A Meditation on Meditation and Embodied Presence

Carrie Heeter
Professor of Media and Information, Michigan State University
Director of Mindtoon Lab
heeter@msu.edu

published in *Presence* 25:2, 175-183 2016

ABSTRACT

The major theories of presence in virtual worlds (social presence, co-presence, self-presence, hyper presence, and external presence) all define presence as an illusion about the virtual-ness of a virtual experience (Schultze, 2010). Their approach implies that we are always present when there is no virtuality. In this essay I will argue that 1) regardless of virtuality, we are almost never present; 2) embodied presence is an attentional orientation that can be learned and practiced and 3) the design of virtual experiences can facilitate embodied presence.

I begin by discussing how the mind does and does not pay attention to bodily sensations. I describe advances in neuroscience that expand the concept of interoceptive awareness to encompass all sensory input representing the condition of the entire body, including embodied emotions and thoughts. Drawing on the Krishnamacharya-Desikachar System of Yoga and Meditation, I suggest that meditation teaches how and why to achieve embodied presence. Then I suggest five approaches to facilitating embodied presence in virtual experiences that are inspired by my work with meditation. I conclude with an example of an original meditation my meditation teacher, Marcel Allbritton, and I designed with the goal of facilitating the experience of embodied presence in a virtual beach environment (Heeter and Allbritton, 2015b). Perhaps VR can provide a training ground, a sandbox, an embodied presence simulator, for practicing this skill.

http://carrie.seriousgames.msu.edu/docs/A_Meditation_on_Embodied_Presence_and_Meditation.pdf
Accompanying audio Demo 1
Accompanying audio Demo 2

ESSAY

1. Self Introduction

In 1992, I wrote an article for Presence about the idea that the design of the experience, not just the technology, resolution, or media richness, can impact personal, social, and environmental presence (Heeter, 1992). My research findings also hinted at individual differences in the susceptibility to experiencing presence. Now, in 2016, I am exploring the experience of embodied presence from the perspective of meditation. I have had the privilege of studying meditation one-on-one for more than four years with my meditation teacher, mind-body therapist, and collaborator, Marcel Allbritton. Marcel and I recently designed ten 10-minute

"movement meditations" for VR, which are available on Cubicle Ninja's *Guided Meditation VR* platform for Gear VR, Oculus Rift, and Vive.

2. Introduction

To be human is to be embodied, to exist in a sea of bodily sensations far vaster than our limited attentional spotlight can attend to. Bodily sensations are the substrate of all experience. Even our emotions and thoughts are experienced in and by the body. And yet, most of the time, most of us focus on something other these present moment sensations. Most of the time, we are not present.

How people structure their attention "determines what will or will not appear in consciousness" (Csikszentmihalyi, 1990). Embodied presence occurs when our mind integrates attention to embodied feelings with other present moment bodily sensations to produce a heightened awareness of the moment and of the sensory self. However, the major theories of presence in virtual worlds (social presence, co-presence, self-presence, hyper presence, and external presence) all define presence as an illusion about the virtual-ness of a virtual experience (Schultze, 2010). Their approach implies that we are always present when there is no virtuality. In this essay I will argue that 1) regardless of virtuality, we are almost never present; 2) embodied presence is an attentional orientation that be learned and practiced and 3) the design of virtual experiences can facilitate embodied presence.

By embodied presence, I am referring to a state of discerning somatosensory attentional orientation that is agnostic to whether the body is represented by an avatar or experiencing a virtual environment (Heeter and Allbritton, 2015a). I begin by discussing how the mind does and does not pay attention to bodily sensations. I describe advances in neuroscience that expand the concept of interoceptive awareness to encompass all sensory input representing the condition of the entire body, including embodied emotions and thoughts. I suggest that meditation teaches how and why to achieve embodied presence. Then I suggest five approaches to facilitating embodied presence in virtual experiences that are inspired by my work with meditation. I conclude with an example of an original meditation Marcel and I designed with the goal of facilitating the experience of embodied presence in a virtual beach environment (Heeter and Allbritton, 2015b). Perhaps VR can provide a training ground, a sandbox, an embodied presence simulator, for practicing this skill.

The MP3 audio files for the interoception demonstration and the present moment awareness training demonstration are available on the Presence website [http://bit.ly/HeeterDemo1]. "Movement" Meditations for VR that Marcel and I designed are available within Cubicle Ninja's *Guided Meditation VR* app on Gear VR (http://guidedmeditationvr.com/).

3. The Wandering Mind and Default Mode Network

Mind wandering is the antithesis of embodied presence. The natural resting state of the human brain, known as the Default Mode Network (DMN), is a wandering mind (Buckner, Andrews-Hanna, & Schacter, 2008; Mittner et al., 2014). Thoughts are uncontained. They jump around.

They wander (Killingsworth, Matthew & Gilbert, Daniel, 2010). The DMN includes but is not limited to Stimulus Independent Thought (SIT) (thinking about what is not happening, about something other than what you are feeling). When the DMN is active, the interoceptive awareness network is suppressed. You are not paying attention to what your body is experiencing. You are not present to what your body is experiencing. *In other words, the normal human condition is to not be present.* (I wonder how this situation impacts the outcomes of presence research. Finding that people feel present in a virtual world when their normal state is to not feel present would be quite an accomplishment!)

The DMN operates not just while we are resting but also throughout daily life. Research suggests that modern humans spend close to half of waking hours (46.9%) in a state of mind-wandering, based on approximately 250,000 random moment samples during waking hours among about 5000 adults from 83 countries (Killingsworth & Gilbert, 2010). Mind wandering tends to be have a negative valence, focusing abstract critical self-reflection, ruminating about the past or worrying about the future. Thinking about something other than what is happening, something other than what you are feeling, can be positive, such as goal-setting, creativity, or problem solving (Vago & Zeidan, 2016) But for the most part, attention on immediately experienced feelings appears to be adaptive, whereas abstract ruminative self-focus appears to be maladaptive (Watkins & Moulds, 2005). So, not only are we not present, but the predominant alternative (self criticism and negative thoughts) fosters unhappiness.

4. Interoceptive Awareness

Interoceptive awareness is a prerequisite for embodied presence. The interoceptive pathway and the DMN are competing neural pathways. They are not active at the same time. By definition, a wandering mind is not aware of present moment bodily sensations. The interoceptive pathway represents the current state of all aspects of the physical condition of the body (Craig, 2014). Interoceptive awareness refers to sensitivity to and awareness of physical sensations such as temperature, pain, touch, and sensing from internal gastro-intestinal, respiratory, cardio-vascular and uro-genital systems. (There are many other neural pathways, but interoception and DMN are the most important for presence.)

Whether or not we pay attention to it, our minds are embodied in a sea of bodily sensations. Our brains continuously receive sensory inputs from the whole body, including skin, viscera, muscles, joints, teeth, vestibular and endocrine systems, and more (Craig, 2014; N. Farb et al., 2015). Everything we experience is experienced through the lens of the body. The external world is experienced by the body. The internal world is experienced by the body. Virtual worlds are experienced by the body (Heeter & Allbritton, 2015a).

Even when the mind is not wandering, we only consciously able to pay attention to a tiny fragment of our embodied experience. For a demonstration of a few of the myriad sensations we are ignoring most of the time, try out the "interoception demonstration" audio. You could simply read the instructions below, but it would a richer, more vivid demonstration if you stop reading and experience the two minute MP3 audio [http://bit.ly/HeeterDemo2], and follow my instructions about directing your attention. This demonstration is adapted from similar orientation steps in the meditations Marcel and I guide (Allbritton and Heeter, 2013-2016).

A. <u>We start by noticing environmental physiological sensations</u>

Sit comfortably. Close your eyes. Place your hands on your legs. [PAUSE] Notice the feeling of the chair you are sitting on. [PAUSE] Feel your hands where they are resting. [PAUSE] Notice the feeling of your body under your hands. [PAUSE] Notice the air where it is touching your skin. [PAUSE]

B. *We direct attention to internal sensations of our own breath.*
Then take a look at your breathing. [PAUSE] As you inhale, there's rising. [PAUSE] As you exhale, there's a lowering. [PAUSE]

C. Then we observe the mind.
Bring your attention to your thinking. [PAUSE] Notice the level of activity of your thinking. [PAUSE]

D. Finally, we notice how the environment we are situated in feels.
Now open your eyes. Bring your attention to the world around you. [PAUSE] Notice what the world around you feels like. [PAUSE]

Notice the diversity of sources of bodily sensations available to be felt all the time. There is a lot to unpack from this short demonstration.

Part A, noticing environmental physiological sensations, highlights just a handful of the continuous bodily sensations we (or at least, our bodies) experience. A more elaborate body scan meditation could go on for an hour, directing attention to each specific body part. Part B directs attention to the internal bodily function of breath. Part C reminds us that it is possible for the mind to observe itself. Part D demonstrates that we can direct attention to how a place we are inhabiting feels.

Remember the thought experiment, "if a tree falls in a forest and no one is around to hear it, does it make a sound?" We may not be around to "hear" bodily sensations about how our hands feel, what they are touching, where the air in the room is touching our bodies, and so on, but these sensations continuously occur. Surely they impact us when we don't hear them. But that is a topic for a different essay.

5. Emotions and Thoughts are Embodied

Emotions and thoughts are also experienced as bodily sensations. An emerging paradigm in neuroscience reveals that our bodies do not merely receive, perceive and make sense of information – they also engender (embody) emotions and thoughts. Researchers have acknowledged a role for the body in the experience of presence: as an information acquisition, processing, and display system (Biocca, 1997; Ratan & Hasler, 2010). New understandings of the body's role in embodying feelings and thoughts (Craig, 2004, 2009, 2014) demand a fresh look at the central role of the body in all experiences, and particular, in the experience of presence. Craig's pioneering research shows that the Anterior Insular Cortex (AIC) is involved in all subjective feelings and plays a fundamental role in human awareness (Craig, 2009, 2014). His work offers a new way of understanding "mental" phenomena. The AIC engenders (creates) bodily feelings that represent emotions. The AIC also engenders (creates) bodily feelings that

represent thoughts. Bodily feelings represent "sensations, perceptions, emotions, intentions, and thoughts" (Craig, 2014).

Our bodies serve as magnificent feeling simulation devices. Nummenmaa and colleagues found that emotions are culturally universal "categorical somatosensory maps."(Nummenmaa, Glerean, Hari, & Hietanen, 2014) Different emotions are associated with discernable sensation patterns and major changes in physiological functions. Subjective (consciously felt) emotions are triggered by perceiving emotion-related bodily states. Their study exposed participants in Western Europe and East Asia to emotional stories, movies, words, and facial expressions. Participants then colored parts of the front and back of the body where there was increased activity and parts where there was decreased activity. Basic emotions (anger, fear, disgust, happiness, sadness, surprise) had strong cross cultural similarities. In other words, bodies appear to have a universal language for embodying basic human emotions. Perhaps these feelings are a language our bodies have evolved to try to communicate with the mind.

The previous section demonstrated a few of the myriad bodily sensations that are occurring all of the time, that we ignore. The current section expands the universe of sensations that are occurring and are available to be noticed. Given the limited capacity of our attentional spotlight and our proclivity for mind wandering, most of the body's ongoing emotion and thought embodiments occur without being noticed by the mind.

5. Roles for the Mind in Emotions

A primary role for the mind is to be aware of, or notice what we are feeling. Noticing feelings requires directing attention to interoception. Feelings such as foreboding, or rightness or wrongness, anxiety or relief arise in the body in response to external or internal circumstances (including thoughts). Unfortunately, the mind may not notice the body. We can be experiencing anger or empathy or life without noticing the bodily sensations that are happening. As we will discuss shortly, embodied presence hinges on noticing.

The mind can connect with emotions in other ways than noticing them when they arise. We recruit our body's emotion simulation powers when we experience empathy, to understand how someone else is feeling. When we say "I feel your pain," we are accurately describing empathy (Ernst, Northoff, Böker, Seifritz, & Grimm, 2013; Singer & Klimecki, 2014).

Our thinking can trigger an embodied experience of an emotion. When we remember vivid feelings we've experienced in the past, we do so by recreating how we felt. For example, the mind can recruit the body's simulation powers to embody anger. Try it. Think about a situation when you felt angry. Remember how you felt in that situation. Notice what just happened in your body. A hint of what was occurred in your body when you were in that situation is probably occurring right now. Thinking about an idea, remembering a situation from the past or anticipating a future experience, cause the body to engender bodily feelings associated with those ideas or experiences.

6. Interoceptive Awareness and Embodied Presence

Interoception is an attentional process not simply of attending to but also acting in the world informed by this physical and emotional information (Craig, 2009). Interoception focuses on the present moment. Craig argues that interoceptive awareness is the source of feelings of being alive, of our felt sense of self. This perspective on interoceptive awareness is synonymous with embodied presence. Embodied presence is attending to and acting in the world informed by physical and emotional information that is experienced through interoceptive awareness.

Embodied presence requires sustained attention to interoceptive awareness. Learning to suppress the natural habit of stream of consciousness mind-wandering requires effort and discipline (Schooler et al., 2011). Directing sustained attention toward and perceiving subtle bodily signals of interoception (activating the interoceptive pathway) are skills that can be developed.

Interoceptive awareness is a skill that can be developed, practiced, and cultivated. Learning how and what to notice and how to interpret bodily sensations can be a lifetime journey. Some interoceptive signals can be easily perceived (if we pay attention to them) and are associated with strong affective feelings (such as fatigue, fullness, or pleasant social contact) that help guide emotional behaviour. Other interoceptive signals can be consciously perceived (again, if we pay attention to them) but the sensations feel somewhat vague. Examples include the sense that another entity is not trustworthy (Riedl & Javor, 2012), or the subjective sense of knowing a word before recalling it (Kikyo, Ohki, & Miyashita, 2002). Those changes in bodily sensations provide emotional motivation that (if we learn to pay attention) can help guide decision-making. Still other interoceptive signals are subliminal, involved in keeping the body alive without obvious or conscious connection to feelings. The information interoceptive awareness can reveal is nonverbal, subtle, impossible to describe, and probably quite idiosyncratic. A major focus of my ongoing twice daily meditation practices has been on learning to notice, perceive and interpret these kinds of subtle interoceptive signals.

7. Meditation and Embodied Presence
    a. Meditation Trains Interoception

Meditation helps train interoceptive awareness. Meditation "brings interoception forward" so that the individual more easily and more often shifts to the Interoceptive Awaress neural network (Farb, Segal, & Anderson, 2013). Like exercise does for muscles, attention activates and strengthens neuropathways. When we "practice" meditation, we are practicing directing our attentional spotlight, suppressing the wandering mind neural network and activating interoceptive subjective feelings of the moment (Craig, 2009).

Enhanced emotional and bodily awareness can develop from long term mind-body contemplative practices (Mehling et al., 2011). During a mind-body practice, even for beginners, observing sensations of breath and movement helps to inhibit mind-wandering. It gives the mind something to do and can help lessen distractions and anchor attention on these present moment sensations (Allbritton, 2012-2016). When our attention is directed at present moment bodily sensations, we are activating interoception. With practice and intention, interoceptive awareness can be activated more often, become richer and deeper, and become part of life experiences outside of meditation.

My colleagues and I studied the effects on interoceptive awareness of a 6-week program Marcel

and I designed to engage hospice and palliative caregivers in a regular meditation practice using meditations delivered via smartphone (Heeter, Allbritton, Lehto, & Day, 2016). Pre- and post-measurement of interoceptive awareness showed that regular meditation practice (2 to 6 days per week for 6 weeks) resulted in large, significant improvements along 6 dimensions of interoceptive awareness in Mehling's Multidimensional Assessment of Interoceptive Awareness (MAIA) scale. MAIA dimensions of interoceptive awareness include Noticing (awareness of bodily sensations), Attention Regulation (ability to sustain and control attention to bodily sensations), Emotional Awareness (awareness of bodily sensations' connections to emotions), Self-Regulation (ability to regulate distress by attention to bodily sensations), Body Listening (tendency to actively listen to the body for insights), and Body Trusting (experiencing one's body as safe and trustworthy) (Mehling et al., 2012).

b. The Krishnamacharya-Desikachar System of Yoga and Meditation

The form of meditation that I study is based on the Krishnamacharya-Desikachar system of yoga and meditation. In this system, meditation refers to practices that 1) regulate the human system and refine mental states 2) so that the mind can be directed towards an object 3) to bring about a change in the human system (Allbritton 2012-2016).

For example, for several months the meditation object my teacher choose for my personal daily practice was to connect with a meadow in the middle of a forest. The details of what the meadow was like and my experience of the meadow emerged from doing the meditations. The meadow felt safe, sunny and brimming with life, but also peaceful and timeless. Sometimes my entire being was the meadow. Sometimes I was a tiny wildflower in the meadow surrounded by other plants rooted in the ground and basking together in the sun in the meadow. After a period of preparation, I would spend up to 10 minutes with my attention focused on the feeling and experiencing the meadow. During the meditation I embodied the nourishing, safe, peaceful, alive feelings of the meadow. I was learning how it feels to feel safe and nourished.

The stages of meditation described in chapter 3 of the Yoga Sutras of Patanjali begin with the mind in a refined state, so that it can be directed without distraction. This is why meditation typically begins with practices (such as breath and movement) to regulate the human system and refine the mind. The next stage of meditation is reached when the practitioner binds the refined mind in one direction (the mind is directed exclusively toward a single object of meditation). If the mind wanders, attention is brought back to the object. For advanced practitioners, with practice over time, attention on the object is maintained with less effort and more natural concentration ease as the mind becomes absorbed (Desikachar, 1995, 2009).

c. Embodied Presence as a Long Term Goal of Meditation

A central philosophical goal of practicing meditation has striking parallels to what neuroscience describes as embodied presence.

The diagram below, presented in Chase Bossart's lectures, originated with meditation teacher TKV Desikachar (Bossart 2013-2016). It outlines what I think of as raja yoga philosophy's perspective on embodied presence. The round rectangle represents our material self — our body

and mind -- as the lens through which we experience life. The four horizontal lines on the right are bodily sensations (perceptions) that arise in response to an object (person, place, thing, idea, emotion). The object is represented by the triangle. The filled circle on the left is our unchanging, non-material self – that part which witness and observes. The line from the circle into the body is intuition, feelings, subtle guidance or knowing. A long term goal of practicing meditation is to manage the way our system functions in order to be more able to identify, trust, and be guided by that inner voice; to improve our capacity to discern, from moment to moment, that special quality of insight. In other words, to refine the mind in order to attend to and act in the world informed by a special quality of insight available through feelings. To experience embodied presence.

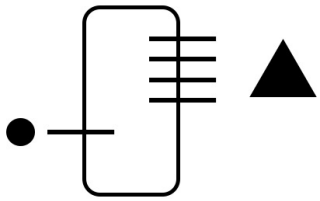

Figure 1. Raja yoga philosophy's perspective on embodied presence (from TKV Desikachar via Bossart, 2013-2016)

8. Facilitating Embodied Presence in Virtual Worlds

Here I will offer some ideas about how virtual experiences could be designed to facilitate embodied presence, based on my work with meditation and on the science of interoceptive awareness.

a. Closing The Eyes Activates Interoception

This first idea is counterintuitive. Closing the eyes activates interoception, but who wants to enter an immersive virtual world and close their eyes? When Marcel and I started designing meditations for VR, we realized that in fact, closing eyes some of the time enhanced interoceptive awareness and when eyes re-opened, the virtual world felt different. More vivid.

Neuroscientists have been examining what parts of the brain are activated when eyes are open (EO) compared to brain activation when eyes are closed (EC). It turns out that opening your eyes, even in a totally dark room, instantly changes how your brain operates.

Closing the eyes animates our somatosensory systems including touch, proprioception (vibration and position), pain and temperature (Jao et al., 2013). Closing the eyes also activates olfaction (smell) and gustatory systems (taste), even in the absence of olfactory or gustatory stimuli (Wiesmann et al., 2006). Closing the eyes activates our interoception network (used for processing the internal state) that includes imagination and memory (Xu et al., 2014).

Opening the eyes is associated with stronger "local efficiency" in specific regions of the brain and an increase in specialized information processing. But this comes at a cost. Opening the eyes suppresses interoception. Opening the eyes reduces the synchronicity, global efficiency and integrated connections across visual, somatic and auditory sensory systems (Jao et al., 2013; Xu

et al., 2014). Opening the eyes suppresses imagination, memory, and perception of internal states.

Clearly we are still able to use imagination and perceive our internal state with eyes open. But when we do so, we are working against the natural strengths of our activated brain network. We are less effective at perceiving internal states with eyes open than we would be if we matched the state of our eyes (open or closed) to the activity. To experience embodied presence in the world, we need to master the ability to switch between interoception and other modes of thought.

b. Preparation

Meditations in the Krishnamacharya-Desikachar system of yoga and meditation begin with preparation to regulate the human system – to calm the mind if it is agitated or to energize the mind if it is dull, so that the mind becomes directable. Here is a short exercise involving focusing attention on synchronizing breath with gentle movement intended to regulate the human system, bringing you closer to a state of present moment interoceptive awareness. You could simply read the instructions below, but it would a richer, more vivid demonstration if you stop reading and experience the 30 second MP3 audio [insert link], and follow my instructions. If you are not going to the audio, read the entire instructions below first. Then try doing it. This demonstration is adapted from similar steps designed to regulate the human system in the meditations Marcel and I guide (Allbritton and Heeter, 2016).

Sit comfortably with room to raise your arms up in front, toward the ceiling. Close your eyes. As you inhale, raise your arms up in front, only moving as far as is comfortable. As you exhale, lower your arms down. Try to match the length of the movements to the length of your inhale and exhale. When the breath starts, the movement starts. When the breath ends, the movement ends. The natural length of the breath determines the length of each movement.

OK, thanks for reading. Now actually try doing this 4 times. Remember to close your eyes.

This simple combination of breath and movement gives the mind something to do and helps bring you closer to a state of present moment awareness, helping to temporarily quiet the wandering mind. There is still plenty of time for the mind to wander, but the challenge of focusing the mind on interoception is made easier because the mind has a task it can focus on (aligning movement with breath).

c. Cueing

As you experienced in the demonstration audio, cueing attention to specific experiences helps the mind choose what to focus on, reducing uncertainty and distraction from the cacophony of embodied stimuli. Virtual experiences could explicitly cue attention.

d. Space

As you experienced in the demonstration audio, experiencing interoception takes time. The pauses between instructions of where to direct your attention were essential to give you time to

to feel. Leaving space for the virtual experience participant to feel is a must.

e. Training

Experienced meditators are probably much better at experiencing vivid spatial presence and self presence in virtual worlds, if they try to do so, because they are skilled at directing attention to interoception. This hypothesis is testable. If supported, we can conclude that if you want to have great presence experiences, you should adopt a regular daily meditation practice.

For those in more of a hurry, perhaps situational embodied presence can be trained within a particular virtual experience, to enhance the experience. Right before a virtual experience begins, perhaps there is a short meditation-like experience to bring embodied presence forward.

9. Beach VR Meditation for Embodied Presence

Practicing an appropriately designed meditation could cultivate the capacity to experience embodied presence during meditation and in the world. In theory, meditations can also be designed to cultivate embodied presence in a virtual world. To explore this idea, Marcel and I designed a VR meditation with a goal of heightening the sense of embodied presence in a virtual world. Cubicle Ninjas CEO Josh Farkas invited us to use his Costa del Sol VR beach environment (Heeter & Allbritton, 2015a, 2015b).

Our Beach VR Meditation for Embodied Presence moves through carefully sequenced steps to help the player connect with their visual and auditory perception of the virtual beach and with their interoceptive awareness of bodily sensations to more deeply experience being at a virtual beach. As the meditation guide, Marcel instructs the player where to direct their attention. You begin by looking around at the virtual beach – the ocean, the beach, the palm trees -- and listening to the waves and the birds. Then you connect with your body, feeling your hands, what your sitting on, moving your fingers and shoulders slightly, feeling each movement. You return your attention to the beach, more aware of both your body and the beach. You close your eyes and concentrate on your breathing, noticing a slight rising on inhale, a slight lowering on exhale. You open you eyes and feel yourself experiencing the beach. In this state of embodied presence, the beach feels more vivid and you feel more fully there.

The hope that our Beach VR meditation for Embodied Presence experience actually facilitates embodied presence is a hypothesis I haven't had time to test yet. My personal experience and casual reports from others who have tried it suggests that the meditation changes the way the virtual environment feels.

10. Conclusions

In summary, I suggest that a wandering mind – the default neural state of modern brains – is the antithesis of presence. The human system is structured to be capable of experiencing embodied presence, but we rarely achieve or remain in that desirable, optimal state. Researchers who study presence in virtual environments should pay more attention to the role of interoceptive awareness and bodily sensations (including embodied thoughts and feelings) that may impede or enhance

presence in virtual worlds. The idea that embodied presence requires training has interesting implications for improving the experience of presence in VR. Perhaps VR can provide a training ground, a sandbox, an EP simulator, for practicing this skill not just for virtual experiences but to enhance daily life.

My essay elaborates on many of the concepts that have been animating my design and research related to embodied presence, interoceptive awareness, and presence. Fellow scientists are welcome to use the VR meditations described here in your research, and to contact me to brainstorm possible collaborations.

REFERENCES

Allbritton, M.
2012-2016 Classes, workshops, one on one teaching, yoga therapy, personal conversations http://marcelallbritton.com

Allbritton, M. and Heeter, C. (2013-2016). Introducing Mindtoons. https://mindtoonlab.com/mindtoons/

Biocca, F. (1997). The Cyborg's Dilemma: Progressive Embodiment in Virtual Environments [1]. *Journal of Computer-Mediated Communication*, *3*(2), 0–0. http://doi.org/10.1111/j.1083-6101.1997.tb00070.x

Bossart, C. (2013-2016). Classes, workshops, one on one teaching, yoga therapy, personal conversations.
http://www.yogawellinstitute.com/about-chase/

Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The brain's default network: Anatomy, function, and relevance to disease. *Annals of the New York Academy of Sciences*, 1–38.

Craig, A. D. (Bud). (2004). Human feelings: Why are some more aware than others? *Trends in Cognitive Sciences*, *8*(6), 239–241. http://doi.org/10.1016/j.tics.2004.04.004

Craig, A. D. (Bud). (2009). How do you feel — now? The anterior insula and human awareness. *Nature Reviews Neuroscience*, *10*(1), 59–70. http://doi.org/10.1038/nrn2555

Craig, A. D. (Bud). (2014). *How do you feel? An interoceptive moment with your neurobiological self*. Princeton, NJ: Princeton University Press.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper and Row.

Desikachar, T. K. V. (1995). *The Heart of Yoga: Developing a Personal Practice*. Rochester, Vt: Inner Traditions.

Desikachar, T. K. V. (2009). *In Search of Mind*. Chennai, India: Krishnamacharya Yoga Mandram.

Ernst, J., Northoff, G., Böker, H., Seifritz, E., & Grimm, S. (2013). Interoceptive awareness enhances neural activity during empathy. *Human Brain Mapping*, *34*(7), 1615–1624. http://doi.org/10.1002/hbm.22014

Farb, N. A. S., Segal, Z. V., & Anderson, A. K. (2013). Mindfulness meditation training alters cortical representations of interoceptive attention. *Social Cognitive and Affective Neuroscience*, *8*(1). http://doi.org/10.1093/scan/nss066

Farb, N., Daubenmier, J., Price, C. J., Gard, T., Kerr, C., Dunn, B. D., … Mehling, W. E. (2015). Interoception, contemplative practice, and health. *Consciousness Research*. http://doi.org/10.3389/fpsyg.2015.00763

Heeter, C. (1992). Being there: The subjective experience of presence,. *Presence: Teleoperators and Virtual Environments*, *1*(2), 262–271.

Heeter, C., & Allbritton, M. (2015a). Being There: Implications of Neuroscience and Meditation for Self-Presence in Virtual Worlds. *Journal For Virtual Worlds Research*, *8*(2). http://doi.org/http://dx.doi.org/10.4101/jvwr.v8i2.7164

Heeter, C., & Allbritton, M. (2015b). Playing with Presence: How meditation can increase the experience of embodied presence in a virtual world. In *Foundations of Digital Games*. Asilomar, CA. Retrieved from http://carrie.seriousgames.msu.edu/docs/playing-with-presence.pdf

Heeter, C., Allbritton, M., Lehto, R. H., & Day, T. (2016). Effects of a 6-week cybermeditation program for hospice professionals on meditation engagement, interoceptive awareness, and compassion fatigue. *International Journal of Yoga Therapy*.

Jao, T., Vértes, P. E., Alexander-Bloch, A. F., Tang, I.-N., Yu, Y.-C., Chen, J.-H., & Bullmore, E. T. (2013). Volitional eyes opening perturbs brain dynamics and functional connectivity regardless of light input. *NeuroImage*, *69*, 21–34. http://doi.org/10.1016/j.neuroimage.2012.12.007

Kikyo, H., Ohki, K., & Miyashita, Y. (2002). Neural correlates for feeling-of-knowing: an fMRI parametric analysis. *Neuron*, *36*(1), 177–186.

Killingsworth, M. A., & Gilbert, D. T. (2010). A Wandering Mind Is an Unhappy Mind. *Science*, *330*(6006), 932–932. http://doi.org/10.1126/science.1192439

Killingsworth, Matthew, & Gilbert, Daniel. (2010). A Wandering Mind Is an Unhappy Mind. *Science*. Retrieved from http://www.sciencemag.org.proxy1.cl.msu.edu/content/330/6006/932.full?sid=f7d67c90-337b-47fe-ba9d-e14ca7ab7a9c

Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Stewart, A. (2012). The Multidimensional Assessment of Interoceptive Awareness (MAIA). *PLoS ONE*, *7*(11), e48230. http://doi.org/10.1371/journal.pone.0048230

Mehling, W. E., Wrubel, J., Daubenmier, J. J., Price, C. J., Kerr, C. E., Silow, T., … Stewart, A. L. (2011). Body Awareness: a phenomenological inquiry into the common ground of mind-body therapies. *Philosophy, Ethics, and Humanities in Medicine*, *6*(1), 6. http://doi.org/10.1186/1747-5341-6-6

Mittner, M., Boekel, W., Tucker, A. M., Turner, B. M., Heathcote, A., & Forstmann, B. U. (2014). When the Brain Takes a Break: A Model-Based Analysis of Mind Wandering. *The Journal of Neuroscience*, *34*(49), 16286–16295. http://doi.org/10.1523/JNEUROSCI.2062-14.2014

Nummenmaa, L., Glerean, E., Hari, R., & Hietanen, J. K. (2014). Bodily maps of emotions. *Proceedings of the National Academy of Sciences*, *111*(2), 646–651. http://doi.org/10.1073/pnas.1321664111

Ratan, R., & Hasler, B. S. (2010). Exploring Self-Presence in Collaborative Virtual Teams. *PsychNology Journal*, 11–31.

Riedl, R., & Javor, A. (2012). The biology of trust: Integrating evidence from genetics, endocrinology, and functional brain imaging. *Journal of Neuroscience, Psychology, and Economics*, *5*(2), 63–91. http://doi.org/10.1037/a0026318

Schooler, J. W., Smallwood, J., Christoff, K., Handy, T. C., Reichle, E. D., & Sayette, M. A. (2011). Meta-awareness, perceptual decoupling and the wandering mind. *Trends in Cognitive Sciences*, *15*(7), 319–326. http://doi.org/10.1016/j.tics.2011.05.006

Schultze, U. (2010). Embodiment and presence in virtual worlds: a review. *Journal of Information Technology*, *25*(4), 434–449. http://doi.org/10.1057/jit.2010.25

Singer, T., & Klimecki, O. M. (2014). Empathy and compassion. *Current Biology*, *24*(18), R875–R878. http://doi.org/10.1016/j.cub.2014.06.054

Vago, D. R., & Zeidan, F. (2016). The brain on silent: mind wandering, mindful awareness, and states of mental tranquility. *Annals of the New York Academy of Sciences*, *1373*(1), 96–113. http://doi.org/10.1111/nyas.13171

Watkins, E., & Moulds, M. (2005). Distinct modes of ruminative self-focus: impact of abstract versus concrete rumination on problem solving in depression. *Emotion (Washington, D.C.)*, *5*(3), 319–328. http://doi.org/10.1037/1528-3542.5.3.319

Wiesmann, M., Kopietz, R., Albrecht, J., Linn, J., Reime, U., Kara, E., … Stephan, T. (2006). Eye closure in darkness animates olfactory and gustatory cortical areas. *NeuroImage*, *32*(1), 293–300. http://doi.org/10.1016/j.neuroimage.2006.03.022

Xu, P., Huang, R., Wang, J., Van Dam, N. T., Xie, T., Dong, Z., … Luo, Y. (2014). Different topological organization of human brain functional networks with eyes open versus eyes closed. *NeuroImage*, *90*, 246–255. http://doi.org/10.1016/j.neuroimage.2013.12.060