Exploring the Transformative Potential of Immersive Technology through Embodied Interaction

by

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Abstract

In our life time there are certain moments where we suddenly discover new truths and meaning about ourselves. After these experiences we are not the same person we were. *Transformative experiences* encompass such a radical transformation of the self-world in terms of beliefs, character, identity, and interpersonal relationships. Through different types of transformative experiences, people can change their long-held beliefs about their ability to succeed in life (e.g., through a sense of empowerment and self-efficacy), their perceived importance of self (e.g., self-transcendence), perceived interpersonal connectedness (e.g., social connection), and so on. Immersive technology has the potential to support such meaningful positive transformative experiences, especially with the potential for embodied interaction that it affords. In this dissertation we explored three types of transformative experiences with two immersive artworks and associated studies: self transcendent experience (STE) and empowerment in the first study, and interpersonal connection in the second study. These two immersive artworks and studies significantly contribute to designing transformative experience with embodied interaction through immersive technology. In the first study, we designed *Virtual Transcendent Dream* – A VR flying experience inspired by dream-flying. With this virtual environment, we explored if a VR flying interface that provides more embodied self-motion cues could contribute to the benefits associated with flying dreams (i.e., STE and empowerment), using a mixed-method within-subjects experiment. Results indicated that a more embodied flying interface indeed better supported STE and empowerment. We discussed design considerations that designers could directly utilize – such as keeping the experience obscure and open to interpretation, using extraordinary light with its numinous quality for a sense of boundary dissolution, and providing a supportive setting. In the second study, we designed *Breath of Light*, an immersive art installation aiming to foster a feeling of connection and meditative awareness through breath synchronization, exhibited at the 13th Shanghai Biennale in March 2021. During the exhibition we observed interactions and interviewed participants to investigate how we could foster social connection through public art in the face of an ongoing pandemic. We found that this technological mediation of breathing has the transformative potential to revive the connective connotations of shared breathing, and cultivate inter-human connection and introspection, which might be supported by the use of metaphors, symbols, and ambiguous instructions. Over-

all we propose that embodied interaction can contribute to transformative experiences by emphasizing bodily action, perception and awareness in the experiences. We further posit connection to bodily self as a potential gateway towards transformation, and the tension between more active states and less active states as a key design parameter for transformative experience design.

Keywords: transformative experiences; immersive technology; embodiment; transcendence technology; dreaming; empowerment; social connection

Dedication

To my mother, Jingjuan; my father, Fenmin; and my dearest grandmother in heaven.

Acknowledgements

I would like to express my gratitude and appreciation to my supervisory team. I am thankful to my senior supervisor, Prof. Bernhard Riecke, for his always timely support and guidance, whether in my research or in my life. I learned so much from him beyond research. I am also grateful to Prof. Thecla Schiphorst, who showed me love for knowledge, people and the world. I would also like to thank Prof. Cheryl Geisler, who taught me proposal writing as a way of life.

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Chapter 1

Introduction

> Gravity disappears – I'm floating, slowly moving down stairs. I feel weightless, free, and possessing a secret superpower. At some point I feel the world is moving together with me–we are one. Eyes opened, I try to reminisce, but the dream fades away fast. All that remains are mysticality, a sense of empowerment, and oneness.

This was one of my earliest and yet most profound transcendent dreams, which possessed a mystical and transformative quality. *Transformative experience* is a term used to describe experiences that increase one's feeling of connectedness, restructure their worldview and motivate a positive behavioral change [Gaggioli et al., 2016]. Research has shown that immersive technology has the potential to support transformative experience, especially with it's embodied characteristic [Quesnel and Riecke, 2018, Chirico et al., 2018]. Dourish [Dourish, 1999] proposed that embodied interaction is situated in both physical and social context, which give the interaction and experience meaning in the first place. More specifically, embodied interaction in Virtual Reality has been shown to contribute to meaningful transformative emotions such as self transcendence [Quesnel et al., 2018, Stepanova et al., 2019b, Kitson et al., 2019, Glowacki et al., 2020], empowerment [Banakou et al., 2018, Rosenberg et al., 2013] and interpersonal connection [Desnoyers-Stewart et al., 2019a, Stepanova et al., 2022]. However there is still little knowledge on how different paradigms of embodied interaction within immersive technology could contribute to meaningful transformation. In this dissertation we explored three different transformative emotions with two projects: self transcendence and empowerment in *Virtual Transcendent Dream* (Chapter 2) and interpersonal connection in *Breath of Light* (Chapter 3). Each project has two different aspects–artistic creation and the associated user study. In chapter 2 we explored leaning-based flying interface as the embodied interaction in a single-user VR flying experience. In chapter 3 we explored an embodied breathing-based interface in a projection-based dyadic meditation experience. These two artworks and associated user studies significantly contribute to designing transformative experience through immersive technology.

This is a cumulative thesis which consists of two studies investigating different aspects of an overall larger problem: **how and to what extent does embodied interaction contribute to transformative experiences through immersive technology**. Both studies explored how embodied interaction (leaning-based interfaces or breathing) might support different aspects of transformation (self-transcendence and empowerment or social connection) in a immersive setting (Head Mounted Display or Projection). Individual studies are reported as different papers. Therefore, the introduction, related works and motivation of each study are discussed in the relevant chapters below. In the first study, we explored if a VR flying interface with more embodied self-motion cues could contribute to the benefits associated with flying dreams (i.e., self-transcendent experience and empowerment), using a mixed-method within-subjects experiment. Flying without assistance is a fascinating phenomenon that may arise in dreams. These flying dreams are often transcendent dreams–dreams marked by feelings of awe, magical accomplishment, extraordinary sources of light, and shifts in visual-spatial orientation. Such transcendent flying dreams are one way of having a **self-transcendent experience** (STE). Another quality observed in the experience of transcendent flying dreams is an increase in **empowerment**. The dreamers often possess an exceptional ability to attain their goals, with a powerful/competent feeling associated with flying or floating. Therefore, transcendent flying dreams have a great potential to foster empowerment through self-efficacy and thus enhance human accomplishment and positive well-being. Despite these benefits, flying dreams occur only on an infrequent basis. Lucid dreaming, a rare phenomenon where the dreamers know they are dreaming while in the dream [Eeden, 1913], has also been suggested to have transformative potential [Kitson and Riecke, 2018]. Though dream flying could be either lucid or non-lucid, dream flying is a more common occurrence for lucid-dreamers [Barrett, 1991], and these potential benefits are not easily accessible to most people, especially non-lucid dreamers. Since VR provides a particular opportunity for supporting specific types of self-transcendent emotions, such as awe and a sense of connectedness, with a multisensory embodied experience, we are interested in investigating if we could design VR flying experiences akin to dream flying and thus elicit the positive emotions associated with flying dreams. This would allow more people (especially non-lucid dreamers and dreamers who rarely have flying dreams) to achieve the benefits without having to train in lucid dreaming and transcendent flying dreams. To answer this question, we conducted an experiment using a counterbalanced within-subject design. The participants were randomly assigned into two groups, and invited to participate in a virtual flying experience. One group of the participants first went through the VR experience with standard VR controllers, which lasted approximately 15 minutes. After one week, they were asked to go through the same experience with a more embodied interface. The other half went through the experience with the more embodied first and tried the standard Controller one week later. For each session, each participant went through a 2-minute meditation before the VR experience, with instruction to imagine

a flying experience. The virtual environment took the immersants on a journey through four stages–bedroom, kingdom of clouds, space, and finally encounter with a tree of light and flying towards immense Earth. Immediately after the two flying experiences, the participants filled out six questionnaires that measure empowerment and self-transcendence, and participated in a 15 minutes long semi-structured interview.

In the second study, we designed *Breath of Light*, an immersive art installation aiming to foster a feeling of connection and meditative awareness through breath synchronization, exhibited at the 13th Shanghai Biennale. The growing issue of social isolation has been further exacerbated by the COVID-19 pandemic. By designing *Breath of Light* we tried to investigate how we might bridge the segregation resulting from the pandemic restrictions with the transformative potential of immersive technology, to cultivate inter-human connection. Within immersive environments, breathing has been used directly as a form of interaction to bring individuals' attention to their own body and to encourage connection to bodily self. Furthermore, sharing physiological data with others allows us to expose ordinary hidden intimate internal states, which can remind us of our unity as human species, and promote social connectedness. Considering the advantages of immersive environments, breathing-based interface and physiological data sharing, we combined these strategies and created an interactive artwork aiming to foster genuine human connection. We explored the connective power of shared breath through this technology-mediated art installation and conducted a qualitative study in the wild. During the exhibition, visitors breathed into the microphone playfully and collaboratively with minimal instructions. The lead artist approached visitors at the entrance to the installation, and asked for their permission to be interviewed. Participants were invited to freely explore the installation for two minutes. Then instructions on the functioning of the system were provided and visitors were encouraged to explore for another three minutes. They were instructed to consider taking off their masks temporarily and to breathe in through their nostrils and out through their mouth. We observed audiences' interaction and conducted 5-minute semi-structured interviews to better understand their experience of the installation.

In the following chapters, we will present the two studies (Chapter 2 and 3), then summarize their joint contributions, limitations and future works in Chapter 4.

- **Chapter 2 - Virtual Transcendent Dream: Empowering People through Embodied Flying in Virtual Reality**: This chapter describes how a VR flying interface with more embodied self-motion cues could contribute to the benefits associated with flying dreams. A mixed-method experiment was conducted to understand the role of embodied locomotion interface in a virtual flying experience. This study was presented and published as a full paper at the 2022 CHI Conference on Human Factors in Computing Systems [Liu et al., 2022].

- **Chapter 3 - *Breath of Light*: A Meditative Installation Reimagining Shared Breathing**: This chapter investigates how social connection could be fostered through breathing interaction during an exhibition at the 13th Shanghai Biennale. We observed audiences' interaction and conducted semi-structured interviews, to investigate social connection through public art during pandemic. It is submitted and under review for Leonardo at the time the thesis is being written.
- **Chapter 4 - General Conclusion**: This chapter discusses the overall contributions of this thesis, the main conclusions, and an outlook on future research.

Chapter 2

Virtual Transcendent Dream: Empowering People through Embodied Flying in Virtual Reality

Flying dreams have the potential to evoke a feeling of empowerment (or self-efficacy, confidence in our ability to succeed) and self-transcendent experience (STE), which have been shown to contribute to an individual's overall well-being. However, these exceptional dreaming experiences remain difficult to induce at will. Inspired by the potential of Virtual Reality (VR) to support profound emotional experiences, we explored if a VR flying interface with more embodied self-motion cues could contribute to the benefits associated with flying dreams (i.e., STE and empowerment). Our results indicated that a flying interface with more self-motion cues indeed better supported STE and empowerment. We derived several design considerations: obscurity, light and supportive setting. Our results contribute to the discourse around design guidelines for self-transcendence and empowerment in VR, which may further be applied to the improvement of mental well-being.

2.1 Introduction

Flying without assistance is a fascinating phenomenon that may arise in dreams. It has a rich cross-cultural background reaching back thousands of years and implicating numerous cultures, religions and mystical traditions [Bulkeley, 1995]. These flying dreams are often transcendent dreams–dreams marked by feelings of awe, magical accomplishment, extraordinary sources of light, and shifts in visual-spatial orientation [Kuiken, 1995]. Such transcendent flying dreams are one way of having a **self-transcendent experience**. Self-transcendent experience (STE) is characterized by a decrease in self-saliency (ego dissolution) and a resulting sense of global interconnectedness [Yaden et al., 2017]. Some self-transcendent experiences can be associated with particular self-transcendent emotions such as compassion, awe, gratitude, appreciation, inspiration, admiration, elevation, love, and flow [Yaden et al., 2017]. Self-transcendent emotions are typically positive experiences associ-

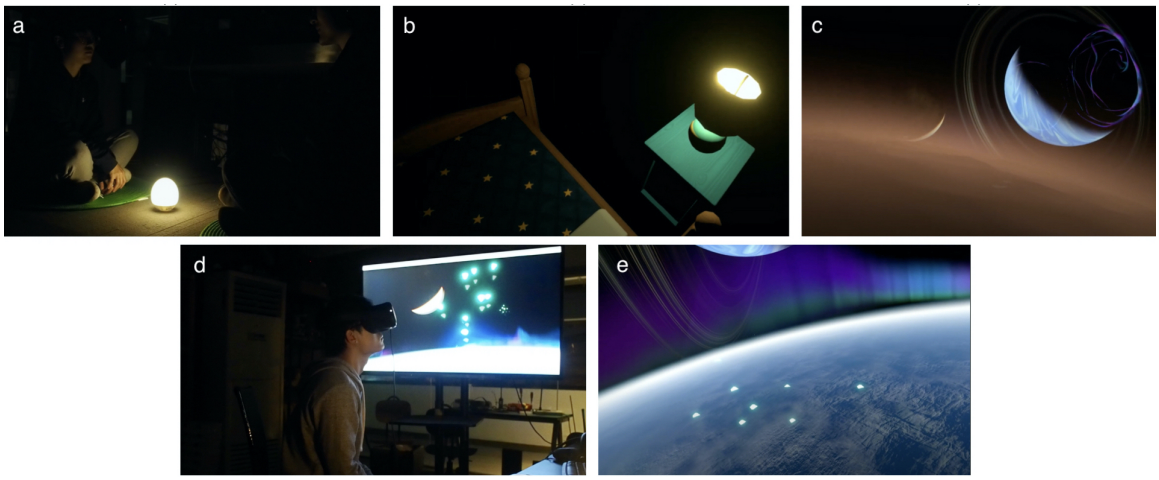

Figure 2.1: (a) A participant is being guided through a 2-minute meditation before the VR experience. (b) When participants put on the headset, the screen would fade into a bedroom with dim light. (c) Abstract lifeless landscape. (d) One participant flying into space with HeadJoystick interface. (e) The Space environment in the flying experience.

ated with benefits for an individual's well-being [McCarthy et al., 2018, Yaden et al., 2017, Kitson et al., 2020a] and pro-social intentions and behaviour [Stellar et al., 2017, Li et al., 2019, Pizarro et al., 2021]. Therefore, transcendent flying dreams provide an intriguing opportunity for promoting the well-being benefits of self-transcendence.

Another quality observed in the experience of transcendent flying dreams is an increase in **empowerment** [Mitchell, 2019] –in transcendent dreams, the dreamers often possess an exceptional (or even magical) ability to attain their goals, and the powerful/competent feeling could be understood as a kinaesthetic aspect of movement efficacy (including flying or floating) [Kuiken, 2015]. Conger et al. translated from Bandura's self-efficacy model [Bandura, 1978] and define empowerment as a process of enhancing feelings of self-efficacy [Conger and Kanungo, 1988]. Self-efficacy is an important notion in personality psychology, describing one's belief in their capacity to succeed at a task. The stronger the sense of self-efficacy, the more likely a person is to select challenging tasks, persist at them, and perform them successfully [Bandura, 1978]. The sense of self-efficacy develops with our experiences, i.e., experiencing being successful at a challenging task (such as flying) enhances our overall sense of self-efficacy. Interestingly, experiences of being successful at tasks or movements in our dreams also has the capacity to enhance self-efficacy, alike real life experiences [Kuiken, 1995]. Therefore, transcendent flying dreams have a great potential to foster empowerment through self-efficacy and thus enhance human accomplishment and positive well-being.

Despite these benefits, flying dreams occur only on an infrequent basis, and some people rarely or never experience flying dreams. As a consequence, these potential benefits are not easily accessible to most people. To address this issue, Picard-Deland and colleagues sug-

gested that brief exposures to a simulated flying task in VR could selectively increase the occurrence of unassisted flying dreams [Picard-Deland et al., 2020]. In addition, they proposed that feelings of dream-flying constituted a type of vection illusion (illusion of self-motion, [Riecke, 2011]), which could be activated in a VR flying experience. Since VR provides a particular opportunity for supporting specific types of self-transcendent emotions with a multisensory embodied experience [Quesnel and Riecke, 2018, Chirico et al., 2018], we are interested in investigating if we could design VR flying experiences akin to dream flying and thus elicit the positive emotions associated with flying dreams with a dream-inspired flying experience in VR. However, there is little knowledge on what design elements are required to support the experience of dream-like flying in VR. To guide our design, we look to another type of dream experience in VR, namely lucid dreaming. Lucid dreaming, knowing one is dreaming while in the dream [Eeden, 1913], has been suggested to have the potential to induce STE [Kitson and Riecke, 2018]. Though dream flying could be either lucid or non-lucid, dream flying is a common occurrence in lucid dreaming [Barrett, 1991]. There is not a lot of design guidance around dream flying in VR, but there is lucid dreaming in VR (Section 2.2.1) that is similar to our design goal, which may serve as a starting point for this project. Furthermore, feelings of dream-flying constitute embodied self-motion illusions, which in VR can be significantly enhanced by locomotion interfaces providing self-motion cues, such as leaning-based interfaces [Hashemian et al., 2022, Adhikari et al., 2021, Kruijff et al., 2016, Riecke, 2011]. With leaning-based interfaces, the immersants lean towards the desired direction for virtual motion [Hashemian et al., 2022]. Thus, we suspect embodied VR flying interfaces, such as leaning-based interfaces, could better support the positive emotions induced by actual flying dreams. However, most embodied VR flying interfaces are only evaluated in a more practical context (i.e., maneuvering performance, taskload, accuracy, or overall usability), and it remains an open research question whether or to what degree VR flying could support the feeling of dream flying, especially feelings of self-transcendence and self-efficacy associated with dream flying.

Alternatively, the standard VR flying interface, such as handheld controllers with thumbsticks, also show promising evidence of being preferred by the users because of familiarity and ease of use. People often prefer more familiar interfaces for 3D user interfaces [Bowman et al., 2008]. In a recent study, the standard hand-held controllers has been rated as more comfortable, intuitive and ease-to-use among the latest prevalent locomotion interfaces [Boletsis and Cedergren, 2019]. Additionally, embodied VR flying interfaces have their own limitations compared with standard hand-based interfaces. Previous studies showed that novel leaning-based interfaces may feel unfamiliar and unsafe, and more likely to induce physical fatigue [Hashemian et al., 2022, Adhikari et al., 2021, Kruijff et al., 2016, Zhang et al., 2019]. These factors might negatively affect STE and empowerment that is associated with flying dreams. Therefore, we are interested in investigating if a more embodied VR flying interface that provides more self-motion cues could better support the feeling

of dream flying, specifically self-transcendence and self-efficacy. To test the contributing role of self-motion to elicited STE and sense of self-efficacy, we compared a standard and widely used non motion-cueing interface, **VR Hand Controller** that has very low embodiment, with a motion-cueing interface **HeadJoystick** (a novel leaning-based interface that provides increased embodiment, discussed in detail in Section 2.2.4 and Section 2.5.3).

A mixed methods approach was adopted, with quantitative methods to investigate if a dream-inspired flying experience could contribute to STE and empowerment, and if a more embodied interface might be able to enhance those experiences, and qualitative methods to make sense of and better understand the participants' experiences how the different factors might have contributed.

2.2 Related Work

2.2.1 Self-transcendent VR

There is a growing interest in designing positive technology that can support self-transcendence [Buie, 2018, Gaggioli et al., 2016]. The immersive capacity of VR technology presents a promising direction for simulating rich, profound experience that may not be accessible in real-life, but which are known to provide benefits such as eliciting self-transcendent emotions. Some examples of these experiences include the Overview Effect, lucid dreaming, and psychedelic experiences, that we will briefly discuss below.

Overview Effect

The Overview Effect is a profound awe-inspiring experience that astronauts have reported when witnessing the astonishing beauty of our home planet from outer space [White, 1998, Yaden et al., 2016]. Inspired by the transformative capacity of seeing Earth from outer space, several researchers and commercial and non-profit companies have attempted to simulate this experience with VR [Stepanova et al., 2019a]. Quesnel & Riecke [Quesnel and Riecke, 2018] evaluated Google Earth VR as a stimulus for awe induction through elicitation of the Overview Effect. *AWE* [Quesnel et al., 2018, Stepanova et al., 2019b] is an immersive mixed and virtual reality installation designed to elicit feelings of awe and wonder. Stepanova et al. [Stepanova et al., 2019a] reviewed the psychological research on the Overview Effect and awe, and proposed guidelines for VR around four aspects: embodied experience and self-relevance, privacy and social space, visual style, and storyline. While the Overview Effect guidelines recognize the importance of embodied experiences and specifically weightlessness, none of the studies to date have addressed in detail the role of the interface and the sense of embodiment in the overall self-transcendent experience of the Overview Effect.

Lucid Dreaming and Altered States Systems

Lucid dreaming, knowing one is dreaming while dreaming, is an important tool for exploring altered states of consciousness and self-transcendence. Because of these benefits, recently researchers and VR designers have began to explore how lucid dreaming-inspired VR experiences could help train users to achieve lucidity in their dreams, or to directly receive well-being benefits associated with lucid dreaming through a VR experience. *Lucid Loop* [Kitson et al., 2019] is a VR experience where one can practice lucid awareness via neurofeedback. Visuals are creatively generated before your eyes using a deep learning Artificial Intelligence algorithm to emulate the unstable and ambiguous nature of dreams. The virtual environment becomes more lucid or "clear" when the participant's physiological signals (brainwaves) indicate focused attention. *Inter-Dream* [Semertzidis et al., 2019] is a multisensory interactive artistic experience driven by neurofeedback. It is comprised of an interactive bed, ambient score, and dynamic visuals procedurally generated from EEG data fed back to the "dreamer" through VR and projection mapping. *Spinoza Cafe* [Gott et al., 2021] is another example of VR simulation aimed to help users train to recognize lucid dreams by noticing obscure changes in the environment. After practising meta-cognitive reflection in *Spinoza Cafe*, participants experienced significantly more lucid dreams over a 4-week period. From these dream related systems, we translated Kitson et al. [Kitson et al., 2018]'s and Semertzidis et al. [Semertzidis et al., 2019]'s design guidelines from a broader concept of dreaming to specific flying dreams: vividness and clarity; multisensory experience; exploration; playfulness; flying; sense of control and agency; ease in and out of VR (seamless transitions); ceremony and rituals; abstract and nature elements. We carefully followed these strategies when designing our experience.

Psychedelic Technology

Psychedelics are famously known for their potential to induce strong self-transcendent experiences and ego dissolution [Pahnke and Richards, 1966]. However, since their use is associated with health risks and is illegal in many countries, the potential of immersive technology to simulate psychedelic experiences has sparked the interest of several designers and VR developers. *Hallucination Machine* [Suzuki et al., 2017] is a deep-dream neural network immersive 360 video system that simulates the visual hallucinatory experiences in a biologically plausible and ecologically valid way, as evidenced in two experiments. *Isness* [Glowacki et al., 2020] is a multi-person VR journey where participants experience the collective emergence, fluctuation, and dissipation of their bodies as energetic essence, comparable to a psychedelic experience. Instead of achieving benefits with 'top-down' changes in a participant's brain, both of *Hallucination Machine* and *Isness* aimed to support 'bottom-up' changes through perceptual sensory inputs with immersive technology. However, rather than simulating psychedelic visuals like in *Hallucination Machine*, *Isness* focused on how

immersive technology might be used to construct mystical-type experiences, a construct of self transcendence [Yaden et al., 2017], comparable to those that arise during psychedelic drug experiences. Inspired by *Isness*, we are interested in investigating how immersive technology might be used to elicit self-transcendent experiences associated with those that arise during flying dreams.

To sum up, the HCI community has investigated how to evoke self-transcendence in VR through simulating the overview effect, altered states and psychedelic experiences. By exploring dream-flying, we might discover and validate a new way to contribute to self-transcendence, and inspire and guide future self-transcendent VR experience design.

2.2.2 VR Systems Supporting Empowerment

Banakou et al. [Banakou et al., 2018] placed participants in a virtual body of Einstein, which signifies super-intelligence, and reported that virtual body ownership could increase self confidence and enhance executive functioning. In the *Virtual Superheroes* study, Rosenburg et al. [Rosenberg et al., 2013] found that acquiring the superhero ability to fly in VR increased helping behavior. They suggested that having the power of flight primed concepts and stereotypes associated with superheroes (e.g., Superman) which may activate a change in self-concept and subsequent helping behavior. These two experiences suggest that VR has the potential to empower the immersants–having a magical ability and even extending it to the real world. Though with different design purposes, we find *Virtual superheroes* the closest VR flying experience that investigated empowerment to the best of our knowledge. We noted the embodied feature in *Virtual superheroes* and how a certain flying gesture primed concepts and stereotypes (e.g., superman for power, bird for freedom). We carefully considered our choice of flying interface according to the degree of embodiment and the conceptual priming (discussed in more detail in Section 2.2.4).

2.2.3 Embodiment in Transcendent Dreams

Kuiken [Kuiken, 1995, Kuiken et al., 2006] suggested that, in transcendent dreams, the dreamers feel powerful and competent and possess an exceptional ability to attain their goals. More specifically, this powerful/competent feeling could be understood as a kinaesthetic aspect of movement efficacy (including flying or floating) [Kuiken, 2015]. This literature suggests that the movement in transcendent dreams plays a key role towards constructing the experience. Mitchell [Mitchell, 2019] reported that the control of movements in flying dreams are related to a sense of power, with four participants using the terms 'powerful' and '**empowerment**'. More recently, Picard-Deland et al. [Picard-Deland et al., 2020] proposed that the feelings of dream-flying constitute a type of self-motion illusion, which could be activated in a VR flying experience. Thus we are interested in investigating how the key factor associated with control, degree of embodiment for VR interfaces, could affect self-efficacy and self-transcendent emotions in a virtual flying dream experience.

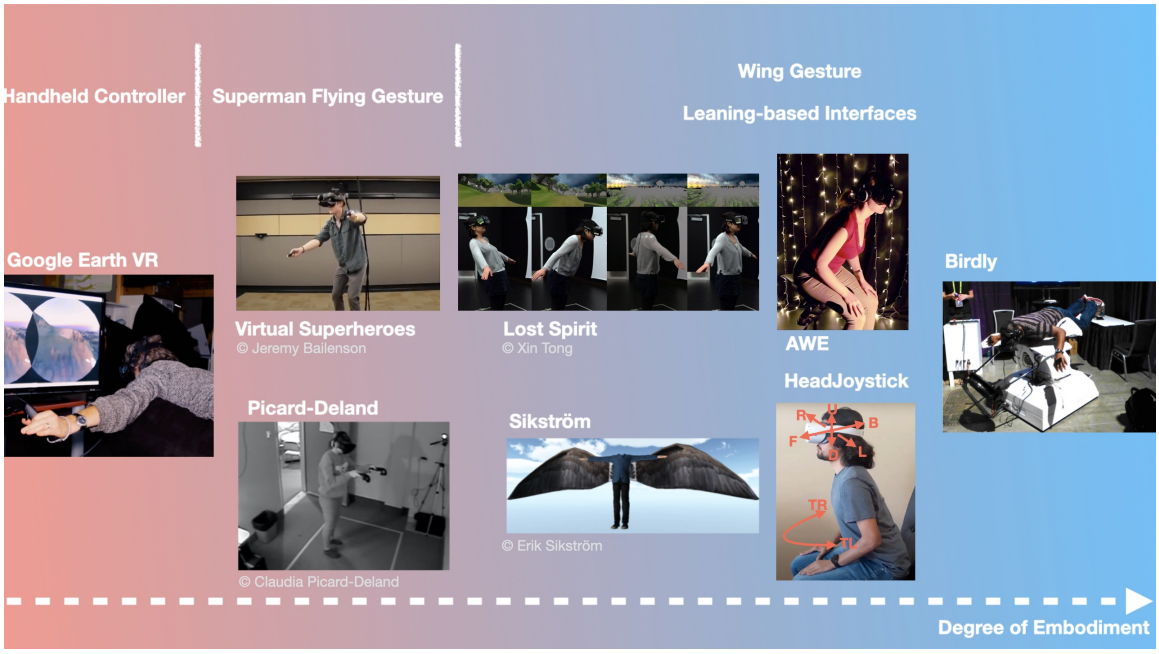

Figure 2.2: Flying interfaces with different degree of embodiment on an ordinal scale.

2.2.4 Flying Interface Paradigms Based on Embodiment

Our chosen flying interfaces are situated within the global context of embodied VR flying interfaces. In the following section, we list out selected existing flying interfaces with different levels of physical motion cues/bodily involvement and examine our chosen interfaces' relationship to the general concept of embodiment. In our paper, there is an important distinction between the *sense of embodiment*, the subjective experience of feeling embodied in VR, and the *degree of embodiment*, the objective degree of embodied movement in VR afforded by an interface. The earliest definition of embodiment in VR comes from Kilteni et al. [Kilteni et al., 2012], who define the *sense of embodiment* perceived by a user as the sense that emerges when a body's properties are processed as if they were the properties of one's own biological body. Within their framework, they further suggest that a sense of embodiment is expressed on a continuous scale from no embodiment to full embodiment. When we compare different VR flying interfaces, we refer to embodiment not as a user's perceived agency, but as the degree of embodiment afforded by the locomotion interfaces. An online survey by Zielasko & Riecke [Zielasko and Riecke, 2021] showed a trend that the more body parts involved, the higher degree of embodiment an interface tend to have. Hence, we roughly classified the degree of the embodiment of each locomotion interface based on the level of physical motion cues or bodily involvement. Here we do not aim to cover all existing flying interfaces, but to carefully select interfaces which are prototypical for specific embodied flying mechanism (i.e., flying by moving fingers, moving hands, flapping arms or leaning one's body), and have the potential to support self-transcendence or

self-efficacy. We mapped out the chosen interfaces within a spectrum of embodiment, based on the level of bodily involvement, which is shown in Figure 2.2 on an ordinal scale. The figure served as a rough measure to help us evaluate and select the suitable flying interfaces for our experience. We motivated our choices of two interfaces considering the degree of embodiment, the desired feeling of dream flying, as well as the affordability.

Handheld Controller (Thumbstick/Touchpad)

In Google Earth VR [Käser et al., 2016], the navigation via hand-held controller as input device worked by using a trigger button (right hand) to point, select, and drag the environment; a thumbstick or touchpad (depending on the controller) enabled forward and backward movement (right hand); and a thumbstick/touchpad (left hand) enabled a vertical or horizontal orientation on the Earth. As one of the most prevalent control paradigms, the level of physical motion cues/bodily involvement (finger movement) of the thumbstick/touchpad controller was the least coupled to embodied self motion in VR and provided no vestibular self-motion cues, thus we considered it as a low embodied flying interface.

Superman Flying Gesture

In *Virtual Superheroes* [Rosenberg et al., 2013], the user's hands were tracked with markers. When the participants raised their hands above their head, they flew higher in the virtual city; Picard-Deland et al. [Picard-Deland et al., 2020] adopted a similar interface while designing a flying experience to induce flying dreams–with a wireless controller in each hand, participants moved their arms to control their flying movements (e.g., move arms to the left, turn left). They controlled flying speed by moving the controllers away from (accelerating) or toward (decelerating) the body.

The strength for the superman style flying interface was that it mimicked superhero-style flying and showed a potential to empower people [Rosenberg et al., 2013] and induced flying dreams [Picard-Deland et al., 2020]. However, in terms of degree of embodiment, the proprioceptive cues from the superhero arm/hand movements were still less directly coupled to self-motion in VR compared with wing-flapping or leaning-based interfaces. Moreover, the flying gestures did not provide any direct vestibular cues that were known to facilitate self-motion perception [Lawson, 2014, Riecke and Schulte-Pelkum, 2015]. Besides, it was not hands-free and users needed to hold trackers/controllers in their hands to mediate the agency.

Fly with Wings

Lost Spirit [Tong et al., 2016] is a VR experience where standing participants could use their body gestures as a Natural User Interface (NUI) to control flying movement via Microsoft Kinect: lean forward/backward to go forward/backward and move arms up/down

to go up/down. It combined wing flapping and leaning and was reported as intuitive and easy to control. Sikström et al. [Sikström et al., 2015] compared a hand-held video game controller with motion tracked shoulder control. In the latter condition, participants flew in VR by repeatedly moving the shoulder up and down for controlling the wing movement and the upwards translation. The study suggested that the hands-free shoulder control lead to stronger experienced embodiment of the wings in terms of ownership and agency. *Birdly* [Rheiner, 2014] is aimed to provide a bird-like flying experiences and users were lying face down on a purpose-built actuated motion platform that allowed them to embody a bird of prey by means of multisensory stimulation, including proprioceptive (i.e., the flapping arm movements correlate with the wings of the bird), tactile (e.g., headwind simulated by a fan), audio, and olfactory feedback.

In terms of degree of embodiment, these interfaces show a high level of bodily involvement, especially *Birdly* which involved the whole body during the VR experience and included some vestibular self-motion cues. Thus, we rate *Birdly* as the most embodied flying interface of those compared here. However, it is also the least affordable at $189,000 USD, making it unfeasible for most VR users and the current study. Besides, these interfaces were specifically designed for simulating being and flying like a bird, which is not aligned with our intention to create dream-like human flying experiences (which only rarely involve becoming a bird) in VR. Furthermore, bird-like VR flying interfaces might also not be suitable for long-time flying for human. For instance, in *Lost Spirit* researchers observed that their participants quickly became tired with their arms feeling heavy and hurting after several minutes of use because humans, unlike birds, have little practice stretching their arms to the sides for long time [Tong et al., 2016].

Leaning-based Interfaces

In *AWE* [Quesnel et al., 2018], for the first three prototypes the researchers used a custom leaning-based interface with a rotating swivel chair. This interface allowed for more natural locomotion compared to standard interfaces [Kruijff and Riecke, 2017], but was seldom able to induce the sense of floating [Quesnel et al., 2018]. In their latest prototype, they used a custom interface based on the *Limbic Chair* that supports each thigh in a way that allows legs to move independently. Sensors in the chair were mapped to navigation controls in the virtual environment so that the immersant may steer gently with their legs and torso. While these interfaces allowed the user to move more easily horizontally, vertical locomotion was more challenging. More recently, Riecke, Hashemian et al. [Riecke, 2017, Hashemian et al., 2022, Adhikari et al., 2021] developed a seated or standing leaning-based flying interface, called HeadJoystick, where the user moves their head and/or leans in the direction they want to navigate, and the position of the already-tracked head-mounted display is used to control the locomotion. In Hashemian et al's study, participants were asked to fly toward nine tunnel way-points and fly through the tunnels of decreasing

diameter without colliding with the walls [Hashemian et al., 2022]. Assessing the interface in this maneuvering task, Hashemian et al. concluded that the HeadJoystick performed better than the standard hand-held controllers in terms of accuracy, precision, ease of use, ease of learning, usability, long term use, presence, immersion, a sensation of self-motion, workload, and enjoyment. In terms of degree of embodiment, we found that leaning-based flying interfaces had a higher level of bodily involvement than most wing-flapping flying interfaces where only the arms or shoulders were involved, with *Birdly* being the exception where full-body was involved. Leaning-based interfaces also by their nature provided vestibular self-motion cues coinciding with simulated accelerations/deceleration, which were known to enhance self-motion illusions [Hashemian et al., 2022, Adhikari et al., 2021], an important aspect in flying dreams [Picard-Deland et al., 2020].

For the current study, we chose to compare the commonly used hand-held VR flying controllers to HeadJoystick, because HeadJoystick provides relatively high levels of embodiment and vestibular self-motion cues, and it has been shown to enhance self-motion illusions [Hashemian et al., 2022, Adhikari et al., 2021]. Moreover, it requires no additional cost, thus making it suitable for broad audiences (i.e., anybody with an HMD could use it). Our choices also help to avoid priming users with a superhero or bird metaphor, and aligns better with our aim to create a more general-usage floating or spacewalk flying style that has a better potential for supporting a sense of weightlessness for flying dreams.

2.3 Research Questions

This paper investigates the design of a VR flying dream experience to support self-efficacy and self-transcendence. It aims to address the overarching research question: *How and to what extent could an embodied and dream-inspired VR flying experience support self-efficacy and self-transcendence?* The question was broken down into three sub-questions as follows:

1. Can a dream-inspired VR flying experience support feelings of dream flying, especially self-transcendence and empowerment?

Virtual reality has been demonstrated to be able to support positive emotions [Kitson et al., 2019, Yaden et al., 2018]. More specifically, an increasing amount of research has demonstrated how VR could support self-transcendence [Quesnel and Riecke, 2017, Chirico et al., 2018] and empowerment [Rosenberg et al., 2013, Banakou et al., 2018]. Yet, to the best of our knowledge, no previous research has investigated how to achieve these benefits through simulating a flying dream experience, as well as the relationship between STE and unassisted flying experiences. By exploring this question, we may discover and validate a new way to contribute to self-transcendence, and inspire future development of self-transcendent VR experience design. We hypothesized that our dream-inspired virtual flying experience would induce emotions of self-efficacy and self-transcendence, irrespective of the flying interfaces.

2. Does a more embodied locomotion interface better support feelings of dream flying (including self-transcendence and empowerment) compared to a less embodied locomotion interface? Recently Picard Deland et al. proposed a new vection-based explanation of dream flying, which suggested that self-motion was a key aspect in dream-flying [Picard-Deland et al., 2020]. In addition, studies showed that embodied (leaning-based) VR flying interface could enhance self-motion, i.e., vection [Hashemian et al., 2022, Adhikari et al., 2021]. However, most research on embodied VR flying interfaces only assessed it in maneuvering [Hashemian et al., 2022] or spatial orientation tasks [Adhikari et al., 2021], rather than in the context of profound emotional experiences. Thus, we have little knowledge about how embodied interfaces could support the emotional benefits of dream flying. In addition, since people are familiar with the less embodied Hand Controller interface (but not the embodied one), it remains an open question whether the more embodied interface does or does not provide an advantage over the traditional Hand Controller in terms of supporting self-transcendence and self-efficacy through a virtual flying dream experience. Hence, we address this research gap by investigating if or in what ways a more embodied VR flying interfaces might better support virtual flying dream experiences. We see a trade-off between the familiarity of an interface and its capacity to support a feeling of self-motion. On the one hand, since more embodied interfaces, such as leaning-based interfaces, were in the past rated better in terms of controllability and self-motion perception [Hashemian et al., 2022, Adhikari et al., 2021, Kruijff et al., 2016, Riecke, 2011], we hypothesize that a more embodied flying interface (HeadJoystick) would lead to higher scores on self-efficacy and self-transcendence compared to a less embodied flying interface (Hand Controller). On the contrary, since most participants are more familiar with the Hand Controller interface, using it would require less effort and training. Additionally, it would avoid the risk of making users feel unsafe and physically fatigued after long use, as has been shown to happen with novel leaning-based interfaces [Hashemian et al., 2022, Zhang et al., 2019]. This suggests that the Hand Controller interface could provide a more seamless experience of navigation in VR, ultimately being more beneficial for supporting well-being outcomes of virtual dream flying. Considering this trade-off of familiarity vs. self-motion and embodiment, we are interested in comparing the two interfaces to identify which could better support emotional outcomes of VR flying dream.

3. What are the key design elements that contributed to participants' (emotional) experience? There exists only limited research exploring virtual flying dreams [Picard-Deland et al., 2020]. To better understand the design opportunities for creating flying dreams in VR, we include a qualitative component to our mixed-methods study. Through this study, we hope to begin to unpack the elements of the experience of flying in dreams as simulated in VR. While there is little research on virtual flying dreams, there has been some research focusing on how lucid dreaming could guide self-transcendent VR experience design [Kitson et al., 2018, Kitson and Riecke, 2018]. Considering the strong association be-

tween flying dreams and lucid dreams, and their shared potential for contributing to STE, these guidelines might preliminarily help us approach the design challenge for dream flying in VR. However, we lack an understanding of specific design elements afforded by VR design for supporting flying transcendent dream-like experiences. We aim to extend these lucid-dreaming based guidelines with observations from our virtual flying experience, which will inform future development of more compelling flying simulation experiences capable of inviting STE.

2.4 Experience Design

To address these research questions, we designed a novel VR experience inspired by transcendent flying dreams. We began our design process with a co-design workshop. Using observations from the workshop, we designed the experience including the pre- and post-VR segments.

2.4.1 Co-design Workshop

Though there has been discourses on guidelines for self-transcendent experience design in VR inspired by lucid dreaming [Kitson and Riecke, 2018], these guidelines were not tested yet. Hence, we held an internal co-design workshop in order to inform our design for the VR experience in addition to the existing guidelines. During this one-hour workshop, we distilled six key qualities of flying dreams which might contribute to the desired emotions (STE and empowerment) and helped to guide our system design: embodiment, transition, height, weightlessness, vivid detailed imagery, and adverse emotions before lucid.

2.4.2 Virtual Environment

The virtual environment took the immersants on a journey through four stages. First, the immersants would find themselves in a dark bedroom, which is designed for familiarity and transition between the physical lab room and the virtual bedroom. The immersants would then slowly float up through the ceiling into an abstract lifeless landscape (see Figure 2.1 (c)). After hearing a sound of a singing bowl, the immersants could start to move freely using the hand-held controller or HeadJoystick. Second, the immersants would fly beyond the clouds and transit into a kingdom of clouds environment. Third, the immersants would fly higher, go through clouds and enter space (see Figure 2.1 (e)). Several dangerous-looking planets were designed to trigger adverse emotions. Along the immersants' journey, several flocks of glowing creatures would lead the way (see Figure 2.1 (d)). A blue light in the far distance would guide the immersants to the next stage of the journey. From the blue light, a tree of light would grow (Figure 2.7). Finally, the tree would transform into a light bridge and the immersants would fly along with the lights towards an immense Earth

that gradually appeared. The world faded to black and they were transported back to the bedroom. (walk-through video link: https://youtu.be/56rG_E8j7jM)

2.4.3 Set and Setting

The set (short for mindset) and setting (physical and social environment) were initially used to describe the physical, mental, social, and environmental context one brings into a psychedelic experience [Leary et al., 1971]. Recently Kitson et al. suggested that set and setting are important in supporting profound emotional experiences in VR [Kitson et al., 2020b]. Following these recommendations, we have carefully designed for the full experience wrapping the VR simulation to support the desired experiential qualities in our participants. Specifically, as detailed below, we carefully designed transitions into the lab and into VR to help participants to slow down, relax and open up to the experience. The out of VR and out of the lab transitions were designed to help participants accommodate their experience and transition back to their everyday life.

Into the Lab: Before the VR experience, the participant entered a dark room with dim lights, fabrics and ambient music designed to place them at ease.

Into VR: We placed cushions for participants to sit on along with a mood lamp to create a welcoming space. We chose the similar color tone to the tree of light in VR for the mood lamp–warm canary yellow–to foreshadow the light element in the VR experience. The participant went through a 2 minute co-meditation with the facilitator, where they were guided to imagine a flying experience or recall a flying dream they have had before (see Figure 2.1 (a)). During meditation, the mood lamp also served as a Yantra (i.e., a single point for a meditation practitioner to gaze at). When they put on the headset, the screen would fade into a bedroom with dim light (see Figure 2.1 (b)), with the same ambient music as that in the room playing through the HMD headphones.

Out of VR: The screen would fade out and fade in again into the original dark bedroom illuminated by dim lights. The ambient music in the flying experience would linger until the participant exited the lab.

Out of the Lab: We encouraged conversation about the thoughts and feelings that arose immediately after the flying experience. When the participants were filling out questionnaires and participated in the interviews, the ambient music was played through external speakers. We also prepared pop candies and chocolate bars to support physical comfort.

2.5 Method

In this study, we adopted a mixed methods approach, with the quantitative component to measure the effect of self-motion as mediator on STE and empowerment, and the qualitative component to better understand the meaningful qualities of a virtual flying dream

experience and contributing factors, as well as how it can provide insights for VR designers. We conducted an experiment using a counterbalanced within-subject design.

2.5.1 Participants

Twenty (thirteen females) participants (P1-P20) were recruited with an average age of 25.7 years (SD = 5.50). Participants were recruited through social media or word-of-mouth during the COVID-19 pandemic from April 2021 to July 2021 in China. Participants had no reported history of fear of height, seizures, severe headaches, uncorrected eye or ear conditions, or any condition affecting balance.

2.5.2 Technical Apparatus and System

The experience was created using the Unity game engine. We adopted the HeadJoystick interface as the more embodied motion-cueing flying interface in that it could provide vestibular cues for enhanced illusion of virtual self-motion (vection) and effectively reduce motion-sickness [Hashemian et al., 2022]. Correspondingly, we used the standard hand-held controller as a less embodied and non motion-cueing interface for comparison. We chose the controller that came with the Oculus Quest headset because it is the most prevalent head-set on the market, and the thumbsticks on the controllers are similar in design to the most prevalent controllers in both VR and non-VR gaming. The program was run on a portable desktop computer and streamed to an Oculus Quest HMD with Oculus Link. Participants sat on an office swivel chair that could rotate 360°.

2.5.3 Flying Interfaces

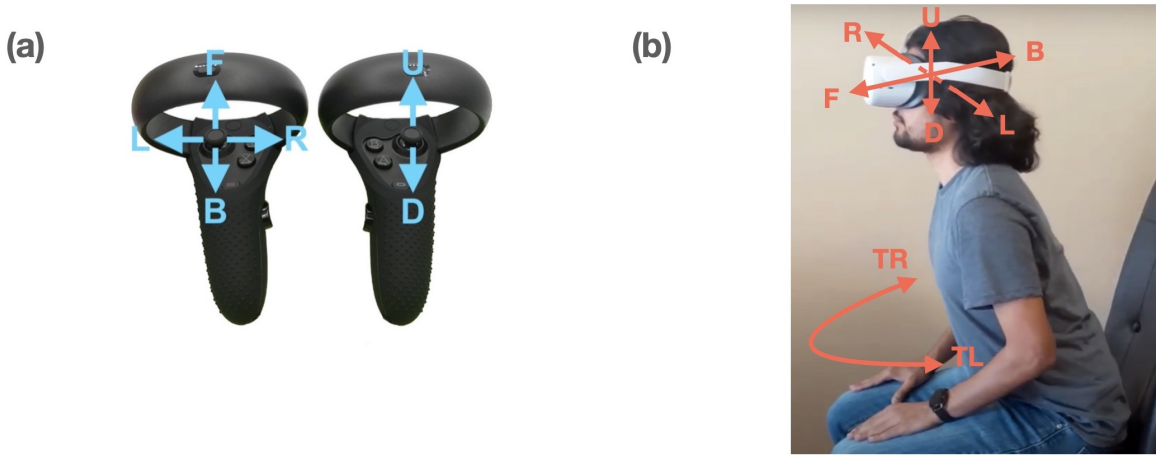

Figure 2.3: (a) In Hand Controller, the left thumbstick controls the horizontal velocity (**F**orward, **B**ackward, **L**eft, **R**ight) and the right thumbstick controls the vertical velocity (**U**p, **D**own) (b) In HeadJoystick, the user's head position controls the velocity. In both cases, users rotate physically (**T**urning **R**ight, **T**urning **L**eft).

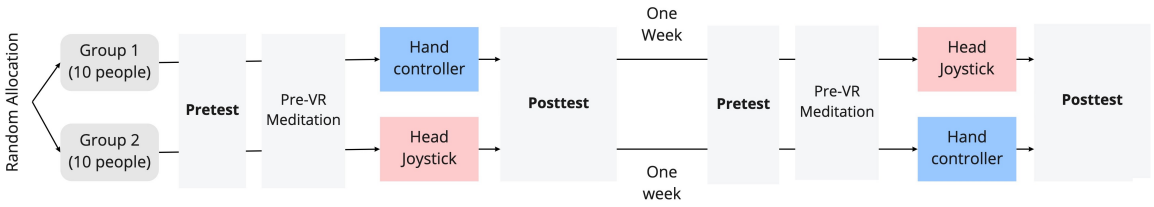

Figure 2.4: A flow chart illustrating the procedure of the study.

Hand-Held Controller Interface

For the Hand Controller interface, the left control stick controlled horizontal translation velocities as illustrated in Figure 2.3 (a). The right control stick controlled upward/downward translation speeds.

HeadJoystick Interface

As shown in Figure 2.3 (b), in the HeadJoystick interface, head position determined the translation. The interface calibrated the zero-point before each use. Moving the user's head in any particular direction from that zero-point made the player move in the same direction in VR. The distance of the head from the zero-point determined the speed of the virtual translation, using exponential mapping [Hashemian et al., 2022]. That is, leaning forward/backward caused the user to move forward/backward, leaning left/right caused sideways motions, stretching their body up or slouching down created upward or downward motions, and coming back to the center stopped the motion.

2.5.4 Procedure

Figure 2.4 shows the procedure of the study. The participants were randomly assigned into two groups, invited to the lab, where they signed the informed consent form on an iPad. Each group went through two sessions with different flying interfaces, with 1 week (rearranged as 8 days for P13 and P20, 9 days for P16) between the 1st and 2nd session in order to minimize carry-over effects. For each session, each participant went through a 2-minute meditation before the VR experience, with instruction to imagine a flying experience. Half of the participants first went through the VR experience with handheld VR controllers, which lasted approximately 15 minutes. After one week, they were asked to go through the same experience with the HeadJoystick interface. The other half went through the experience with the HeadJoystick first and tried the Hand Controller one week later. For both groups of participants, immediately after the two flying experiences, they filled out six questionnaires (presented in both English and Chinese) and participated in a 15 minutes long semi-structured interview in Chinese conducted by the first author.

2.5.5 Experimental Design

In this study, we adopted a counterbalanced 2×2 within-subject design. The independent variables were flying interface (HeadJoystick vs Hand Controller) and the order of interfaces (HeadJoystick first vs Hand Controller first); the dependent variables here corresponded to the first two sub research questions: self-efficacy and self-transcendent emotions.

Data Collection Methods

Quantitative Data: A total of six validated questionnaires were used for data collection. Four of them were used to capture elements of **self-transcendence** including: Modified Differential Emotions Scale (mDES) [Fredrickson et al., 2003], the Nondual Awareness Dimensional Assessment (NADA-S) [Hanley et al., 2018], the Awe Experience Scale(AWE-S-6) [Yaden et al., 2019] (we have shortened the questionnaire ourselves to six questions with highest loading) and the Inclusion of Other in the Self (IOS) Scale [Aron et al., 1992]. Self-reported **self-efficacy** was measured through the New General Self-Efficacy Scale (NGSE) [Chen et al., 2001]. Finally, to understand participants' overall experience with VR, which can mediate the effects on self-efficacy and self-transcendence, we asked participants to complete the Simulator Sickness Questionnaire (SSQ) [Kennedy et al., 1993], a 16-item instrument including questions on self-motion, with additional immersion and presence questions [Hashemian et al., 2022].

Qualitative Data: We used lab observations in the form of video recording to gather data of all the interactions performed with the prototype. We also performed semi-structured interviews as they gave both the interviewer and interviewee the freedom to expand on open-ended questions and talk about new topics emerging from the interview [LeCompte and Schensul, 1999]. During the interviews, the researcher started from a simple question to initiate the conversation, e.g., *'How are you?'; 'What stands out for you?'; 'What do you like about this experience?'.* Subsequently, the researcher probed and discussed the patterns of behaviour from the observational data collected. Finally, the researcher asked open questions including what aspects supported participant's experience of flying and how could we improve the experience to provide immersants with a more compelling dream-like experience. All interviews were conducted and audio recorded by the first author in Mandarin Chinese.

Data Analysis Methods

On the quantitative side, we ran a within-subject 2×2 ANOVA including both trials to analyze the data collected through surveys. The mDES data were not included because it could not be directly used as a marker for STE.

On the qualitative side, 610 minutes of recorded interviews were transcribed into digital format in Mandarin Chinese, and were analyzed in NVivo Qualitative Analysis Soft-

ware by the first author. The first author subsequently translated themes and selected quotations from Chinese into English to review the themes and discussed larger analytical patterns with other co-authors who cannot read Mandarin. We used thematic analysis [Nowell et al., 2017] with a hybrid approach of both inductive and deductive coding to examine themes within the data. We coded deductively through particular lenses of transcendent dream [Kuiken, 1995, Kuiken et al., 2006], existing design guidelines [Kitson et al., 2020b, Kitson et al., 2018, Stepanova et al., 2019a] and themes emerged in our co-design workshop, such as embodiment, transition, agency and weightlessness. Meanwhile we allowed for themes to emerge directly from the interview data through inductive coding.

2.6 Results

2.6.1 Quantitative Results

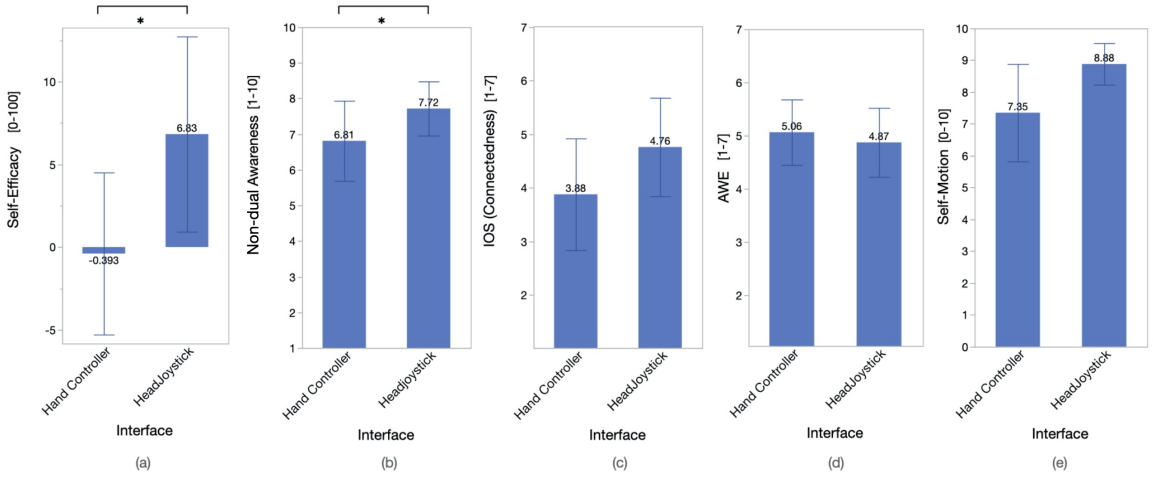

Figure 2.5: Mean values for participants using Hand Controller (left) versus HeadJoystick (right), with error bars showing 95% confidence intervals for (a) the difference between participants' pre- and post-test self-efficacy score, and mean ratings for (b) NADA-S (non-dual awareness) (c) IOS (connectedness) (d) AWE and (e) self-motion.

The different measures were analyzed using two-way 2 (interface: HeadJoystick vs. Hand Controller) $\times$ 2 (order: 1st trial vs. 2nd trial) repeated measures ANOVA. For all the tests, we did not have any significant order effects or interactions between interface and order. Hence, we only report on the main effects of interface below. All assumptions were tested and met unless stated otherwise.

Self-Efficacy

We used the NGSE (New General Self-Efficacy Scale) to measure self-efficacy before and after the VR experience with two different interfaces, and ran the 2 $\times$ 2 ANOVA on the difference between pre-test and post-test scores.

Participants in trials with the HeadJoystick reported significantly higher self-efficacy increases ($M = 6.83, SD = 10.22$) than with the Hand Controller ($M = -0.39, SD = 8.49$), $F(1, 12) = 6.05, p = .03, \eta_p^2 = .55$, which showed no increase in self-efficacy. This finding aligned well with our first hypothesis in **RQ2** that a more embodied flying interface could better support the feeling of empowerment, which is marked by self-efficacy. Somewhat unexpectedly, using the Hand Controller did not enhance self-efficacy, contradicting predictions of **RQ1** that both interfaces would evoke emotions of self-efficacy and self-transcendence.

Self Transcendence

We used three questionnaires to measure three different aspects of self-transcendence: NADA-S (non-dual awareness, characterized by experiences in which the self and world are unified or the boundaries of the self dissolve into emptiness [Gyamtso, 2001]); IOS (connectedness); and AWE-S-6 (feeling of awe).

In alignment with our hypothesis in **RQ1**, the absolute ratings of self-transcendence measures for both of the interfaces were relatively high. The mean ratings of non-dual awareness for both interfaces are around 7 (from 1 "Not at all" to 10 "Very Much"); the mean ratings of connectedness for both interfaces are around 4 and 5 (from 1 "No Relationship" to 7 "Close Relationship"); and the mean ratings of awe are around 5 (out of 7), labeled as "Somewhat Agree".

Non-dual Awareness The results show a significant main effect of interface on Non-dual Awareness ($F(1, 15) = 6.74, p = .02$). From Figure 2.5 (b) we observed a 13% higher ratings with the HeadJoystick ($M = 7.72$, $SD = 1.48$) compared to the Hand Controller ($M = 6.81$, $SD = 2.19$), which aligned with our first hypothesis in **RQ2** that the more embodied interface would better contribute to self-transcendence.

IOS: connectedness Similarly to Non-dual Awareness, and in alignment with our first hypothesis in **RQ2**, from Figure 2.5 (c) we see that the HeadJoystick lead to 22% higher ratings on the IOS scale ($M = 4.76$, $SD = 1.79$) compared to the Hand Controller ($M = 3.88$, $SD = 2.03$), although this trend reached only marginal significance ($p = .06$).

AWE-S-6: feeling of awe Though not significant, as shown in (Figure 2.5 (d)) we observed slightly (4%) lower awe ratings for the HeadJoystick ($M = 4.87$, $SD = 1.26$) compared to the Hand Controller ($M = 5.06$, $SD = 1.20$), $p = .46$, which is in conflict with our first hypothesis in **RQ2**.

It is important to understand if participants are new to VR, as the feeling of novelty is also associated with awe and might have biased the results [Keltner and Haidt, 2003]. The majority of participants had experienced VR 1 - 5 times ($M = 2.89, SD = 1.33$, 0 = never used VR before, 7 = more than 50 times). Among the sample, four participants

reported never using VR and four reported using VR more than six times. We conducted a mixed 2 (interfaces) $\times$ 6 (previous VR experience) ANOVA for AWE ratings to test for a potential novelty effect [Chirico and Gaggioli, 2019]. We found no significant main or interactions effects (all $p's > .078$). This suggest that awe ratings were likely unaffected by users' previous experience with VR or novelty effects.

Self-Motion

As self-motion perception is one important aspect of embodiment as discussed above, we asked participants to indicate their perceived self-motion by rating their level of agreement with the statement "I had a strong sensation of self-motion with the interface. (It felt like I was moving towards the landmarks rather than the landmarks were moving towards me.)" From Figure 2.5 (e) we observed a trend that participants reported higher feelings of self-motion with the HeadJoystick ($M = 8.88$, $SD = 1.27$) compared with the Hand Controller ($M = 7.35$, $SD = 2.98$), which was approaching significance ($p = .06$). In alignment with our classification in Figure 2.2, we checked that compared with Hand Controller, HeadJoystick did show higher degree of embodiment.

In summary, we observed that compared with the non motion-cueing interface (Hand Controller), the motion-cueing flying interface (HeadJoystick) better supported self-efficacy and self-transcendence (especially Non-dual Awareness). In addition, we observed marginally significant trends for increased ratings of connectedness (IOS scale) and increased perception of self-motion with the HeadJoystick interface.

2.6.2 Qualitative Results

Guided by our design process and existing literature on transcendent dreams, we identified and prioritized three themes that were related to our desired user experience: embodied flying, extraordinary light and engagement. We report participants' quotes with (P#), ranging from P1-P20. An overview of the themes identified in the interviews are presented in Figure 2.6.

Theme 1: Embodied Flying

Embodied Movement Firstly, many people mentioned the HeadJoystick interface "fit [their] own sensation better" and is "Physiologically natural" because there is a stronger sense of **self-motion**: *"I feel that today's way [HeadJoystick] made my emotional experience more intense, yes. I did not spend too much brain power or energy on how to move, it was really intuitive–that's where I want to go, so my body or head is facing that direction... It is more similar to what I would do when my body moves [naturally]."* (P11) With that feeling of embodied control supported by self-motion, P11 described flying as *"the feeling of being integrated into the whole being"* and that *"there is a feeling that the barriers disappear"*.

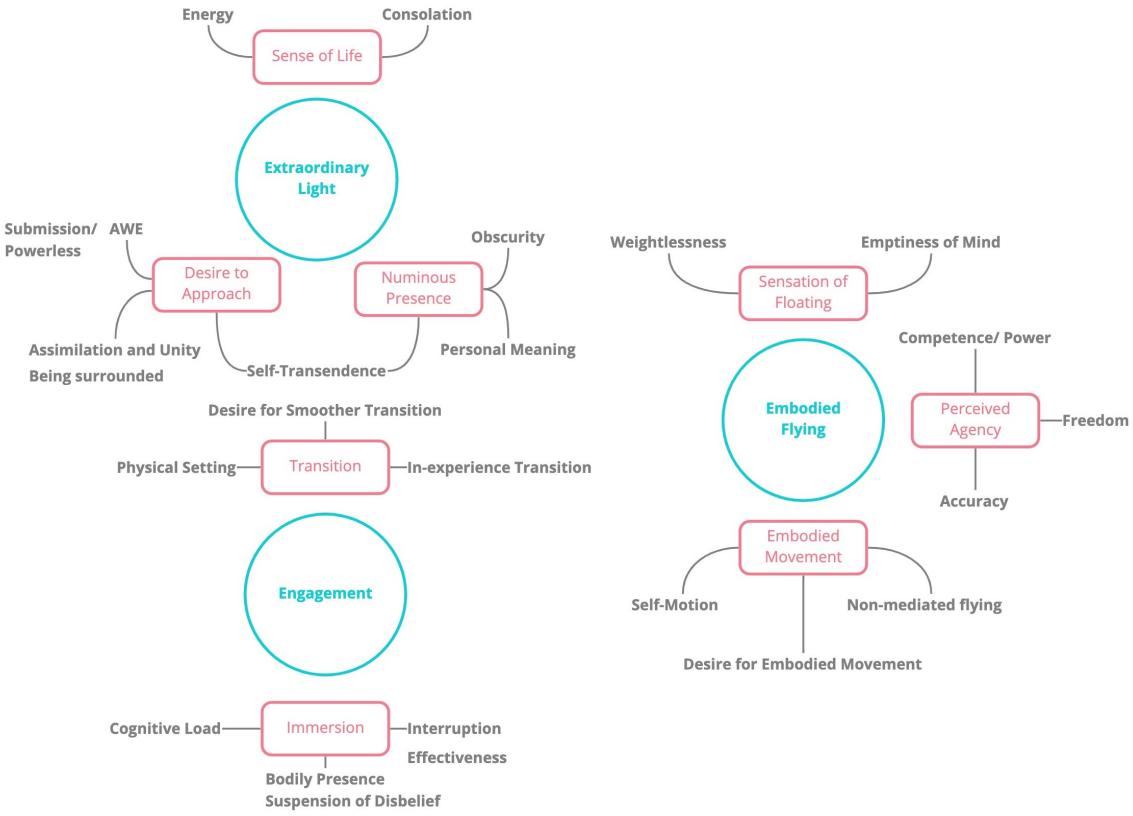

Figure 2.6: Mind map of themes identified in this paper. The three main themes are presented in blue.

This indicates that the full-body involvement in movement allowed for a more liberating and engaging experience.

Moreover, there was a general **desire for embodied movement** for both interfaces. From the video recording, we observed that P1 was flapping one's arm during the whole flying experience. *"I think I need to move. If I am a bird, I have to flap my wings so I can fly. I don't sit here and stay still...This is more consistent in my cognition. My behavior is consistent with my feelings"* (P1). P1 describes here how she felt compelled to engage in embodied behaviour that was not serving any functional purpose for locomotion, but was a reenactment of her feeling of being a flying bird. This desire for flying gesture was also expressed by P14: *"At that time, I had the urge to open my arms, and then...Yes, I wanted to be like this, but I thought it was too stupid, so I restrained it."* Even for participants who were using the Hand Controller, there was a desire for physical movement, and P10 even suggested to improve the interface to enable "controlling by head" when she was trying the experience with Hand Controller interface for the first time:

> What is missing is the control of flying, the control of my body, because if I am in a dream, I can actually control how I can control my [direction of] front and back, left and right, up and down. But the difficulties in this [Hand Controller interface] may prevent me from feeling that, this thing [flying] is really my own doing [behavior]...For example, if it is controlled by head, I don't know if it would be better. Because when I fly upwards, my head will go up... I feel that controlling it with the direction of my head or eyes will make me feel like I am actually flying.

As a result, most participants reported a more **non-mediated** experience of flying when using the HeadJoystick compared with the Hand Controller, and they felt it was their **own competence** to fly. When using the HeadJoystick P5 felt that *"one's whole body was exploring inside [of the environment]"*, and that *" flying is [their] own ability."* (P1). This also resonated with the sub theme that some feel they are like a "flying animal" or a "bird". On the contrary, when using the Hand Controller, participants felt that their movement wasn't their own, but they were rather being carried around: *"I was on a boat or in a hot air balloon"* (P1).

These findings are consistent with the literature in that motion-cueing can often enhance perception of self-motion [Riecke, 2006, Riecke and Feuereissen, 2012, Harris et al., 1999].

Sensation of Floating Another important element in participants' experience seemed to be a feeling of **floating** and **weightlessness**, which seemed to greatly contribute to a feeling of **emptiness of mind**: *"It's like you grab the edge of the swimming pool. Your whole body floats flat like this, without thinking about anything, your mind is empty, and then floating."* (P5) Interestingly, this feeling was also shared by a participant with the

Hand Controller interface: *"When flying at low altitudes, I felt that I had forgotten a lot of things. It [my mind] felt very empty."* (P10)

Perceived Agency Most participants reported that the perceived agency brought by the HeadJoystick interface contributed to the sense of **agency and freedom**:*"After I took control of this thing [HeadJoystick interface], I felt a sense of freedom in the virtual world... first of all, you forgot that you have to control something. Basically, I am more capable of going where I want to go. Then I can achieve that kind of freedom, where I can get the view or angle I want to see, and there is also the feeling of exploring the unknown. "* (P16) While for the Hand Controller, P16 mentioned: *"I didn't have it last time [the Hand Controller interface]. I was more restrained last time, because when I wanted to move, it [avatar in VR] might not move according to my will. So in the end I felt that I was playing a game at the time."* It seemed that most participants agreed that the intuitive control and embodied element of the HeadJoystick interface provided them with stronger agency for flying, which offered them the ability and freedom for exploration.

Some participants also reported that the better **accuracy** brought by the HeadJoystick made them more confident while flying (P7, 8, 11), which aligned with a previous HeadJoystick study where flying leaning-based interfaces showed higher accuracy/precision compared to the handheld interfaces [Hashemian et al., 2022]. However, in this study, the responses about the accuracy were mixed since some participants also reported that the Hand Controller brought more accuracy (P3, 5, 6). This may be because participant's prior game experience affected their comfort with different interfaces.

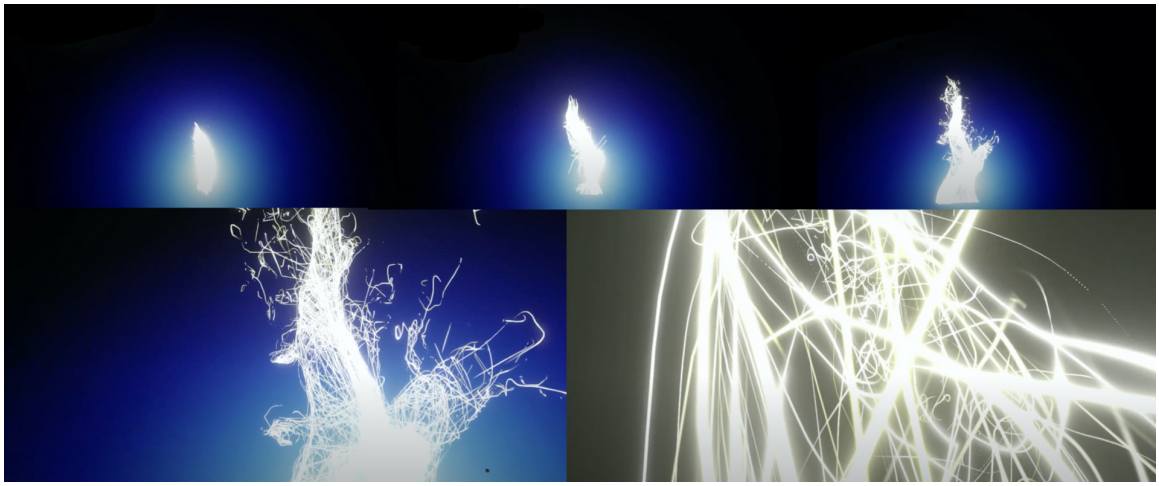

Figure 2.7: The enormous tree of light in the VR experience, composed of slowly growing light rays.

Theme 2: Extraordinary Light

Desire to Approach and Assimilate Many participants expressed the **desire to approach** the source of light at first sight: *"Many [impressive moments] are related to light. I feel like an insect, and I am naturally attracted to light"* (P3). Many reported that they experienced the most awe and a desire to merge into something larger than themselves when they were inside the tree of light (Figure 2.7) :*"When I see a halo that grows upwards and upwards, I will bury my whole body in it."*(P10) and *"I saw the constant change of light and I would really like to assimilate into it"* (P11). In addition, the atmospheric refractions were also reported to have a similar effect: *"When you go to those places where there is such halo [of the atmosphere], it will blend you in...the process is very delicate...Step by step you blend into the light."* (P5) The feeling of assimilation seemed to further contribute to **self-transcendence** as indicated in the quotes expressing perceived vastness and the diminished sense of self typical for self-transcendent experiences: *"The universe merges with me, and then I feel that the whole world is so big, I am very small, and I feel like a star."* (P1) and *"I feel very small, but then I feel that I am more closely connected with the world."* (P17)

Sense of Life One of the reasons for this desire to approach might be the source of light bringing the immersant a **sense of life**, and P2 even compared it to a feeling of "spring": *"In this space, I can feel that I am a living thing, but this space seems to be dead, yes, because it feels like in outer space, this space is deadly silent. When there is a being [the tree of light] like me, who also has this vitality, when there is this kind of dynamic feeling of living things, you will be very delighted...to see its growth, to see the divergence of its branches and buds, and then it also feels like it is chasing life, like in spring when you see the buds of grass and flowers bloom."* Furthermore, that sense of life seemed to even bring **energy** and a touch of **consolation** for some: *"if you are in a bad mood, if you are down, you may find a touch of consolation. Then it has a kind of energy that spreads to the body. It was in an instant."* That sense of comfort is also shared by P5, P6, P14 and P17.

Numinous Presence and Personal Meaning Participants reported different personal meanings from the same experience. P6 highlighted the **existential value** he perceived when he was climbing up the tree of light: *"I also feel that I am important. I don't know how to express it, but I feel that I am important."* When P2 witnessed the tree transformed into a bridge toward the earth, she described: *"There is a feeling of hope, yes, and the tree suddenly created a light path. It feels like it is going to take me to a certain place, and that place will be very beautiful."* Many participants felt a sense of the sacred, or perceive a **numinous presence**: *"I have a feeling of being with the spirit. Well... can you imagine? Because I am a Christian myself, and sometimes when I pray, I will tell God some words. So [in the experience] I felt like I was praying with my eyes closed."* (P10)

Theme 3: Engagement

Immersion First, compared with the Hand Controller, the HeadJoystick seemed to enhance immersion by reducing **cognitive load**. The HeadJoystick interface *"eliminated a node for information processing and transmission"* which helped participants *"focus more on the experience itself"* (P2, 3, 5, 11). Second, the intuitiveness of the HeadJoystick interface seemed to contribute to **suspension of disbelief**, which might further enhance immersion. This is demonstrated by P15 who had a slight condition of Acrophobia (fear of height) but did not tell the researcher until the interview–*"At the beginning, I was not very proficient in control, but I knew that I would not suddenly fall off–it would not cause me harm. I am afraid of heights because I, as a flightless person in the real world, will definitely be [pulled] by gravity and fall, but at that time [in the experience] I believed that I had this ability to float."* Whereas for the Hand Controller, participants reported that by moving their hand, they were still aware of the outside world: *"Because you actually feel that you have strengthened the connection with the outside world through the Hand Controller... Every time you operate, it will reflect that you are actually sitting here [in the real world] and operating."* (P2); Similarly, many participants felt pausing and **interruption** when they took their fingers off the joystick (P3, 15, 16, 20)–*"When I don't operate with both hands, I will stick there; it's as if your mind is suddenly interrupted."*(P3) This break of flow seemed to easily pull the immersant out of the flying experience, while HeadJoystick interface provided a more "fluent" and "seamless" sensation of flying.

Transition Participants appreciated both the **physical setting** and the **virtual transition** for helping them more easily transition from the "real world" into a more dream-like experience. The mini-meditation session, the subdued lighting of the room, and even the calming voice of the guide–all seemed to contribute to transition and engagement: *"There was a sense of guidance or a small transition, especially when I just came in [the room], you asked me to sit on the cushion to meditate for a while, or just close my eyes and imagine [the feeling of flying]. In fact, it quite made me dreamy."* (P14). P4 reflected on the multi-sensory aspects of the transition into the experience that allowed them to slow down and relax: *"The ambient light was very dark, and then you spoke like a Daxian (spiritual master in ancient Chinese culture). It feels like your words are trying to calm me down, or they are different from daily life. . . "* P20 provided the most detailed elaboration on how his imagined content granted **personal meaning** and resonated with the self-transcendent experience in VR:

> The imaginary scene in my mind at the time was very clear. I was on the cliff between the two mountains–that kind of canyon–and then flew in the middle [of the canyon]. Then I also knew where the top of the canyon is, so I flew in the canyon–[during flying] there was a feeling of falling, but there was also a feeling

> of lifting ... Finally I flew above the grand canyon, [the cliffs of] the grand canyon came together. At this moment I could see me standing on the edge of the Grand Canyon, and the sun just rising from there... When I was flying among the light rays [in VR], I thought of these things in an instant.

In addition, the bedroom-transition in the virtual world was brought up frequently when participants were asked about the dream-like quality. Yet, there was still a **desire for smoother transition** into the virtual world: *"[After lifting from the bed] the scene of bedroom suddenly passes through the darkness, and then [I] enters the world of dreams. It is still a bit sudden in the transition part."* (P7)

2.7 Discussion

2.7.1 RQ1: Can a dream-inspired virtual flying experience support feelings of self-transcendence and empowerment?

Our hypothesis in **RQ1** was that irrespective of the interface the user experienced, both of the dream-inspired virtual flying experiences would induce self-transcendent emotions and self-efficacy. In alignment with our hypothesis, the quantitative results indicated that for both Hand Controller and HeadJoystick, the participants have reported strong evidence of *self-transcendence* considering the three different aspects: non-dual awareness, awe and connectedness. Likewise, our results indicated an increase in experienced self-efficacy, however only when supported with an embodied interface. This illustrates that VR does indeed have the capability to support positive emotions associated with transcendent dreams, i.e., self-transcendence and empowerment (assessed here through self-efficacy), through simulating a flying dream experience. This presents a new possibility of supporting self-transcendence and empowerment in VR, along with simulating the Overview Effect, Lucid Dreaming and Psychedelics in VR. We propose that unassisted flying within a dream-inspired virtual environment is a promising direction for exploring new ways of contributing to self-transcendence and empowerment with technology, which may ultimately support users' well-being. In the following sections, we discuss in what ways our experience contributes to STE and empowerment, and what other designers can further explore to eventually arrive at design guidelines for technologically mediated self transcendent experiences.

2.7.2 RQ2: Can embodied flying interface better support self-transcendence and empowerment?

Embodiment and Familiarity with Interfaces

Most of our participants were more familiar with the conventional Hand Controller interface ($M = 3.32, SD = 2.14$, 1 = never used hand-based controller before, 7 = more than 50 times) compared with leaning-based interface ($M = 1.42, SD = 0.84$, 1 = never

used leaning-based interface before, 7 = more than 50 times). However, while previous research suggests that conventional interfaces are often preferred for their ease of use [Kitson et al., 2017, Bektaş et al., 2021], our quantitative results showed that the dream-like experiences of STE and empowerment were better supported by the novel and more embodied interface, HeadJoystick. Thus, in relation to the trade-off between familiarity vs. embodiment, we observed that a greater degree of embodiment had a more dominant effect for the purpose of supporting STE and empowerment. This was also reflected in our qualitative results. For example, P3&6&19&20 mentioned that effectiveness of the Hand Controller did not necessarily make the experience more compelling. They reported that, though physically less easy to control, the high-embodied HeadJoystick felt more natural to move with and was more engaging. This highlights that designing for STE and empowerment in VR might require different considerations than most dominant research on navigation interfaces within accurate maneuvering or goal-oriented contexts. Designers of affective VR experiences might need to re-evaluate our current understanding of participants' preferences and locomotion interfaces' affordances where felt experience seems to be more important than functionality.

Tension of Perceived Power between Awe and Empowerment

"When I was little, I dreamed that I could become infinitely big, but now [in VR] I feel that I am infinitely small..." (P19). While it is clear that empowerment in a transcendent dream indicates perceived power for the dreamer [Kuiken, 2015], the powerless feeling within awe is less salient. Keltner suggests that the feeling of awe in its nature makes the *self* feel small and powerless [Keltner and Haidt, 2003]. The contrast between these two powerful and powerless feelings thus create a tension between empowerment and awe. This tension was reflected in our quantitative findings where participants with the HeadJoystick interface reported stronger feelings of empowerment and a slightly less feeling of awe compared with the Hand Controller. Despite this tension, we still observed relatively high ratings of both empowerment and awe in the HeadJoystick group, which suggests that these two emotions were not mutually exclusive. Furthermore, participants reported greater agency using the interface with a higher degree of embodiment, which seemed to associate with increased self-efficacy and decreased self-transcendence. P8&9 reported that with the HeadJoystick, where their body is more active, they felt more sense of control and freedom and less awe, while with Hand Controller their body moved less and they felt more peaceful and dreamy. We thus suspect agency might contribute to the powerful and competent feeling participants reported, which resemble the concept of *movement efficacy* in flying dreams [Kuiken, 2015].

In terms of degree of embodiment, we cautiously suggest that high-embodied flying interfaces would grant more agency and thus the overall user experience would lean towards empowerment. Agency, however, can also be achieved through designing the progression of the experience even within a single interface–the designer might be able to tweak the param-

eters of the interface (e.g., sensitivity and speed limit) throughout the experience to control the degree of agency granted by including transitions between the environments where more or less control is given to the user. For example, in *AWE* [Stepanova et al., 2019b], participants transitioned from a forest environment, with full control over their movement, into the lake environment where they surrendered to sinking in and they were only able to sway within a predetermined tunnel of their movement. This could create a richer experience for users through the narrative arc of the story by transitioning between supporting a stronger sense of empowerment and the small sense of self experienced in awe. The study on set and setting with *AWE* illustrates how this discrepancy between the initial agency in pre-VR and lack of it during the VR experience can shape an emotional experience [Kitson et al., 2020b]. As a result, we suggest designers and researchers carefully design the timing and degree to release and withhold agency in order to adjust the dynamic balance of awe and empowerment throughout the unfolding of the experience.

Embodied Elements Supporting STE and Empowerment

Self-motion Prior evidence suggests that, in transcendent dreams, the dreamers feel powerful and competent and possess an exceptional ability to attain their goals [Kuiken, 1995, Kuiken et al., 2006]. This powerful and competent feeling "could be understood as a kinaesthetic aspect of movement efficacy (including flying or floating)" [Kuiken, 2015]. This literature suggests that the dreamer's self-motion in transcendent dreams contributes to the sense of empowerment. In alignment with these findings, our results from the theme "embodied flying" suggest that, in a dream-inspired VR experience, the perception of self-motion contributed to participants experiencing a **perceived agency** of flying as their own competence, which further contributed to the feeling of empowerment.

Furthermore, in transcendent dreams, engagement is an important foundation for emotion transformation, and this engagement in transcendent dreams is often laced with vigorous and graceful movements [Kuiken, 1995]. Our results from the theme "engagement" suggest that, the enhanced feeling of self-motion could provide stronger **bodily presence and immersion** in the VR experience, which further contribute to potential elicitation of self transcendence and empowerment. This is in keeping with previous studies which indicated that immersion and presence brought by perceived self-motion could contribute to positive experience [Kitson et al., 2017, Hashemian et al., 2022] and are more likely to evoke transformative experience [Stepanova et al., 2019b].

In summary, we suggest that self-motion could support empowerment through perceived agency. Additionally, self-motion could support both STE and empowerment through engagement (presence and immersion). VR designers may further explore integrating motion cues and physical movement in VR for a more empowering and engaging experience.

Sensation of floating Hunt suggested that the visual-spatial imagery (e.g., flying and floating) of transcendent (archetypal) dreams reasserts characteristics of STE [Hunt, 1989], but it is still not clear how flying and floating support STE. Our results from the subtheme "sensation of floating" suggest that the feeling of floating brought by the HeadJoystick contributed to non-dual awareness through a perceived **emptiness**, which was in alignment with the definition of Non-dual Awareness–the boundaries of the self dissolve into emptiness [Gyamtso, 2001]. This linkage with Non-dual Awareness is also reflected in our quantitative results, where immersants with the HeadJoystick reported higher ratings on Non-dual Awareness compared with the Hand Controller. The feeling of emptiness induced by floating in VR is consistent with previous research where the sensation of floating might contribute to clarity of mind and a semi-conscious state in a mediated immersive meditation experience [Vidyarthi and Riecke, 2014]. We suggest VR designers explore multi-sensory stimuli capable of eliciting the sensation of floating in VR (e.g., ambient sound, abstract visual, tactile feedback etc.) to create a calming and reflective space that allows for an emptiness of mind to emerge, in order to better induce STE.

To conclude, our findings suggest the perception of self-motion during embodied flying in VR supported the feeling of empowerment through perceived agency. In addition, it supported STE through bodily presence and an emptiness of mind related to floating. Thus, we suggest self-motion as a key design element for a VR flying experience aimed to achieve the benefits similar to transcendent dreams. This finding is also consistent with Picard-Deland et al's claim that vection is a key component of feelings of dream flying [Picard-Deland et al., 2020]. We encourage designers to involve more motion cues and bodily control in order to evoke stronger self-efficacy and self-transcendent emotions.

2.7.3 RQ3: Design Considerations for Self-Transcendence and Empowerment

Obscurity

Keltner suggests that objects that the mind has difficulty grasping are more likely to produce the sublime experience (awe) and describes this difficulty as **"obscurity"** [Keltner and Haidt, 2003]. Our results from subtheme **personal meaning** suggested that different participants seemed to have their own interpretation of the final act. Some voiced a feeling of hope, some felt being guided, and some related to sacred and religious experience. This obscurity not only in sensory stimulation, but also in narrative suggests that intentionally keeping the VR experience abstract and open to individual interpretations might have actually helped immersants to fill these open spaces in the narrative with their own personal meanings and connect to their own individual backgrounds and experiences. We posit that this obscurity relates to the "imaginative immersion" aspects of immersive experience design [Ermi and Mäyrä, 2005, Vidyarthi and Riecke, 2014], and might have allowed participants to more actively co-create the experience.

Extraordinary Light

According to our results from theme **extraordinary light**, extraordinary light seemed to contribute to STE (especially unity and connectedness) mostly through **numinous quality** and a **sense of life**. The numinous quality is in keeping with prior research where Jung described numinous presence as a key characteristic in transcendent dreams (or big dream) [JUNG, 1966]. The sense of life is in alignment with Kuiken's description of self-transcendence within transcendent dreams as an "unbounded sense of life in all things". [Kuiken et al., 2006] In addition, in alignment with Hunt's opinion that light metaphorically reasserts STE [Hunt, 1989], we found the extraordinary light as a metaphor for ego-dissolution experiences. This was resonant with the common experience of assimilation shared by nine participants. Despite the substantial role of light in transcendent dream, designing with extraordinary/magical light is often underutilized in VR. We suggest that VR designers consider designing dynamic light with graceful movement, in order to bring the immersant a sense of life and a desire to approach.

Set and Setting

According to our results from theme **transition**, we identified **meditation session** as a integral part of the overarching experience with participants' self-generated stories. From a reported resonance of STE between meditation and VR, we further speculate that certain **dream stimulation techniques** like targeted reactivation in dream research could be translated into VR in order to design for stronger emotional experiences.

Meditation Session The visualized scenery and narratives from the meditation at the beginning of the experience seemed to complement the overarching experience in every participant's own way: P17 felt *"pleasantly surprised"* because in her imagination her perspective was more drone-like and never got outside of the planet. On the other hand, both P15 and P18 found that the VR experience seemed to *"concretize the scene I imagined with my eyes closed"*. This suggests that the stories generated by participants themselves during meditation blended into the narrative in VR and enriched the emotional experience. We suspect that the imagined flying as a pre-VR narrative eased participants into the dream-flying mindset and thus contributed to a sense of **continuity**. Meanwhile, the mini-meditation session seemed to help to prime participants' imagination while at the same time left gaps in participants' imagination before entering VR, which allowed them to actively engage with and co-create the experience. This in turn allowed them to actively engage with and co-create the experience. This again resonate with the design element **obscurity** above, and more specifically the concept of "imaginative immersion". The quote from P20 (in section 6.2.3 *Transition*) on how his imagined content resonated with the self-transcendent experience in VR suggests that the imagined content primed him into a self-transcendent mindset,

which reinforced the emotional experience later on in VR. Besides, we saw the potential of the meditative setting (i.e., lighting and ambience melody) to connect emotional states from the pre-VR meditation session to the VR experience itself, which will be further discussed in the section below.

Overall, our results seem to suggest that self-generated content during meditation contributed to continuity, obscurity and priming, which is in keeping with prior research that shows narratives help transition people into VR and keep them immersed in the experience [Pausch et al., 1996].

Parallel with Dream Stimulation Techniques According to P20, the extraordinary light in VR resonated with that in his imagined flying during meditation. In the physical setting, we used the mood lamp to foreshadow the extraordinary light element in VR, and played the same ambient melody during both meditation and VR. By doing so, we initially intended to create a smoother transition as well as stronger feeling of continuity. However, since the participants mentally rehearsed or recollected memory of dream flying along with the visual and audio stimuli (i.e., ambience lighting and melody), and were re-exposed to these stimuli in VR, another possible explanation for how the dream-like state was supported in our VR experience is **targeted memory reactivation** (TMR). In targeted reactivation, a stimulus is paired with specific content during wake, and when the stimulus is re-presented during sleep its associated content is reactivated [Carr et al., 2020]. The re-exposure to the stimulus paired with targeted memory is in keeping with the flying dream induction study by Picard-Deland [Picard-Deland et al., 2020]. In this study, selected participants were re-exposed to a four-tone melody presented during flying in VR and a following morning nap, through a targeted memory reactivation procedure. Similarly, we re-presented the visual and audio elements during the VR experience, which were paired with mental rehearsal or memory of dream flying. Thus, we further speculate that the re-exposure to foreshadowing elements during VR play a similar role to targeted reactivation procedure in dream research. We suspect that the physical setting with a paired emotional state has the potential to reinforce and linger the self-transcendent emotions that emerged during VR, through foreshadowing abstract elements (lighting and sound in our case). We see the potential of dream engineering techniques for incubating the dream experience being applied to VR, which may help nudge the immersants' overarching emotional experience towards the designers' desired direction. We encourage the design community to further explore and translate dream stimulation techniques into VR to design for stronger emotional experiences.

2.7.4 Limitations and Future Directions

Some of the major limitations of the study include incomplete participation of P9 and P18. P9 quit the study due to COVID restrictions and P18 only went through one condition

(HeadJoystick). Thus we eliminated both P9 and P18 from quantitative analysis but still used P18's qualitative data. There were also missing data on self-efficacy for P2, P3, P5, which made the analysis of the data not perfectly counterbalanced. Furthermore, due to the COVID-19 pandemic, we were not able to run the study with more participants, which reduced statistical power and might have contributed to several trends in the data not reaching significance, e.g., for sense of connectedness and self-motion perception. We plan to further iterate on the flying experience based on our insights, and run more participants once the pandemic restrictions are reduced.

In terms of the experience itself, some participants suggested adding more foreground objects for reference in that sometimes they were wondering if they were moving or not, along with adverse feelings of anxiety and confusion, which broke their experience for a while. In addition, many participants mentioned the HeadJoystick interface "involve too much bodily movement" which could be very tiring even for a 10-15 minute use. An optimized parameter configuration might help to reduce the physical fatigue.

We cannot compare our results with actual transcendent dreams because our participants may not have had many transcendent dreams that they could reflect on. Thus, while our design was inspired by transcendent dreams, we could only evaluate whether it brought the benefits associated with transcendent dreams, but we could not evaluate if it were similar or more or less effective then transcendent dreams. Yet, it provides us with an intriguing opportunity for supporting well-being with VR through eliciting self-transcendence and self-efficacy, thus allowing participants to achieve the benefits without having to train in lucid dreaming and transcendent flying dreams.

The several design elements we identified for supporting profound experiences were only examined in one specific virtual experience and within one cultural context, i.e. Chinese. Thus, we should be cautious in generalizing the results. Participants made meaning from their experience relating to it through their own cultural background–for example, P4 mentioned "Daxian", spiritual master in ancient Chinese culture, during the pre-VR experience. This culturally specific term also connotes a person who could influence the course of events by using mysterious forces. Naturally, we can anticipate that people coming from different cultures wouldn't have associated the researcher's calming voice with a character from Chinese folklore. Instead, different participants would have likely interpreted their experience within their own cultural and autobiographical context, possibly finding a different association that is meaningful for them personally, and possibly of a similar character with a wise, calming, and mysterious voice. This highlights the challenge observed in the research of design supporting subjective affective experiences, where findings have to be interpreted with the acknowledgement of the cultural context they are situated in. While it may not always be possible to generalize results directly to diverse cultural contexts, nonetheless considering the cultural context enriches the interpretation and allows us to speculate how the cultural context may shape the meaning-making from the experience.

2.8 Conclusions

Our results suggested that, compared with the standard non motion-cueing interface (Hand Controller), the motion-cueing flying interface (HeadJoystick) better supported self-efficacy and self-transcendence (especially Non-dual Awareness). We identified and prioritized three themes that were related to our desired user experience: embodied flying, extraordinary light and engagement. We suggested there was a tension between empowerment and awe, which VR designers should be cautious about when designing for agency. We then derived three design considerations for designers when designing for self-transcendence and empowerment: obscurity, extraordinary light and supportive setting. We also highlighted that certain dream stimulation techniques in dream research could be translated into VR for stronger emotional experiences. We encourage the design community to further explore dream-flying as a new way of supporting self-transcendence and empowerment.

Chapter 3

Breath of Light: A Meditative Installation Reimagining Shared Breathing

3.1 Abstract

Breath of Light is a breath-responsive immersive art installation designed to foster a feeling of connection and meditative awareness through the process of interpersonal breathing synchronization, exhibited at the 13th Shanghai Biennale in March 2021. During the exhibition the authors observed interactions and interviewed participants to better understand their experience of *Breath of Light*. The authors found that this technological mediation of breathing has the transformative potential to revive the connective connotations of shared breathing, and cultivate introspection and inter-human connection during the pandemic and beyond, with the use of metaphors, symbols, and ambiguous instructions.

3.2 Introduction

Pushing a curtain aside, you enter a dim room, isolated from the bright exhibition hall. You see two microphones delicately suspended from the ceiling and a large projection screen showing two small glowing orbs that subtly shimmer and fluctuate. You step up to one of the microphones and blow into it. One of the orbs responds, emitting a burst of bright particles that float towards the sky on the screen in front of you. Experimenting with the system you discover the orb grows and becomes excited with your exhale before shrinking again. Another person enters the space with you. As they breathe into a second microphone, the other orb of light expands on the screen and comes to life. You start to playfully breathe together, watching the orbs merge and grow in response. As the rhythms of your breathing coincide, you see a ripple of light that grows and expands, filling the entire screen with wisps of light (Figure 3.1). As you breathe together, you hear a Tibetan singing bowl resonating through the air around you. Its sound is calming, yet seems to invite you to

Figure 3.1: Two users synchronizing their breath in *Breath of Light*.

explore further, to breathe together with this stranger for a while longer. *Breath of Light* is an interactive installation that invites visitors to breathe together to create a beautiful and ethereal audiovisual experience. The dark exhibition space is brought to life by visitors' breathing, transforming the gallery into a communal meditative space. In creating *Breath of Light*, we were motivated by the growing issue of social isolation which has been further exacerbated by the COVID-19 pandemic [Kumar and Nayar, 2021]. While masks and social distancing measures are designed to protect us from the spread of coronavirus, they also conceal important social cues and separate us from one another. Culture spaces are valuable for stimulating new connections and building community crucial for our mental health, yet during COVID, art galleries were among the first venues that had to close. In response, *Breath of Light* was created to reconnect people in public spaces, as such opportunities once again become possible. Interpretive anthropologist Cliford Geertz [Geertz, 1973], describes culture as "an ensemble of texts" (p. 452). These 'texts' include objects, actions, and behaviors that carry the systems of cultural meanings. Breathing in a public context is one such cultural text, whose connotations have transformed drastically over the recent years, and will continue to evolve in the future. Breathing has long implied life, spirit, and connection. In Chinese philosophy, breath is described as *qi* [Goldin, 2020], which can bear many senses—breath, air, the substance of the body, the physical basis of one's energy, one's demeanor or temper. Ancient Chinese advocated seeking the mental state of *"equilibrium and harmony"* by learning how to control *qi* [Goldin, 2020]. Likewise, Aristotle, in his treatise 'On Respiration' [Aristotle, 1935], speaks of phenuma as an extended soul that is part

of the surrounding air and enters the body as we breathe in. With this shared breath, our inter-human connection is both physical – literally as the shared air that is incorporated into our bodies; and spiritual – relating us to others and our surrounding social context. At the same time, breath is typically invisibile, making its connotations implicit, and its ever-present connective power imperceptible. However, this connective potential of shared breathing is undergoing a transformation of its connotations. Along with the ongoing pandemic comes an increased awareness of the potential exposure to the invisible virus in the air. The cultural text of shared breath has become associated with danger, fear, and even death. These negative connotations often overwhelm long standing positive associations of breath as essential to life and conducive to human connection. *Breath of Light* was created to counter these negative connotations of breath that were continually reinforced during this pandemic.

3.3 Design and Artistic Inspiration

We created *Breath of Light* to explore the connective power of shared breathing and synchronization in an immersive meditative installation. The meditative environment is intended to help participants reconnect with their often unnoticed breathing, and then allow them to extend this connection to their partner through synchronization.

3.3.1 Immersive Technology for Mindful Meditation

Mindfulness meditation can support mental health by cultivating mindful awareness and helping to reduce stress [Kabat-Zinn, 1990]. In *The Meditation Chamber* [Seay et al., 2002] participants achieve the benefits from meditation practice through a bioresponsive animation, guided muscle relaxation and breathing meditation in an immersive virtual environment. Sonic Cradle [Vidyarthi et al., 2012] is a dark chamber where users shape a peaceful soundscape using only their respiration. It was designed to foster a meditative experience by facilitating users' sense of immersion while following a specific attentional pattern easing novices into the mindfulness practice. Inspired by these works, we designed a dark space to help participants draw attention to their breathing. We incorporated meditative elements such as ocean waves and singing bowl sounds into the audio-visual feedback responsive to participants' breathing, encouraging them to slow down and direct their attention inwards.

3.3.2 Breathing Interaction in Immersive Environment

Within immersive environments, breathing has been used directly as a form of interaction to bring individuals' attention to their own body and to encourage mindfulness. Osmose [Davies and Harrison, 1996] utilizes breath as an interaction design method for navigating a virtual space, inspired by artist's own practice of scuba diving. By navigating in a magical nature-themed environment using balance and breath the audience is encouraged to attend

to the relation between their breath and bodily movement reconnecting with their bodies as the site of their experiences and an inter-mingled constituent of nature. Oceans of Air [Feast, 2017] visualizes breath as blue stream of dots floating from audience's mouth in the virtual reality experience. The trees and leaves in the virtual environments are also composed of dots, which invites a sense of connection to nature through breathing. In this muti-person experience, breath could be seen by other audience but can not be interacted with. These works have capitalized on the power of bringing attention to breath to bring people a sense of connection to their own body and nature. We further explore the poetic and embodied potential of breath-based interaction to invite reflection and elicit interpersonal connection in a dyadic interaction through visualization of shared breath in *Breath of Light*.

3.3.3 Bio-signal Sharing and Synchronization for Social Connection

Sharing physiological data with others allows us to expose ordinary hidden intimate internal states, which can remind us of our unity as human species. For instance, Pulse Corniche [Lozano-Hemmer, 2015] uses heartbeat biosensing to connect an individual to their community by displaying their pulse in the sky. Moreover, becoming aware of the physiological rhythms of other people can foster interpersonal synchronization associated with social connection [Palumbo et al., 2017]. In JeL [Desnoyers-Stewart et al., 2019b], the breathing of two participants is represented as a movement of jellyfish in an underwater world they see in a virtual reality headset or projection. When immersants synchronize, a coral-like structure emerges representing and rewarding their connection. Inspired by these works, *Breath of Light* was designed to facilitate breathing awareness and synchronization in a culture space to promote social connectedness.

3.4 The Installation Set-up and COVID Restriction

Setting up an installation during a lull in the pandemic, we were aware that some visitors may not be comfortable with touching physical interfaces used by many people, even when they were regularly sanitized. This was a design constraint requiring a solution that would minimize health risks and support inclusivity of participants with diverse comfort levels and expectations. Accordingly, while belts are often used to sense breathing, we used sound-based sensors (i.e., microphones) instead to provide a contactless interface. The installation was exhibited in a dark and quiet room to create an immersive environment. The system was composed of two microphones, a hidden 2020 iMac computer, and a projector with built-in speakers (Figure 3.2). The microphones were hung from the ceiling at eye-level as a physical affordance to guide attention and spark curiosity.

Though all kinds of breathing could apply to the installation, pilot testing showed that pursed-lip breathing worked best in terms of responsiveness. With this technique the exhalation could also be picked up by microphones through masks, though distorted and weaker

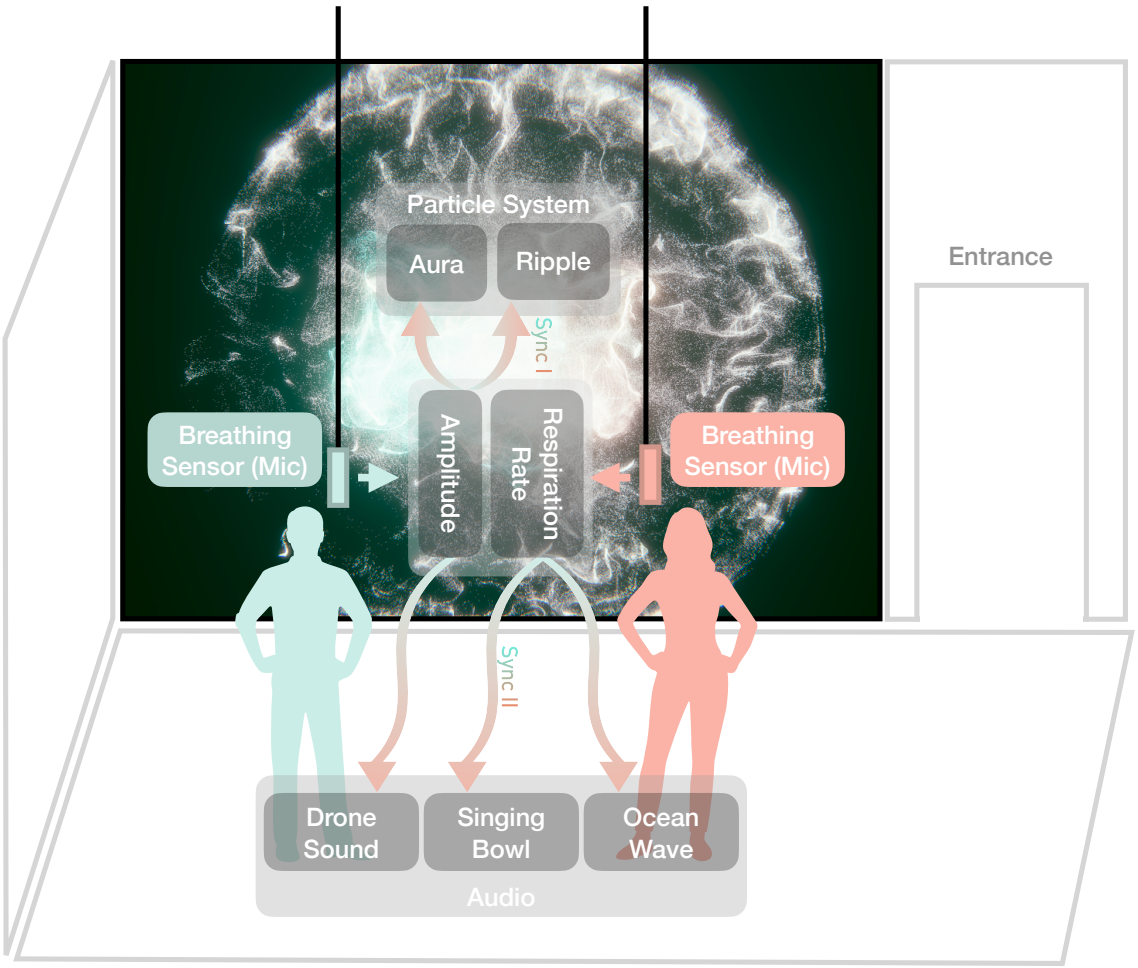

Figure 3.2: Schematic diagram of the installation. Microphones hang from the ceiling with a projection shown on the wall. The breathing data from the microphones drive the audio and visuals.

compared with unmasked breathing. Participants had the option to take their mask off while interacting at a safe distance.

3.5 Aesthetic, Symbolism and Building Towards Synchronization

Procedural Ocean Wave - Indirect Mapping of Breathing. When the user starts to breathe into the mic, the system senses the breathing cycle by detecting if the amplitude exceeded a predefined threshold. Each time this threshold is exceeded the system counts another breath. Based on this, the user's respiration rate is calculated and an ocean wave sound is played matching this rate. When only one user is interacting with the system, the rhythm of the ocean wave moves corresponding to their breathing. When another user joins

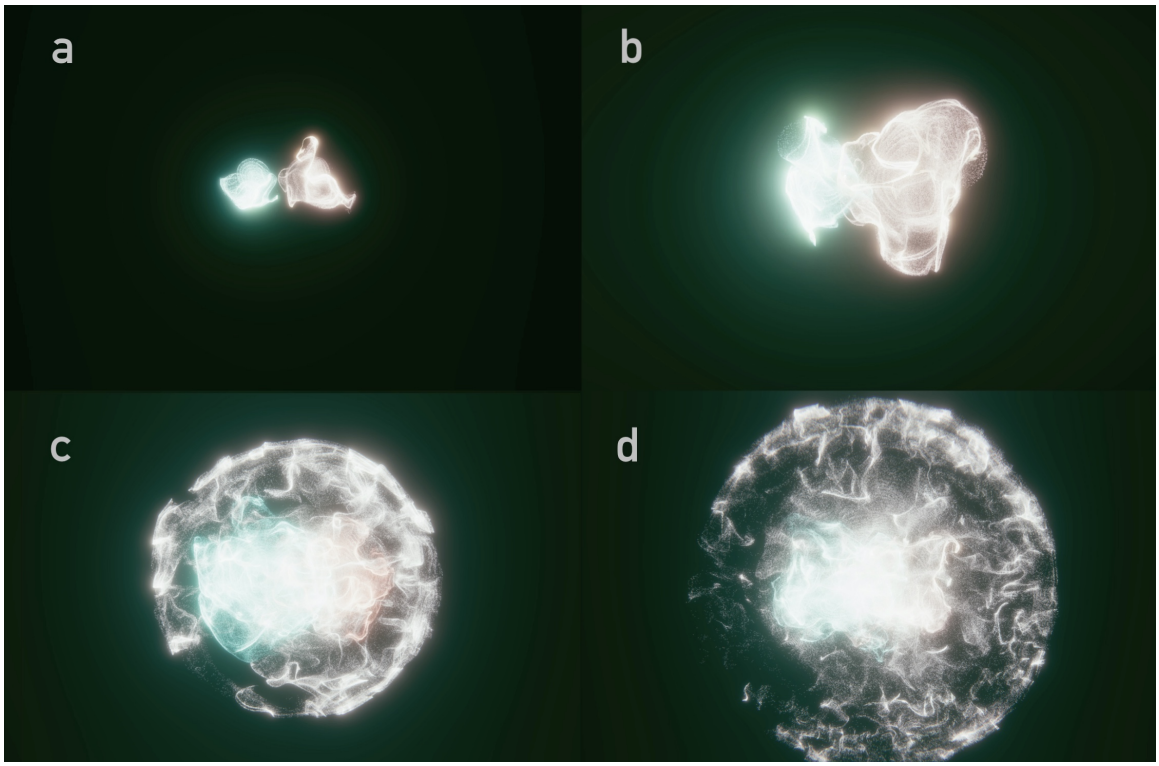

Figure 3.3: Progression of synchronization: (a, b) At first, when a breath is detected, two small orbs glow and expand with airy drone sound . (c, d) As the two users synchronize their exhalation, a ripple is generated and moves outwards . Finally, when the two users' breathing rates synchronize, a singing bowl sound emerges.

in, the frequency of the ocean wave takes the average value between two respiration rates, guiding the users to breathe along with the wave rhythm to converge at an average rate between them, thus encouraging synchronization at a rate suitable to each pair.

The Aura - Direct Mapping of Breathing Our breathing by its nature is expansive, but typically is invisible and imperceptible to us. Here when participants exhale, they see the expansiveness of their breath in an aura of glowing particles on a large immersive projection, generated along with changing airy drone sound (see video in Supplementary Video). The luminous aesthetic of the aura was chosen to symbolize a spiritual quality of expanding breath leaving our body. The spawn rate and particles' speed, the aura's size, and the drone's sound volume change along with the amplitude of the breathing sound to reflect participants' breathing. Participants can associate their breathing with the expanding and contracting auras, thus subtly guiding attention back to their bodies and helping them reconnect with their breathing.

The Ripple - First stage of Synchronization When both users breathe into the microphones simultaneously, a ripple of light grows and expands as a shared creation (Figure 3.3).

The fluid aesthetic of both aura and the co-creation was inspired by water, chosen because of its associations with life and nature. Participants witness their auras along with the ripple expanding and overlapping, which visualizes how our breathing and air going through our bodies are ordinarily shared with others, expanding throughout the room. Following this metaphor, the expansion animation symbolizes the expansion and dissolution of our bodily boundaries, and the connection emerging from it. The ripple extends outward, shifting participants' perception towards unity and connectedness through a mediated experience visually representing our ever-present entanglement of our bodily selves and space. Encouraging continuous breathing synchronization is challenging because the lag in calculating synchronization can take up to 30 seconds between sensing the breathing rate and identifying persistent synchrony. By using the ripple we capture the subtle forms of synchronization to give the user timely feedback, nudging them towards deeper synchronization.

Singing Bowl Sound - Second stage of Synchronization There is a long tradition of using singing bowls for communal meditation in Buddhism. Here, when users' respiration rates are synchronized, a sound of a singing bowl is played, representing their meditative connection. By using an ambient sound as an indicator of synchrony, we avoid focusing participants on the goal of synchronization, which could lead to an undesirable "chasing behavior" as observed in JeL [Desnoyers-Stewart et al., 2019b]. Instead, users are encouraged to maintain focus on their own breathing with this subtle ambient feedback. Chiming and lingering, the singing bowl sound weaves together into the soundscape of the ocean wave and the airy drone in the periphery of users' attention.

3.6 Insights from Conversations with Viewers: Connection Through Breathing

Breath of Light was exhibited at Shanghai, China from March 5th through March 21st, 2021. For 3 days during the exhibition, we observed audiences' interaction and conducted a 5 minute semi-structured interviews in Mandarin with 12 visitors to better understand their experience of the installation. Their quotes presented below were translated by the lead author. The lead artist approached visitors at the entrance to the installation, and asked for their permission to be interviewed. Participants were invited to freely explore the installation for two minutes. Afterwards, they were told how the system worked and encouraged to explore it for another three minutes. After the interaction, participants were asked the following questions:

- *"What three adjectives would you use to describe the experience?"*
- *"What was your emotion during the experience?"*
- *"What was your emotion towards your partner during the experience?"*

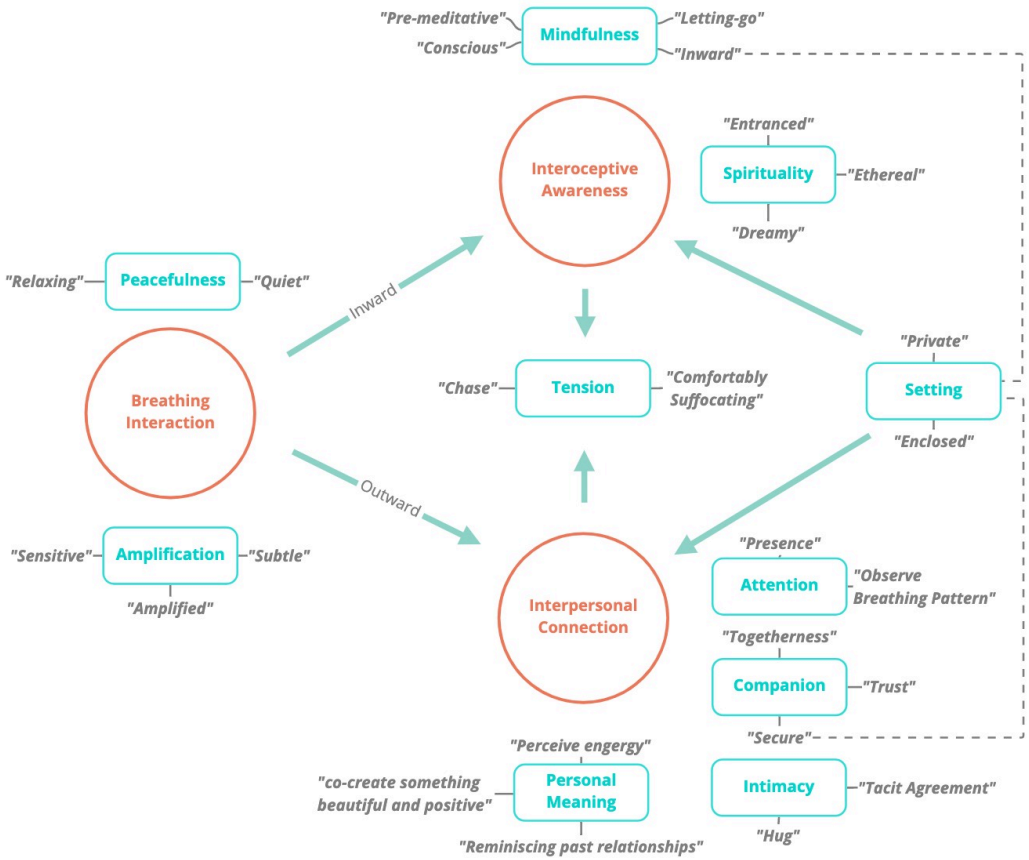

Figure 3.4: Mind map of themes identified in participants' descriptions of their experience with Breath of Light. The three main themes are presented in red, with subthemes in blue and quotes in black. The arrows indicate contribution and dotted lines indicate loose connection.

From the responses of this small group of participants we identified themes and experiential qualities that were elicited through the interaction (See Figure 3.4). In the following discussion, specific quotes in response to the above questions are *"italicized with quotes"* while **themes** and **subthemes** are bolded.

Participants described their **interactive breathing** experiences as **peaceful**. *"Quiet"* and *"relaxing"* are two of the most frequent keywords during the interviews and are shared by 9 participants out of 12. Peacefulness seems to be a foundational emotional layer of the experience. Indeed, we observed that most participants appeared to be calm and quiet when interacting through their breath. Peacefulness is often associated with meditation practice, aligning with our design goal of encouraging mindful meditation, and is closely related to the mindfulness theme. The breathing interface also sensitized participants to their shared breath by **amplifying** it. The interaction was *"sensitive"* for some and *"subtle"* for others. Participants were observed consciously slowing or accelerating their breathing to explore the

interaction with their expansive aura. These observed behaviors aligned with our design's aim of enhancing awareness of breathing.

The breathing interaction then allowed participants to shift attention inward and cultivate **interoceptive awareness**. Participants reported qualities relating to **mindfulness**: they experienced *"inward"* focus, being more *"conscious"* of their breathing or *"letting-go"*, akin to a *"pre-meditative"* state. This is likely supported by the peaceful amplification of breathing. In addition, some participants reported qualities relating to **spiritual** experiences: they found the visualizations *"entrancing," "ethereal,"* or *"dreamy"*. In mindfulness-based stress reduction (MBSR), increases in mindfulness were associated with increases in spirituality [Carmody et al., 2008]. Thus, these spiritual qualities and mindfulness related qualities may have a mutually beneficial relationship strengthening interoceptive awareness.

Despite the inward focus promoted by the installation, many participants reported three different levels of **interpersonal connection** interweaved by **personal meaning** through the installation. Some participants reported shifting their **attention** outward to their partners' *"presence"*, and starting to *"perceive [their] energy"* and *"observe [their] breathing pattern."* In addition, some participants further described the interpersonal connection afforded by the installation as a **companionship**. Through interaction they reported building up *"trust"* and feeling *"secure"* and a sense of *"togetherness"* with the presence of the partner. Finally, some participants even perceive distinct qualities of **intimacy**. One participant reported she wanted to *"hug"* her partner, also a friend of hers, to deepen their relationship. Another participant reported that he felt a sense of *"tacit agreement"* when matching the pace of respiration together with his partner. All these levels of connection seem to be accompanied by **personal meaning** and interpretation as afforded by the installation. For example, one participant described the experience as *"co-exploring"* and *"co-creating"* and noted the enjoyable quality of their experience because they were co-creating something beautiful and positive together. This also indicated that interpersonal connection emerged not only from a shared breathing pattern, but also from co-creating shared personal meaning and an aesthetic experience.

These themes and experiential qualities represented in Figure 3.4 reveal how breathing-based interaction can both support inward direction of attention, but also an outward direction to the other participants and their shared experience. These two distinct directions of attention created a **tension** between letting go and control. Some participants oscillated between a mindful connection to oneself and a more conversational and playful connection to the other. They felt the need to *"hold [their] breath"* or to *"chase"* their partner's breathing. This was also reflected in our observations—some participants seemed short of breath when trying to match a very different breathing rate. Interestingly, two participants from separate pairs both mentioned they felt out of breath but relaxed at the same time. One of them described this feeling as *"comfortably suffocating"*. In addition, all 4 participants who reported tension also reported experiencing peace and mindfulness, which indicates that

this breathless feeling and positive emotions are not mutually exclusive. However, we still do not know if or how the tension contradicted other experiential qualities. As a result, we suggest that this interpersonal tension should be carefully considered in the design to either minimize or take advantage of it.

Finally, participants found that the supportive **setting** allowed for an intimate connection to emerge. Participants further described the experience to be *"private"* and *"enclosed."* It helped them direct attention *"inward"* and allowed them to feel *"secure"* while establishing an outward connection. We intentionally placed the installation in a dark and enclosed space in the otherwise open and bright exhibition space to help cultivate meditative mindfulness. The subthemes peacefulness and mindfulness suggest that our installation indeed contributed to the qualities typically associated with mindfulness practices. These indicate that a dark and at least partially enclosed setting could potentially help to create a private and safe space for both interoceptive awareness and interpersonal connection to emerge.

3.7 Insights from Observation:Connection Beyond Breathing

3.7.1 A Tendency Towards Physical Contact over Breathing

While some visitors intuitively engaged with microphones as intended by exhaling into them, some participants initially tended to explore physical ways to interact with the system instead. Without explicit instructions, many people began by physically touching and playing with the microphones despite the central role of "breath" in the artwork's description. Some visitors would whistle, clap, chant, sing, grip or even scratch the mic. These participants' behavior either encouraged the other visitors to follow the pattern or inspired them to create their own ways of interacting.

3.7.2 Hesitation and Socially Restricted Breathing

During COVID-19 pandemic there is a social pressure to avoid breathing deeply and visibly in public, especially without masks. This pressure is dependent on the cultural and social context, and in some circumstances people may shame those who do not wear masks, while in others mask wearing might be seen negatively. This diversity of attitudes towards open breathing in public and perceived social pressure gave rise to various creative forms of engagement with our breath-responsive interface. One example was a participant who was observed swinging the hanging microphones like a pendulum instead of breathing into it. It seemed she was trying to replace her own breath with the air flowing across the microphone. The physical affordances of a microphone allowed the audience to find their own ways of engaging with the installation corresponding to their comfort level. Regardless of whether they were more comfortable with breathing openly in public, taking off their masks, touching an object, etc. participants could find a way to interact with the artwork in a way that

aligned with their preferences supporting inclusivity and exploring playful interpersonal connections.

3.7.3 Appropriation – A Tension Between Playful Connection and Meditative Connection

While the original installation design aimed to support a meditative connection experienced through relative quietness and stillness, participants' engagement sometimes took on a more playful, vibrant and chaotic form. Ignoring the artwork description or having a lower level of comfort for interacting through breathing, some audiences appropriated the installation. People sometimes started to mirror their movements in a playful and exploratory way. Many of the movements, such as tapping, provide only discrete input compared to breathing which is continuous making it harder to trigger and interpret the ripple effect that represents synchrony. Even when participants continuously scratched or tapped the mic to occasionally trigger the ripple, the sporadic response likely did not allow participants to understand its meaning. For some other sound-based interactions, such as whistling and chanting, the experience could become more poetic and personally meaningful. For instance, one participant whistled like a bird's chirping, changing pitch and rhythm. The cloud of light grew and dissolved lively along with the delicate chirping, with the ambient sound mystically echoing with the whistle.

3.8 Learning through Exhibition during a Pandemic

3.8.1 The Evolving Connection in Culture Spaces

Culture spaces are important social venues which have historically offered opportunities to build inter-human connections openly and freely. The ways culture spaces can offer this connection has transformed due to evolving restrictions and emerging social norms during the COVID-19 pandemic. Wearing masks and maintaining physical distancing has become an integral part of our social interaction in public, which will likely continue to affect social norms long after the pandemic. These norms of what interactions feel "safe" shift rapidly, and are dependent on geographic region, the state of the pandemic and public health guidelines, and an individual's own life situation and beliefs at a given moment. In *Breath of Light*, we have observed how varying levels of comfort of interacting through breathing or touch in a public space have shaped individuals' experiences, and the extent to which they felt safe to interact and connect. This feeling of safety afforded by the mediation of the installation created space for discovery and connection through shared exploration. *Breath of Light* invited participants to reflect on the role of shared breathing in our interactions, and how this role and connotation of shared breathing have transformed in recent years. This technological mediation of breathing allowed to revive the connective connotations of shared breath, while respecting hygiene precautions and participants' diverse comfort levels.

3.8.2 Use of Metaphors and Symbols for Immersive Connection

We used luminous particles as a metaphor for breath as extension of one's spirit, and the ripple for expanding connection. The visualizations along with aural feedback let us perceive how breathing is shared and exchanged, connecting us with other participants. While we remain at a safe distance wearing masks, we can still experience this exchange metaphorically, while still restricted from the material connection through breath by masks. The symbolism of water, luminosity and expansion used in *Breath of Light* could also be read as cultural texts where life, spirit, and connection converge. Our interviews suggest that some participants perceived and reflected on these cultural meanings. Thus, using metaphors and symbols has the potential to stimulate reflection and reshape the connotations of shared breathing.

3.8.3 Ambiguous Instruction for Creative Exploration and Inclusivity

Though the artwork was designed to encourage breathing synchronization, we did not place any explicit instruction beyond the brief artwork description. This seemed to open up space for different people to find their own comfort level and engage with the installation and other viewers. The volatility of individual comfort levels presents a particular design challenge, where the interactive art during pandemic and beyond should become more adaptive and inclusive. Additionally, through open instruction and creative exploration, the visitors acquire the freedom to appropriate the artwork, making it personally meaningful.

3.9 Conclusion

Hundreds of years ago, breath was celebrated as a means of communication between all beings and elements of the animate world across diverse ancient cultures on east and west, including Greece, China, and Indigenous tribes [Abram, 1996, Goldin, 2020, Aristotle, 1935]. Today, we leverage the same connotation of shared breathing that connected us before to transform how it is being experienced now, mediated through our installation. With radically reshaped social norms inhibiting our open breathing in public spaces, our work suggests a possible future path for inter-human connection. By focusing participants on their shared act of breathing as metaphorically visualized by the installation, we hope to help them overcome social boundaries through the very thing that we are protecting each other from, revitalizing breath as symbol of life and connection, nudging the world towards a more connective and introspective future.

Chapter 4

General Conclusion

4.1 Summary and Main Contributions

Though research shows transformative experiences are associated with multiple indicators of well-being including positive emotions, positive behaviour change, pro-sociality and satisfaction, there is no unified approach for how to design technology-mediated experiences that provide the conditions to support a transformative experience. Thus in both studies presented in this thesis, we strived to answer how transformative experiences with different qualities can be invited by means of interactive technologies, especially with embodied interaction. We explored the transformation with different interaction techniques – embodied flying interface for self transcendence and empowerment in a purpose-designed VR flying experience (Chapter 2), and breathing for introspection and interpersonal connectedness in an interactive art installation (Chapter 3). We translated such knowledge into tentative design principles for developing experiences that aim to support meaning in life and personal growth, which could ultimately contribute to mental and physical well-being.

4.2 Revisiting Overarching Research Question

In chapter 1 we raised the overarching research question: **how and to what extent does embodied interaction contribute to transformative experiences through immersive technology**. We visualize the role of embodied interaction in supporting specific transformative emotions (self transcendence, empowerment and social connection) and situate them in the broader context of transformative experience design frameworks [Gaggioli et al., 2016, Stepanova et al., 2018] in Figure 4.1.

The frameworks propose that a person's transformative experience start from a novel **perceptual experience** that is able to elicit an emotional response. If the experience does not fit with one's current worldview, then one ought to change the worldview to **accommodate** for the new perspective, otherwise one will reject the new perspective. A successful accommodation then would lead to a **cognitive shift**. However if one fails

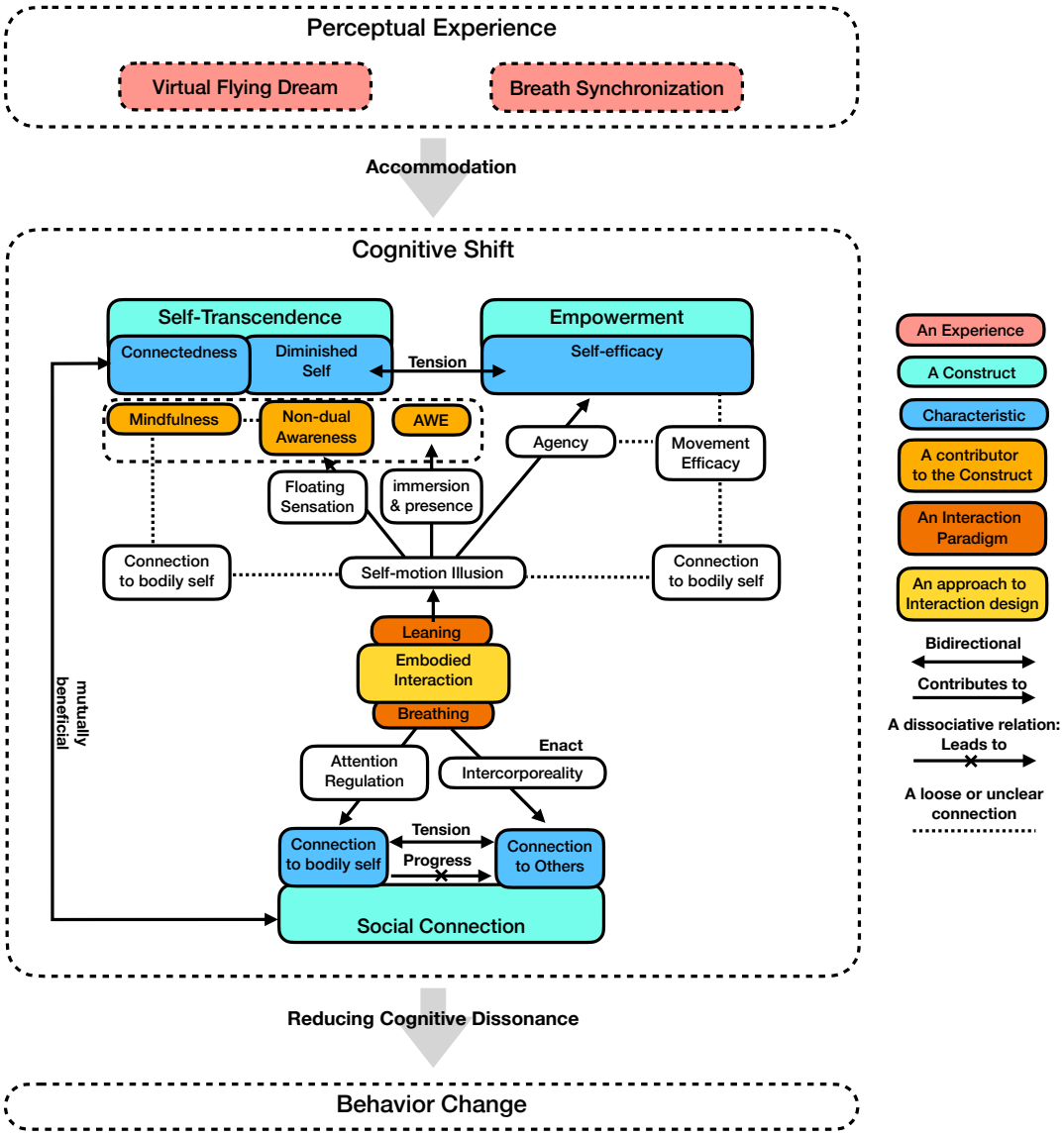

Figure 4.1: Schematic of a tentative framework for embodied interaction contributing to transcendent, empowering and connective transformation.

to accommodate, one may explain the experience as an illusion or a hallucination. For technology mediated immersive experience, it is especially easy for people to disregard the experience as not real. Thus it is important for designers and researchers to prepare the participant to suspense disbelief in a virtual experience. After one experiences a cognitive shift in one's worldview, if one's behavior is inconsistent with the new worldview, one will **change behavior** to reflect the new values of the expanded mental model. Within these frameworks we further propose how embodiment contribute to the three different transformative emotions as illustrated in Figure 4.1.

Self-Transcendence: Our results from the first study suggest that the enhanced feeling of self-motion through the more embodied interface could provide stronger **bodily presence and immersion** in the VR experience, which further contribute to potential elicitation of self transcendence. Meanwhile, the leaning-based interface might have contributed to **non-dual awareness** through the enhanced sensation of **floating**. Furthermore, though we did not measure mindfulness directly, some participants compared the experience to mindful meditation and altered-state experiences, and described the experience as calming and relaxing. We suspect that the more embodied (leaning-based) interaction again help participant shift their attention towards their bodily movement and thus helped to strengthen that **body-mind connection**, which support the emotional states associated with **mindfulness**.

Empowerment: Our results from the first study also suggest that, in a dream-inspired VR experience, the perception of **self-motion** contributed to participants experiencing a **perceived agency** of flying as their own competence, which further contributed to the feeling of empowerment. Meanwhile, this competent feeling could also be understood as a kinesthetic aspect of **movement efficacy** in flying or floating [Kuiken, 2015]. We hypothesize that this movement efficacy is an important component of empowerment, and is preceded by enhancing **connection to bodily self**. This connection is also potentially supported by self-motion illusions.

Social connection: Our results from the second study suggest that breathing interaction support both inward connection to bodily self and outward connection to others. On the one hand, we tentatively propose that the breathing interaction contributed to inward connection by guiding user's **attention** back to their own breathing, and thus enhance the body-mind connection. On the other hand, participants reported forming intercorporeal connection, where affective and subjective understandings of others emerges from a reciprocal resonance between bodies [Merleau-Ponty, 1964], through **enacting** their partner's breathing pattern and co-creating shared personal meaning.

To conclude, we propose that embodied interaction contribute to transformative emotions by putting bodily action, perception and awareness right at the center of the experiences.

4.3 Key Insights, Limitations and Future Directions

In this section we draw connections between the two studies and describe key insights that emerged from revisiting both studies in the context of transformative experience design framework. Finally we offer suggestions for future work that can further the work on the

key qualities associated with embodied interaction and how they could contribute to transcendent, empowering and connective transformation.

4.3.1 Embodied mindfulness (connection to bodily self) as a potential gateway towards transformation

In both of the experiences, users started by experimenting with their bodily interaction (movement/breathing) and form a sense of connection to their bodily self. Based on Neurobiology, Khoury et al. [Khoury et al., 2017] proposed this body–mind connection through embodied practices as embodied mindfulness, where top–down conceptual awareness (i.e., memories, beliefs, and emotions) and bottom–up sensory feedback (awareness of bodily signals) converge. And the central aspect of embodied mindfulness is the ongoing awareness of bodily sensations. In both of the experiences participants reported embodied mindfulness as a underlying and ongoing layer of experience beneath transformative emotions with profound meaning. Yaden [Yaden et al., 2017] has pointed out that there may be a spectrum of intensity along which one may experience self transcendence, and that state of mindfulness may be on the lower part of the spectrum. Furthermore, Stepanova et al. [Stepanova et al., 2022] suggested that in order to connect with another person and ultimately reach a sense of social connectedness, we first have to connect to our bodily self and sensory experience. Thus we propose that the connection to bodily self through embodied mindfulness could serve as a low-intensity but foundational emotional layer in the transformative experience.

As a result, it could be worth exploring the role of embodied mindfulness in transformative experience. More specifically, could embodied mindfulness be a potential gateway towards transformation? If so, we may discover a experiential pathway towards transformation and better design future experiences to encourage behavior change. One of the related limitations in our studies is that we did not collect quantitative data around mindfulness. Though the qualitative responses indicated that mindfulness served as a foundational step for the subsequent transformation, further studies are needed to test this hypothesis and provide more reliable evidence. Another limitation is that the transformation here was only examined within specific contexts: self-transcendence, empowerment and social connection. There are many other forms of transformation and practice of achieving a transformative experience, and it may not always be possible to generalize results directly to diverse transformation contexts.

However, we can start to approach this question by improving measurement. For subjective measures, we could try to bring participant's attention to the chronological order of how the emotions emerge, and design the study accordingly to evaluate the relationship between embodied mindfulness and transformation with mixed methods. For objective measures, we could be looking deeper into the neurobiological parameters (such as electroencephalographic activity, cerebral blood flow, and neurotransmitter activity), and body

physiological parameters (blood pressure, body temperature, heart rate, and galvanic skin responses). These parameters can be correlated with mindfulness or specific transformative states and may help us see clearer patterns when combined with the simultaneously collected subjective measures.

4.3.2 Tension between more active and less active state in embodied interaction

In both studies participants reported tensions between more active emotional states associated with higher bodily involvement (empowerment, excitement, outward exploration) and less active emotional states associated with lower bodily involvement (awe, relaxation, inward reflection). In the first study, the more active states associated with the more embodied interface were reported to contribute to agency and empowerment but mitigate the peaceful emotion, while the less active states associated with the less embodied interface were reported to induce higher sense of calmness and relaxation but less agency and control. Overall we observed trade-off between the feeling of powerful (related to empowerment) and powerless (related to awe), excitement and relaxation, and outward exploration and inward reflection, all brought by the different levels of body involvement originated from the more embodied and less embodied interfaces.

In the second study, on the one hand, the more active states associated with the playful interaction (tapping, gripping or even scratching) allowed people to make connections by mirroring their movements in a exploratory way, but the accompanying discrete input also making it harder to trigger and interpret the ripple effect that represents synchrony. On the other hand, the less active states associated with quiet breathing interaction better facilitated meditative introspection and inward connection, but might weaken playfulness and outward connection. As a result we observed a trade-off between playful exploration and focused synchronization, and outward connection to others and inward connection to bodily self, brought by different levels of body involvement within interactions for the same breath-based interface.

To conclude, we observed trade-offs between the more active and less active states, which are associated with higher and lower body involvement either within or between embodied interfaces. These tensions of both emotional and bodily activeness keep mediating the overall experience, and could be an important design parameter in embodied interaction to explore in future work. By understanding how these tensions contribute to the emotional experiences, we may be able to leverage the knowledge around tension to expanse design space in transformative experience design with immersive technology, and create a richer experience that invite bodily awareness and reflection.

However, similar to investigating the role of mindfulness, it is challenging to examine the tensions due to the situatedness within different transformative goals – for example, empowerment vs awe, connection to self vs others, exploration vs meditation. Adopting

evaluation methods combining physiological data with in-depth qualitative phenomenological analyses in the context of controlled and reproducible immersive environments could help to shed light on this question.

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