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

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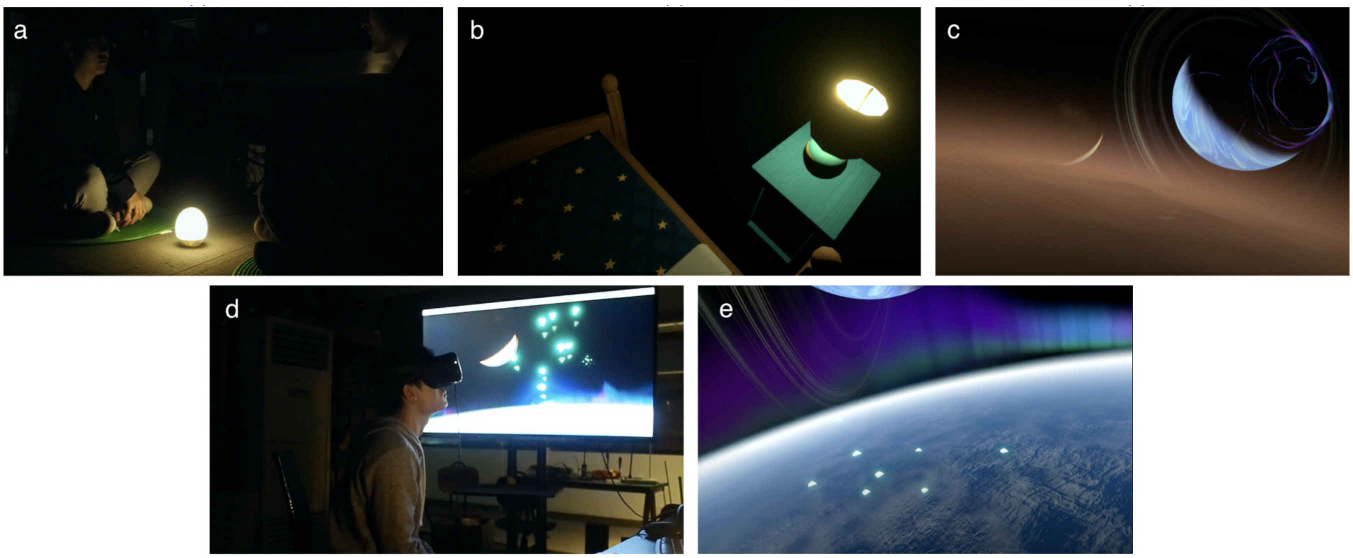

Figure 1: (a) A participant is being guided through a 2-minute meditation before the VR experience. (b) When participants put on the headset, the screen would fade into a bedroom with dim light. (c) Abstract lifeless landscape. (d) One participant flying into space with HeadJoystick interface. (e) The Space environment in the flying experience.

ABSTRACT

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, extraordinary 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.

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CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *Interaction design.*

KEYWORDS

Dreaming, transcendent dream, flight simulation, gravity imagery, virtual reality, empowerment, self-transcendence, vection

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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 [10]. 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 [39]. 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 [74]. Some self-transcendent experiences can be associated with particular self-transcendent emotions such as compassion, awe, gratitude, appreciation, inspiration, admiration, elevation, love, and flow [74]. Self-transcendent emotions are typically positive experiences associated with benefits for an individual's well-being [31, 47, 74] and pro-social intentions and behaviour [46, 53, 66]. 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** [48] –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) [40]. Conger et al. translated from Bandura's self-efficacy model [4] and define empowerment as a process of enhancing feelings of self-efficacy [15]. 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 [4]. 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 [39]. 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 suggested that brief exposures to a simulated flying task in VR could selectively increase the occurrence of unassisted flying dreams [52]. In addition, they proposed that feelings of dream-flying constituted a type of vection illusion (illusion of self-motion, [59]), 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 [13, 55], 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 [16], has been suggested to have the potential to induce STE [34]. Though dream flying could be either lucid or non-lucid, dream flying is a common occurrence in lucid dreaming [5]. There is not a lot of design guidance around dream flying in VR, but there is lucid dreaming in VR (subsubsection 2.1.2) 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 [1, 25, 37, 59]. With leaning-based interfaces, the immersants lean towards the desired direction for virtual motion [25]. 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 [8]. 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 [7]. 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 [1, 25, 37, 77]. 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 subsubsection 2.4.4 and subsection 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 RELATED WORK

2.1 Self-transcendent VR

There is a growing interest in designing positive technology that can support self-transcendence [9, 19]. 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.

2.1.1 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 [72, 75]. 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 [67]. Quesnel & Riecke [55] evaluated Google Earth VR as a stimulus for awe induction through elicitation of the Overview Effect. *AWE* [56, 68] is an immersive mixed and virtual reality installation designed to elicit feelings of awe and wonder. Stepanova et al. [67] 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.

2.1.2 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* [32] 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* [64] is a multi-sensory 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* [21] 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. [35]'s and Semertzidis et al. [64]'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.

2.1.3 Psychedelic Technology. Psychedelics are famously known for their potential to induce strong self-transcendent experiences and ego dissolution [50]. 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* [69] 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* [20] 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 [74], 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 VR Systems Supporting Empowerment

Banakou et al. [3] 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. [63] 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 subsection 2.4).

2.3 Embodiment in Transcendent Dreams

Kuiken [39, 41] suggested that, in transcendent dreams, the dreamers feel powerful and competent and possess an exceptional ability

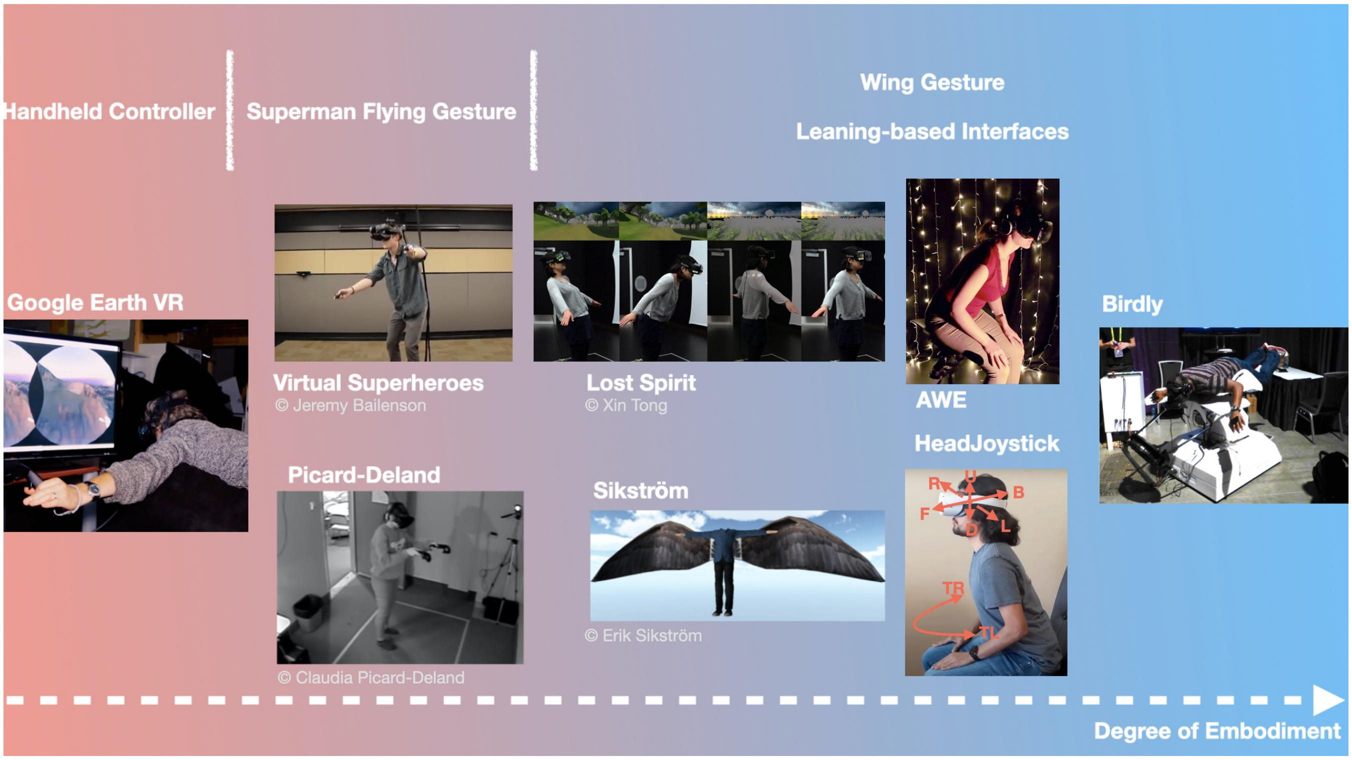

Figure 2: Flying interfaces with different degree of embodiment on an ordinal scale.

to attain their goals. More specifically, this powerful/competent feeling could be understood as a kinaesthetic aspect of movement efficacy (including flying or floating) [40]. This literature suggests that the movement in transcendent dreams plays a key role towards constructing the experience. Mitchell [48] 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. [52] 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.

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. [30], 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 [78] 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 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.

2.4.1 *Handheld Controller (Thumbstick/Touchpad).*

In Google Earth VR [42], 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.

2.4.2 Superman Flying Gesture. In *Virtual Superheroes* [63], 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. [52] 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 [63] and induced flying dreams [52]. 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 [43, 62]. Besides, it was not hands-free and users needed to hold trackers/controllers in their hands to mediate the agency.

2.4.3 Fly with Wings. *Lost Spirit* [70] 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. [65] 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* [57] 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 multi-sensory 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 [70].

2.4.4 Leaning-based Interfaces. In *AWE* [56], 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 [38], but was seldom able to induce the sense of floating [56]. 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. [1, 25, 60] 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 waypoints and fly through the tunnels of decreasing diameter without colliding with the walls [25]. 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 [1, 25], an important aspect in flying dreams [52].

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 [1, 25]. 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.

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 [32, 73]. More specifically, an increasing amount of research has demonstrated how VR could support self-transcendence [13, 54] and empowerment [3, 63]. 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 [52]. In addition, studies showed that embodied (leaning-based) VR flying interface could enhance self-motion, i.e., vection [1, 25]. However, most research on embodied VR flying interfaces only assessed it in maneuvering [25] or spatial orientation tasks [1], 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 [1, 25, 37, 59], 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 [25, 77]. 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 [52]. 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 [34, 35]. Considering the strong association between 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.

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.

4.1 Co-design Workshop

Though there has been discourses on guidelines for self-transcendent experience design in VR inspired by lucid dreaming [34], 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.

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 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 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 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 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)

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 [44]. Recently Kitson et al. suggested that set and setting are important in supporting profound emotional experiences in VR [36]. 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 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 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.

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.

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.

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 [25]. 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 headset 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°.

5.3 Flying Interfaces

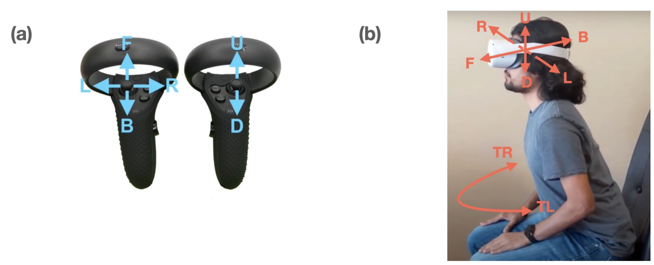

Figure 3: (a) In Hand Controller, the left thumbstick controls the horizontal velocity (Forward, Backward, Left, Right) and the right thumbstick controls the vertical velocity (Up, Down) (b) In HeadJoystick, the user's head position controls the velocity. In both cases, users rotate physically (Turning Right, Turning Left).

5.3.1 *Hand-Held Controller Interface.*

For the Hand Controller interface, the left control stick controlled horizontal translation velocities as illustrated in Figure 3 (a). The right control stick controlled upward/downward translation speeds.

5.3.2 *HeadJoystick Interface.*

As shown in Figure 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 [25]. 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.

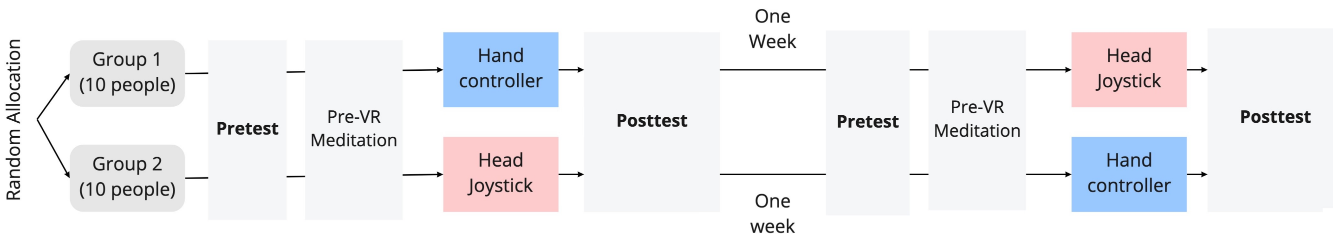

Figure 4: A flow chart illustrating the procedure of the study.

5.4 Procedure

Figure 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.

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.

5.5.1 *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) [18], the Nondual Awareness Dimensional Assessment (NADA-S) [23], the Awe Experience Scale(AWE-S-6) [76] (we have shortened the questionnaire ourselves to six questions with highest loading) and the Inclusion of Other in the Self (IOS) Scale [2]. Self-reported **self-efficacy** was measured through the New General Self-Efficacy Scale (NGSE) [12]. 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) [29], a 16-item instrument including questions on self-motion, with additional immersion and presence questions [25].

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 [45]. 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.

5.5.2 *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 Software 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 [49] 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 [39, 41], existing design guidelines [35, 36, 67] 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.

6 RESULTS

6.1 Quantitative Results

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.

6.1.1 *Self-Efficacy.*

We used the NGSE (New General Self-Efficacy Scale) to measure self-efficacy before and after the VR experience

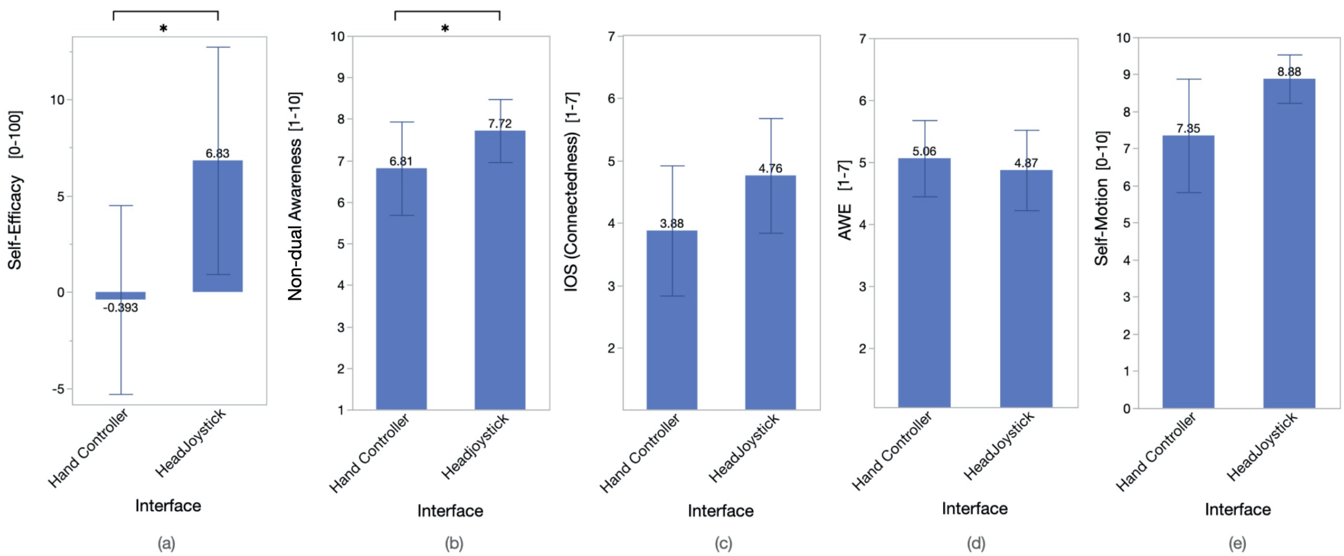

Figure 5: Mean values for participants using Hand Controller (left) versus HeadJoystick (right), with error bars showing 95% confidence intervals for (a) the difference between participants' pre- and post-test self-efficacy score, and mean ratings for (b) NADA-S (non-dual awareness) (c) IOS (connectedness) (d) AWE and (e) self-motion.

with two different interfaces, and ran the 2×2 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.

6.1.2 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 [22]); 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 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 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 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 [28]. 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 [14]. 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.

6.1.3 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 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, 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.

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 6.

6.2.1 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"*. 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 [24, 58, 61].

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 [25]. 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.

6.2.2 Theme 2: Extraordinary Light.

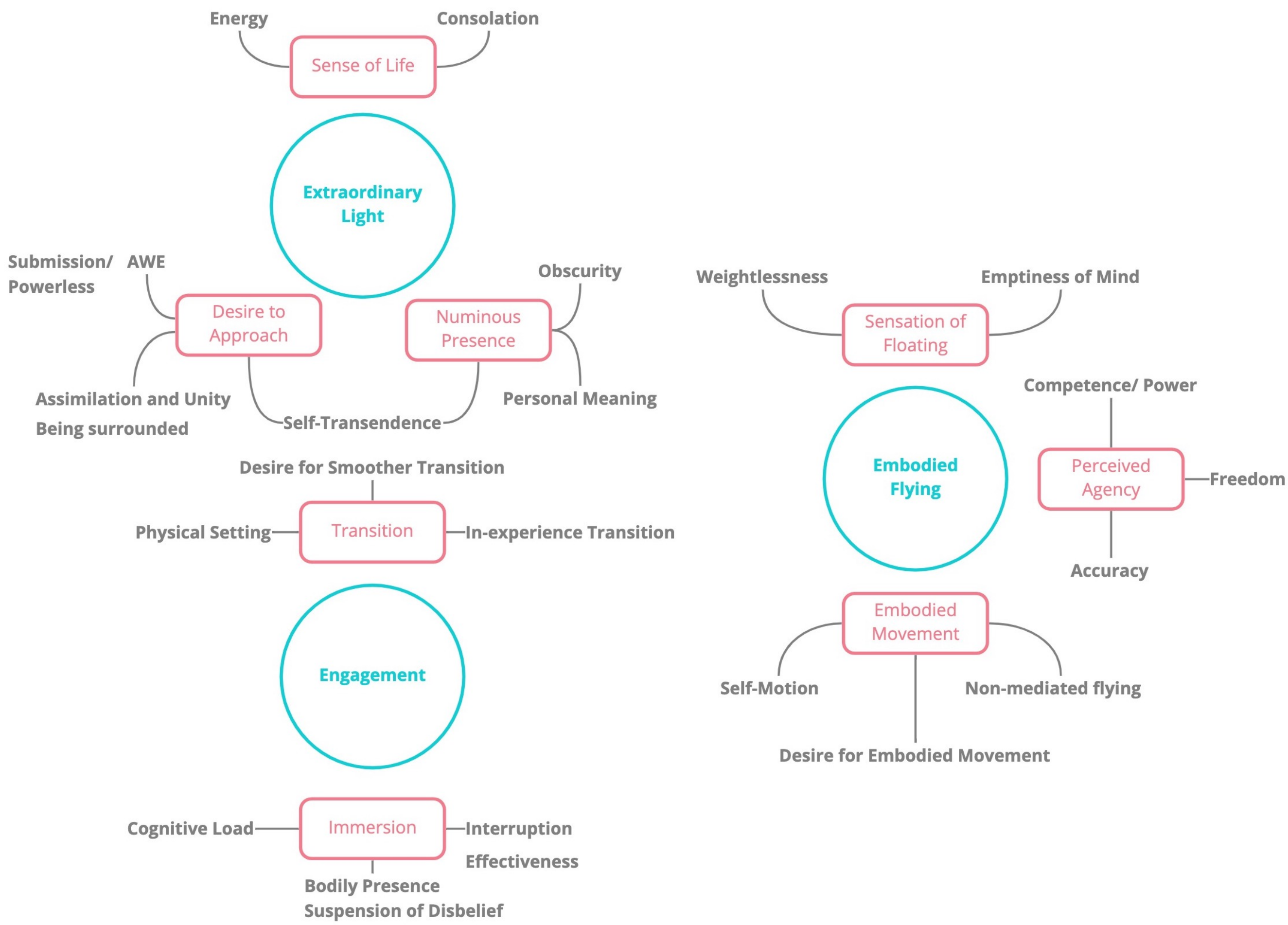

Figure 6: Mind map of themes identified in this paper. The three main themes are presented in blue.

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 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*

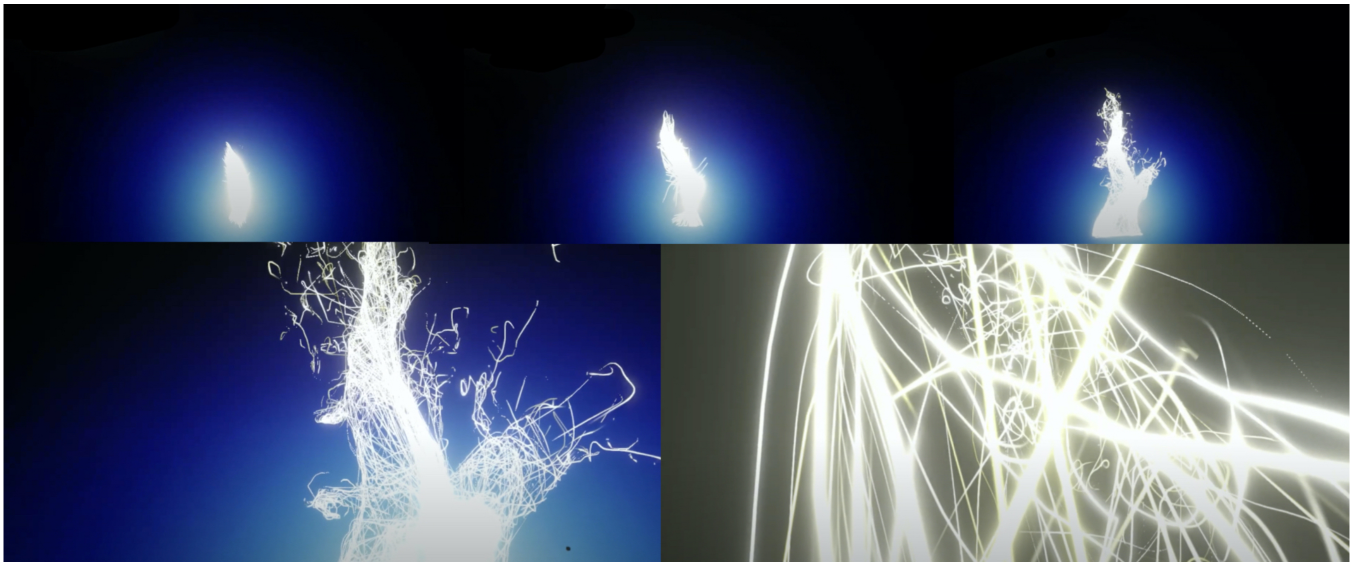

Figure 7: The enormous tree of light in the VR experience, composed of slowly growing light rays.

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)

6.2.3 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)

7 DISCUSSION

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.

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

7.2.1 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 [6, 33], 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.

7.2.2 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 [40], 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 [28]. 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 [40].

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 parameters 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* [68], 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 [36]. 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.

7.2.3 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 [39, 41]. This powerful and competent feeling "could be understood as a kinaesthetic aspect of movement efficacy (including flying or floating)" [40]. 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 [39]. 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 [25, 33] and are more likely to evoke transformative experience [68].

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 [26], 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 [22]. 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 [71]. 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 [52]. We encourage designers to involve more motion cues and bodily control in order to evoke stronger self-efficacy and self-transcendent emotions.

7.3 RQ3: Design Considerations for Self-Transcendence and Empowerment

7.3.1 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"** [28]. 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 [17, 71], and might have allowed participants to more actively co-create the experience.

7.3.2 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) [27]. 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". [41] In addition, in alignment with Hunt's opinion that light metaphorically reasserts STE [26], 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.

7.3.3 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 [51].

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 [11]. The re-exposure to the stimulus paired with targeted memory is in keeping with the flying dream induction study by Picard-Deland [52]. 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.

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.

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.

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REFERENCES

[1] Ashu Adhikari, Abraham M. Hashemian, Thinh Nguyen-Vo, Ernst Kruijff, Markus von der Heyde, and Bernhard E. Riecke. 2021. Lean to Fly: Leaning-Based Embodied Flying can Improve Performance and User Experience in 3D Navigation. *Frontiers in Virtual Reality* 2 (2021), 1–20. https://doi.org/10.3389/frvir.2021.730334

[2] Arthur Aron, Elaine N. Aron, and Danny Smollan. 1992. Inclusion of Other in the Self Scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology* 63, 4 (1992), 596–612. https://doi.org/10.1037/0022-3514.63.4.596

[3] Domna Banakou, Sameer Kishore, and Mel Slater. 2018. Virtually Being Einstein Results in an Improvement in Cognitive Task Performance and a Decrease in Age Bias. *Frontiers in Psychology* 9 (2018), 9–17. https://doi.org/10.3389/fpsyg.2018.00917

[4] Albert Bandura. 1978. Self-efficacy: Toward a unifying theory of behavioral change. *Advances in Behaviour Research and Therapy* 1, 4 (Jan 1978), 139–161. https://doi.org/10.1016/0146-6402(78)90002-4

[5] Deirdre Barrett. 1991. Flying dreams and lucidity: An empirical study of their relationship. *Dreaming* 1 (Jun 1991), 129–134. https://doi.org/10.1037/h0094325

[6] Kenan Bektaş, Tyler Thrash, Mark A. van Raai, Patrik Künzler, and Richard Hahnloser. 2021. The systematic evaluation of an embodied control interface for virtual reality. *PloS One* 16, 12 (2021), e0259977. https://doi.org/10.1371/journal.pone.0259977

[7] Costas Boletsis and Jarl Erik Cedergren. 2019. VR Locomotion in the New Era of Virtual Reality: An Empirical Comparison of Prevalent Techniques. *Advances in Human-Computer Interaction* 2019 (Apr 2019), e7420781. https://doi.org/10.1155/2019/7420781

[8] Doug Bowman, Sabine Coquillart, Bernd Froehlich, Michitaka Hirose, Yoshifumi Kitamura, Kiyoshi Kiyokawa, and Wolfgang Stuerzlinger. 2008. 3D User Interfaces: New Directions and Perspectives. *IEEE computer graphics and applications* 28 (Nov 2008), 20–36. https://doi.org/10.1109/MCG.2008.109

[9] Elizabeth Anne Buie. 2018. Exploring techno-spirituality: Design strategies for transcendent user experiences.

[10] Kelly Bulkeley. 1995. *Spiritual dreaming: a cross-cultural and historical journey.* Paulist Press, New York.

[11] Michelle Carr, Adam Haar, Judith Amores, Pedro Lopes, Guillermo Bernal, Tomás Vega, Oscar Rosello, Abhinandan Jain, and Pattie Maes. 2020. Dream engineering: Simulating worlds through sensory stimulation. *Consciousness and Cognition* 83 (Aug. 2020), 102–115. https://doi.org/10.1016/j.concog.2020.102955

[12] Gilad Chen, Stanley M. Gully, and Dov Eden. 2001. Validation of a New General Self-Efficacy Scale. *Organizational Research Methods* 4, 1 (Jan 2001), 62–83. https://doi.org/10.1177/109442810141004

[13] Alice Chirico, Francesco Ferrise, Lorenzo Cordella, and Andrea Gaggioli. 2018. Designing awe in virtual reality: An experimental study. *Frontiers in psychology* 8 (2018), 23–51.

[14] Alice Chirico and Andrea Gaggioli. 2019. When Virtual Feels Real: Comparing Emotional Responses and Presence in Virtual and Natural Environments. *Cyberpsychology, Behavior and Social Networking* 22, 3 (Mar 2019), 220–226. https://doi.org/10.1089/cyber.2018.0393

[15] Jay A. Conger and Rabindra N. Kanungo. 1988. The Empowerment Process: Integrating Theory and Practice. *The Academy of Management Review* 13, 3 (1988), 471–482. https://doi.org/10.2307/258093

[16] Frederik van Eeden. 1913. *Proceedings of the Society for Psychical Research.* Vol. 26. Society for Psychical Research, London, 431–461.

[17] Laura Ermi and Frans Mäyrä. 2005. Fundamental components of the gameplay experience: Analysing immersion. In *DIGRA*. DIGRA, Vancouver, Canada, 1–17.

[18] Barbara L. Fredrickson, Michele M. Tugade, Christian E. Waugh, and Gregory R. Larkin. 2003. What good are positive emotions in crises? A prospective study of resilience and emotions following the terrorist attacks on the United States on September 11th, 2001. *Journal of Personality and Social Psychology* 84, 2 (Feb 2003), 365–376. https://doi.org/10.1037//0022-3514.84.2.365

[19] Andrea Gaggioli, Alice Chirico, Stefano Triberti, and Giuseppe Riva. 2016. Transformative interactions: designing positive technologies to foster self-transcendence and meaning. *Annual Review of Cybertherapy and Telemedicine* 14 (2016), 169–175.

[20] David R. Glowacki, Mark D. Wonnacott, Rachel Freire, Becca R. Glowacki, Ella M. Gale, James E. Pike, Tiu de Haan, Mike Chatziapostolou, and Oussama Metatla. 2020. Isness: Using Multi-Person VR to Design Peak Mystical Type Experiences Comparable to Psychedelics. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems.* ACM, Honolulu HI USA, 1–14. https://doi.org/10.1145/3313831.3376649

[21] Jarrod Gott, Leonore Bovy, Emma Peters, Sofia Tzioridou, Stefano Meo, Çağatay Demirel, Mahdad Jafarzadeh Esfahani, Pedro Reis Oliveira, Thomas Houweling, Alessandro Orticoni, Anke Rademaker, Diede Booltink, Rathiga Varatheeswaran, Carmen van Hooijdonk, Mahmoud Chaabou, Anastasia Mangiaruga, Erik van den Berge, Frederik D. Weber, Simone Ritter, and Martin Dresler. 2021. Virtual reality training of lucid dreaming. *Philosophical Transactions of the Royal Society B: Biological Sciences* 376, 1817 (Feb 2021), 201–217. https://doi.org/10.1098/rstb.2019.0697

[22] Rinpoche Khenpo Tsultrim Gyamtso. 2001. *Progressive stages of meditation on emptiness.* Zhyisil Chokyi Ghatsal Publications, Auckland, N.Z.

[23] Adam W. Hanley, Yoshio Nakamura, and Eric L. Garland. 2018. The Nondual Awareness Dimensional Assessment (NADA): New tools to assess nondual traits and states of consciousness occurring within and beyond the context of meditation. *Psychological Assessment* 30, 12 (Dec 2018), 1625–1639. https://doi.org/10.1037/pas0000615

[24] L. Harris, M. Jenkin, and D.C. Zikovitz. 1999. Vestibular cues and virtual environments: choosing the magnitude of the vestibular cue. In *Proceedings IEEE Virtual Reality (Cat. No. 99CB36316).* IEEE, Houston, TX, USA, 229–236. https://doi.org/10.1109/VR.1999.756956

[25] Abraham M. Hashemian, Matin Lotfaliei, Ashu Adhikari, Ernst Kruijff, and Bernhard E. Riecke. 2022. HeadJoystick: Improving Flying in VR Using a Novel Leaning-Based Interface. *IEEE Transactions on Visualization and Computer Graphics* 28, 4 (Apr 2022), 1792–1809. https://doi.org/10.1109/TVCG.2020.3025084

[26] Harry T. Hunt. 1989. *The multiplicity of dreams: memory, imagination, and consciousness.* Yale University Press, New Haven.

[27] C. G. JUNG. 1966. *Collected Works of C.G. Jung, Volume 15: Spirit in Man, Art, And Literature.* Princeton University Press, Princeton. http://www.jstor.org/stable/j.ctt5hhr2c

[28] Dacher Keltner and Jonathan Haidt. 2003. Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition and Emotion* 17, 2 (Jan 2003), 297–314. https://doi.org/10.1080/02699930302297

[29] Robert S Kennedy, Norman E Lane, Kevin S Berbaum, and Michael G Lilienthal. 1993. Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The international journal of aviation psychology* 3, 3 (1993), 203–220.

[30] Konstantina Kilteni, Raphaela Groten, and Mel Slater. 2012. The Sense of Embodiment in Virtual Reality. *Presence: Teleoperators and Virtual Environments* 21, 4 (Nov 2012), 373–387. https://doi.org/10.1162/PRES_a_00124

[31] Alexandra Kitson, Alice Chirico, Andrea Gaggioli, and Bernhard E. Riecke. 2020. A Review on Research and Evaluation Methods for Investigating Self-Transcendence. *Frontiers in Psychology* 11 (2020), 1–27. https://doi.org/10.3389/fpsyg.2020.547687

[32] Alexandra Kitson, Steve DiPaola, and Bernhard E. Riecke. 2019. Lucid Loop: A Virtual Deep Learning Biofeedback System for Lucid Dreaming Practice. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, Glasgow Scotland Uk, 1–6. https://doi.org/10.1145/3290607.3312952

[33] Alexandra Kitson, Abraham M. Hashemian, Ekaterina R. Stepanova, Ernst Kruijff, and Bernhard E. Riecke. 2017. Comparing leaning-based motion cueing interfaces for virtual reality locomotion. In *2017 IEEE Symposium on 3D User Interfaces (3DUI)*. IEEE, Los Angeles, CA, USA, 73–82. https://doi.org/10.1109/3DUI.2017.7893320

[34] Alexandra Kitson and Bernhard E. Riecke. 2018. Can Lucid Dreaming Research Guide Self-Transcendent Experience Design in Virtual Reality?. In *2018 IEEE Workshop on Augmented and Virtual Realities for Good (VAR4Good)*. IEEE, Reutlingen, 1–4. https://doi.org/10.1109/VAR4GOOD.2018.8576889

[35] Alexandra Kitson, Thecla Schiphorst, and Bernhard E. Riecke. 2018. Are You Dreaming?: A Phenomenological Study on Understanding Lucid Dreams as a Tool for Introspection in Virtual Reality. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*. ACM Press, Montreal QC, Canada, 1–12. https://doi.org/10.1145/3173574.3173917

[36] Alexandra Kitson, Ekaterina R. Stepanova, Ivan A. Aguilar, Natasha Wainwright, and Bernhard E. Riecke. 2020. Designing Mind(set) and Setting for Profound Emotional Experiences in Virtual Reality. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference (DIS '20)*. Association for Computing Machinery, New York, NY, USA, 655–668. https://doi.org/10.1145/3357236.3395560

[37] Ernst Kruijff, Alexander Marquardt, Christina Trepkowski, Robert W Lindeman, Andre Hinkenjann, Jens Maiero, and Bernhard E Riecke. 2016. On your feet! Enhancing vection in leaning-based interfaces through multisensory stimuli. In *Proceedings of the 2016 Symposium on Spatial User Interaction*. ACM, NY, USA, 149–158.

[38] E. Kruijff and B. Riecke. 2017. Navigation interfaces for virtual reality and gaming: Theory and practice. In *VR*. IEEE, Los Angeles, CA, USA, 433–434. https://doi.org/10.1109/VR.2017.7892362

[39] Don Kuiken. 1995. Dreams and feeling realization. *Dreaming* 5, 3 (1995), 129–157. https://doi.org/10.1037/h0094431 129.

[40] Don Kuiken. 2015. *The contrasting effects of nightmares, existential dreams, and transcendent dreams.* Routledge/Taylor & Francis Group, New York, NY, US, 174–187.

[41] Don Kuiken, Ming-Ni Lee, Tracy Eng, and Terry Singh. 2006. The influence of impactful dreams on self-perceptual depth and spiritual transformation. *Dreaming* 16 (Dec 2006), 258–279. https://doi.org/10.1037/1053-0797.16.4.258

[42] Dominik Käser, Evan Parker, and Matthias Bühlmann. 2016. Bringing Google earth to virtual reality. In *ACM SIGGRAPH 2016 Talks (SIGGRAPH '16)*. Association for Computing Machinery, New York, NY, USA, 1. https://doi.org/10.1145/2897839.2927441

[43] Ben Lawson. 2014. *Motion Sickness Symptomatology and Origins*. Vol. 20143245. CRC Press, Florida, US, 531–600. http://www.crcnetbase.com/doi/abs/10.1201/b17360-29 ch 23.

[44] Timothy Leary, Ralph Metzner, and Richard Alpert. 1971. *The psychedelic experience : a manual based on the 'Tibetan book of the dead'*. Academy Editions London (7 Holland St., W.8), N.Y. 94 pages.

[45] Margaret Diane LeCompte and Jean J Schensul. 1999. *Designing and conducting ethnographic research*. Vol. 1. Rowman Altamira, Lanham, Maryland.

[46] Jing-Jing Li, Kai Dou, Yu-Jie Wang, and Yan-Gang Nie. 2019. Why awe promotes prosocial behaviors? The mediating effects of future time perspective and self-transcendence meaning of life. *Frontiers in psychology* 10 (2019), 1–17.

[47] Valerie Lander McCarthy, Lynne A Hall, Timothy N Crawford, and Jennifer Connelly. 2018. Facilitating self-transcendence: an intervention to enhance well-being in late life. *Western journal of nursing research* 40, 6 (2018), 854–873.

[48] Claire Mitchell. 2019. An exploration of the unassisted gravity dream. *European Journal for Qualitative Research in Psychotherapy* 9 (Jun 2019), 60–71.

[49] Lorelli S. Nowell, Jill M. Norris, Deborah E. White, and Nancy J. Moules. 2017. Thematic Analysis: Striving to Meet the Trustworthiness Criteria. *International Journal of Qualitative Methods* 16, 1 (Dec 2017), 1609406917733847. https://doi.org/10.1177/1609406917733847

[50] Walter N. Pahnke and William A. Richards. 1966. Implications of LSD and experimental mysticism. *Journal of Religion and Health* 5, 3 (Jul 1966), 175–208. https://doi.org/10.1007/BF01532646

[51] Randy Pausch, Jon Snoddy, Robert Taylor, Scott Watson, and Eric Haseltine. 1996. Disney's Aladdin: first steps toward storytelling in virtual reality. In *Proceedings of the 23rd annual conference on Computer graphics and interactive techniques (SIGGRAPH '96)*. Association for Computing Machinery, New York, NY, USA, 193–203. https://doi.org/10.1145/237170.237257

[52] Claudia Picard-Deland, Maude Pastor, Elizaveta Solomonova, Tyna Paquette, and Tore Nielsen. 2020. Flying dreams stimulated by an immersive virtual reality task. *Consciousness and Cognition* 83 (Aug. 2020), 102958. https://doi.org/10.1016/j.concog.2020.102958

[53] José J Pizarro, Nekane Basabe, Itziar Fernández, Pilar Carrera, Pedro Apodaca, Carlos I Man Ging, Olaia Cusi, and Darío Páez. 2021. Self-transcendent emotions and their social effects: Awe, elevation and Kama Muta promote a human identification and motivations to help others. *Frontiers in psychology* 12 (2021), 1–17.

[54] Denise Quesnel and Bernhard E Riecke. 2017. Awestruck: natural interaction with virtual reality on eliciting awe. In *2017 IEEE Symposium on 3D User Interfaces (3DUI)*. IEEE, Los Angeles, CA, USA, 205–206.

[55] Denise Quesnel and Bernhard E. Riecke. 2018. Are You Awed Yet? How Virtual Reality Gives Us Awe and Goose Bumps. *Frontiers in Psychology* 9 (2018), 1–22. https://doi.org/10.3389/fpsyg.2018.02158

[56] Denise Quesnel, Ekaterina R Stepanova, Ivan A Aguilar, Patrick Pennefather, and Bernhard E Riecke. 2018. Creating AWE: artistic and scientific practices in research-based design for exploring a profound immersive installation. In *2018 IEEE Games, Entertainment, Media Conference (GEM)*. IEEE, Galway, Ireland, 1–207.

[57] Max Rheiner. 2014. Birdly an attempt to fly. In *ACM SIGGRAPH 2014 Emerging Technologies (SIGGRAPH '14)*. Association for Computing Machinery, New York, NY, USA, 1. https://doi.org/10.1145/2614066.2614101

[58] Bernhard E. Riecke. 2006. Simple user-generated motion cueing can enhance self-motion perception (Vection) in virtual reality. In *Proceedings of the ACM symposium on Virtual reality software and technology (VRST '06)*. Association for Computing Machinery, New York, NY, USA, 104–107. https://doi.org/10.1145/1180495.1180517

[59] B. E. Riecke. 2011. Compelling Self-Motion Through Virtual Environments Without Actual Self-Motion – Using Self-Motion Illusions ("Vection") to Improve User Experience in VR. In J. Kim (Ed.). In *Virtual Reality*, Jae-Jin Kim (Ed.). InTech, London, 149–176. http://www.intechopen.com/articles/show/title/compelling-self-motion-through-virtual-environments-without-actual-self-motion-using-self-motion-ill doi: 10.5772/553.

[60] Bernhard E. Riecke. 2017. Could Virtual Reality Make us More Human? https://youtu.be/cMGOftEi4UU

[61] Bernhard E. Riecke and Daniel Feuereissen. 2012. To move or not to move: can active control and user-driven motion cueing enhance self-motion perception ("vection") in virtual reality?. In *Proceedings of the ACM Symposium on Applied Perception (SAP '12)*. Association for Computing Machinery, New York, NY, USA, 17–24. https://doi.org/10.1145/2338676.2338680

[62] Bernhard E. Riecke and Jörg Schulte-Pelkum. 2015. An Integrative Approach to Presence and Self-Motion Perception Research. In *Immersed in Media: Telepresence Theory, Measurement and Technology*, Frank Biocca, Jonathan Freeman, Wijnand IJsselsteijn, Matthew Lombard, and Rachel Jones Schaevitz (Eds.). Springer. doi: 10.1007/978-3-319-10190-3_9, New York, 187–235. doi: 10.1007/978-3-319-10190-3_9.

[63] Robin S. Rosenberg, Shawnee L. Baughman, and Jeremy N. Bailenson. 2013. Virtual Superheroes: Using Superpowers in Virtual Reality to Encourage Prosocial Behavior. *PLOS ONE* 8, 1 (Jan 2013), e55003. https://doi.org/10.1371/journal.pone.0055003

[64] Nathan Arthur Semertzidis, Betty Sargeant, Justin Dwyer, Florian Floyd Mueller, and Fabio Zambetta. 2019. Towards Understanding the Design of Positive Pre-sleep Through a Neurofeedback Artistic Experience. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, Glasgow Scotland Uk, 1–14. https://doi.org/10.1145/3290605.3300804

[65] Erik Sikström, Amalia de Götzen, and S. Serafin. 2015. Wings and flying in immersive VR — Controller type, sound effects and experienced ownership and agency. *2015 IEEE Virtual Reality (VR)* 2 (2015), 281–282. https://doi.org/10.1109/VR.2015.7223405

[66] Jennifer E Stellar, Amie M Gordon, Paul K Piff, Daniel Cordaro, Craig L Anderson, Yang Bai, Laura A Maruskin, and Dacher Keltner. 2017. Self-transcendent emotions and their social functions: Compassion, gratitude, and awe bind us to others through prosociality. *Emotion Review* 9, 3 (2017), 200–207.

[67] Ekaterina R. Stepanova, Denise Quesnel, and Bernhard E. Riecke. 2019. Space—A Virtual Frontier: How to Design and Evaluate a Virtual Reality Experience of the Overview Effect. *Frontiers in Digital Humanities* 6 (April 2019), 7. https://doi.org/10.3389/fdigh.2019.00007

[68] Ekaterina R. Stepanova, Denise Quesnel, and Bernhard E. Riecke. 2019. Understanding AWE: Can a Virtual Journey, Inspired by the Overview Effect, Lead to an Increased Sense of Interconnectedness? *Frontiers in Digital Humanities* 6 (2019), 1–21. https://doi.org/10.3389/fdigh.2019.00009

[69] Keisuke Suzuki, Warrick Roseboom, David J. Schwartzman, and Anil K. Seth. 2017. A Deep-Dream Virtual Reality Platform for Studying Altered Perceptual Phenomenology. *Scientific Reports* 7, 1 (Nov. 2017), 15982. https://doi.org/10.1038/s41598-017-16316-2 Number: 1 Publisher: Nature Publishing Group.

[70] Xin Tong, Alexandra Kitson, Mahsoo Salimi, Dave Fracchia, Diane Gromala, and Bernhard E. Riecke. 2016. Exploring embodied experience of flying in a virtual reality game with kinect. In *2016 IEEE International Workshop on Mixed Reality Art (MRA)*. IEEE, Greenville, SC, USA, 5–6. https://doi.org/10.1109/MIXRA.2016.7858996

[71] Jay Vidyarthi and Bernhard Riecke. 2014. Interactively Mediating Experiences of Mindfulness Meditation. *International Journal of Human-Computer Studies* 72 (Aug 2014), 674–688. https://doi.org/10.1016/j.ijhcs.2014.01.006

[72] Frank White. 1998. *The overview effect: Space exploration and human evolution.* AIAA, Reston, Virginia, USA.

[73] David B Yaden, Johannes C Eichstaedt, and John D Medaglia. 2018. The future of technology in positive psychology: methodological advances in the science of well-being. *Frontiers in psychology* 9 (2018), 962.

[74] David Bryce Yaden, Jonathan Haidt, Ralph W. Hood, David R. Vago, and Andrew B. Newberg. 2017. The Varieties of Self-Transcendent Experience. *Review of General Psychology* 21, 2 (Jun 2017), 143–160. https://doi.org/10.1037/gpr0000102

[75] David B Yaden, Jonathan Iwry, Kelley J Slack, Johannes C Eichstaedt, Yukun Zhao, George E Vaillant, and Andrew B Newberg. 2016. The overview effect: awe and self-transcendent experience in space flight. *Psychology of Consciousness: Theory, Research, and Practice* 3, 1 (2016), 1.

[76] David B. Yaden, Scott Barry Kaufman, Elizabeth Hyde, Alice Chirico, Andrea Gaggioli, Jia Wei Zhang, and Dacher Keltner. 2019. The development of the Awe Experience Scale (AWE-S): A multifactorial measure for a complex emotion. *The Journal of Positive Psychology* 14, 4 (Jul 2019), 474–488. https://doi.org/10.1080/17439760.2018.1484940

[77] Yaying Zhang, Bernhard E. Riecke, Thecla Schiphorst, and Carman Neustaedter. 2019. Perch to Fly: Embodied Virtual Reality Flying Locomotion with a Flexible Perching Stance. In *Proceedings of the 2019 on Designing Interactive Systems Conference.* ACM, San Diego CA USA, 253–264. https://doi.org/10.1145/3322276.3322357

[78] Daniel Zielasko and Bernhard E. Riecke. 2021. To Sit or Not to Sit in VR: Analyzing Influences and (Dis)Advantages of Posture and Embodied Interaction. *Computers* 10, 6 (June 2021), 1–20. https://doi.org/10.3390/computers10060073 Number: 6 Publisher: Multidisciplinary Digital Publishing Institute.