Rethinking Breath in VR: A Performative Approach to Enhance User Flow with Bio-sensing Wearable Interfaces.

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Abstract

A significant number of Virtual Reality (VR) applications focus on mindfulness, using biosensor technologies (e.g., ECG) to provide real-time feedback on users' physiological states. However, the measurement of data for the human body is complex. Commercial devices often lack precision, while medical-grade sensors require controlled environments, which can lead to disruptions and break immersion, affecting the flow of VR experiences. Thus, complicating the evaluation of mindfulness. *Pinch To Awaken XR* is a VR art game that utilizes wearable interfaces to measure breathing from a holistic perspective. Showcased as an Extended Reality (XR) performance, it uses first-person research methods by embodying both the researcher and performer, placing the body as the central source of inquiry. This case study reveals that integrating a performative approach can enhance the flow and engagement in mindfulness VR experiences, while also offering a novel approach for evaluating biosensing interfaces in HCI user studies, using a body-centered design.

CCS Concepts

• **Human-centered computing** → **Virtual reality**; • **Computing methodologies** → *Virtual reality*; • **Applied computing** → Performing arts;

Keywords

Virtual Reality, Mindfulness, Bio-sensing, Wearable Interfaces, Performative Interaction, First-Person Research.

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1 Introduction

The dialogue between interactive art and the field of HCI is increasingly frequent and fruitful [8], fostering complementation and mutual learning. From an artistic perspective, HCI contributes to the design of intelligent interactive systems, offering new possibilities for experimentation. Meanwhile, interactive art introduces new representations and experiential designs that challenge and expand the traditional scope of HCI [7]. The reflection and exploration proposed by this case study, as part of the aforementioned dialogue, not only seeks to highlight into the borders of the articulation between HCI and interactive art, but also fundamentally contributes to user studies within the context of user experiment design in HCI. This paper presents *Pinch to Awaken XR* (PTA), a research-creation project situated at the intersection of HCI, tangible computing, game studies, performance, and XR. PTA re-establishes the significance of breath as a gesture of attention toward the body. Rooted in the Yoga and bodywork practices of the first author (from now on, the researcher-performance), the project draws on Eastern philosophies, where breathing is considered 'an ancient technology of self-knowledge' [9]. By directing attention inward, one can live in the present moment—an experience foundational to mindfulness. In PTA, breath is not merely an input for control but a holistic process that centers the body in the VR experience. It is further informed by Polyvagal Theory [25], which explains the relationship between the neuroregulation of our viscera and how the environment relates to our nervous system and vice versa, affecting social behavior and emotions. The vagus nerve, key part of the parasympathetic system (responsible for the regulation of involuntary functions) is activated by diaphragmatic breathing, promoting calm by signaling to the body that it is in a safe environment. Although the parasympathetic system is involuntarily, it can be influenced through conscious breathing. This understanding rethinks the role of breath as a holistic and conscious bodily process, positioning the body of the researcher-performance as a resource to explore the connection between movement, tactile sensation, and proprioception [35]. This aligns with the principles of Somesthetic interaction design, "a mindset in interaction design that emphasizes bodily play in first-person engagement—for both designers and users" [14]. Adopting a body-centric computing perspective, PTA employs wearable interfaces made with stretchable resistive yarn to measure body expansion while breathing. This embodied dimension led PTA into a physical set of scripted instructions that guide the user's actions within a narrative. Blending instruction-based

and situated action dynamics introduces a performative approach to the work. PTA draws on the situated nature of action, which Suchman describes as action that "takes place in the context of particular, concrete circumstances. Such action is always improvised, depends on the particularities of the situation in which it occurs, and cannot be entirely predetermined by plans or rules" [34]. Acknowledging this opens up the possibility for designing a more dynamic VR experience. Within this performative approach, an actor in the role of guide encourages users to become active participant in the story. As the utilization of wearable biosensors on users always requires a controlled environment to function properly, a balance between scripted guidance and improvisation is needed to adapt it to the user's behavior. Thus, the instructions evolve into a dynamic script that adapts through live performance, fostering deeper immersion from the on-boarding stage. This performative approach helps structure the user's journey, offering a personalized guidance and enriching the overall flow of the interaction. This case study illustrates how a performative approach during user studies can enhance task execution and provide new insights for the design and evaluation of VR mindfulness experiences.

2 Context

A wide range of Virtual reality (VR) applications, from gaming to wellness, [12] focus on mindfulness by utilizing biosensor technologies (ECG, EDA, EMG) to render audiovisual responses that reflects users' physiological states [39]. However, capturing this bio-data in real time presents significant challenges [21]. Often, a single sensor is insufficient and a combination of various sensors is required to capture a fuller picture of the body's state [18]. Synchronizing this multi-modal data in real time adds another layer of complexity to the measurement process. Commercial devices, while designed to be affordable and easy to use, often offer precision by restricting the user to maintaining specific body postures with negligible body movements. For instance, devices like pulse oximeters require users to remain still for accurate readings, limiting their use in dynamic contexts. Similarly, the AD8232 Heart Rate Monitor, often used in consumer health applications, provides basic heart rate data but becomes imprecise with motion or disrupted sensor contact. While accurate medical-grade devices exist, they often prioritize accuracy in controlled environments but lack the flexibility and comfort needed for interactive and artistic experiences. This reliance on controlled modes of use also complicates the evaluation of interfaces, especially in demonstrating the usability of the experience to promote self-awareness, a fundamental need for achieving relaxation [16]. In VR settings, minimizing immersion-breaking disruptions is essential to sustaining the user's sense of 'flow'—a psychological state where individuals are fully immersed in the activity [20]. Technical or design-related issues can easily pull users out of this immersive state, leading to frustration and a diminished experience. In addition, the high cost and limited availability of accurate sensors make it difficult to disseminate the benefits of these experiences to the community [5]. Addressing these challenges is crucial for developing effective VR mindfulness experiences that can significantly improve users' mental health and well-being [40]. Ultimately, the central challenge on this case study aims to address is the lack of effective bio-sensing solutions available for mindful VR experience that considers breath as a holistic process through the use of non-invasive wearable interfaces. The prototype presented here focuses on wearability and responsiveness, enabling users to engage freely with the performance while still providing reliable data to drive the experience. This balance aims to enhance the interactor's comfort and immersion, aligning with the goals of creating an intimate and transformative experience.

3 Related Works

Breathing has been a recurrent theme in interactive artwork, with developments ranging from medically oriented devices, e.g., *Mobile Feelings II* [31] to experimental wearable interfaces, e.g., *BioFLeXo* [36]—an organic algae-based textile exoskeleton capable of converting carbon dioxide into oxygen, absorbed through the wearer's skin. Within the HCI discipline, the interaction designs based on physiological processes rely on the use of bio-sensing devices to quantify effects and guide design decisions [29]. Bio-sensing data dynamically refines interaction by adjusting visual or auditory feedback in real time based on users' physiological states. This feedback loop enables designers to create personalized, adaptive, and responsive experiences tailored to individual needs. There is an increasing trend toward integration VR to offer gamified immersive experiences [33]. E.g., *Life Tree* [22], is a VR game in which the player controls the growth of a tree by practicing pursed-lip breathing using a microphone. Many works that uses the breath of players measures the air flow with spirometer [2] or thermistor [32] that measures temperature changes. In relation to artistic VR experiences, Char Davies' *Osmose* [4] stands as a historical precursor. Based on scuba diving practice, it associates breathing with navigation through a vest as an interface that measures chest expansion during inhalation. PTA is builds on Davies' background, as it is the only known case [26] that considers breathing not only as air flow, but the movement of the thorax through inhalation and exhalation. Nowadays, online app stores like *Meta* and *Steam* offer thousand of VR apps for mindfulness that can be used at home. For example, *Tripp* [37], is a VR game that collects breathing data to quantify meditation, and after gameplay it posed questions to track player's performance by earning 'mindfulness points'. However, such experiences divert mindfulness from its 'essential value', as Goldstein puts it "in meditation practice, the best way to understand is to let go of the evaluating, and simply be present with whatever arises" [11]. Moreover, the lack of real-time feedback in *Tripp*, further undermines the experience of mindfulness.

Despite these developments, the current trend to measure breath primarily through mouth exhalation does not align with the full potential of diaphragmatic breathing, which engages the entire body [30]. This gap highlights the need for more holistic approaches that consider a full range of subtle body movements and sensations involved in the act of breathing. This research addresses this gap, by rendering the user's breathing through multi-sensory responses within an immersive environment, with non-invasive wearable interfaces. By combining subjective insight from the Yoga practice of the researcher-performance, with the Polyvagal Theory, this work rethinks the role of breath as a holistic and measurable bodily process that can be harnessed to design wearable interfaces that measure these body movements, specifically the expansion of

the lungs and diaphragm. The proposal to use non-invasive interfaces, aims to enhance the interactor's full attention with the body while breathing, thus redefining the immersive VR mindfulness experiences available in the market.

4 Methodology

4.1 Description of the artwork - Pinch To Awaken XR

Over a three-year period, a research-creation project was conceptualized. By integrating immersive technologies (VR) and wearable bio-sensors (breathing) as input modality, it aims to explore the relationship between body and technology. *Pinch to awaken XR* is an artistic VR game driven by the natural movements of the body that utilize wearable interfaces to measure breathing, showcased as an XR performance.

PTA features a first-person perspective, full-body tracking, and a self-avatar. The user engages in intentional breathing guided by sound instructions (pre-recorded and live), thus prompting a dynamic dialogue with the virtual environment. The overall aim is to channel attention to the body while breathing. Throughout the game, the user rediscover the forgotten body in the process as a reward, while engages into conscious breathing. By rendering their breathing through immersive audio-visual and haptic responses, the system provides user with real-time feedback. This creates a closed feedback (Figure 1) where the user's breathing synchronizes with the virtual environment, enabling a responsive dialogue—what Krueger describes as "responsive environments, (which) involve the computer perceiving interactors's actions and intelligently responding through immersive audio-visual displays" [17]. The use of full-body tracking, supported by trackers on the hands and feet, further enhances this embodiment, allowing the user to engage in natural, fluid movements. This choice aligns with the use of yarn for the wearable bio-sensors, as it reflects a shift beyond traditional screen-based interfaces toward tangible user interfaces and hybrid forms.

The performance takes place in a designed staged and intimate environment. The installation space is dimly lit with a comfortable temperature. The dimly lit space is comfortably tempered, with a VR headset suspended above a glowing circular area at the center. A performer, acting as a guide, stands within the circle wearing a garment (Figure 2) featuring blinking X-shaped lights on the chest, mirroring their VR representation. Nearby, a mannequin equipped with wearable sensors, a neckband and an abdominal strap—stands as part of the setup. The 19-minute experience begins with a 6-minute live interaction where the guide welcomes the interactor, engages in direct eye contact and scripted dialogue, and assists them in wearing the sensors, trackers, and headset. Once in the virtual space, the interactor sees the guide's virtual representation, who leads them through the 10-minute immersive experience. The performance concludes with a brief 3-minute transition as the interactor removes the headset and resets, allowing time to reflect on the experience.

4.2 Role of Researcher as a Performer

The performative unfolds in the space described above, where the researcher-performer act as both a virtual and tangible guide, leading the user through a called hybrid performance. Users can see a virtual representation of the guide, who helps them to wear the

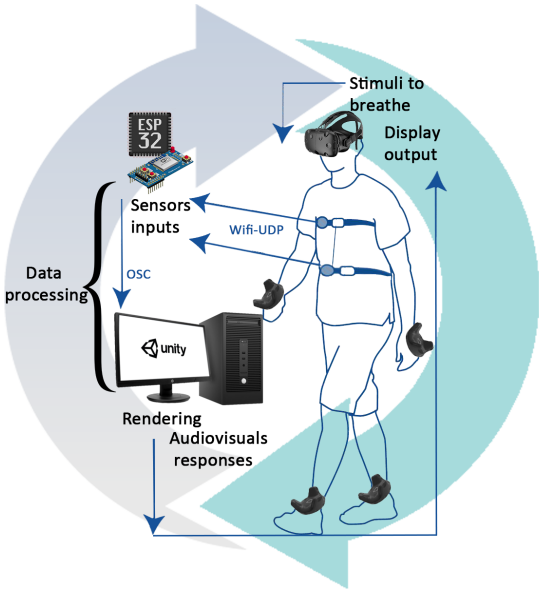

Figure 1: Schematic diagram of the closed feedback loop. Illustrate the wearable interface: 4 HTC Vive trackers on hands and feet, HTC Vive VR headset and the 2 straps.

on-body interface, while engaging with them from outside/inside the virtual space at key moments throughout the journey (Figure 3). This hybrid performance fosters human connection through physical interactions, while the wearable interfaces capture the user's breathing patterns, allowing the user to move forward in the game. The design of the performance required, a characterization of the guide through a costume to embody the role of a guide, a script to sequence the instructions, and a fitting staging with assets. The script story was created to give a warm and friendly welcome to the user, while carefully informing a consent to establish the type of interaction, such as entering the interpersonal space to ensure the correct emplacement of the interface by making physical contact on chest and abdomen.

Figure 2: Performer/guide characterized with a garment.

The on-boarding mechanisms enhance world-building and the creation of atmospheres, encouraging user's participation by awakening their imagination and allowing them to understand their role, without too much textual information. This represents a metaphor for the threshold between the virtual world and the material, and the ordinary one. This liminal quality connects the act of performance to the idea of ancient rituals [28]. Therefore, a storytelling for the onboard state to cross the threshold into virtuality was created, "by the combination of the use of 'human interface' with the ritualistic situation of taking on the virtual reality headset, participants can be part of an initiation ceremony, a rite of passage". [1].

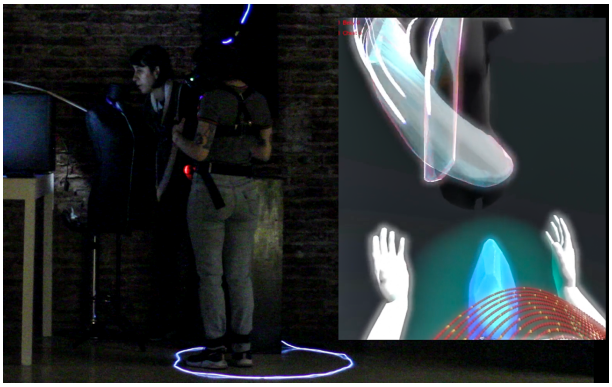

Figure 3: User's VR perspective, displaying the virtual guide alongside their physical counterpart.

4.3 Design Approach

This research follows a Research through Design (RtD) approach [41], where the design process itself became a mode of inquiry, in which artifacts and iterative prototypes generated valuable insights into the user experience. Iteratively refining wearable interfaces revealed new challenges and informed adjustments that improved interaction mechanisms, both hardware and software.

The playtesting sessions throughout the development process were essential, driven by both technical and experiential insights, with an emphasis on refining the experience as a whole. (Figure 5). During the call for these sessions, the typical reaction the potential users was 'being a guinea pig'. This preconception, however, contrasted with the project's essence. The aim of the experience was to foster states of relaxation and trust, avoiding any sense of being observed or treated as part of an experiment. This approach aligns with the principle of Participatory Design,which emphasize involving users as active contributors in the design process. By recognizing users as co-creators, the process grants them agency to shape the outcome and ensures the design is meaningful and inclusive [3].

To fulfill such objective, it was necessary to create a coherent communication of the storyworld of the piece. Hence, a fictional approach was used as a strategy to reach the user's body by dressing them with the wearable interface. A narrative to allow the researcher-performer to hold the user hand or touch their chest, underpin a relational connection by physical presence. Using notions

Figure 4: Voltaje divider circuit module with ESP32 microcontroller. Two multiclient modules and one server module.

of care and access intimacy [19], the goal is to offer a safe-space where the user can trust, and to go with the flow of the immersive experience, by focus only on breathing. Using first-person research methods [27], the body as the central instrument of inquiry was positioned by embodying both the performer and researcher during the exhibition state. This method combined the acknowledging of process-based insights through RtD, has the potential to make more in-depth contributions that reflect on a cultural and social background during the early rehearsal stages, where less formal and fast iterative prototyping takes place. This led to evocative and personal insights by focus into the mediation of the technology with the body, as a kind of physiological extractivism as counter to unlimited technification. In HCI, first-person research methods have been utilized at different stages of the design process, such as Soma Design [13]. For instance, Höök explored horseback riding to gain insight into bodily experiences, which informed design considerations for bodily interactions [14]. HCI researchers who have employed this method emphasize its value in addressing questions related to embodiment [6]. Overall, first-person research methods explore lived experiences from within, yielding personal insights that are often inaccessible through other HCI research methods [15].

4.4 Technical Implementation

The interface consists of experimental wearable controllers crafted in a DIY (Do-it-Yourself!) approach—two stretch straps knitted with resistive yarn connected to a voltage divider circuit, meant to be worn around the chest and the abdomen. During inhalation, it stretches and the resistance value of the fabric changes, while during exhalation it becomes the initial value. To process the raw data, the resistance values are first converted to digital voltage readings through an analog-to-digital converter (ADC)on the Arduino, and

Figure 5: Playtesting at Pasaje 17 Art Gallery, Argentina, and in TOPO Centre de création numérique, Canada.

then averaged to obtain the values. The processed data is sent to a machine learning algorithm in Python during a calibration phase, where the system classifies the data into inhalation and exhalation clusters. This calibration phase allows the system to establish personalized thresholds for each user, ensuring it adapts to individual variations in breathing patterns. The data is managed and transmitted via the ESP32 microcontroller (Figure 4) to the Unity game engine using the protocol Open Sound Control (OSC). Breathing patterns are then mapped to real-time audiovisual responses, including light intensity, shader opacity, motion, volume adjustments, and the control of a Pure Data generative synthesizer.

The two straps are used to capture two different types of breathing. The upper strap monitors chest (superficial) breathing, which engages the upper lungs and is commonly used. The lower strap tracks abdominal (deep) breathing, which engages the diaphragm and abdomen. These two breathing types are integrated into different levels of the game: chest breathing is introduced at the early stages, while abdominal breathing—less commonly practiced—is emphasized as the user progresses to higher levels. It is worth noting that measuring breathing patterns through the expansion of the thorax and abdomen presents challenges in achieving proper interface functionality. Initially, users provided negative feedback because the straps needed to be tight around the thorax to function properly, which made breathing uncomfortable and invasive. Throughout the iteration process, different strap designs were tested using different stitches with resistive yarn(Figure 7). In comparison, there exists in the market a heart rate chest belt monitor *POLAR* [24], which offers supremely precise measurements through advanced electrical sensors (ECG). This sensor is worn tightly gripped to the chest with a strap and requires direct skin contact. While the POLAR monitor offers high accuracy and has been successfully validated against medical instruments [10], its requirement for tightness around the body makes it unsuitable for artistic installations. After these iterations, a tailor-made design of experimental wearables was developed, with the primary objective of ensuring the comfort of the user (Figure 8). The solution involved creating a more flexible, unobtrusive interface by knitting the resistive yarn loosely (Figure 6). In this way, the elastic fabrics adapt to body movements gently. The election of yarn follow a "material-centered" approach to interaction design [38]), focusing on the material's texture, adaptability, and flexibility. The yarn offers a smooth adjustment around the chest and abdomen, due to the soft texture and flexible elasticity. These physical characteristics of the material were considering to ensure user conformability as an essential aspect for the interfaces, as the goal is to embrace a more holistic approach to breathing.

Figure 6: Latest and current version of the stretch straps.

As an alternative prototype, a harness-shaped was developed to improve the capture of upper chest movement during breathing. This design adapts a posture-correcting harness, but repositions it on the chest instead of back (Figure 8). This adjustment was informed by observations and interviews conducted with participants to understand various breathing patterns and body movements. The prototype employs small cords made of resistive yarn (Figure 9)

strategically integrated into the strap. These cords detect expansion and contraction of the thorax in multiple directions, allowing a more comprehensive measurement of breath movements. The stretchable nature of the harness ensures that it adapts to the body's dynamic movement, enhancing wearability and comfort without compromising data accuracy.

Figure 7: Samples of the yarn straps throughout the design iterations.

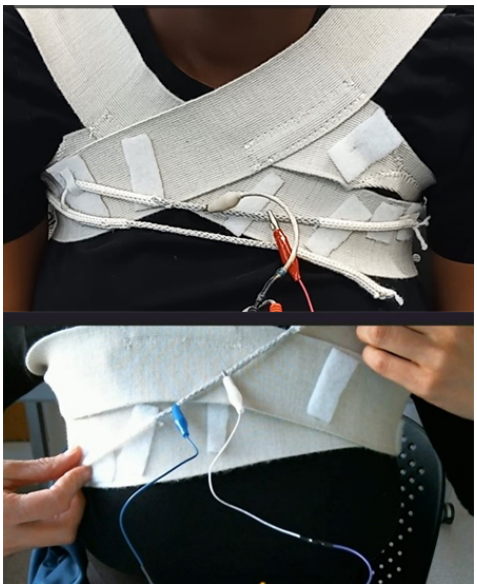

Figure 8: Prototype of an alternative version for a harness-shaped stretchable strap.

Figure 9: Different resistive yarn knit patterns used throughout the design iterations.

5 Findings

This study is part of a broader artistic and research-creation practice, with the primary aim of exploring user engagement through a performative experiential, embodied, and subjective insights, rather than adhering to conventional evaluative methods. The PTA was presented in art galleries as open studio format (Pasaje 17 Gallery, Exhibition TecnoSimbiosis. Buenos Aires, Argentina. 2022),and in artistic residencies (TOPO, Centre de création numérique, Participatory Multimedia Performance, Eastern Bloc. Montréal. Canada. 2023, and Bodies in Residency, OCAD, Toronto, Canada 2023), allowing the public book one-hour slot to try out the experience in an intimate and one-on-one setting with the researcher-performer. After the XR performance, users were invited to share their thoughts through open-ended questions in an informal setting. While no formal coding software was used, notes were reviewed to identify recurring patterns, such as the level of engagement in the experience, its relationship to physiological responses and interest in its subsequent adoption. Though this unstructured approach lacks formal qualitative analysis methods, it prioritized immediate, authentic user feedback in this exploratory research phase. The themes emerged inductively through repeated reviews of interview transcriptions, identifying recurring concepts. These themes were grounded in participant responses, presented as direct quotes or paraphrased summaries. Theme validation involved a review of relevant academic literature, [23] to contextualize their relevance. This process was further strengthened by the iterative nature of the the data collection, as as both the system design and interviews evolved over time, enhancing the reliability of the identified themes. The study involved 21 participants in the most advanced phase of the interaction design of the XR performance. Additionally, 35 participants contributed to pre-tests during the interaction design of the VR application, conducted in different locations and over a significant time interval. Participants, aged 28-40, with a balanced representation of men and women, and varying levels of familiarity with using VR, were self-recruited through targeted calls in artistic and research settings, including open studio exhibitions, artist residencies, university labs, and art exhibitions. This recruitment strategy ensured a broad range of creative perspectives, while aligning with the study's focus on artistic engagement with VR.

5.1 Engagement Levels

A recurring theme was the previous reluctance to try VR technologies due to lack of sufficient guidance and information. One participant stated: "I usually refuse to try VR because I don't really understand what I have to do, I'm afraid of falling or bumping into things…" This hesitation could be due to a lack of familiarity with VR technology, sort of "being alone in an unknown world". The PTA proposal addresses this bias by providing close accompaniment to the interactant: "... this time it was different, I felt cared for and accompanied at all times by the performer, for the first time I felt that I could have a truly immersive experience". Not only the guidance, but also the characterization of the guide was effective in creating an atmosphere of safe-space, they introduced themselves as the user breath, "I'm your breath and I will be accompanying you during the journey".

One user remarked: "the smoothness of your voice and the pace of your explanations made me feel cared". Before the last level of the game, the researcher-performer holds the user's hand. In the first instances of PTA we avoided this type of interaction because we considered it distracting, interrupting the immersion of the user. However, this carefully orchestrated interaction generated a positive response, enhancing the participants' acceptance of physical contact, since they were able to hear the performer's voice from outside the virtual environment, as well as through pre-recorded instructions. One user reflected: "I didn't expect to be touched, it actually made me feel I wasn't alone, it gave me confidence that what I was doing was right to do" (Figure 10).These interactions were designed to guide the user during moments when the system was not receiving the necessary inputs to advance the experience, such as when the interface was faulty. One participant shared: "At one point, the light of my breath did not shine on the inhale, but the performer's voice gently told me what to do. I didn't feel disconnected from the experience at all".

5.2 Physiological Responses

Another theme emerging from the comments was the achievement of relaxation. While talking, users often yawned and spoke slowly, indicating the calming effects of deep breathing. One user remarked: "When I took off the headset, I realized how deeply relaxed I was, like the calm feeling I get after a good yoga class." Breathing patterns were visualized and sonified within the immersive digital environment, enhancing engagement with the instructions and encouraging users to synchronize their breath with the virtual world through dynamic audiovisual feedback. This interaction reflected a sense of agency over the virtual surroundings. The final scene takes place in a hyper-realistic 3D forest. Users particularly engaged with it when they realized they had control over the movement of the self-avatar. Many participants forgot about their breathing as they became absorbed in exploring body movements and navigating the environment naturally. In general, they expressed that they did not want to leave the simulation. "When I realized I had a body, it felt like discovering a whole new way of moving. It was liberating, and I didn't want to leave the forest—it was just so cozy and beautiful."

5.3 Interest in Adoption

A significant portion of the feedback revealed that users not only felt immersed but also expressed a desire for the experience to be part of their regular relaxation routine. For example, one user remarked: "I wish I could have this in my house when I want to take a break from the world and visit nature." This comment underscores how important it is to address the limited availability of low-cost and accurate bio-sensing sensors to ensure the widespread dissemination of VR mindfulness experiences.

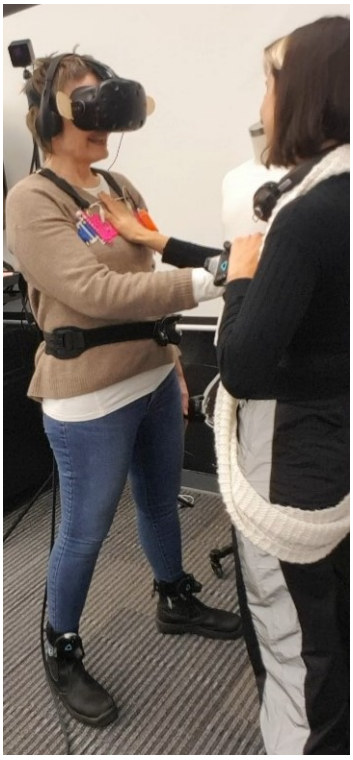

Figure 10: Performer and a user synchronize their breathing patterns through physical touch during a virtual reality experience. Bodies in Residency, OCAD.

6 Reflections

This research demonstrates the potential to enhance the flow of mindfulness-oriented VR experiences through the integration of a performative, narrative-driven approach. While bio-sensing technology typically requires controlled environments, this approach integrates those restrictions by embedding technical needs, such as calibration, into the story world. The performative elements create a fictional context where the researchers enact as guides, ensuring functionality and maintaining a sense of controlled environment. The guides compensate for any disruption by gently guiding the user through the experience, allowing them to focus on relaxation through breathing—by following a coherent progression. This makes the experience intuitive and grounded by personalized guidance. The physical presence of the researcher-performer establishes a trusted environment, and the intimate setting during the on-boarding phase bridges the real and virtual worlds, significantly enhancing immersion and engagement.

6.1 Implications for the HCI Community

This study rethinks the controlled environment required for biosensors to ensure accurate data collection. This limitation can disrupt user immersion, especially in VR mindfulness applications. The performative approach embeds the controlled environment into the narrative, maintaining flow even when technology fails, challenging conventional rigid controls and encouraging more fluid, dynamic environments. It highlights how a narrative can compensate for interruptions caused by technology, restoring user engagement. Breathing, as understood through the Yoga and Polyvagal Theory lens, is a holistic and embodied process. The HCI community should consider adopting more holistic bio-sensing designs that account for the user's embodied experience. Particularly in mindfulness VR applications, where comfort and immersion are key, the non-invasive and flexible interfaces that support free movement should be prioritized in HCI design. This case study reveals that narrative and performance can mitigate technological shortcomings, ensuring user engagement overall. This opens up new possibilities for incorporating fiction into experimental design, allowing HCI researchers and designers to maintain a balance between system performance and user experience. In response to the findings, we propose this case study as input for the development of a Performative Approach for the design and testing of mindfulness-oriented VR experiences. This approach could provide a more natural context for user testing, potentially yielding more accurate and insightful results. It also challenges the standard HCI practice of conducting studies in controlled laboratory settings. By conceptualizing bio-data not merely as input but as part of a dynamic interaction that facilitates novel dialogue between the user and performer, this approach uncovers the potential of performance to create storytelling for intimate encounters. It raises questions about the research-creation project regarding the role of interfaces as mediators in this interplay: Can technology truly grasp the subtleties of breath gestures as effectively as the touch of a hand on the chest?

6.2 Limitations

This case study lacks structured qualitative studies or quantitative methods, which could provide greater robustness and scalability to the findings. Moreover, there is a lack of structured guidelines regarding the technical aspects of the project, particularly in the design and knitting patterns of the resistive yarn straps. The variations in the materials used across different samples were not systematically addressed, and there was no clear analysis of how these variations impacted the performance of the interface. These limitations highlight the need for more rigorous methodological approaches, including the development of explicit technical guidelines and a more structured qualitative methods.

7 Conclusion and Future Work

This case study encourages HCI researchers and practitioners to embrace a performative approach in the design and evaluation of mindfulness VR experiences challenging traditional norms of user studies conducted in controlled settings. By considering breathing as a holistic bodily process, this study advocates for a shift in biosensing technology design through first-person research methods. Both approaches are interrelated: narrative-driven interaction creates an immersive experience that adapts to users' needs, while first-person methods offer deeper insights into bodily interactions. Together, they can offer intuitive user-centered experiences in less restrictive environments with more responsive engagement. This approach offers a valuable alternative for conducting more intimate and flexible user studies in the context of HCI. While this paper does not systematically present detailed guidelines for designing mindfulness VR experiences, it derives actionable insights from the research process. These include the importance of real-time user interaction, personalization through breathing patterns, and achieving a delicate balance between immersion and guidance. Future research will prioritize the explicit definition and systematic presentation of these guidelines. Additionally, structured qualitative and quantitative methods will be implemented to empirically validate the effectiveness of the performative approach. A crucial step will be conducting comparative studies to evaluate how the absence of real-time performer guidance impacts user engagement, relaxation, and mindfulness outcomes. Validating the proposed guidelines through empirical studies will ensure their reliability and relevance. Furthermore, the integration of more robust ML algorithms could enhance data management and analysis, improving the system's responsiveness to users' real-time breathing patterns. By collecting user breathing data over time, AI could personalize the experience further, adapting to individual user behavior and physiological responses. Ultimately, future research should focus on facilitating the wider dissemination of VR mindfulness experiences by making the technology more accessible and scalable, ensuring that more users can engage with these transformative experiences.

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