XBP

Text: Janne Kummer

MMM

Fig 4: Actuator Suit (2022).
Design by Codi Körner.

Introduction

As a director, performance artist, and creative technologist, I work with physical bodies on physical theatre stages as well as virtual bodies in 3D digital environments created using game engine software. My research revolves around linking these two realms, exploring how to involve the sensing, feeling physical body while having a virtual experience.

In physical theatre, the audience can be ›somatically‹[1] engaged through the activation of their senses with light, sound, scent, and the presence of physical bodies. Additionally, theatre as a public space has the potential to be a hub for social and cultural exchange. With the onset of the COVID-19 pandemic in 2019, theatre experiences had to shift to digital formats. This motivated my exploration on how to foster communal digital experiences and on creating sensory interactions despite spatial separation. Frequently, the focus of my work centered on exploring methods to emphasise the sensory and physical nature inherent in humans when working with computational media. How can technology be designed to engage with, reflect upon, and enhance bodily experiences and awareness, promoting a more embodied interaction with digital or virtual environments?

I started experimenting with ›sensors‹[2] to measure physical body data and ›actuators‹[3] to assert multi-sensory stimulations on the body. I aimed to create an experience that combines mechanical somatic stimulations of the players' bodies with methods to heighten body awareness, all within the context of exploring body politics in a virtual game.

My research culminates in the project *XBPMMM – A Travelogue of Morphing Bodies* (2022/23), a VR multiplayer game I will use to describe my approach, methods, technical setup, and challenges.

1 I use the term ›soma‹ or ›somatic‹ to describe the holistic experience of the body as perceived from within. It encompasses the awareness of bodily sensations, movements, and emotions, emphasising the mind-body connection.

2 A ›sensor‹ is an input device that measures and monitors environmental conditions and converts them into
signals that can be measured or monitored.

3 An ›actuator‹ is a device that moves or controls a mechanism or system, often in response to a signal from a sensor.

The game

The VR game *XBPMMM – A Travelogue of Morphing Bodies* was conceptualised and designed in conjunction with Steph Holl-Trieu and Anton Krause, with the active involvement of a team of multiple artists and the ERDF-funded research project XR_Unites at HTW Berlin. Consequently, throughout this reflection on the process, I will use ›we‹ instead of ›I‹, as it truly represents our collaborative effort.

The game explores the Western concepts of body normativity and discipline within a society built on exploitation and meritocracy. It is a multiplayer experience lasting 45–50 minutes. The game was officially released in the framing of a

multimedial theatre performance at the Hebel am Ufer Theater in January 2023 (Fig. 1). Additionally, various iterations of the game were showcased at the Stuttgarter Filmwinter 2022/23, at the Media Lab of the Berlin Open Lab Berlin and the Athens Digital Arts Festival 2023.

Over the course of the game, the players find themselves in a perpetual state of transformation, as their avatars evolve in response to the different levels (Fig. 2). Each level explores mechanisms of societal control, analysing processes like measurement, quantification, and optimisation as tools for governing and regulating bodies. More in-depth information on game content, its mechanisms and storyline can be found in the Expanded Playbook publication (2023, free PDF Version) or by playing the game which is also free to download (2022/23).

The game is playable on its own, but to enable stronger somatic involvement we enhanced the stage version by setting up a feedback system of sensors and actuators. Here, monitored bodily data impacts the in- game experience and vice versa, which will be explained in detail in the upcoming section.

VR multiplayer

Since our goal was to create an immersive, body-engaging experience, we opted for Virtual Reality (VR) using Oculus Quest 2 headsets. Unity game engine was the primary development software.

As we aimed to facilitate a high degree of shared experiences and interaction, we designed a multiplayer game, allowing the performance to be attended not only on-site but also online globally. Therefore, we used the Mirror library,[4] an

4 Mirror handles the networking aspects of a Unity game, enabling players to connect and interact with each other in a multiplayer environment. https://mirror-networking.com/

Fig. 1: Premiere at HAU (2023)

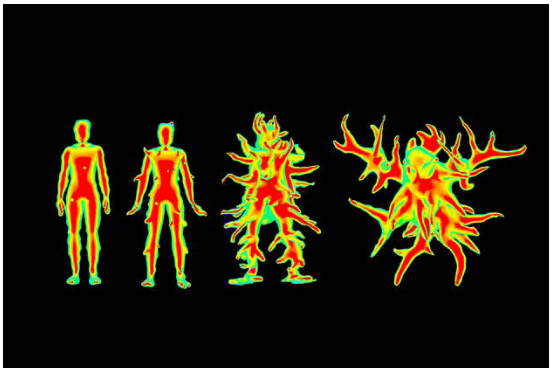

Fig. 2: Screenshot of Avatar Transformation

Fig. 3: Shark Sensor Belt, 3D printed belt buckle, rubber sensor. Design by Codi Körner, Anton Krause, Janne Kummer (2022)

open-source networking tool for multiplayer and networked games. The players communicated through their avatars using movements, such as waving, dancing, and running together. Communication over voice chat needed to be disabled, as it caused feedback within the performance space.

Breathing sensors and meditation practice

Initially, our task was to determine which physical data of the player should be monitored for in-game interactions. After testing various parameters such as heart rate, temperature, and movement, we decided to focus on tracking the breathing rhythm. This decision aligns with the principles of mindfulness, where concentrating on one's breath is a key technique for achieving increased bodily awareness, reducing anxiety, and enhancing relaxation.

In pursuit of scaling up the sensor enhanced experience for a broader audience, we opted for a cost-effective version of a sensor-breathing belt using e-textiles.[5] Inspired by Hannah Perner Wilson's design (Perner Wilson 2020), this sensor is a simple tool for monitoring either chest or stomach breathing. It functions by measuring the material's resistance to stretch. Our explorations led us to two materials: a crochet blend of stainless steel and polyester yarn, and conductive rubber. Ultimately, for aesthetic appeal, we chose the rubber for our final design (Fig. 3).[6]

This sensor relies solely on the widening and extending of the rib cage during breathing to function effectively. By incorporating repetitive meditative practices into the gameplay, we trained participants to be conscious not only of their breathing but also of their body's expansion with each breath. We crafted a unique level where the player's breathing directly steered an avatar in an underwater environment. Inhaling caused the avatar to ascend, and exhaling led to a descent. The objective was to reach the ocean floor

by elongating the exhalations. In other levels, we heightened players' awareness of their breathing by visually representing it through a translucent bubble surrounding the avatar, which expanded and contracted in sync with the player's breathing rhythm.

Wearable actuator suit

It was important to us that experiences in the virtual world have a direct and intended impact on the physical body of the player. To achieve this, we developed three tailor-made wearables (Fig. 4)

5 E-textiles, short for »electronic textiles« are fabrics or textiles that incorporate electronic components and conductive materials to enable various functionalities, such as sensing, lighting, or data transmission.

6 The design of the 3D printed belt buckle features the shark, a character from the game that symbolises fear.

»An important part of our design process was making sure that the wearables could fit different body sizes. This was crucial because it aligned with our goal of challenging traditional body size norms, which our game actively critiques.«

in collaboration with creative technologist and fashion designer Codi Körner.[7] Each piece is designed for a different body region and incorporates three distinct actuators, all interconnected with Unity.

An important part of our design process was making sure that the wearables could fit different body sizes. This was crucial because it aligned with our goal of challenging traditional body size norms, which our game actively critiques. To achieve this, we incorporated Velcro straps into the design, offering multiple options for adjusting and securing the wearables to ensure a comfortable fit for a wide range of body shapes.

Actuator types

We selected physical stimuli that we believed would have a significant impact on the player's body: pressure, heat, and electric triggers. The actuators were strategically deployed to enrich the environmental ambiance in various levels (Fig. 5).

1.For applying pressure, we integrated inflatable PVC air cushions into the lining of the wearables. We chose leather for the suits due to its durability and lack of stretch, allowing the air cushions to expand inside and exert physical pressure, simulating the feeling of being touched in response to in-game events. This kind of pressure stimulation can evoke the body's memory of touch, enhancing the sense of embodiment and aligning the avatar's experiences with the player's perceptions (Stenslie 2010). These actuators were meant to work in sync with a breathing sensor, so that breathing could trigger tactile sensations on different body parts for a synaesthetic experience. We used a system of 12-volt pumps and valves for inflation and deflation. However, due to latency[8] in the transmission rate, this effect was sometimes diminished as the perception was offset.

2.Our second type of actuator was electrical muscle stimulation (EMS) devices, designed to attach to muscles and deliver electrical impulses to cause involuntary muscle contractions. The devices create impulses that are transmitted through electrodes placed near targeted muscles. For example, when a player experiences a stressful in-game scenario, like escaping a massive jaw, the EMS devices activate. We focused on targeting muscle groups in the extremities, such as the arms and legs, to avoid potential panic reactions or unintended physiological responses near the torso and heart.

3.Recognising that heat therapy can relax muscles by increasing blood flow and tissue elasticity, we incorporated heat patches with coils to generate warmth in areas where players were likely to experience tension – the back, shoulders, upper arms, and thighs. The heat impulses were intended to foster a feeling of relaxation, safety, and openness. They were most prominently used in the third and final level, The Swamp, which celebrated the »bubbling, boiling, foaming, and melting body«, suggesting a new openness in how bodies can be perceived and engaged with.

7 Due to the complex and time-consuming fabrication of the wearables, and given that we utilised up-cycled motorbike suits for materials, we were only able to produce three pieces and implement them into interactions with fewer visitors (Stuttgarter Filmwinter and Berlin Open Lab).

8 Latency in sensor/actuator data transfer to a game engine refers to the time delay between a sensor's/ actuator's action and the corresponding response in the game software and vice versa.

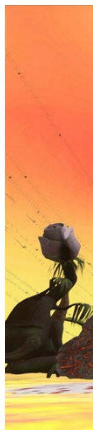

Fig. 5: Examples of actuator-level matches. left to right: EMS/panopticon, inflatables/jaws, heat coils/swamp (2022), photos and screenshots.

MQTT architecture

We connected the sensor data with the game engine by employing a protocol called Message Queuing Telemetry Transport (MQTT). MQTT is a standard protocol in Internet of Things (IoT)[9] applications, that allows devices to communicate with each other over the internet. To connect the sensors and actuators to the MQTT network, we used microcontrollers[10] with a custom-developed MicroPython[11] code.

Through applying the MQTT Protocol, we could use the data from sensors placed on individuals on-site to change or manipulate the virtual environment. The data – in the case of XBPMMM, the breathing data – is digitised by the microcontroller and sent to a remote MQTT broker[12]. A broker is a crucial component in MQTT architecture. It functions somewhat like a post office, managing incoming and outgoing data within a network.

For instance, in the *XBPMMM* Network, we register and publish the data from each breathing sensor under a specific ›topic‹. The VR app can subscribe to this topic, and it operates similar to a newsletter – whenever sensor xy transmits data, the app receives this data. This information can then be used in a variety of ways to alter the digital environment, such as enlarging or shrinking the ›breathing sphere‹ around the avatar. Similarly, data generated by actions or events in the virtual world can be sent back to activate the actuator suit worn by participants in the physical environment.

Control unit

The challenge was to integrate a control unit that contained all essential components yet was compact enough to seamlessly fit into a suit's design. We chose a belly pouch (`Fig. 7`) as the housing for the control unit, as it could be easily secured by the wearer after putting on the suit.

Locomotion

Besides the actuators, we aimed to enhance players' physical involvement using locomotion mechanics. Unlike many VR games that use controller buttons for movement, we developed a system that employed the Inertial Measurement Units (IMUs) in Oculus Quest headsets.

This allowed players to use their actual body movements to navigate the virtual environments. For instance, players could run by swinging their arms, with the game detecting this motion by tracking the controllers' position changes.

9 The Internet of Things (IoT) refers to a network of interconnected devices and objects that can collect and exchange data between physical and digital worlds.

10 A microcontroller is a small computer on a single chip used to control electronic devices. We used ESP32 is a type of microcontroller as it can connect to Wi-Fi and Bluetooth and is therefore often used in smart devices.

11 MicroPython is a simplified version of the programming language Python designed to work on small electronic devices like microcontrollers.

12 An MQTT broker is a piece of software that runs on a server that manages the communication in an MQTT network by receiving, storing, and distributing messages to connected clients based on their subscriptions.

Onboarding and performative set-up

While the game can be played without a performative framework, it was originally designed as a hybrid digital performance piece, as demonstrated at Hebel am Ufer (HAU) theatre in Berlin in 2023. The onboarding process, which involves explaining game mechanics, functionalities, and the donning of headsets, was seamlessly integrated into a performative experience. In the version created for HAU, as audiences entered the space, they were assigned to one of four performers. Taking inspiration from traditional flight onboarding procedures, an extensive tutorial was presented, with performers choreographically guiding participants through the functionality of the headset and game navigation (Fig.8) The stage design featured translucent partitions, resembling elements from the game, used to separate the four groups. During the gameplay experience, participants could interact with performers who played a role akin to flight attendants, providing assistance with anyin-game issues and serving as approachable personnel for addressing concerns related to the experience. To mitigate potential triggers, participants received a briefing about possible stimuli they might encounter and were encouraged to report any incidents of cyber harassment or feelings of unease to the accompanying performers.

Reflection

To gain a deeper understanding of player experiences and improve our game, we conducted a survey (XBPMMM Questionnaire 2022) at various stages of development. Based on the responses we received, we concluded that our objective to enhance bodily experiences and self-awareness was primarily achieved through four elements:
1) Synchronised visual feedback during interactions with one's avatar, such as moving body parts in harmony with the avatar, engaging with reactive shadows, reflections, or the avatar's bubble inflating and deflating in sync with the player's breathing. 2) Interaction with other players, like waving or moving in unison, with a strong interest expressed for more of these interactions. 3) Incorporation of breathing and meditative exercises in the game. Segments focused solely on breathing were perceived as essential pauses in the visually intense gameplay, providing moments for reflection and reconnecting with one's body. Levels that required physical activity particularly enhanced bodily awareness. 4) The use of wearable actuators synced with virtual events significantly improved players'physical perception.

However, we encountered challenges that were off-putting for players, primarily related to latency and performance issues. The standalone nature of the Oculus device had limitations, especially in graphical performance, leading to motion sickness in some cases. Our solution was to reduce the vertex count in graphic-intensive levels, resulting in a more ›low poly‹[13] aesthetic than originally planned. Latency became a problem as more devices joined the network, slowing down data transmission. This was particularly noticeable when synchronising breathing with virtual elements like the opaque bubble or mechanical triggers like actuators, leading to delayed reactions. This delay disrupted the illusion of the player perceiving the avatar's body as their own, interrupting the positive sense of embodiment. Moreover, precise tuning of the actuators was essential, as high-frequency triggers could become uncomfortable. Communal experiences could be achieved, even though the players could only communicate through the physical movement of their avatars. These interactions were described as joyful and helpful for spatial orientation during the course of the game. Considering advancements in data transfer and computational power for real-time applications, it's worthwhile to revisit a similar setup in the future to see if issues like latency and performance can be more easily resolved, thereby achieving a stronger and more consistent form of bodily awareness.

13 Low-poly is a style in 3D graphics that uses simple shapes to minimise computational performance requirements.

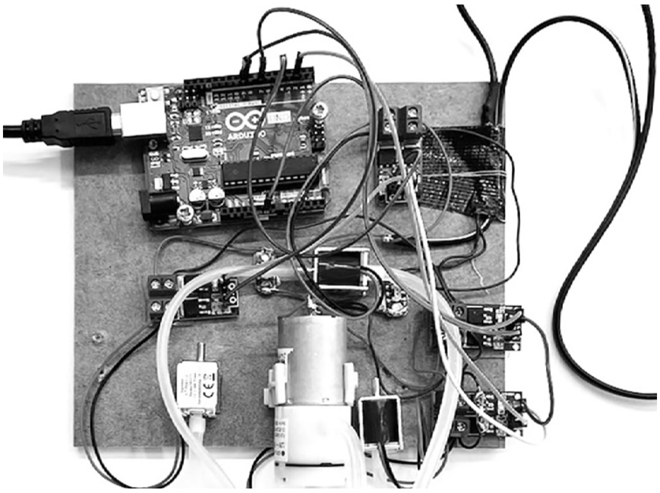

Fig. 7: Early Control unit version, Arduino Micro Controller, 12V Micro Vacuum Pump, 12V Solenoid Valves,

Fig. 8: Onboarding process at the HAU

Janne Kummer (they/them) is an interdisciplinary artist and educator. JK's work explores the representational politics of bodies in both analogue and digital space, currently focusing on developments in AI. Their creative process is based on a somatic understanding that recognizes the body as a primary source of knowledge and transformation. Their works are presented in Germany and internationally. They have held fellowships at the Academy of Theatre and Digitality, "DiGiTal" program of BCP, "ATLAS Residency Impulstanz Vienna", "Berlin OpenLab", and German Academic Scholarship Foundation.

Breit, Sigrid, Aleksandra Kupferberg, Gerhard Rogler & Gregor Hasler (2018): Vagus Nerve as Modulator of the Brain-Gut Axis in Psychiatric and Inflammatory Disorders. Frontiers in Psychiatry 9 (44), 6-9.

Garone, Priscilla M. C., Sérgio Nesteriuk & Gisela B. Campos (2020): Sensory Design in Games: Beyond Visual-Based Experiences. Presented at International Conference on Human-Computer Interaction, Copenhagen, 19–24.07.2020.

Gerritsen, Roderik J. S. & Guido Band (2018): Breath of Life: The Respiratory Vagal Stimulation Model of Contemplative Activity. Frontiers in Human Neuroscience 12 (397), 5–10.

Gerry, Lynda J. (2017): Virtual Reality and Empathy: Embodied Simulations and Perspective Taking in the Body of Another. Master's thesis, University of Copenhagen.

Goveia da Rocha, Bruna, Oscar Tomico, Daniel Tetteroo & Panos Markopoulos (2019): Inflatable Actuators Based on Machine Embroidery. Presented at Textile Intersections Conference, London, 12–14.09.2019.

Holl-Trieu, Steph, Janne Kummer & Maja Stark (2023): *XBPMMM* – The Expanded Playbook. Berlin: HTW Berlin.

Höök, Kristina (2018): Designing with the Body: Somaesthetic Interaction Design. Cambridge, Massachusetts: The MIT Press.

Kummer, Janne, Anton Krause & Steph Holl-Trieu (2022/23): GAME – A Travelogue of Morphing Bodies, Koproduktion. https://www.hau4.de/janne-kummer-anton-krause-steph-holl-trieu-a-travelogue-of-morphing-bodies

Fig. 8 kennedy+swan, Mixed Signals (2023) augmented book. © kennedy+swan date of retrieval: 01.01.2023).

Longo, Mathew & Patrick Haggard (2012): What Is It Like to Have a Body? Current Directions in Psychological Science 21 (2), 140–145.

Mah, Kristina, Lian Loke & Luke Hespanhol (2021): Towards a Contemplative Research Framework for Training Self-Observation in HCI: A Study of Compassion Cultivation. ACM Transactions on Computer-Human Interaction 28 (6), 1–27.

Park, Evelyn J., Dónal Holland, Panagiotis Polygerinos, Gareth J. Bennett & Conor J. Walsh (2014): Shared Design Tools to Support Research and Development in Soft Robotics. Presented at Advances in Soft Robotics Workshop, Berkeley, 13.07.2014.

Perner Wilson, Hannah (2020): Breathing Belt. Example Projects. https://www.kobakant.at/DIY/?p=8171 (date of retrieval: 01.08.2022).

Schiphorst, Thecla (2009): soft(n): Toward a Somaesthetics of Touch. Proceedings of the 2009 CHI Conference on Human Factors in Computing Systems. New York: Association for Computing Machinery, 2427–2438.

Schwartzman, Madeline (2011): See Yourself Sensing: Redefining Human Perception (Illustrated ed.). London: Black Dog Press.

Schwartzman, Madeline (2018): See Yourself X: Human Futures Expanded. London: Black Dog Press.

Shusterman, Richard (2008): Body Consciousness: A Philosophy of Mindfulness and Somaesthetics. Cambridge: Cambridge University Press.

Shusterman, Richard (2012): Thinking through the Body: Essays in Somaesthetics. Cambridge: Cambridge University Press.

Stenslie, Ståle (2010): Virtual Touch: A study of the use and experience of touch in artistic, multimodal and computer-based environments. https://aho.brage.unit.no/aho-xmlui/handle/11250/93049 (date of retrieval: 11.03.204)

Svanæs, Dag (2019): Designing with the Body. Journal of Somaesthetics 4 (2), 79–95.

Wilde, Danielle; Anna Vallgårda & Oscar Tomico (2017): Embodied Design Ideation Methods: Analysing the Power of Estrangement. Proceedings of the 2017 CHI

Conference on Human Factors in Computing Systems. New York: Association for Computing Machinery, 5158–5170.