water, in part because it's dark."

> P25: "I would describe it kind of like floating in space. In outer space, that's how I imagine it would feel."

However, the vast majority of comparative description situated *Sonic Cradle* as an experience intimately related to floating in water:

> P6: "[It's like] when you swim in the ocean or sea or a larger body of water, and you're underwater and you're snorkeling, you're very conscious of your breath because it resonates through your snorkel, but then you also hear every other sound. A boat goes by, fish are darting along, people are splashing somewhere. Because you're floating and calmly moving along, it's sort of a meditative 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, like passing your hand through a bucket of water. It's not like having an ore, it's like being able to push them rather than actually 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."

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."

P12: "Definitely [felt like] floating, you're underwater, some of the sounds felt underwater, part of the [feeling of] floating, I guess."

P14: "The very first time I scuba dived after I got certified and went about 100 feet deep, it was just so quiet, quiet like I've never had ... I almost stopped breathing underwater for a second because it got so relaxing. In here, it was almost one of those experiences again, like it was so incomparable to something I've experienced before ... you almost forget that you're supposed to keep breathing."

4.6.3. An Initial Tendency to Explore the Control Paradigm

When placed into the *Sonic Cradle* with instructions to control sound through respiration and two strain gauges tied around the abdomen and chest, participants typically spent time exploring and playing with the system's controls. Many participants clearly described this type of engagement at the very beginning of the experience:

P1: "At the beginning, I wanted to know what I could do, how I could influence the sound. Trial and error, is it my stomach or chest? Is it holding my breath and moving my stomach? How do I compose the symphony I hear in my ears?"

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."

P22: "The first half I was just kind of playing with it, even the first 5 minutes not even understanding, not trying to figure out but playing with the effects of it. After a while I could control it, and understand what different effects I have by breathing. I definitely felt in control of the sound, [but there was] a lot of randomness."

P26: "At the beginning I was dealing with the interaction a little bit, understanding how it goes."

P30: "Probably because of the novelty of it, at the beginning I was sort of playing like speeding my breathing or slowing it and seeing how the sound would respond."

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:

> P14: "I think I ... didn't understand right at the beginning when I started how I could control the experience with my breathing, so as I got closer to, I guess, where the middle would be, I got better at controlling the experience a little bit, which I found really interesting."

> 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."

> P32: "Probably for like [the first] third of the experience or half the experience I was thinking about [a contradiction in the controls] when I probably shouldn't have been thinking about it, and then I was thinking okay I'm going to just test it, I just want to see how responsive it is, I want to see how much feedback there is and get an idea of the parameters of the system ... and then I was able to realize that there was real-time feedback and it was responding to how I was breathing even though I had a counter intuitive map of how I thought that response should happen."

4.6.4. An Eventual Transition to Less Intentional Control

While the first half of sessions were mostly spent exploring the control paradigm, there was a clear transition away from this approach in most cases. Although expressed differently by different participants, the majority of people reported an eventual halting of intentional control. P32 was especially articulate in communicating this loss of intention:

> P32: "Right at the end I got into a zone where I let go of my preconceived idea or the notion I had to understand why, and then I got to an equilibrium place where I wasn't thinking about controlling it, I wasn't thinking about how complex or uncomplex [the sound] should be, 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 ... at the end of the experience, I didn't have to think about thinking."

While not all participants were so articulate on this matter, many referred to such a transition using different words, including those who described themselves as intentionally exploring the control paradigm early in the session. P4 got *"totally into … going along for the ride"*, while P5 *"let everything come naturally."* P9 described *"a holy moment of more pure being,"* which is a significantly more dramatic description than P10 who abandoned his intentional control and *"got into a groove."* P11 summarized the end of the experience using the word *"surrender"*, an idea P24 elaborated in a description of how she *"just sort of surrendered to it … first figuring out the mechanics of it, then ultimately disappearing into a place where [she] wasn't fully conscious."* Despite all these different descriptive words, there seems to be an underlying theme of a transition from intentional control to

what P39 called *"drifting off in a hypnotic way."* Several of those who had prior experience with meditation – and even a few with no meditation experience – explicitly described this state as meditative:

> P6: "You start out with your breathing, then you get used to the sights and sounds and you just kind of go along with it, and it becomes very meditative."

> P22: "I could see myself in that mode, after that second phase, I could see myself actually using this to meditate."

> P36: "In the middle it was more meditative ... I stopped trying to [control] ... when I let go I realized the intensity of the sound just sort of, more intense, and I just lost myself, I guess. That was much more pleasurable and I found myself smiling a lot."

One of the most interesting aspects of this theme was that, although the interview question asked participants to divide the experience into a beginning, middle and end, many responses clearly expressed only 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."

> P22: "The first [phase] was like a first introduction, and the second phase was more meditative."

> P34: "I guess at the beginning I was more just trying to assess how it was working, what's going on and that sort of thing. The middle I'd say was more kind of going with whatever was going on, and the end was more just seeing where it goes." [Interviewer asks difference between participant's state at middle and end] "I think it was similar."

> P38: "[I] can't really distinguish the middle from end."

Although this state of less intentional control was an overarching primary theme, it is important to note that not every single participant experienced such a transition; three participants in particular found themselves mentally activated instead:

> P15: "I felt like I was clutching for something ... I felt like there was something, I felt like every time I tried, and I was like 'ooh ooh that!' and then it would like, kind of, disappear."

> P28: "I found it very counter-intuitive, to calm the music I had to activate my breath and to activate the music I had to calm my breath, so I found myself thinking a lot."

> P38: "I was able to focus at the beginning but more distractions came at the middle and end."

4.6.5. 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:

> 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 ... I'm not saying I really saw something but more like [in the mind's eye]."

> P9: "A little vision of galaxies and space ... I was kind of like in a planetarium like vibe, but open. I was getting that vibe from the sound, relaxation. I was feeling galactic."

> 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, which I've never experienced when I've meditated before ... It's almost like when you look at those pictures that have a hidden picture when your eyes go out of focus, my eyes were in that state but I was seeing, like, stars, which was pretty cool."

This induction of visual experience was a particularly surprising finding, especially when participants were able to describe their visions to high levels 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 that came in. Kind of this mostly green I was trying to see it through the grey. Every time I tried to see it through the grey, like I wanted to move the grey out of the way, the green went away."

> P16: "You know when you close your eyes and you can see light and colour? ... There was this orange orb and then it sort of turned purple ... it was a circle and then it would stretch apart like silly putty or something, like an amoeba."

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

> P6: "Where the music went, it somehow reminded me of [a scene from 'The Usual Suspects'], I haven't seen or thought about that movie in years, [yet] I totally re-played that entire scene in my head ... down to the camera cuts, dialogue ... [that scene] is totally my mental picture of what calm looks like."

> 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, happy moments, almost like the last 5-6 minutes at the end ... [the system] seemed to evoke very visual memories or moments related to things that have nothing to do the conference or what's happening

at work today but things that rest on your mind that you don't often think about day to day."

Two participants reported that their visual experience was so powerful that it overtook everything else, defining the experience for them:

> P25: "In the middle I was continuing to focus on my breath, but I was more interested in what I was seeing in my visual experience ... I had a visual experience as well ... Towards the end, I was so focused on my visual experience and realized that I had totally forgotten to pay attention to my breathing ... [but] I was [still] trying to maximize the complexity of the music pretty much the whole time."

> P26: "Amazing, at certain points, maybe because of the different sounds, I began to see things, like shapes, I was thinking that I have the eye open, it was like shadows, something like this, with closed eyes ... Never happened to me, except in a dream. It was related with the sound, it was changing. And then [in the middle] I relaxed, and then that [visual] thing happened so I leave myself, I fully, I don't know how to say in English, but I go for the feeling you know? Let all my thoughts go with that images ... the story was, I was thinking about this thing, then at a certain point relaxed and began to see things ... I like a lot music, I close my eyes, even when I go to ... the best concerts I have been, I don't remember anything, but I have never seen shapes. So I think that is so amazing for me, for someone that is musician, that is like 'whoa'."

4.6.6. An Expressed Desire for More

In order to provide a reasonably deep experience of the system while still enabling a large participant sample, I decided to run 15 minute sessions at the conference. After the experience, many participants claimed that they would have appreciated a longer session:

> P1: "You could sit in here for an hour."

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

> P10: "It was great, very relaxing, I could have used 30 more minutes, I didn't want to come down."

> P13: "Towards the end I started to return to conscious thought thinking 'I hope this isn't going to end soon' ... I would have been in here longer."

> P15: "The end when it started going down, I felt like I wanted to reach toward it, there was something, I wanted to keep going."

> P31: "At the end it was like 'oh my god it's going to end now', I didn't want it to end."

P36: "[the end was] like if you were dreaming and you start to wake up and you become aware that you were dreaming and you want to get lost in the dream again."

This desire for a prolonged experience was particularly striking, as all participants were in the system as opposed to enjoying *TEDActive*: an exciting and engaging conference taking place at a beautiful resort. Other participants expressed a desire for deeper engagement with the system through an interest in more sessions and home installations:

P6: "I would do it again."

P11: "It was great, like I said I'm probably fairly typical in that I just don't get enough time to do this kind of thing."

P13: "It's a feeling I would like to have again, I feel like this is something that I need."

P27: "For someone like me who is type A and stressed out with three kids, I totally would let go [if I had this in my home]."

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 list. But no, this is the list. That is a piece that probably would be unique to me."

4.6.7. Bodily Sensations

A small but clearly present group of participants reported bodily sensations while experiencing *Sonic Cradle*. While there was neither an overarching consensus on the nature of the sensation, nor a majority of participants who felt such an effect, all three qualitative data coders grouped comments referring to the body together. The major effects seemed to be illusions of motion and displacement:

P6: "I know I wasn't rotating because I saw my feet, but with my eyes closed I felt slow counter clockwise rotation."

P13: "It felt like I was moving side-to-side even though I knew I wasn't. I didn't feel connected to the ground."

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 [my waist] down was lower than the ground. I know I wasn't in the floor, but it felt that way for some reason, I don't know why. When I started coming out of it, I felt really deep."

P23: "I felt like I was actually moving back and forth ... [an] illusion of motion [which] kind of dissipated away when the music changed."

> P25: "I felt like I was moving, I had my eyes closed, and every now and then I opened my eyes to see where that blue light [on the computer] was, and it was in the same place, which was weird 'cause I kept feeling like I was moving around, like physically."

While not related to the body, the aforementioned motion illusions depict P5's feeling of disorientation as relevant:

> P5: "Two-thirds in, I got this feeling of not knowing up or down: disorientation. It was really cool ... The first third I kept thinking of ... where a sound was located, but at the end everything kind of blended together, I lost spatial awareness."

Interestingly, a few participants who all happened to have no previous meditation experience described forms of numbness and loss of embodiment:

> P12: "My body was numb ... it's a 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."

> P15: "My feet got numb and my chin got numb and my pinkies got numb. My jaw and cheek went very slack, and I couldn't feel my chin, and for some reason both of my pinkies went numb."

> P36: "It seems really [conducive] to get lost in the sound a bit, and kind of feel detached more from my body in a way. I guess when I say that I felt more detached from the body, that's not exactly accurate, I also sort of felt this body high, very pleasurable, I guess, sort of in this like sexual way, like right before or after an orgasm, but kind of like a constant buzzing high feeling, I guess? ... I think it's just feeling the music in a way that flows through you, I guess just, in a vibrational kind of way, not feeling to understand tactile difference between your body and a surface, but feeling in the sense of being united with or aware of all the senses around you, I guess that's how the body sensation was to me ... I was feeling enraptured and lifted and kind of cradled in a cocoon of sound, yeah like a meditative cocoon of sound ... I thought it would have been nice to be suspended [with my arms more outstretched], I wanted to feel completely like I didn't have to be aware of my body touching anything."

4.6.8. Clarity of Mind, Reduced Thinking, and Emptiness

A majority of participants described their experience with reference to a reduction of thought, in general. P13 perhaps most clearly articulated this element:

> P13: "It became just something that was filling my auditory nerve but without having an impact on my head, so it did give the sense of sensory deprivation. I'm floating [and] my ears are being filled with stuff, but it's nothing I can hang on to, so it just forced me to be completely in my head. I'd say that it essentially let me empty my mind. I'm an entrepreneur, I own a company, I have all the stress of owning a company, and in that environment you're

never off work, you're always worrying ... it's very rare that you ever find that type of peace, and I don't know if peace is the right way to describe it, 'cause peace feels to me like a conscious thing, like you're finding a state of tranquility, and 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, that's probably how I'd describe it."

Many participants alluded to such diminished levels of thought:

P5: "My thoughts were blank ... I felt myself thinking less and less as the whole thing progressed."

P18: "I had no sense of time or space and I was in harmony with breathing ... [it was] kind of an environmental experience that ... touches multiple senses. It relates to you in a way that helps you remove thinking, focusing your own thoughts. From my perspective, there's rarely a moment that goes by that I don't have 10 different things on my mind that I'm attending to. [Especially] the past few days/months of extreme levels of business where you don't actually relax in the same way as I felt relaxed in the past 10 minutes, 'cause there's literally nothing else to do and you're not sleeping, you're not really thinking... just a peace and calm I haven't felt in a while."

P20: "It quickly became all about the experience of being here in the chair, instead of reflecting on whatever thoughts I had ... I was just kind of lost, not that internal narrative, not trying to do anything, not even thinking at all ... 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."

P23: "Like a bike ride, where thoughts have been cleared you're taken away from the details of your daily life."

P27: "I think I had some like moments of just nothing, and my first thought was 'did I just have moments of nothing?' ... a new thought would come into my head, and I would try to think 'this is weird, what was the last thought?' I couldn't tell you right now or in that moment what [that] last thought was, they were completely gone, and that I'm not used to. Usually I can track the monkey brain, and they were gone immediately, and so that was a weird thing for me."

P29: "I work in creativity, and when we're challenged or in an idea block we try to go to take a walk or do something like that, but it's really hard to actually get away from the topic. This [system] would be a really good way to cleanse the mind palette between sessions."

> P34: "I found myself getting lost in a lot of different random thoughts then coming back to different sequences, pulling me back out of that into less thinking."

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:

> P7: "Because I was trying to control it and see what it would do, I had to pay attention to my breathing and my mind couldn't wander."

> P8: "Because you're controlling the sound with breathing ... you don't want to let your mind wander ... I wasn't even thinking that much actually [at the end]."

> P9: "The sonic world and all the frequencies really helped tune the body and the mind ... [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."

> 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 ... I think it was very meditative, you got to take a break from the everyday noise in your head."

These articulations of a clear-minded mental state align with low self-reported levels of distraction. When asked what percentage of the time spent in the system was spent thinking of unrelated thoughts, the average of all participants' responses was approximately 18%, which translates to only 2 minutes and 42 seconds out of a 15 minute session (**figure 17**).

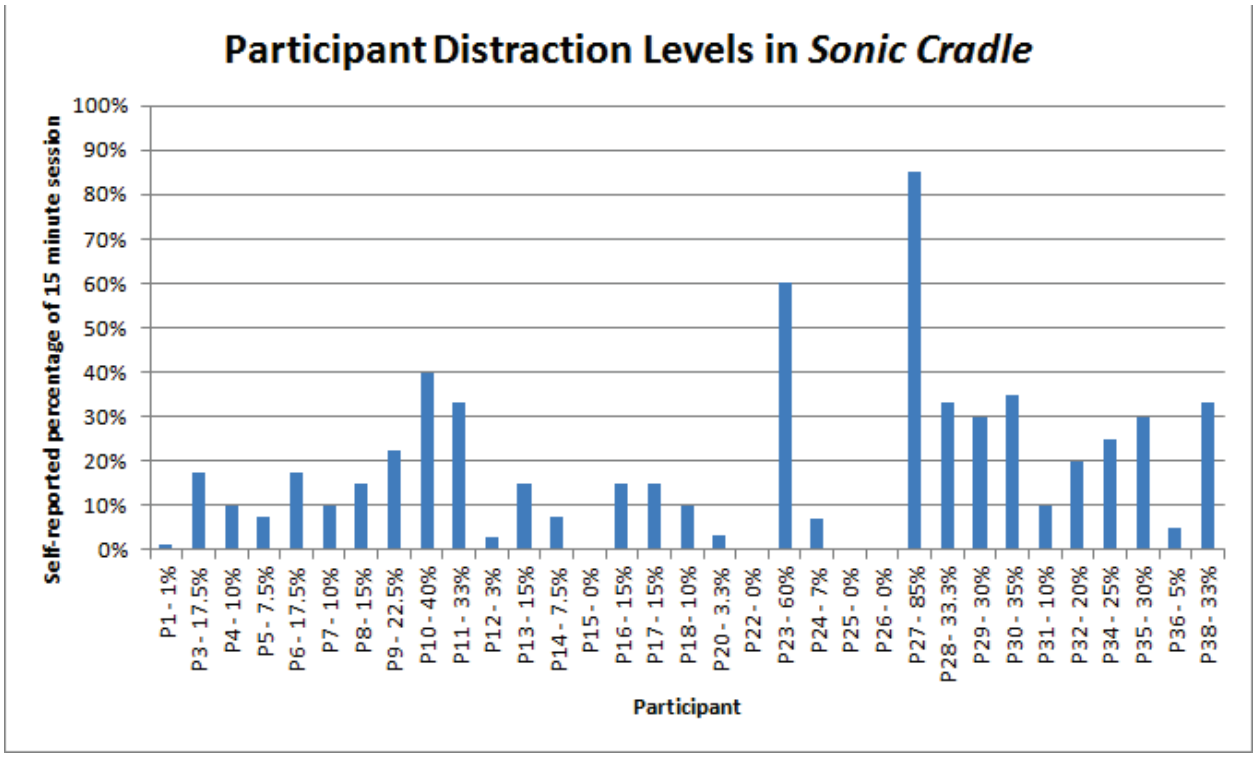

Figure 17. Plot of participants' self-reported distraction levels in Sonic Cradle.

Note. This plot depicts each participant's verbal response when asked "what percentage of the time would you say your attention was focused on distractive, completely unrelated, everyday thoughts?"

4.6.9. A Distorted Sense of Time

A few participants in each group communicated a feeling that time sped up while they were in the system:

> P1: "It went by really fast."
>
> 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 eight hours."
>
> P12: "I felt like the time had passed really quickly."
>
> 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."

P27: “It didn't feel like 15 minutes at all.”

Some participants even expressed a feeling of surprise when the session ended:

P7: "I couldn't believe 15 minutes was up."

P11: “Early on I felt like sometimes 15 minutes can be like a long time, but this actually ... felt incredibly short. I was actually shocked when the music started coming down.”

On this topic of time distortion and illusion, P28 articulated a temporal disorientation which actually prevented him from describing different segments of the experience:

P28: "I don't know that my experience was a linear experience, so it's kind of hard to do beginning-middle-end. It swirls in my recollection ... I know I had certain thoughts but I couldn't tell you [when] ... The only thing that is clear to me was when the door opened and closed, and that was the beginning and end."

4.6.10. 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:

P3: “I loved it, I could do this all day.”

P6: “I enjoyed it greatly. I would highly recommend it to folks ... This is completely awesome."

P7: “It was amazing.”

P9: “It was really great.”

P10: "Wonderful, it was great. The idea of being encapsulated by sound, and having a soundtrack, and having certain sounds come from certain areas was very intriguing, very interesting."

P15: “It was great, I loved it.”

P18: “I thought the experience was really cool.”

P23: “Enchanting.”

P24: “I really liked it. It was interesting.”

P25: "I think this is an awesome project."

P27: "First word would be amazing, second word would be surprising. It was just really unbelievable. It was hard to describe."

P30: "I loved it. I'm really excited about what you're up to."

P32: "It was great, it was really interesting, I've never experienced sound in that way before. Really unique."

P36: "I think it was just amazing to feel, to have sound go through you in a very pleasurable way."

Beyond the ubiquitous data clusters grouping these comments from all three coders, this overwhelmingly positive response was further evidenced by participants voluntarily recommending the experience to other attendees; after a few sessions on the first day, I was overwhelmed with demand from word-of-mouth during the rest of the week-long conference.

Some participants in this category went beyond a simple positive comment and communicated a deeper emotional response to the system. This small subset of participants communicated enough depth when describing their positive response to the system that all three data coders included a separate cluster in both groups dedicated specifically to emotional responses. These emotional and affective clusters were typically grouped with those pertaining to simpler positive responses, but coders agreed that they were qualitatively different. The strength of this emotional data cluster despite relatively few participants making relevant comments is presumably due to the impact of those comments; they hint at a rather profound experience of the system which extends beyond mere enjoyment. P4 was transported to a comfortable moment from her childhood:

P4: "The sounds on the left, this is going to sound crazy, they brought me back to when I was a child and we went to a zoo at the monkey cages ... [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."

Other participants discussed emotional responses which were less specific:

P9: "You finally feel everything, feeling overrides the thinking."

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, this is great."

P24: "I was very content. It didn't bring anything disturbing out, and it didn't give me like an epiphany, I don't think I was in there long enough, but I felt really happy and I was really glad I was doing it."

Two participants in particular had intense emotional responses which they did not want to share during the interview, but approached me later during the conference to explain them. P16's intense emotional response was first alluded to during the interview:

> P16: "There were like footsteps almost, they sounded like someone was in a closet, like [claps]. There were actual claps it sounded like, and I felt like I wanted to follow whatever sound it was. My head literally like wobbled over to where the [claps were] coming from, and then there was a big, [deep] sound that started playing from [the other side], but I couldn't leave [the claps]."

Hours later, P16 approached me to confess that when the particular sounds which she described as *"footsteps"* were *"leaving,"* she *"cried a bit"*. P24 was the other participant who approached me with an additional comment; he referred to an emotional attachment to the system which manifested itself as he was leaving the session. Apparently he had been struck by a particular feeling when I was in the process of helping him stand up from the suspension hammock:

> P24: "When you said to [be careful] because this [is] the only prototype, I was overwhelmed thinking I was responsible for the only prototype of something, a thing so important to our world."

4.6.11. An Intense Engagement with Sound (Some Meditation Experience)

It would be fairly impossible for any participant not to mention sound in an interview directly after experiencing 15 minutes in what is essentially a sound chamber. However, while participants with no meditation experience referred to the sound as a constituent element of a larger experience, those with previous meditation experience were much more likely to go a step further, describing engagement with specific sounds and reflecting on their aesthetic:

> 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."

> P6: "The sounds that were being played were ... very natural and they feel very organic. ... at least for me, when synthetic sounds appeared, I was ... trying to filter those out ... at one point a synthetic high pitched sound came in, but it was cool where my head was at."

> P10: "I was trying to decipher what sounds emerge, and [their] origin ... There was a talking sound, but I wasn't sure what the words were."

> P20: "Then in the middle, once I got the parameters down ... I was really getting into the sound ... What's that sound? What's it doing to me? Do I like that sound? ... [I was] getting into the sound aesthetics."

> 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 whole system that allows you to go into one sound and into another sound, like a journey."

Some of the participants with previous meditation experience went further, describing their heightened engagement with the sound as a direct mental connection which somehow sidestepped the respiratory control paradigm as mediator:

> P8: "Your thoughts are directly linked, you're controlling the sound."

> 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 ... [Describing the experience to a stranger,] I would talk about the sound a lot, I would talk about the feeling of the sound responding and almost interacting with the way I was focusing on breathing."

> P31: "At some point I was thinking that, the music, only I could hear it. It felt so inside of myself, coming from inside myself" [interviewer confirms by asking if she meant that the sound was not in the physical room with her] "Right, exactly."

> P38: "I would think of other stuff but would naturally return to the system. At the beginning, I was actually trying to focus on other things but I couldn't, the system would suck me back in."

4.6.12. Comparison to Meditative Practices (Some Meditation Experience)

It is not surprising that only those participants with meditation experience were likely to compare the system to existing meditative practices, as those were the only participants who had such experience to draw from. Further, the fact that participants were forewarned of the system having something to do with meditation likely had a lot to do with such comparisons. What was surprising, however, was not only the nature of the comparisons made, but also the sheer number of participants who made such comparisons; almost every single participant with some meditation experience made some form of connection between existing techniques and *Sonic Cradle*. It was not uncommon for participants to explicitly describe the system's similarities and differences with respect to their understanding of meditation:

> P4: "When I wake up with ideas and I can't go to sleep, I put on YouTube and try to meditate, with music you just want more. And that's what happened here ... [but] this was different because the sound was completely different."

> P17: "[It was like] meditation, because of the breathing. The relationship between your breathing and your space, and your environment. Also because meditation is like a focusing act, and this felt like a focusing act. Only it feels like you have more of a mental object to focus on. The opposite of distraction."

P25: "Amazing, like a deep meditation in a different way because it was very sensory."

P28: "One time I tried a meditation technique that makes me feel more focus on my breathing than I usually put, and I believe it had an access to something for me. That I didn't get to [here]... 'cause I feel like I'm only seeing the tip of the iceberg."

P30: "It mimicked sort of lessons that I've found out with my meditation in general ... the meditation deepened kind of halfway through. I entered what it takes me usually about 6 or 7 minutes to get into ... but there was definitely something added to this. I don't know if it's better but different, this feeling of floating and being sort of lost in the cosmos. When I'm meditating and sitting with my back straight, it's very much about being in this room, here. And this felt like breathier and floatier to me, which was very different ... in the sense that there's something actually acting on you like a massage."

P35: "It's ... a guided meditation, I think. There were some yogas I've done that were guided, I'd compare [this as] an alternative to guided meditation."

While certainly initial expectations of the system likely triggered many of these comparisons, they cannot account for the fact that many participants went a step further, describing *Sonic Cradle* as an augmentation of meditation in one way or another:

P3: "I've been working on breathing techniques, but this is a much better version to have something that responds, it really gets you there."

P5: "Sometimes when I go to bed I try this relaxation technique, and that feeling seemed to come really quickly. Normally I fall asleep during that but I didn't here, I wasn't tired I was just relaxed."

P9: "It's instantly on par with the best of the few meditations I've had, the good ones ... I felt it, it was there."

P11: "It was good, I've done some meditation before, and I found it really similar in the early parts of the session ... at first I was really anxious, it's very similar to when I've tried to meditate in the past - I have a hard time turning my intellect off ... It did remind me of ... a yoga retreat [I went to] in Mexico and there were a couple of moments out there where you just lost yourself, so it's a little bit like that ... I had a bit of an epiphany ... it felt like a great meditation session."

P16: "I've been in places of not being able to feel my body and only being breath, but I'm not sure if I consider that to be meditation. I don't think I had a long enough chance in [those] other instances to be in a meditative state completely ... [but] I would consider this a meditative state ... I would

have been able to stay forever, but it was long enough to feel it ... like it's long enough to feel as though I was in a meditative state."

P20: "I do guided meditation... a few times a year, and even in that I don't get to this space. I don't know why, [the guided meditation] is like an unravelling of my brain and letting certain things through which don't get through normally, but they're still things. This one just like, didn't. I just let it go. It's really just about letting go of that conscious self, it was really cool."

P22: "I've dabbled with meditation and would love to incorporate sound and feedback ... the control, being able to meditate to a soundtrack that is feeding back to you, it takes that meditation to another level."

P31: "There's something [here] that makes meditation easier, 'cause while doing meditation you're trying to concentrate on your breathing but it's very hard because there are many other things that are happening in your mind. But when you can actually hear that breathing, it's much easier to concentrate on that, all you think and hear is breathing ... I compare it to meditation, but even the best meditation sessions that I've had were very far from this in the sense that in the other meditation sessions, my mind will be somewhere else. Here [I] was [distracted] 10% [of the time] but in other meditation sessions it would be 50%."

P11 later elaborated on how his experience of the session as a *"great meditation experience"* was based on an epiphany he had:

P11: "I'm wrestling with something really major, like there is some major shit [affecting] how I make my living. This was a very pleasant piece of that experience. There is this thing I told my executive coach about a year ago, and I literally had the thought again sitting here, which I think helped me ... that was really important."

P30 was another participant who experienced a sort of personal realization:

P30: "I'm going through a tough situation with my wife, and I felt an easing of that. I felt sort of a sense of relief and grounding that was both based on some of what we've been working through this week, and also just based on kind of like, this week is over, I'm sitting in a dream state now, and something let go. And that was pretty profound to me."

While most of the participants mentioned in this section compared the experience to meditation in name only, P4 articulated *Sonic Cradle* as a metaphor for living a mindful life of accepting truths in the present, perhaps without even knowing she was doing so:

P4: "[It's] a place where you can go and experience different sounds in the beginning, where you can probably relate them to different things that happen during your day, thinking 'oh that's annoying' or 'slow that down'. Once you start interacting with whatever's happening and 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, just, get over everything, and just be ... In the beginning, I felt like I didn't know what to expect. [Just like when] you wake up every day and you don't know what your day is gonna be like ... Some of the sounds were annoying, sometimes it got too loud, sometimes there was a sound and ... I was like 'I don't like that'. Metaphorically, some things are just annoying and I just want them to change, 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."

4.6.13. A Semi-Conscious, Sleep-like State

Since all three coders included relevant data clusters in both analytical groups, the notion of a semi-conscious, sleep-like state was considered a primary theme across all data:

> P5: "Imagine what it's like when you're falling asleep, just when you are at the border of falling asleep and you feel like you're losing your logical thinking and you haven't fallen asleep yet, you're in that area and you kind of extend that."

> P13: "I almost felt myself drifting off to sleep but I wasn't sleeping, it was sort of a sleep-like state."

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

> P30: "I would compare it to falling asleep at a down-tempo party, being at a party at 3 or 4 in the morning ... sleeping against cushions not in your normal position, I would describe that as the closest feeling. Not sleeping, more of that laying and being present but sort of feeling semi-conscious."

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 merely in a sleep-like state, almost as if they had not considered the question intellectually until that moment:

> 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."

> P20: "I may have fallen asleep a little bit but I don't think I did. It was just sort of like I became unconscious in a good way."

> P29: "At the end I was sort of in a state half-awake, well, I was awake - I [just] wasn't really thinking about anything or even conscious of my breath."

When P24 described her semi-consciousness as *"that hazy dreamlike place"*, she was likely alluding to the same feeling which brought P15 a nostalgic return to his childhood exploration of lucid dreaming:

> P15: "When I was young I used to do lucid dreaming, and there is definitely something similar [here]. That's what I was clutching for, I recognized that. Now that I say that, I know that's what I was doing, but I wasn't thinking that at the time. I had a recognition of it and, yeah. I'm just kind of starting to understand, 'cause I recognized something about that [visual] pattern [that I saw]. I don't know what, it was familiar to me ... the state and the [feeling of physically] sinking, there were a number of cues that were very similar to [when I used to do lucid dreaming]. That's a weird one, that's really weird. I haven't done [lucid dreaming] since I was in high school or something."

Although much more flippantly, P10 made a similar comparison in his suggestion that *Sonic Cradle* was *"almost a lucid dream ... where there are parts I can control."*

4.6.14. Personal Development and Epiphanies (No Meditation Experience)

Among those who had never experienced any type of meditative practice before, there were several participants who expressed profound experiences. Some such comments referred to deep engagement during their session:

> P1: "It was relaxing but also really thought provoking. I was super in tune to how I was sitting and relaxing and concentrating on my breathing. That's the word, it was introspective."

> P15: "The [visual] pattern for me ... [was] a riveting thing, the green stencil-y pattern. I wouldn't say I had any further understanding per se, other than now I want to do a little bit of lucid dreaming, like oh wow."

A few other non-practitioners reported that *Sonic Cradle* played a role in some form of personal development:

> 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 ... it was like 'you conquered it'. [So] you don't stop obsessing with yourself ... just be with that, it's right there."

> P18: "Important topics in my life right now that [I] don't reflect about a lot came to mind in a very focused way and a very surprisingly visual way."

> P32: "[It was] about how the body could control music, how the breath could control music, and it made me think about my relationship and the relationship of breath to experience. And that fundamental relationship and how it can be modulated, and the experience has made me think about that a lot more ... I would say that this is another jigsaw puzzle piece in my little journey of letting go."

> 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."

A few days later, P32 sought me out at the conference to elaborate further:

> P32: "in retrospect, I really think that your installation was a subtle catalyst for a rather profound transition/life epiphany."

For two participants in particular, the system influenced them to actually engage with contemplative practices after their session. P39 approached me with a story about how he was riding on a bus and spontaneously decided to single out all the sounds in his environment, an act which he claimed had a calming effect on him; after doing this for a little while, he realized that it was just like *Sonic Cradle*. As an even stronger example of this effect, consider the e-mail sent to me by P13 days after the conference:

> P13 (via e-mail, a few days after the session) : "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."

4.7. Discussion of Qualitative Findings

Now that each primary theme revealed by qualitative analysis of semi-structured interviews has been presented in participants' own words, I will draw from design hypotheses, aforementioned theoretical underpinnings, and existing explanations of meditation to interpret them. This section will discuss the theoretical implications of the themes presented in the previous section. Although these findings were the result of a rigorous and systematic analysis, the reader should note that I did not include a control condition for practical reasons related to collecting data at a conference. While certainly some findings were largely a product of the system (e.g. a feeling of floating, illusions, etc.), it is impossible to determine whether more typical findings (e.g. relaxation, positive response, etc.) were simply due to a forced break from the busy conference program or from the actual *Sonic Cradle* system.

4.7.1. A Desirable Experience

Participants' strong positive responses to *Sonic Cradle* (*4.6.10*) 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, like many individual qualitative findings of this study, these positive responses are hardly enough evidence to claim that participants were experiencing mindfulness; they could have reacted positively to the experience for a multitude of reasons including pleasant music, technological novelty, comfortable

seating, and much more. However, one conclusion which can be drawn from participants' positive responses to *Sonic Cradle* is that the system has potential to draw use simply because it is enjoyable. In fact, another primary theme of the study was an explicitly stated desire for more and longer sessions (*4.6.6*), demonstrating that practical implementations of the system (i.e. a public or home installation) may attract extended use. Whatever other findings suggest about *Sonic Cradle*, it should be noted that this desire for extended use implies that these findings will likely be strengthened by users' intrinsic motivation to engage with more than the single 15 minute session investigated in the present study. If further analysis reveals that this human-computer interface affords an experience of mindfulness meditation, presenting it to users in such a context will clearly bring positive associations to mindfulness; further, participants' desire for more sessions suggests that the experience might also be able to motivate participants to pursue this psychologically self-regulating practice outside of the system as well.

4.7.2. 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., 1990). 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 (*4.6.1*). This relaxation may be a result of induced mindfulness, but again, it could just as easily be a result of other mechanisms; perhaps the same as those fueling the effects of the aforementioned studies. At this point in our discussion of qualitative findings, we can describe *Sonic Cradle* as an enjoyable and relaxing experience according to the vast majority of participants in our study, but we cannot yet tie it directly to mindfulness.

The fact that participants were relaxed during the experience (*4.6.1*) 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 a meditative state, 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."* This discourse is particularly interesting in its implication on how meditation should be interpreted:

> "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 (*4.6.13*), 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)

Contrary to the idea that *Sonic Cradle* overused relaxation techniques inducing an excessively dulled state compared to the balance sought in meditative practices, one might interpret participants' feelings of intense relaxation not as an imbalance, but instead as a perceived change toward balance relative to a normative state of excitement. Not only was ours a purposive sample of highly active and busy people in the context of a fast-paced socially dense environment (the *TEDActive* conference), but 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. Oh, that we could work at being undistracted – and be undistracted when we work."

If participants' perceived relaxation was relative to this generally wandering mental state in a contemporary media environment of information overload, the interpretation of their reported semi-conscious, sleep-like state becomes much more interesting. Perhaps the feeling of semi-consciousness was a direct product of the clarity and reduced thinking which was revealed as a primary theme of qualitative analysis across participants (*4.6.8*). 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 meditative clarity of mind and reduced thought may simply interpret it as an abnormal, semi-conscious and almost dreamlike state without actually being asleep. This interpretation makes sense of the fact participants who had some prior meditation experience were highly likely to compare the experience to the meditative practices, yoga, and breathing exercises

(*4.6.12*), with some even describing the system as an augmentation of these practices. 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).

Participants' reported relaxation and semi-consciousness seem to 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 if this is indeed the case. At this point in our interpretation of qualitative findings, it is still impossible to conclude whether *Sonic Cradle* induced participants with an experience related to mindfulness or simply with a pleasant feeling of intense relaxation. However, the clarity of mind and reduced thinking observed as a primary theme in qualitative analysis suggests the former.

4.7.3. Clearing the Mind Suggests Mindfulness

The clarity of mind participants reported as part of the *Sonic Cradle* experience (*4.6.8*) 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, 2006). In the words of Kang & 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 mind of novice practitioners 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 may pre-empt such faculties, and can definitely be described as the *"directness of access to experiential content"* which characterizes

mindfulness. It is important to note that such states of experiential focus which lack internal narrative have been shown to be neurally distinct (Farb et. al., 2007). Participants experiencing this mediated clarity of mind often expressed surprise at their own progress. Some participants, including those with no meditation experience, reported experiential phenomena which allude to a reflexive awareness of one's own mental progressions, implying that *Sonic Cradle* was able to give rise to a faculty of meta-awareness to some degree. However, participants' minimized distraction levels cannot be directly linked to some observant meta-awareness as re-orientations of attention toward breath were likely a response to sound changes. Still, *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 perhaps interesting. However, for the present work, this questionnaire is most useful for the role it played in measuring differences between mindfulness practitioners engaged in a two-day retreat, those engaged in a two-week retreat, and those engaged in a three-month retreat (Forte et. al., 1987). While those subjects in the two-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 (*4.6.8*). Interestingly, compared to subjects in the two-day retreat, results from those in the two-week retreat share other characteristics with the experience of *Sonic Cradle*: simple imagery effects (*4.6.5*), perceived changes in bodily state (*4.6.7*), and distortions of time (though in the opposite direction; *4.6.9*). 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 two-week retreat. As these effects were diminished in the three-month group, expert practitioners have perhaps surpassed the need for such an intervention. Accordingly, our systematic qualitative analysis did not produce any finding which aligns with the key subjective characteristic of Forte et. al.'s most experienced meditators: *"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"*.

4.7.4. Loss of Intention Suggests Mindful Stress Reduction

In continued discussion as to whether *Sonic Cradle* is able to produce an experience relevant to mindfulness, the concept of stress is inevitable. Superficially, my long-term goal with the project is to experientially educate people about the benefits of psychological self-regulation with hopes to motivate engagement with practices known for stress management. On an analytical level, if *Sonic Cradle* is indeed inducing mindfulness, it should also have a short-term influence on stress. Stoyva & Carlson (1993) imply that effective stress management should not be about forcing relaxation, but instead about mediating a transition from coping to rest. While future studies should include physiological correlates for confirmation, this transition was reflected directly in *Sonic Cradle* participants' transition from an initial tendency to explore the control paradigm (*4.6.3*) to a state of reduced intentional control (*4.6.4*).

Just as in Stoyva & 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 move from an initial intellectual exploration of the system to a letting go of intention. This is not to be read as an eventual boredom with the system; on the contrary, participants maintained focus without distraction while simply abandoning the desire and need to explore the system semantically.

In Stoyva & Carlson's (1993) discussions of stress management, they directly discuss mindfulness meditation, portraying it as a useful mediator of such transitions through a reverberation between paying attention to breath and paying attention to environment. Interestingly, these authors conclude that the *"the main question now is not so much whether a particular technique enjoys an edge over another, but whether the respective techniques tap into different dimensions of the stress reaction."* The implication here is that techniques which mediate the transition from coping to rest in different ways can be combined for additive effects. The strong qualitative evidence that *Sonic Cradle* has a relaxing effect (*4.6.1*) in the context of a single-pointed transition to less intentional control (*4.6.3-4.6.4*), positive emotion (*4.6.10*), and clarity of mind (*4.6.8*) suggests an effective addition of the system's individual elements of sensory deprivation, respiratory biofeedback, bodily suspension, pleasing sound, and mindfulness-inspired controls. These clear experiential effects imply that there is much more work to be done toward understanding *Sonic Cradle* and potentially bringing it out of the lab and into the lives of people in need of the benefits mindfulness can offer. 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.

4.7.5. 'Immersion' in a Holistic Sense

The psychological framework for 'immersion' presented in chapter 2 guided my attempts to design an interface for maximum mediated engagement into the subtle interoceptive stimulus of respiration. All participants seemed to be engaged with the system as a whole 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 (*4.6.11*). While these high levels of participant engagement certainly suggest some level of success in my goal of engaging users, only a few participants articulated a deep engagement with respiration; there was not enough consensus on this point for my methodology to consider it a primary theme (though it was a secondary theme in those with meditation experience and a tertiary theme in those with none). Seeing as other primary themes revealed indications of the system's success in encouraging subjective elements of mindfulness, one might consider the media 'immersion' framework in chapter 2 as simply a productive element of the *Sonic Cradle* design process. However, ignoring its implications on data analysis would miss the relevance of three other primary themes which strongly align with a constructive form of media 'immersion': visual sensations (*4.6.5*), bodily sensations (*4.6.7*), and comparisons to floating (*4.6.2*). 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, two

respiratory sensors, and a few loudspeakers was able to generate profound illusions. I will discuss these phenomena using the framework for 'immersion' which was presented at the end of chapter 2; the reader is advised to return to that chapter if a contextualization of this framework to external literature is desired.

A few participants saw abstract patterns of light which they struggled to articulate into words while others claimed to see specific moments from memory (*4.6.5*). 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 even a tingling which was compared to sexual pleasure (*4.6.7*). It is beyond the scope of this analysis to determine exactly which factors give rise to these complex experiences (sensory deprivation, hyperventilation, sound quality, suspension or biofeedback could all play a role); however, they do align very well with the idea that participants were engaged in a constructive process of 'immersion'. 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. The 'immersive' interaction design approach inspired by the framework presented in chapter 2 has resulted in an interactive system which somehow leads to complex, multimodal experiences based on unimodal stimuli.

Some participants felt a sense of motion which happened to coincide directly with participants' prior knowledge of the physical possibilities of the hammock within which they were suspended. Through a survey of the existing literature exploring motion illusions (a.k.a. *vection*), Riecke (2010) conclude that since observers *"are typically aware whether actual motion is, in fact, possible,"* this cognitive understanding of physical possibilities of movement can facilitate the perception of self-motion, a fact which *"is consistent with informal reports and common practice of seating participants on moveable platforms in situations where vection is difficult to achieve"* (Riecke, 2010). For example, Riecke et. al.'s (2009) investigation of audio-induced motion illusions with 23 blindfolded participants demonstrated how suspension in a hammock renders an observer more prone to illusions of motion when compared to sitting with feet on the ground. *Sonic Cradle* participants were also suspended in a hammock, but they were not provided with sensory suggestions of motion as in Riecke et. al.'s use of audio stimuli which simulate circular rotation. In *Sonic Cradle*, suspension seems to have occluded physical contact with the ground in a way which enabled participants to constructively simulate their own sense of motion.

One of the most interesting primary themes which arose from our qualitative analysis was based on an abundance of participants reporting a feeling of floating (*4.6.2*). The concept of floating suggests an absence of gravity: one of the most consistently felt forces in our daily physical experience. This primary theme implies a clear disengagement from the physical world. This finding is also quite interesting in the context of the media 'immersion' framework from chapter 2, particularly because many experiential comparisons connecting *Sonic Cradle* to the sense of floating did so in the context of water. Participants used metaphors of scuba diving, snorkelling, bathing, swimming, and simply being submerged. As discussed earlier, the concept of 'immersion' is closely related to water. 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). *Sonic Cradle* was obviously not designed with water as a specific aesthetic goal in any way, although there was one crowd-sourced sound of rain, and another of waves on a beach. However, the interface was meticulously designed to align with a wide range of theoretical interpretations of 'immersion' which manifested together as a unifying psychological framework. These divergent, different interpretations of media 'immersion' can all be described as extensions of a common etymological root: being plunged or submerged into water. While participants' comparisons do extend in different directions, the sheer prominence of experiential comparisons related to water thickens the system's relationship to the concept of 'immersion'. *Sonic Cradle* seems to promote the intense engagement which characterizes general use of the term 'immersion' in the context of media. Further, subjective reports of participants' experience in the system include illusions which suggest a form of perceptually constructive interaction, aligning directly with the product of the rigorous literature review of media 'immersion' in chapter 2. Finally, an overwhelming feeling of floating in water depicts *Sonic Cradle* as also channelling some primordial sense of the etymological root of the word 'immersion' through contemporary media.

4.7.6. Glimpses of Csíkszentmihályi's Flow

In seminal work on the psychology of optimal experience, the concept of *flow* is introduced as an optimized ratio between challenge and skill which fosters an energized focus on a particular activity (Csíkszentmihályi, 1997). In my theoretical analysis of media 'immersion' in chapter 2, I chose to opt out of including Csíkszentmihályi's theory of *flow* in my thinking on 'immersion'. Although *flow* is highly relevant to the concept of 'immersion' and vice versa, the fact that this multifaceted psychological theory is based on a lifetime of work implied that it may be premature to discuss until cross-disciplinary exploration of media 'immersion' progresses further. However, this does not prevent me from considering relevant primary themes from our qualitative analysis in the context of *flow*. Csíkszentmihályi describes flow as an ordered and fully-invested attention which tends to arise in the presence of three factors: *"when goals are clear, feedback relevant, and challenges and skills are in balance"*. Despite the lack of challenging goals in *Sonic Cradle*, participants' reports of a distorted sense of time (*4.6.9*) and a positive emotional response (*4.6.10*) to *Sonic Cradle* seem to align with Csíkszentmihályi's *flow* (1997).

Subjective descriptions of *flow* tend to include an accelerated sense of time where *"hours seem to pass by in minutes",* and retrospective positive emotion: *"only after the [flow-inducing] task is completed do we have the leisure to look back on what has happened, and then we are flooded with gratitude for the excellence of that experience – then, in retrospect, we are happy"* (Csíkszentmihályi, 1997). Many participants described their 15 minute session as feeling unusually short. Further, a positive response to *Sonic Cradle* was thematic in interviews conducted after the experience; some even described more intense emotional connections. While this positive response is difficult to interpret temporally as it is impossible to know whether it was present during the experience, we can still be sure that participants' exhibited a positive response after the experience. In the context of low self-reported distraction levels which suggest heightened engagement, the distortion of time and retroactive positivity described by participants in *Sonic Cradle* force us to question its relationship to *flow*. This is surprising, as flow is

more typically observed in personal and passionate contexts. For example, after Csíkszentmihályi (1997) uses an example of skiing to describe flow, he subsequently contextualizes the anecdote as follows:

> "If skiing does not mean much to you, substitute your favorite activity for this vignette. It could be singing in a choir, programming a computer, dancing, playing bridge, reading a good book. Or if you love your job, as many people do, it could be when you are getting immersed in a complicated surgical operation or a close business deal. Or this complete immersion in the activity may occur in a social interaction, as when good friends talk with each other, or when a mother plays with her baby."

While our purposive sample may have had certain shared interests, each participant was most definitely a unique person with their own passions and personal lives. Yet somehow several attributes which characterize *flow* seemed to emerge in these different people relatively consistently while experiencing the musical respiratory biofeedback paradigm in the context of complete darkness which characterizes *Sonic Cradle*. These findings might be coincidental, or they might scratch the surface of something deeper.

With attributes of flow states present in subjective reports from participants – a clear focus, emergent positivity, and a distorted sense of time – even the remote possibility that *Sonic Cradle* may somehow induce states of flow is quite striking, as the system does not involve clear goals or any significant challenge. Of the three factors which underlie *flow* – objectives, feedback, and appropriate challenge – direct feedback is the only one clearly present in the system. The lack of a challenging goal to account for what appears to be *flow* may suggest that participants achieved this state in *Sonic Cradle* through their own paradoxical discovery of the challenge involved in pursuing a lack of goals, a concept described in Csíkszentmihályi's (1997) own casual take on eastern philosophy:

> "The inertia of the past dictates that most of our goals will be shaped by genetic or by cultural inheritance. It is these goals, the Buddhists tell us, that we must learn to curb. But this aim requires very strong motivation. Paradoxically, the goal of rejecting programmed goals might require the constant investment of all one's psychic energy. A Yogi or Buddhist monk needs every ounce of attention to keep programmed desired from irrupting into consciousness, and thus have little psychic energy left free to do anything else."

Perhaps participants achieved states of *flow* in *Sonic Cradle* by taking it upon themselves to devote their psychic energy to rejecting their natural propensity for distraction, engaging with the system in a way which parallels the above quote. On the other hand, as the system's interaction paradigm is more exploratory and does not demand any kind of focused attention, perhaps the system is able to more easily afford a process which normally requires a lot of conscious effort. The system may be serving as a mechanism to offload the conscious effort normally required to sustain *flow* states. This could be attributed to *Sonic Cradle*'s interaction design process which aimed to facilitate attentional patterns of mindfulness in the context of a constructive form of 'immersion'. In any case, these findings raise clear questions for future research surrounding the relationship between 'immersion', mindfulness and *flow*.

4.7.7. Potential for Long-term Effects

So far, this qualitative analysis has given us significant reason to believe that *Sonic Cradle* has the potential to induce a process of active, constructive 'immersion' into a pleasant and relaxing experience which seems to incorporate elements of mindfulness. Certainly this qualitative data is not enough to make substantive claims; however, it has provided a few clear directions forward along with motivation to devote time and resources to further investigations. At this stage, there is one last primary theme derived from systematic qualitative analysis which has not yet been discussed. The fact that several participants among those with no meditation experience expressed personal development and epiphanies (*4.6.14*) may not be the most relevant finding in attempts to detect a subjective experience of mindfulness; however, it is perhaps the most relevant primary theme with respect to our long-term goal of encouraging and demystifying mindfulness for non-practitioners. Interestingly, while those participants who had prior experience were likely to compare *Sonic Cradle* to meditation and related practices (*4.6.12*), there were several novices who articulated the system as a reflective, liberating experience. 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.

One participant in particular – P13 – contacted me weeks 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 P13 with the 'motivation' and 'ability' required to successfully 'trigger' a change in behaviour. The interactive medium somehow persuaded a non-practitioner to attempt to take up mindfulness meditation through informed interaction design. Whether he succeeds in establishing a regular practice or not, it seems *Sonic Cradle* has encouraged this participant to acknowledge the value of psychological self-regulation for his own life. Despite this provocative finding occurring in only one participant, the fact that so many participants experienced elements of mindfulness in the context of demands for longer and more sessions (*4.6.6*) suggests that future design iterations may be able to more reliably bring participants to such value shifts. Extended sessions, longitudinal studies of repetitive engagement, and follow-up investigations which present the system as an educational tool for mindfulness could shed light on the system's potential to help people see the long-term value in pursuing psychological self-regulation. If future iterations of *Sonic Cradle* can be shown to consistently motivate such an interest in practicing mindfulness for self-regulation, installations could seriously help combat the abundance of stress and stress-related clinical problems in people's lives.

4.8. Quantitative Findings

While qualitative findings suggest that *Sonic Cradle* had a clear effect on its users, differences in resting respiration as measured before and after the session may add or subtract weight to the claims of these specific participants by serving as physiological indicators of emotional valence and arousal. As

elaborated in my quantitative hypothesis (*4.1.3*), an reduction of respiration rates, a reduction of thoracic-to-abdominal ratios, and an increase of respiration depth would suggest *Sonic Cradle*'s induction of reduced arousal, positive affect, and healthy psychological states respectively. Four two-way mixed analyses of variance tested for differences between in respiration length, respiration depth, and thoracic-to-abdominal ratio, as measured directly before and after the *Sonic Cradle* experience. Resting respiration length was found to be very significantly increased after 15 minutes of *Sonic Cradle* use when compared to directly before the session across all participants ($F(1, 30) = 15.350$, $p < 0.001$, $\eta^2 = .338$). This is in contrast to a complete lack of such differences across groups in respiratory depth ($F(1, 28) = 1.526$, $p = 0.227$, $\eta^2 = .052$), and thoracic-to-abdominal ratio ($F(1, 29) = 2.030$, $p = 0.165$, $\eta^2 = .065$). There were no interaction effects found between meditation experience (none vs. some) and respiration length ($F(1, 30) = .329$, $p = 0.570$, $\eta^2 = .011$), meditation experience and respiration depth ($F(1, 28) = 1.693$, $p = 0.204$, $\eta^2 = .057$), or meditation experience and thoracic-to-abdominal ratio ($F(1, 29) = .002$, $p = 0.961$, $\eta^2 = .000$). As shown in **figure 18,** the significant implication of this quantitative analysis is that measurements taken after *Sonic Cradle* sessions reflect a strong increase in respiration length, or alternatively stated, a significant decrease in resting respiration rate.

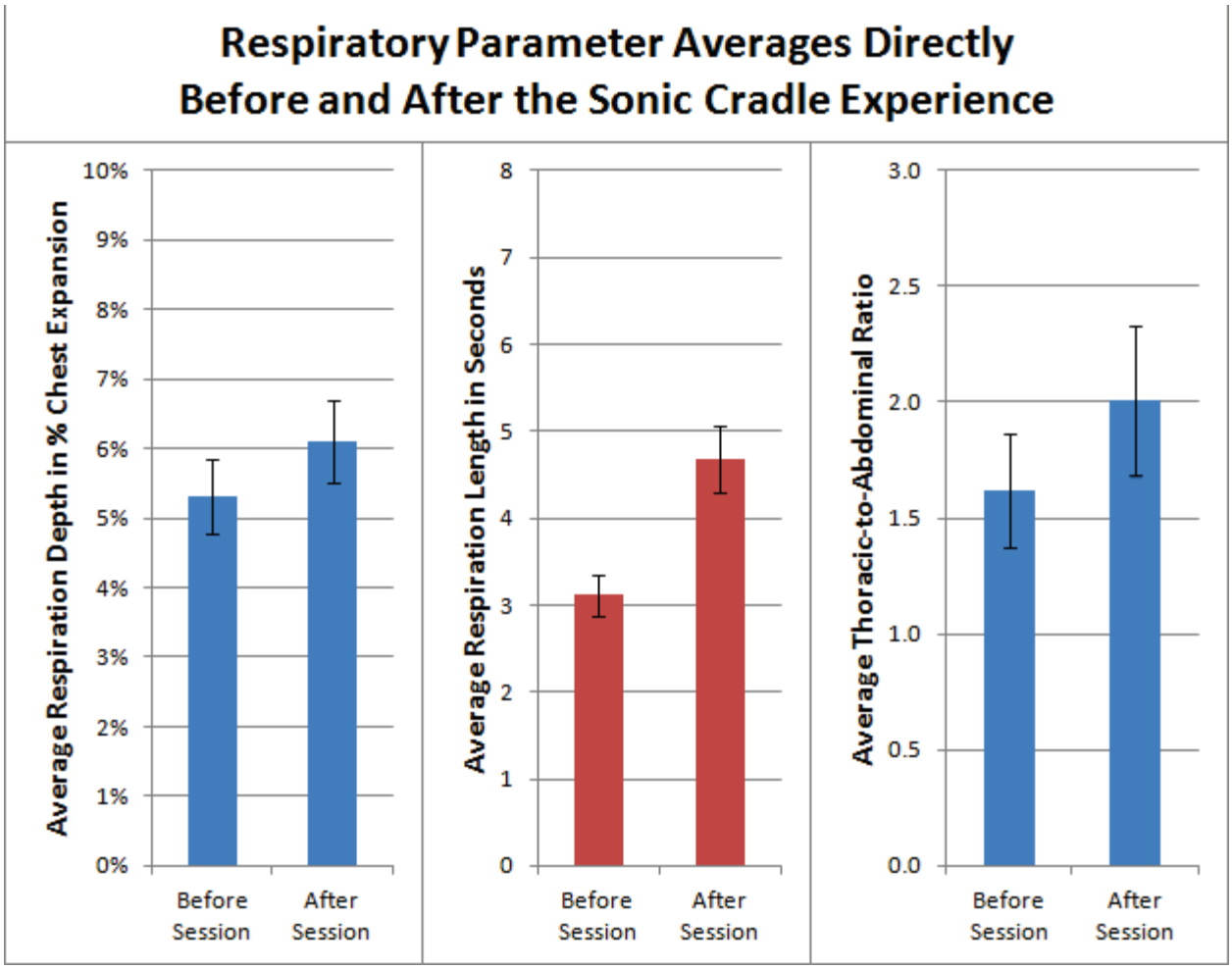

Figure 18. Data plots of Sonic Cradle's effect on resting respiration parameters.

Note. Mean and standard error are plotted for each value. The red bars indicate significant differences.

4.9. Discussion of Quantitative Findings

Sonic Cradle seems to have induced a highly significant reduction in resting respiration rate which suggests that it reduced thought and behaviour in participants, an element which supports qualitative findings quite well. This finding also aligns with Nakamura's (1984) correlation of reduced respiration rates to lower energy music described as 'dismal', 'calm' or 'melancholy'. However, a lack of clear control conditions and the use of a purposive sample severely restrict the validity and generalizability of this finding; these conclusions can only lend additional weight to qualitative findings.

Boiten et. al. (1994) suggest that slowed breathing reflects a tendency toward relaxation independent of increases or decreases in respiratory depth. The fact that statistical analysis revealed no trends in resting respiration depth does not support qualitative findings, but it also does not hinder the significant decrease in respiration rate which implies that Sonic Cradle induced relaxation. Barring any undetected,

nonlinear complexity in the correlation of respiration and emotion, the experience seems to have had an effect towards the dimension between a state of *"resting relaxation"* (characteristic of slow, deepened breathing; top-right of **table 1**), and a state of *"passive grief"*/ *"calm happiness"* (associated with slow, shallower breathing; top-left of **table 1**). We still cannot draw quantitative conclusions about emotional valence without a significant effect on thoracic-to-abdominal ratios. As far as our quantitative data can reveal, the 15 minute session in *Sonic Cradle* could either be relaxing participants in a calm, pleasant sense, or it could be depressing and slowing participants down in a more negative sense. Further, we cannot conclude on what proportion of this effect was a direct result of *Sonic Cradle*'s interaction paradigm without an adequate control condition. However, when this result is taken in concert with qualitative findings, it does prove useful.

The contextualization of *Sonic Cradle*'s apparent reduction of resting respiratory rate to previous research suggests that the system may effectively induce a state associated with reduced arousal, thought, and behaviour. This aligns directly with qualitative findings which strongly suggest that the system relaxed and cleared participants' minds. This result not only strengthens qualitative data, but it also implies a potential physiological response to the system which serves as a basis for justifying randomized, controlled investigations of more robust physiological indicators (heart-rate-variability, salivary cortisol, EEG, etc.) in the future.

4.10. Limitations and Potential Sources of Bias

Although respiratory parameters measured at rest before and after *Sonic Cradle* sessions do corroborate qualitative findings, they are severely limited in external validity due to the use of a purposive participant sample. Further, the lack of a control condition limits internal validity, as the effects of taking a 15 minute break seated comfortably in a room alone may confound the observed reduction of respiration rate which I am tentatively attributing to *Sonic Cradle*. I did not address this confound, as purposive sampling already restricts the generalizability of quantitative findings in this study and a control condition would divide qualitative data collection in half. Resources will be better spent maximizing quantitative validity in a subsequent study with a randomized sample and more robust physiological indicators. As stated throughout this chapter, quantitative data was only collected here due to easy access, and the goal was to crudely triangulate my main contribution: a systematically-developed collection of robust and valid qualitative findings (presented in section *4.6*).

Despite my attempts to adhere to best practices when conducting qualitative interviews, there are a few potential sources of bias which should be mentioned:

- My demographics, body language, and tone as the moderator could have influenced participant responses.
- Although I tried to craft an effective and clear interview without leading questions, there still exists a potential source of bias in pre-determined interview content.

- Questions were asked in the same order for each interview, which may have led to sequentially-driven biases in participant responses.
- Participants may have made overstatements or inaccurate self-reports of their experience.
- While I did recruit two external coders and take a systematic approach to maximizing validity, I may have unintentionally introduced bias in aggregation and reporting (despite my best efforts to maintain an objective stance).

Qualitative methods rely on subjective interpretation and rarely involve control conditions; however, a lack of control could still be a source of potential bias. The simple fact that participants were being asked to sit alone for 15 minutes in the middle of a busy conference program may have contributed to qualitative findings in some way. Finally, it is also important to note that participants had a vague understanding that the experience was somehow related to meditation in advance; this also may have influenced how they responded to interview questions in a number of ways (e.g. attempts to provide answers they believe the moderator was expecting, or responses which align with their own ideas about meditation).

5. Conclusions

Based on the current state of research surrounding stress, mindfulness, human-computer interaction, and media 'immersion', I designed the concept of *Sonic Cradle*: comfortable suspension in darkness while controlling sound through respiration. The initial goal of the concept was to trigger experiences of mindfulness in non-practitioners in a way which may lead to stress relief in the short-term, and perhaps even motivate the adoption of this vital stress management practice in the long-term. After constructing a first prototype, 15 co-design sessions were performed to tweak the interface in an attempt to balance users' perceived sense of control of the system; the goal was to offer a clear feeling of control while remaining vague enough to encourage heightened engagement and exploration of the system. Finally, a mixed methods study was conducted with a purposive sample of 39 busy participants in pursuit of a rich descriptive understanding of the subjective experience of *Sonic Cradle*. Findings were discussed and interpreted in the context of relevant research.

5.1. Elements of Mindfulness

Systematic qualitative data analysis of semi-structured interviews conducted directly after each participant experienced *Sonic Cradle* revealed clear subjective elements of mindfulness (Forte et. al., 1987; Stoyva & Carlson, 1993; Kabat-Zinn, 2006; Lutz et. al., 2006; Kang & Whittingham, 2010). Participants consistently reported starting their experience with a typical, semantic exploration of system controls before transitioning to a loss of intention, reduced thinking, and clarity of mind. Those participants who had some previous informal encounters with meditation were likely to describe *Sonic Cradle* as a similar experience, with many portraying it as an augmentation. Further, our relatively inexperienced participants' reports of imagery, bodily sensations, and time distortions align with mindfulness meditators on a two-week retreat. After a 15 minute session, participants' resting respiration rate decreased significantly. Although a more valid and controlled investigation is needed, this physiological change corroborates qualitative evidence suggesting that *Sonic Cradle* induced relaxation and reduced arousal (Boiten et. al., 1994). In fact, some participants reported a semi-conscious, sleep-like state which may suggest that the system could parallel mindfulness even more closely if it were actually less relaxing. While qualitative evidence is quite promising, subjective reports are inadequate to connect *Sonic Cradle* causally to the practice of mindfulness meditation or reveal explanatory mechanisms. However, I can confidently claim that *Sonic Cradle* was associated with a subjective experience which involves key experiential elements of mindfulness meditation. My novel contribution here is that a carefully designed human-computer interaction paradigm is capable of cultivating user experiences which parallel the vital practice of mindfulness meditation. Further,

participants described *Sonic Cradle* as desirable, positive, relaxing, and refreshing. These are also important findings, as they suggest that the artifact has potential to attract extended use and bring positive association to mindfulness if presented in an appropriate context.

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 minutes alone could give rise to the findings we have seen in this investigation. It is with limitations in mind that I 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, and whether it can directly teach this psychologically self-regulating practice, motivating its adoption in the long-term. Human-computer interfaces which could experientially educate non-meditators about mindfulness meditation and its corollary benefits could have a significant impact on both typical and clinical populations. In the context of stress management technology, this project represents a change in perspective; instead of only focusing on continuous engagement for self-quantification and reflection, biofeedback-based systems can also be instructive, serving as 'training wheels' in one's independent establishment of non-technological practices which manage stress.

5.2. Theoretical Contributions Surrounding Media 'Immersion'

In chapter 2 of this thesis, I performed a deep interdisciplinary investigation of theory surrounding the concept of media 'immersion' which culminated in a novel framework. Although 'immersiveness' can be defined differently for different media, this framework suggests that the concept of 'immersion' refers to a perceptually constructive process of active co-creation in the mind of the spectator. An 'immersive' medium is one which exploits the mind's natural tendency to create a consistent subjective reality, orienting this psychological process toward a hypothetical world depicted virtually through that medium. This conceptualization of 'immersion' was based on leading theories derived from the study of different media. At the end of chapter 2, I used this framework to suggest a few design guidelines for 'immersive' media: occluding the physical world, considering interoceptive senses (pain, orientation, etc.), artfully leaving enough omission, balancing familiarity and abstraction, and priming spectators to be in a consciously creative mode. Along with concepts related to mindfulness meditation, these guidelines represent the basis of the *Sonic Cradle* interaction design.

Qualitative data analysis of *Sonic Cradle* participant interviews revealed evidence supporting the constructive framework of 'immersion'. Participants not only reported low levels of distraction while engaging with the system, but also the cognitive construction of cross-modal experiences. Many participants reported experiences which imply some process of mental simulation including visual illusions, imagery, bodily sensations, illusions of motion, and feelings of floating. With minimized sensory input from the physical world in the context of a respiratory-controlled soundscape, participants seemed to devote prior knowledge toward the internal elaboration of *Sonic Cradle*'s suspension and sound into unique, multimodal perceptual phenomena. While these findings are far from conclusive

evidence, they are interesting in their support of a framework which represents common ground between theories discussing 'immersion' in the context of diverse media. The fact that qualitative data analysis seemed to corroborate the framework only strengthens its claim. When thinking about the concept of media 'immersion', future researchers would be wise to not only consider the framework itself, but also the unexpected and remarkable participant responses to its manifestation in *Sonic Cradle*.

5.3. Research through Design

In pursuing the design of an interactive medium aimed at encouraging experiences of mindfulness, the fruits of my investigation led me beyond simply designing and validating a system. My approach can be considered *research through design* for two reasons: first, it produced a design artifact which explores *"what a potential future might be"*, and second, it *"[led] to theory development even though [that] might not have been the original intention"* (Zimmerman, 2010). The interactive artifact produced – *Sonic Cradle* – stands as an investigation into a *"potential future"* for mediated stress management, interaction design, and teaching psychological self-regulation. Conceptualizing *Sonic Cradle* also led to *"theory development"*, motivating the pursuit of a new understanding of media 'immersion' which appears ripe for theoretical study and discussion in a wide range of fields: literature, media studies, art, human-computer interaction, cognitive psychology, virtual reality, video games, psychophysics, and more. This is a case of design process leading to theoretical implications beyond the proximal artifact, which is the essence of *research through design*.

5.4. Future Directions

The main goal of the *Sonic Cradle* project has been to use theory and methodology to explore the possibility of designing an interactive medium to promote mindfulness. Before getting into specific directions forward, I can summarize by claiming that this study is the first to clearly demonstrate the promise of interactive media designed to cultivate mindful experiences. This is an important finding given our saturated media environment, the growing need for psychological self-regulation, and the proven benefits of mindfulness meditation; more work certainly needs to be done in this area. Further study could apply the interaction design concept of *Sonic Cradle* to acute stress management tools, interventions which persuade clinical patients to take control of their own psychological self-regulation, and educational aids to experientially teach prospective practitioners about mindfulness.

Although findings and results from the present investigation have been quite promising for practical directions forward, they have raised a wide range of new academic questions worthy of pursuit as well. First of all, strong subjective testimonial and rudimentary physiological measurement of our purposive participant sample suggest a clear need for measuring more robust physiological indicators in a randomized participant sample (i.e. heart rate variability, salivary stress hormones, electroencephalogram, etc.). Such an investigation could give us firmer evidence as to the nature of the

system's real-time effects on its users. 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 subjective and physiological 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. This type of factor analysis of the interaction design concept would not only increase theoretical understanding of the mechanisms behind *Sonic Cradle*, but also guide us on which elements to emphasize and develop further for future iterations. For example, investigating the role and importance of bodily suspension could help determine to what extent a more mobile version of *Sonic Cradle* could be created, while investigating different control paradigms could help further optimize and balance users' perceived sense of control.

While progress toward underlying mechanisms would certainly be useful for academic pursuit, other future directions exist which specifically aim to tweak and optimize practical versions of the system. Co-design sessions which pre-empted validation of the *Sonic Cradle* prototype focused on optimizing users' perceived sense of control. However, some qualitative results suggested that the system may have been too relaxing for an optimized experience of mindfulness. It would be useful to run further co-design sessions which aim to balance the design's influence on a dimension between participants' relaxation and excitation. These sessions could attempt less comfortable suspension or even more aggressive sound in pursuit of even stronger experiences of mindfulness. 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 explore intentionally defined collections of sound and altered sound parameters in pursuit of optimizing new iterations. As another direction forward, consider that the present study had participants engage in a single 15-minute *Sonic Cradle* session which many reported to be too short. It could certainly be interesting to try 30-minute sessions or even hour-long sessions to help determine how far an acute *Sonic Cradle* session could go toward strengthening the acute experiential effects revealed in the present study.

It seems as if one clear next step would be to engage a randomized participant sample in longer sessions, replicating the present methodology while simultaneously measuring a series of physiological indicators for additional triangulation and external validity; this study could also include control groups to compare with competing approaches to mindfulness education or help address hypothesized mechanisms for the system's effects. However, before deciding on this next step, consider that the present study hinted at the plausibility of *Sonic Cradle*'s more ambitious goal of persuading participants to take up psychologically self-regulatory practices in the long-term. While a new acute study would certainly provide more academic insight into *Sonic Cradle* and lead to new design iterations for improving short-term effects, it would ignore its behavioural component as a persuasive design. The fact that a short 15-minute session was able to even hint at technology's potential to promote the

uptake of psychologically self-regulatory practices implies that longer single-use sessions are not the only direction worth pursuing. Future studies could also explore the effects of repeated exposure to the system and investigate whether lasting effects remain in follow-up evaluations. If the next study could be conducted longitudinally – for instance, an 8-week *Sonic Cradle* program tracking multiple sessions to parallel Mindfulness-Based Stress Reduction programs – conclusions could also be drawn with respect to long-term changes in behaviour and thought, not to mention an additional, within-subjects dimension of analysis for all physiological data.

Sonic Cradle represents an exploratory human-computer interface design concept which shows an immense amount of promise but does not yet have a clear form for practical use. Results from follow-up studies will have a dramatic influence on future directions toward manifesting the system beyond the lab toward improving lives. For example, if the system turns out to be beneficial in the short-term but does not produce valuable effects after repeated exposures, future iterations will focus on bolstering and optimizing *Sonic Cradle*'s role as an introduction to mindfulness; in this case, work should be done exploring prototypes of the system as a publically available installation for single-use sessions. On the other hand, if repeated exposure to the system generates progressive and evolving benefits, design iterations could focus on developing home installations or even personal, mobile versions of *Sonic Cradle*. Finally, given that the present investigation seemed to reveal the system as a mediator for key stress management transitions from active coping to rest, further studies should also be conducted in clinical populations to gather evidence and design guidance for the implementation of *Sonic Cradle* as a clinical intervention.

5.5. Building Bridges to Better Lives

The stress relief associated with mindfulness meditation can significantly improve people's lives; not only because stress is a subjectively unpleasant phenomenon, but also because it causes and exacerbates a wide range of clinical problems. While other technologies may borrow principles from meditation to help monitor and reduce stress, *Sonic Cradle* is unique in its ability to provide a subjective experience directly comparable to mindfulness. I believe the results presented in this investigation call for more research on human-computer interfaces which aim to teach and demystify this vital practice. Instead of creating self-defeating stress-reduction applications which emphasize self-evaluation and lead to new dependence on technology, the possibility clearly exists for interactive media to introduce and demystify techniques which empower 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)

Almost paradoxically, this thesis demonstrates how interactive systems can be designed specifically to provide the moments of stillness and self-reflection needed to maintain psychological health in saturated media environments. Further, results from my initial investigation show that technology can introduce people to the subjective clarity of mind characteristic of mindfulness meditation. This raises a key question whose potential impact demands further pursuit: can interactive media experientially persuade people to see the value in taking responsibility for their own psychological health through contemplative practices?

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 are distracting us from these mental faculties in favour of stressful, constant productivity, *Sonic Cradle* represents a unique 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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