From capture to texture: affective environments for theatre training in XR

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Adriana La Selva is a theatre-maker, a performer, and a researcher. She is currently a fellow FWO researcher with the project Practicing Odin Teatret's Archives at S:PAM (Studies in Performance and Media- Ghent University) - in association with IPEM (Institute for Psychoacoustics and Electronic Music), Nordisk Teaterlaboratorium, Utrecht University, Manchester Metropolitan University and Aalborg University. She concluded her Master's degree in Contemporary Arts, at the University of Lancaster, UK, on Deleuze and Guattari's notion of becoming in relation to physical theatre. She is member of the international theatre group The Bridge of Winds, led by Odin Teatret actress Iben Nagel Rasmussen. Adriana co-founded Cross Pollination, an international network of performers and researchers, which focuses on dialogues in-between practices and tactics for embodied knowledge building.

Pieter-Jan Maes is professor in systematic musicology at IPEM, Ghent University, Belgium. My research focuses on embodied music and dance interaction. Through empirical research, I aim to better understand the dynamical coordination processes observed in bodily and brain activation of humans engaged in music/dance performance and music listening. I consider the

study of coordination processes as a gateway towards a better understanding of the powerful (inter)subjective experiences that music can evoke. In my research, I explore emerging technologies of extended reality (XR) as innovative methodological tools, both on the level of stimuli creation (simulation of real-life immersive environments, or the creation of "impossible" stimuli), as well as on the level of quantitative measurement of behavior and (neuro)physiological responses. Further, this research is connected in collaborative artistic-creative research in which we aim to explore the possibilities of XR technologies to innovate the cultural-creative sector with new forms of musical interaction and expression. More info can be found at https://research.flw.ugent.be/en/pieterjan.maes.

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Abstract

The notion of 'pre-expressivity' is central to the field of 'Theatre Anthropology', developed by Eugenio Barba and explored by his theatre group Odin Teatret. It refers to the elementary level of the energetic dynamics that render an actor's body scenically "alive" and "present", generating what is understood as scenic *bios*. Therefore, actor training in this tradition is aimed towards the development of an embodied knowledge that regulates corporeal energetic dynamics and facilitates relationships at this pre-expressive level.

In the current study, we explore the potential of immersive display technologies, and bodily interaction interfaces for supporting the transmission of this embodied knowledge through a virtual archive: a tool for investigating the complex web of techniques that link performers to their particular scenic *bios*. We begin by outlining a critical epistemological framework which calls for new accounts of knowledge distribution through immersive technologies and the place of embodied and affective praxis within this frame. We describe the process of mapping different training strands developed by Odin Teatret's actors, using motion capture technology. Further on, we approach one of the key aspects of this research, that of the translation of such embodied practices into data and, consequently, into an immersive experience of archival navigation. In our study, we used 3D visual and auditory objects as environmental constraints, what we term as immersive *archi-textures,* and employ Laban efforts applied to motion capture data analysis as a model for qualifying movement patterns. Whilst critically approaching this textural translation process and raising the implications

of such translations, we will suggest ways in which designed immersive environments can renegotiate experiences of transmission in theatre training.

We will base our writings on a particular experiment of this project, which has captured Odin actress Roberta Carreri's exercise Six States of Water within the virtual archive. In this exercise, the trainee is called to perform a specific score of actions with different qualities of energy, poetically translated as different states of water. In the virtual archive, these states of water are elicited using visual and auditory stimuli, which fuse together to create an immersive *archi-texture*. In addition to the paper, we propose the development of a video essay, providing visuals to our experiment.

Keywords: Theatre Anthropology; virtual reality; texture; constraints; theatre training.

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Introduction

Progress made in the fields of technology, information theory, computational modelling, and immersive multisensory displays put the notion of the *body-as-archive* in a new perspective, especially as far as theatre technique is concerned. In our current research project, linked to the theatre practices of Odin Theatre[1], we explore the potential of immersive display technologies, and bodily interaction interfaces for supporting the transmission of embodied knowledge through a virtual archive; a tool for investigating the complex web of techniques that link performers to their particular poetics.

At Odin theatre, a specific 'goal' of the manifold of exercises and practices developed by the performers of the group in relation to many other codified theatre and dance traditions around the world, is to explore and 'understand' the inherent action-knowledge inside one's body, exploring psychophysical strategies to enhance actor's presence[2].

This development of embodied knowledge is intimately linked to the notion of 'action constraint', as a fundamental principle to achieve creative and expressive states of bodily action. Constraints of bodily action appear in a multitude of ways, within and across the organismic, environmental, and task dimensions (cf. Newell, 1986).

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[1] *Practicing Odin Teatret's Archive* is an ongoing research project funded by the Flanders Research Institute (FWO), taking place at Ghent University in Belgium. It is an interdisciplinary collaboration between the departments S:PAM (Studies in Performance and Media) and IPEM (Institute for Psychoacoustics and Electronic Music), in association with the Nordisk Teaterlaboratorium, Utrecht University, Manchester Metropolitan University and Aalborg University. Prof. Dr. Christel Stalpaert and Prof. Dr. Pieter-Jan Maes are the coordinators of the research project and PhD Candidates Ioulia Marouda and Adriana La Selva are the researchers activating the project.

[2] Odin Teatret is one of the oldest theatre groups in the world, with a tradition of research in embodied practices for more than fifty years. The group was until 2022 the main force of the broader artistic institution known as Nordisk Teaterlaboratorium (NTL) in Denmark, which today is also home to new generations who have built their artistic work in dialogue with Odin's legacy. From November 2022, Odin Teatret has disconnected from NTL and started a new phase of the group's life with the support of Fondazione Barba Varley and their impressive worldwide network. Over these decades, Odin has built up an extensive archive that is a fundamental source of knowledge for creators, academic students, and theatre researchers. For more info about their current projects, please visit https://odinteatret.org/.

Environmental constraints, specifically, pertain to the interaction of humans with their external world. It is about acting in the world, and the environment responding to these actions correspondingly. The processes and principles of action and re-action, of giving and receiving, tap into fundamental human coupled action-perception mechanisms that mediate and regulate interaction with the world. In performance art, it is about gravity, it is about the surface of the stage, the props, and it is about interaction with other actor/dancer's body. All these environmental elements resist, bend, and react. In doing so, they choreograph an expressive dialogue, they afford specific qualities of bodily action to emerge, and eventually, they invite a performer into creative states.

In the present research, we want to explore what the constraint possibilities are of immersive computer-generated, virtual spaces. How can such digital immersive spaces – what we will come to term as immersive *archi-textures* – become a springboard to expressive and creative states, unforeseen in physical spaces, and useful for pedagogical practices? With this research, we want to develop a critical epistemological framework which contributes to new accounts of knowledge distribution through immersive technologies and the place of embodied and affective praxis within this frame.

In this paper, we begin by developing an epistemological framework, which we will then relate to other works in the field of embodied heritage preservation and interaction. We will then approach one of the key aspects of this research, that of the translation of embodied theatre practices into data and, consequently, into an immersive experience of archival navigation guided by virtual environmental constraints. Whilst critically approaching this textural translation process, we will suggest ways in which designed immersive environments can renegotiate experiences of transmission in theatre training. Finally, we will put the theory into practice, by conducting a small proof-of-

concept experiment testing our translation strategies based on Odin actress Roberta Carreri's exercise *Six States of Water* within a virtual archive. For the experiment, we translated the different qualities of energy connected to the different states of water into corresponding interactive virtual environments. In the experiment, we specifically evaluate how these environments – and the interactions they provide – stimulate corresponding qualities of movements in trainees performing the exercise. For this purpose, we have created a layered analysis method – based on the Laban effort categorisation of expressive movement – entangling self-reports via questionnaires, expert-based observation, and quantitative analysis of motion capture recording.

The constraints of action

Action- to move with intention- is a form of agency that doesn't happen in a vacuum. It is always relational and dependent on the constraints surrounding it.

When it comes to action, constraints are the boundaries which give shape to relations, be it with humans or non-human parts. According to Newell (1986: 347-354) these boundaries can be approached from within three main categories, which, although intertwined, they can be distilled for the sake of research: organismic (bodily and operative aspects), environmental (external to the subject, related to physical laws, nature and socio-cultural norms) and task constraints (divided into three subcategories – goals, rules, implements or machines).

Constraint principles are therefore applied to every action that guides our daily behaviour. When it comes to theatre training, the interest falls on the investigation of the principles that guide the performer's *extra-daily* behaviour. Such behaviour is intimately linked to the notion of 'action constraint', as a fundamental principle to

achieve creative and expressive states of bodily action. From this perspective, Eugenio Barba, the director of Odin Teatret, has founded and developed the field of Theatre Anthropology:

> "Theatre Anthropology singles out the principles which the performer must put to work in order to enable a dance of the senses and mind of the spectator. It is the performers' duty to know these principles and to explore their practical possibilities incessantly. In this consists their craft. It will then be up to them to decide how and to what ends to use this dance. This is their ethic. […] It is based on empirical research, from which it extracts general principles. It takes place in an operative dimension with a view to the effectiveness of scenic action. It defines a field of investigation and forges the theoretical instruments to explore it. It singles out pragmatic laws" (Barba, 2021:8).

The notion of 'pre-expressivity' is central to their practice, referring to the elementary level of the energetic dynamics that render an actor's body scenically *alive* and *present*, generating what is understood as scenic *bios*. Actor training in this tradition is therefore aimed towards the development of embodied knowledge that regulates corporeal energetic dynamics and facilitates relationships at this pre-expressive level.

In noh and kabuki theatre for instance, the performers are required to alter their way of walking by immobilising the movement of the hips. This constraint consequently makes them bend their knees and give an impression of a divided autonomy for both legs and the upper part of the body. The performers need to use significant more energy to remain in this extra-daily physical structure and, by doing so, they evoke a different kind of presence on stage- a scenic *bios*.

Our hypothesis is that by designing external constraints in Mixed Reality, we can invite people to act differently, to get to know other forms of understanding

presence and imagination, expanding the notion of pre-expressivity through virtual archives.

The first phase of our project has captured the training practices of six performers, including Odin actresses Iben Nagel Rasmussen and Roberta Carreri; and life-long disciples of this tradition. One of them -still to be captured- is Carlos Simioni from LUME Teatro in Brazil, has been working with Rasmussen for more than 30 years. He has developed a work demonstration- which is a performative lecture about one's artistic discoveries - called Prison for Freedom (Prisão para a Liberdade). In this work demonstration, Simioni speaks at length about the importance of understanding the constraints of technique as a springboard to "something else":

> "There's a pulse of life inside me so strong, so strong that through prison, through technique, I created this pulse that drives me to do things. I wouldn't know how to find this pulse in my daily life, this organic pulse. And actor training is all of that. And the technique comes to frame. Do you know a frame of a picture? The technique is a frame, you just have to find ways to put this organicity, this lion you wake up, in a technique, in a way of doing with the body" (Simioni, in Teixeira and Sachs, 2016:136).

This is to say that the notion of constraints is implicit in theatre training as the necessary rule to achieve a creative state. Indeed, it has been argued for long that constraints are "no more than alternative accounts of the degrees of freedom" (Newell, 1986: 347), a mode of self-organisation which actualises one's agency and creativity as a response to the present moment. What are then the constraint possibilities of the virtual space? And how such space can become a springboard to other creative states, unforeseen in physical spaces?

Related works on archives and preservation of embodied heritage

To find cues for these questions, we have firstly mapped a series of works which resonate with our research. In recent years, there has been an increased interest in revisiting analog archives of bodily practices using digital tools, which opens the possibilities for archives which focus on the dynamics of the human body, rather than following a traditional object-centric approach (Hou et al, 2022). We will share some relevant examples that inspired our thought process in three different ways which we have categorised as visualisation, interaction and training.

First we looked at the research done in ways of visualising virtual archives, as well as mediums used. A notable example in this regard is the Hakka Kungfu Exhibition presented in the Hong Kong Heritage Museum, which combined various media from traditional exhibition of archival material to Multimedia and VR installation to take the visitor into a journey through the techniques of Kung Fu (Lo et al, 2018). The most interesting in terms of representation are the Motion visualisation videos which succeed to present the invisible qualities of the kung fu masters' movement in an abstracted and creative - even though non-interactive - way. Another engaging side of this exhibition is the range of different media, which allow for the interchange of interactive and non-interactive elements as a way of learning. Another source of inspiration is the work of the OpenEndedGroup. works such as Loops (2018), which was introduced in the early 2000's and revisited in VR, where the participants can interact with Merce Cunningham's motions in abstract forms that resemble hand drawings, are a great instance of projects which utilise analog-like aesthetics to achieve a novel and digital result. In both examples presented here, the visual language used succeeds to go beyond representation and aesthetisation of the body towards a visualisation of its inner qualities and morphology.

In terms of interaction, we shifted our focus to projects which go further from interaction with the movement trajectory of choreographic scores and focus on the inner drive of the dancer. The research conducted by the IRCAM group in Paris has been of immense value to the field that is often called Movement Computing (Salazar Sutil, 2017). A notable example is the research in real-time interaction with movement qualities according to the Laban Effort Theory as implemented in the installation Double Skin / Double Mind for Emio Greco |PC Dance Company (Alaoui et al., 2013). The dancer's movement is being analysed and that feeds the properties of the visuals, "an ensemble of virtual masses linked together with springs" (ibid). Following an approach towards the investigation of inner intention of movement, has been a great concern of ours, as it is pivotal for the work of Odin Teatret.

Another source of inspiration has been the dance archives which have led to interactive tools for learning. Seminal works, such as William Forsythe's Improvisation Technologies from 1997 have carved their unique path on how to approach archiving of techniques as a tool for the dissemination of knowledge. Improvisation technologies was a CD-ROM created to "help dancers generate movement material "and to "explain how to look at Forsythe's dances" (Bleeker,2017, 45). Since then, several archives in various mediums have been developed, affording new ways of engaging creatively with archives and thus the emergence of new objects of knowledge (Bleeker,2017, 201).

Above we have noted only few of relevant examples and sources of inspiration for our own work. In terms of aesthetics, there is a plethora of references in the fields of digital performance and new media art. When it comes to digitisation of archival works, we have noticed relevant research which is mainly focused on dance and notation, there is however a lack of research in somatic practices and theatre. Considering all this, we

deem the work of Eugenio Barba and the performers of Odin is the perfect case study for experimenting with archival practices of embodied knowledge in theatre[3].

<Figure 1 here>

Figure 1. Roberta Carreri and Patrick Campbell during their motion capture session, October 2021. Credit: Bruno Freire

<Figure 2 here>

Figure 2. Iben Nagel Rasmussen and Mika Juusela during their motion capture session, October 2021. Credit: Bruno Freire

From capture to texture

This research can be primarily divided in two parts, what we have called navigation and translation. Translation is for us the process of capturing actor performances, distilling and abstracting qualities inherent to these performances and turning them into interactive, multisensory VR displays providing an affective experience for users. Navigation on the other hand, is the accessing and selecting one's path. For this paper, only the translation process is analysed.

In both cases, the notion of texture, interpreted as a *meshwork of lines* according to Ingold (2015, 3) works as a guiding principle to our work. We follow Ingold's long

[3] A full account of the specific practices and trainings being captured by this project can be found at the conference proceedings of the 2022 International Symposium for Electronic Arts (ISEA), within the Second Summit on New Media Archiving's proceedings: https://isea-archives.siggraph.org/wp-content/uploads/2022/11/ISEA2022_Proceedings-of-the-Second-Summit-on-New-Media-Art-Archiving.pdf (46-51). A visual presentation can also be found through the link https://www.youtube.com/watch?v=t1ONYI_9huE&t=1194s.

critical dialogues with the work of Henri Lefebvre, from who he borrowed the term *meshwork,* to develop further his study on *lines*:

> "There is something in common, Lefebvre observes, between the way in which words are inscribed upon a page of writing, and the way in which the movements and rhythms of human and non-human activity are registered in lived space, but only if we think of writing not as a verbal composition but as a tissue of lines – not as text but as texture" (2011:84).

Below, we unfold this notion further relation to processes of translation.

Translation

The translation process involves on the first level the use of devices to capture bodily activity, like movement or (neuro)physiological responses. After multiple iterations, the data captured is reinterpreted and composed as a virtual environment. The final stage of the process is the experience of the virtual interactive environments by the participants. What we are called to do is to abstract the bodily experience and then reconstitute it, revealing in each case a specific technique with which the body trains. The selection of the level of abstraction and interpretation, even though subjective, is a result of research and training to the specific exercises of Odin.

After an intense period of experiments with the data captured, we came to realise that the heart of this affective translation process lies in the texture of the archive, the (virtual) space in-between the user and a practitioner's avatar. The interweaving of these textural formations builds the archive like a net: a fabric of lines, textures that make the materiality of this construction more 'archi-textural than architectural' (Ingold 2010: 11) The term archi-texture, following a tradition of critical thinking in geography and space

studies, refers to '[…] the communicative fabric that mediates between the structural properties of space and the spatial or communicative practices that (re)produce space.' (Janson 2007: 185)

During these months, we came up with three perspectives from which to approach translation. These are the skin, or translating from the outside of the body, the energy, or from the inside out and the user-environment, or the interaction of what one in daily life calls inside and outside. Such perspectives relate deeply with Newell's constraint theory mentioned in our framework above.

Skin

The skin of the performer's body carries the information of its training, culture, race, gender amongst other. For Eugenio Barba, the actor's presence, their scenic *bios*, affects the body of the spectator on a sensorial level (2010: 24). In our research, we choose to free the body of the avatar from any cultural or social signification and work with it as a carrier of embodied knowledge. This approach led us to feminist epistemologies framed upon the notion of figures, expanded throughout Donna Haraway's work. She has shown us that figures allow us to open up concepts for interactions with virtual bodies through archiving practices:

> "Figures help me grapple inside the flesh of mortal world-making entanglements that I call contact zones. […] Figures collect the people through their invitation to inhabit the corporal story told in their lineaments. Figures are not representations or didactic illustrations, but rather material-semiotic nodes or knots in which diverse bodies and meanings coshape one another. For me, figures have always been where the biological and literary or artistic come

> together with all the force of lived reality. My body itself is just such a figure, literally" (2008: 4-5).

Therefore, as much as figures are not representations or didactic illustrations, they do entail a visualisation, which in this archive, will be proposed as virtual textural figures. In this way, we argue, the archive becomes exercised through relations with figures. Figures are semiotic and material and, as Sara Ahmed reminds us: "If figures mean, they matter. If figures matter, they mean. […] When figures are exercised, they move; and we are moved by them". (2014: 17). Assembling an archive around figures allows us to give shape to bodies-as-archives, to think about the practice of assemblage in an archive differently, beyond documents and texts: through actions, affects, remains. The challenge is to translate the *corporal story* of the practitioners through design and interaction. Thus the textural translations of the body have an equally functional and poetic goal, to give information about the training which the participant has chosen, to situate their corporal stories and to inspire movement.

Energy

The body receives, circulates and emits energy. For Eugenio Barba, energy has a pivotal role in the training. The main notion from which he articulates energy is called *sats*. Sats is a word from the Norwegian language which can be only approximately translated as power. *Sats* can be seen as the difference of potential, the muscular, nervous and mental commitment during the transition from intention to action. Take a cat ready to jump for instance, that moment, just before the jump where the body is ready for action- the cat has *sats*.

But how does one capture and translate energy? During our experiments, we have worked with several physiological sensors which could, after development, facilitate this translation and introduce different feedback loops between the environmental stimuli and the body's reaction to them. Further analysis of such concepts goes beyond the scope of this paper. What is central to the translation of bodily energy is the focus on the participant's somatic experience during the immersion.

Following the theories of phenomenology and embodiment, we view the bodily perception as a mediator between internal and external experience. The human body through its action and movement in the world creates its subjective meaning (Dourish, 2001: 116).

It is what Ingold refers to as interweaving, as a metaphor of a fluid reality in which beings are not objects, they penetrate each other and connect, while they grow and move constantly (Ingold, 2015: 13-17).

User-Environment Interaction

Finally, the third way of translating is through the environment. The textures of the designed virtual environment impose several constraints which create a ground for defiance of physical rules and experimentation with invisible forces and qualities. As if the users could carve the air of the virtual (im)material space, allowing different kinds of resistance to be at play.

This creates constant *interactions* between a user's bodily *actions* and corresponding (*re)actions* of the XR multimodal environment. These reactions can entail the motion of scenic elements, objects or particles, as well as their resistance, deformation, colour, among many other features. Yet, the crux of the matter is the

inherent dynamic *quality* of the environmental responses. Designs are specifically aimed towards the *mapping*, or *translation*, of the dynamic qualities of the original performance into the "abstract" responses of a multimodal XR environment.

Our main hypothesis for this research is that the environmental textures, built through virtual constraints, carry kinesthetic information, allowing the user to get to know extra-daily behavioral possibilities. This communicative fabric has been designed by us in the virtual space, constantly being tested in order to set the right environmental constraints which will articulate the conditions for extra-daily action, for new energetic qualities to appear in the body of the user of the virtual archive. They were designed with and for the body, allowing a porous and dynamic exchange. To interact with these environments and its constraints is, we argue, to align one's actions in counterpoint to the modulations of the designed textures, understanding the affordances- the potential- of the virtual for theatre training.

In the section below, we will unfold the hypotheses proposed above through an experiment developed in the past year.

<Figure 3 here>

Figure 3. Fog from Six States of Water Experiment, April 2022, Ioulia Marouda & Adriana La Selva. Screenshot.

Six States of Water

In order to test the hypothesis described above, we designed an experiment which translates the exercise Six States of Water, developed by Roberta Carreri and is taught as part of her Dance of the Intentions' workshop. In the exercise, students are called to explore a fixed score of actions with different qualities of energy, which evoke six states

of water, namely fog, bubbles, amazon river, little creek, iceberg, tempest. Our goal in this case was to create six environments which enhance the experience of each relating state with the aid of interactive visual effects and soundscapes and as a result, impact the quality of score.

<Figure 4 here>

Figure 4. Iceberg from Six States of Water Experiment, April 2022, Ioulia Marouda & Adriana La Selva. Screenshot.

Design

The design process was anything but linear, with a long time spent on hands-on trials of the environments at all stages and reiteration. This allowed us to have an experiential approach and include our own bodies in the design process. For the purpose of the experiment, we reduced the states to three, namely fog, little creek and iceberg. We extracted the key qualities of each state and translated them into audiovisual and interactive textural environments. Fog would evoke density and slowness, the little creek quick and sudden deviations, while the iceberg would evoke rigidity and coldness. The participant would perform their score with the help of a virtual tutor- a figure- in all three states.

Regarding the interaction, the encompassing idea for of all the states is that the participant would emit an attractive force to the particles of the textures with their two hands, which would become a repulsive force as soon as the particles would approach in a diameter of 15cm. This repulsive force is a real-time interactive response of the textural environment, carefully programmed to evoke in the participants a way of moving akin to the qualities proposed by each state. The level of interaction as well as

other parameters such as speed, trail or other forces were variable according to each state.

During the design process, we held the intention to integrate the three layers of translation mentioned before. Even though this scheme is not a clear set of rules, it can be a guiding tool for refining our methodology. The skin layer can be identified in the figure of the tutor, while the environment layer into the various interactive states. The energy layer unfolds within the structure of the score, based on actions of pushing and pulling which are punctuated by moments of *sats* (by means, the transition from one action to another). Its impact can be recognised in the affective relationship between the system and the movement qualities of the participant.

The experience was built for Oculus Quest 2. The non-real-time assets were created in Houdini, while the scenes were set in Unity and the real-time effects were produced by using particle systems in Unity. The soundscapes were built by collecting free recordings online as well as by recording one of our practitioners, Luis Alonso-Aude. We chose to work with hand tracking in our setup, as it allows for more freedom in movement than the oculus controllers. Furthermore, we decided to avoid any visual representation of the hands in the virtual space, other than the interaction with the environment. This was in order to avoid the fragmented and disembodied experience of having only the visual cues of ones' hands.

<Figure 5 here>

Figure 5. Little Creek from Six States of Water Experiment, April 2022, Ioulia Marouda & Adriana La Selva. Screenshot.

Method

The experiment was designed as a one-to-one workshop and VR experience. For this, we invited 12 participants with varied experience in dance and other somatic practices, from novices to professionals, in order to assess to which extent the simulated environments of visual and sound effects can affect movement.

Each participant was given a Qualisys Motion Capture (MoCap) suit with 6 additional trackers for the fingers, for thumb, index and pinky finger. This data was used for the quantitative analysis. After an introductory procedure of generating the participant's skeleton model as required from the MoCap software, the participant had a 15-minute movement workshop by [name omitted for peer-review] in which they memorised a pre-designed score of movement, consisting of nine pushing and pulling actions. All participants memorised the same score.

Next, they wore the VR headset and went through the experience twice in two conditions, first with no accompanying sound and the second time with sound. They would first enter into a virtual training room, where they could perform their score or improvise freely and get accustomed to the experience. A minimal interaction with trails from their hands would facilitate as an introduction to what would be possible. After spending 2 minutes in this space, the participant was transferred to the main experience, in an abstract landscape and they were introduced to their guide, a figure with a body made of roots and the voice of Carreri providing guidance. There, they would be given 3 minutes to perform their score in every state. The order of states was randomised for each experience and for each condition. The total length of the experiment was 11 minutes, consisting of 2 minutes in the training room and 3 states of 3 minutes.

<Figure 6 here>

Figure 6. Participant in the 6 States of Water Experiment, April 2022. Credit: Adriana La Selva

<Figure 7 here>

Figure 7. Participant in the 6 States of Water Experiment, April 2022. Credit: Adriana La Selva

Methods of the analysis

We have developed a layered approach in our analysis of participants' bodily responses, integrating subjective responses of users (questionnaires), expert observations, and quantitative analysis. Such approach brings many innovations to the fields of both Performing Arts and XR design, integrating a deeply human-centered approach to data analysis. In short, the dialogue between lived experience (practice-based research) and digital data (computational modeling and virtual reality research) allows for embodied knowledge to be analysed in an innovative model, which sets the grounds to an actor training archive which can be practiced.

The main framework through which we have integrated all layers of analysis was centered on Laban Movement Analysis. This method, which is also considered a language to annotate dance, aims at reading principles of movement, identified as **space, time, weight and flow**, and observed as factors behind *action.* The understanding of **action** is in resonance with the original term used for effort for Laban and Bartenieff: the German word ***antrieb.*** This original term encompasses an (on) and trieb (drive), representing what a body does in order to make its impulse visible, or its own inner nature known. Our English translation of antrieb- effort, should be understood as the drive of one's inner engagement, one's inner desires/impulses revealed in space. Such approach has been widely recognised and supported through

studies in several areas such as clinical psychology, neurosciences and cognitive behavior[4]. This observation is, however, particularly relevant to understand how movement is thought of in terms of action in theatre studies.

Roberta Carreri, for instance, repeats incessantly that an actor does not work with movement but with actions- movements that are born out of intentions. This approach has led her to create her pedagogical method, called "The Dance of Intentions", from which the exercise Six States of Water is a part of.

> "An action is different from a movement. A movement does not aim physically to change something in the space. An action always wants to produce a change. […] Every action is in fact a reaction to a thought, a need, a sound, or another person's action. A reaction always has a precise in-tension that directly influences the muscular tonicity of the body- but first of all, the eyes" (2014: 67).

For this experiment, we are working with Laban's first five categories of analysis, called Movement Factors:

- **Space Effort** is seen as the body's attitude towards exertion in space. It is the quality of movement towards space or how it is affected or affects the space. For this reason, we shall not read the body speed while in motion as fast and slow but as **Indirect and Direct.**
- **Weight Effort** is also about the exertion of one's weight in relationship with space, or how a body engages its own weight towards the external environment. Therefore the qualities of weight are observed as **Strong and Light.**
- **Time Effort** is translated as how the mover exerts themselves in time. For Laban a body can be driven or lingered in time and this is what we observe in the context of the action. Therefore time is seen as **Sustained and Sudden.**

[4] For a comprehensive overview of studies please see Broughton and Stevens, 2012.

The Effort combinations create the **Basic Effort Action Drive.** By combining 3 drives you can observe the emergence of an action.

- **The Flow** which is the mover's attitude toward goingness or related to the quality of continuity, is not essential to identify an action drive and might be seen as more engaged in the links between actions or how this action unfolds in itself.
- **The Basic Effort Drives** gather all the possible combinations of the movement factors and emerge as follow: **Float** (indirect, light, sustained), **Glide** (direct, light, sustained), **Wring** (indirect, strong, sustained) , **Flick** (indirect, light, sudden), **Punch** (direct, strong, sudden), **Slash** (indirect, strong, sudden) , **Dab (**direct, light, sudden), **Press** (Direct, strong, sustained)

This framework permeated the three different analysis layers undertaken:

Subjective experience, via questionnaire and interview

The questionnaire presented participants multiple choice questions to assess their subjective experience in relation to the basic Effort drive explained above. In addition, we included free answering spaces for describing in their own words the engagement with each of the environments. In this case, we were also interested on investigating ways in which the textural environments designed for this experiment can be used for the transmission of performative techniques to support interactive and creative analytic processes.

The questionnaire was therefore followed by an interview with them, which was recorded and brought up their experience in an even freer way. It was particularly interesting to analyse their gestures while speaking, as embodied translations of the

experience. The conjoined questions addressed directed the participants to self-reflect on their ways of responding to the environments in relation to Laban analysis and using their own metaphors to describe them.

Expert-based analysis (EBA)

After the experiment, we asked Andrea Maciel Rodrigues, a practitioner involved in the project and a Laban-Bartenieff expert, to analyse the videos of each participant. We used the software Elan to annotate on the videos and divided the writings into six concomitant lines of analysis, following the Effort Drive categories: Space, Weight, Time, Flow, Basic Effort Action and Transformations.

The analysis observed above all, the time frames in which the body of the participants in motion reveal an inner impulse towards their visualisation of the space. Each revelation of inner impulse has a beginning, a middle and an end. Therefore, the time frame selection is an effort to read these collections of actions and how they unfold into each other as Basic Effort Actions.

Quantitative analysis of motion capture data

In addition to the self-report questionnaire and the expert based analysis, we carried out a quantitative analysis of the recorded motion capture data, to assess if, and how the expressive qualities of the Laban movement efforts are reflected in the participants' performances. The computation of quantitative features that relate to the Laban movement efforts has been explored in earlier studies, in domains such as movement analysis, classification and human-computer interaction (Alaoui et al, 2017, Guo et al, 2022, Maes et al, 2014). In the present study, we elaborated further on the work of Maes

and colleagues (2014) to assess expressive Laban effort features in a quantitative manner, focusing on performed hand gestures and body displacement in the performance space. For each Laban effort category we defined one or more quantitative features that capture the specific quality of the category.

For the **space category** (direct-indirect), we defined two quantitative measures. The first measure, which we call '**smoothness deviation**', offers a measure for the movement of the participants' right hand, and is based on the 'minimum-jerk' model of Todorov and Jordan (1998) , as applied by Maes and colleagues (2014). The second measure in the space category is the '**direction index**', and is applied similarly as in Maes and colleagues (2014). It captures how basic gestures in hand motion are performed as straight (direct) motion trajectories, or rather as indirect trajectories. For the **time category** (sudden-sustained), we defined the '**impulsiveness**' measure, which considers peak acceleration of basic hand gestures, in relation to their time profile. For the **weight category** (strong-light), we defined '**vertical displacement**' of the participants' waist as measure with, on average, being shorter to the ground indicating 'strong', and being higher from the ground indicating 'light' as quality in the weight category. Finally, in addition to the basic Laban effort categories, we computed two other measures to assess the quality of body movements. In particular, we were interested in how many distance participants traveled throughout the performance space ('**body displacement**'), as well as the distance covered by their hand, with respect to their own body center ('**hand displacement**'). These two quantitative measures provided a general indication of arousal or activation.

Analysis Results

Qualitative (questionnaires and expert-based analysis)

The questionnaires and interviews provided naturally a more subjective, although not less important, insight into the experience of the participants. An overall feeling of excitement towards the project was clear amongst them. Some showed a certain uneasiness with the technological setup and described a certain claustrophobic feeling with the VR glasses in the beginning, a feeling that dissolved throughout the experiment. 91.7% of them agree or strongly agree that the interaction with the displayed environments changed the quality of their movements within the score, making them move in new and different ways[5].

In the **Fog environment**, most of the participants perceived their actions as Indirect (curvilinear plasticity, continuous changes in the direction, multi-focused), Light (airy, delicacy and a gentle touches), and Sustained (slow, gradual, lingering actions in which deceleration prevails).

This combination correlates to the Basic Effort Action called Float and was also confirmed by the EBA as the prevailing effort within the participants throughout the Fog environment.

In the **Iceberg environment**, the majority of the participants perceived their actions as Direct (linear aim with a singular focus, “it’s this way.“), Strong (powerful, forceful, impact, firm pressure and forcefulness prevail) and Sudden (urgent, quickness and acceleration are noticeable). The combination perceived by the majority of the participants correlates to the Basic Effort Action called Punch and is partly within our

[5] Other results of this experiment, particularly regarding the sense of touch in VR will be published at Theatre Dance and Performer Training special edition on touch on June 2023 (issue 14.2).

expectations for the Iceberg environment, as we were expecting the speed to be more sustained, correlating to the Press basic Effort.

However, in the expert-based analysis of the videos, they have been evaluated as Sustained. We could interpret this difference in awareness due to the design of the environment itself and the instinctive association of standing on ice with slippage (Sudden), which in return, creates a sense of caution (Sustained).

The **Little Creek environment** had the most difference in the perception of the actions. The environment was perceived as a joyful, playful space, where notions of flow and freedom of movement were noted by many of the participants. This was also the environment where they took off from the score more often. The majority of the participants perceived their actions as Direct, Strong and Sudden. This combination also correlates to the Basic Effort Action called Punch and is again partly within our expectations for the Little Creek environment, as we were expecting the direction of their actions on space to have a more curvilinear plasticity, indirect and with more changes, correlating to the Slash basic Effort.

Again here, the expert-based analysis of the videos did perceive their actions differently, more indirect indeed and also lighter in weight, corresponding to the Flick basic effort. We could interpret this difference in awareness due to playfulness of the environment, which could have created, as some reported, a different emotional experience, more childlike.

From both analysis (questionnaire and EBA), we can assume that the Fog environment was the most consistent one in terms of finding a common movement quality amongst the participants. The joy of the Little Creek environment, which brings a feeling of being in the open of nature, allowed the participants to free themselves from

the fixed score more often and interact greatly with the virtual waters. The Iceberg environment has mixed feelings connected to it. The design is more overwhelming, the participant can experience being inside a mountain of ice, creating sensations connected to either cautiousness or sublimeness. The score, in this sense, travelled through different peaks of qualities. Another clear remark can be made in relation to the engagement with the exercise and their professional level as actors/dancers. Considering this exercise demands a previous understanding of different principles taught by Roberta throughout her pedagogical method, we predict that developing these steps will help participants with less theatre experience to remain more consistently on the qualities of each environment.

Quantitative

On the outcome of all quantitative measure – 'smoothness deviation', 'direction index', 'impulsiveness', 'vertical displacement', 'body displacement', and 'hand displacement' – we performed further statistical analyses (Friedman tests, with a significance level of $p < .05$) to assess whether statistically significant differences occurred in these measures depending on the state of the VR interactive display, being the 'Creek' state, the 'Fog' state, and the 'Iceberg' state. The outcome of these tests indicate significant effects of the state, on the measures 'smoothness deviation', 'impulsiveness', 'body displacement', and 'hand displacement'. When comparing measures across the individual states (using Bonferroni corrected Wilcoxon signed-rank tests), it was shown that significant differences occurred systematically between the 'Fog' and 'Creek' state (see Fig.9).

In summary, the analysis of the quantitative measures yield consistent outcomes, providing insights into the effect of the States of the VR interactive displays on the participants' movement quality. In general, we found pronounced differences between the movement qualities in the 'Creek' and the 'Fog' state. On average, people moved much smoother and less impulsive in the 'Fog' state compared to the 'Creek' state. In addition, we found that participants were traveling significantly larger distances throughout the performance space, as well as covering larger distances in hand movement in the 'Creek' state compared to the 'Fog' state. Looking at the 'Iceberg' state, one can observe that this state is consistently somewhere in between, but not yielding any significant differences.

<Figure 8 here>

Figure 8. Bar plots giving an overview of the results of the quantitative analysis of the Laban effort measures. Error bars represent the standard error of the mean, asterisks indicate the (Bonferroni corrected) significance value p, with * < .05, and ** < .001.

Conclusion

Through each layer analysed in this experiment we see consistent differences of movement qualities in relation with the original learned score. The next step was then to cross information within the analysed layers. To our contentment, this crossing showed consistent comparative outcomes, reinforcing both our methodological framework based on the textural design of constraint-based interactive VR environments and our main hypothesis that such environments carry kinesthetic information that can change the way participants perform a score. The quality of this emerged kinesthesia and how Roberta Carreri herself would perceive these qualities back in studio practices would be an interesting topic of further investigation.

The process of iterative design and inviting people for experiments taught us a lot about how to further improve and expand our work. It is our intention to create a methodology for our creative process which resonates the principles of the creation of affordances through constraints as well as the importance of the role of the body in the immersive experience. Our aim is to create a series of experiments which explore different qualities of exercises and consequently find patterns in them which connect them conceptually and technically. A useful development will be to further enhance the feedback loop between human and non-human, by adding other sensors to the experience, such as muscle sensors which will feed the system with information about the participants' *sats*.

Additionally, we find it meaningful to explore novel ways of evaluating such projects, as we understand that traditional ways of evaluation used in research, do not fully grasp the multiplicities of an interactive experience. Our goal is to create custom evaluation tools, which include the subjective nature of perception.

This paper is presenting the process of capturing and translating an analog archive of psychophysical techniques into an immersive experience, using the experiment Six States of Water as a case study. Theatre Anthropology approaches the performer's body with several principles which can be very valuable not only for our investigation, but for the creation of frameworks of designing in interactive installations.

In our case, we chose to approach the archive by identifying the inner quality of each exercise and working with methods of abstraction which facilitate the achievement of such qualities and make it experiential in an XR environment, thus creating a new type of transmission of knowledge.

The different levels of evaluation used, allowed us to assess our work from varied perspectives which helped to enhance our argument. However, admittedly the results were in several cases influenced by factors which could not be predicted or clearly defined. This aligns with theories of interaction and experience design, which argue that interactive performance leaves the freedom to the participants to co-create with the system, depending on their subjective experience and their past. This acknowledgment can in turn become part of the process of design, by feeding our methodology so that we further create environments which call for participation and serendipitous engagement. After all, this release of some of the control is itself a constraint which leads to new affordances.