Master Thesis

université PARIS-SACLAY

Master 2 in Computer Science

Human-Computer Interaction Program

Dance, Imagine and Freedom: A Qualitative Analysis on Participatory Design of Interactive Technology for the Transmission of Isadora Duncan's Movement Qualities

Author:
Vennila Vilvanathan

Supervisor:
Sarah Fdili-Alaoui

Hosting lab/enterprise:
Ex-Situ, Universite Paris-Saclay

March 1, 2021 – August 31, 2021

Secrétariat - Tel: 01 69 15 66 36 - Fax: 01 69 15 42 72
Email: Murielle.Benard@u-psud.fr

Contents

Summary

Since dance is a performative art and cannot be displayed in museums, preserving movements is an arduous task compared to other art forms. In such a scenario, how to preserve the legacy of the movements of Isadora Duncan, the Mother of Modern dance, and save it from going obsolete? In this thesis, we conducted a sequence of four participatory workshops with dancers, designers and technologists to develop interactive systems that transmit Isadora Duncan's dance movement qualities onto the learners. We experimented with different technologies including audio-based, virtual reality, mixed reality and on-screen projection.

Our results show that focusing on movement quality, rather than the movement sequence itself, can help in developing kinaesthetic creativity in dancers. We also found that an elastic abstract avatar supported the transmission of Duncan's qualities better than a non-elastic humanoid avatar.

Keywords

Dance learning technologies; movement-based interactions; participatory design.

CHAPTER 1

Introduction

"The Wind? I Am The Wind. The Sea And The Moon? I Am The Sea And The Moon. Tears, Pain, Love, Bird-flights? I Am All Of Them. I Dance What I Am. Sin, Prayer, Flight, The Light That Never Was On Land Or Sea? I Dance What I Am."
-Isadora Duncan

Isadora Duncan was an American dancer in the late 19th and 20th century. Rejecting the conservative restrictions of ballet since childhood, she strived to free dance and accelerated the development of modern dance [8] Also known as 'Mother of Modern dance', she often shocked and surprised her audiences while influencing them with her progressive culture and ideas. However, her controversial life and death often obscures the knowledge of dance imparted by her.

After Isadora Duncan's death, her legacy has been carried forward primarily by six dancers through oral transmission from generation to generation. Unfortunately, since her dance style is neither taught in regular dance classes these days nor it is popular among modern dance learners, this dance style might go obsolete if it is not protected. As she plays an important role in both arts and history, several initiative have been taken recently to protect her dance style. Digital repertoires such as Isadora Duncan Archive [19] that maintains a digital archive of her techniques and choreographies, mostly in the form of videos and texts, indicates the need for such a preservation tool. In this age of new media technologies, it is important to create interactive archives to preserve the modern dance pioneer's knowledge on movements, and provide an engaging learning experience for the dancers to deepen their skills and involvement.

This research aims to explore designing interactive technologies for dancers to experience Isadora Duncan's dance movement qualities. We followed a participatory design approach to conduct a series of four workshops to develop and test interactive prototypes for new learners of Isadora Duncan's dance movements. Our results show how technology supports and constraints the users' learning process through empirical observations from the workshops and feedbacks of the users after using the technological prototypes.

We worked closely with Elisabeth Schwartz, an expert dancer, teacher and dance historian who had been interpreting the repertoire of Duncan's movements for several years. Her knowledge was an important source in conducting this research including developing the three interactive technologies.

CHAPTER 2

Related Works

Over the last few decades, interactive digital technologies have turned more and more ubiquitous, gradually penetrating into everyday human lives and culture from mere workplace. This evolution is termed as third-wave HCI [5]. As we expand and probe into this culture, we aim to address and answer design problems beyond productivity and utility.

HCI and arts have a lot to contribute to one another [33], though there are many challenges in its collaboration. The structured academic nature of HCI and the highly personal and idiosyncratic nature of art practice, can cause a constant friction in embracing their methods and processes [11]. But when accomplished, this also benefits in expanding each other's limits. Dance is one of the leading arts that pushes the boundaries of technologies in various domains including performance, choreography, dance education and research [4].

Dance education using technologies

Several choreographers and artists have previously used technologies for dance education. Famous dancer and choreographer William Forsythe, in collaboration with ZKM Karlsruhe, produced 'Improvisation Technologies' to train his company's dancers [14]. As in figure 2.1, he used graphical effects like animated lines to form geometrical shapes with his body in space and annotated the movement sequences. This was one of the earliest efforts, in the late 1990s, to teach dance using visual metaphors and was released to the learners in the form of videos.

However, the advancements in new media technologies has also led to novel approaches to dance pedagogy that didn't exist before. In the Double Skin/Double Mind project, Alaoui et al presents an interactive learning system that captures and analyses user's movement qualities before displaying corresponding visuals to the dancer [12]. Thus, by displaying such visuals that reflects

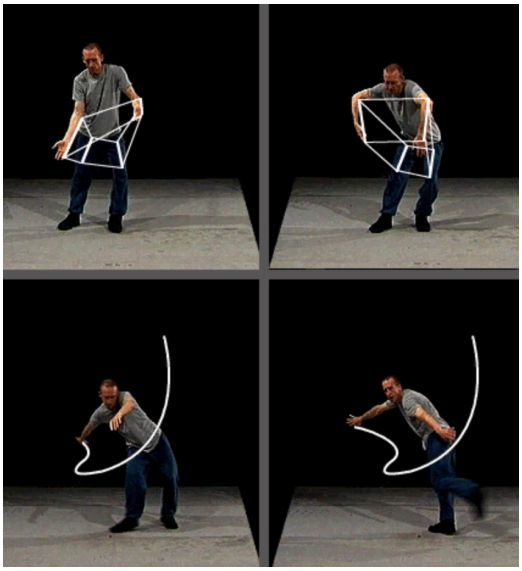


Figure 2.1: 'Improvisation Technologies' by William Forsythe [13]

user's movement qualities in real-time, they intend to improve the dancer's movement that contributes to those qualities. Another example of using movements and manipulating visuals is Isadora, a digital technology created by Mark Coniglio to be used during live performances. This flexible software tool allows for real-time processing of media manipulation and provides interactive control over digital sound and video [38]. Other than using the visuals directly, imagery can also be used to create movement metaphors in digital applications to teach and enhance dancers' movements. The Capturing Stillness project uses a technique called Skinner Releasing Technique (SRT), a image-guided approach to promote effortless movements. For example, a fabric piece is visualised in virtual reality(VR) environment to change its shape and formation. This acts as kinetic metaphor to inspire movements in the dancers. Though the author questions the relation between kinaesthetic movements and such sensorial experiences [15], they doesn't offer a working methodology that can work for transmitting movement qualities by using imagery.

Along the same line, another interesting example is the Choreomorphy project. It is a whole body interactive experience, created for contemporary and ballet dancers to experiment the use of imagery with body movements. Choreomorphy uses avatar in varying shapes, sizes and with human/non-human characteristics, and allowed the dancers to experience the reflection of their own movements in the avatars. The authors found that each avatar created different emotions in the dancers [29]. In the same project, the implementation of visual metaphors, like motion trails and traces or particle systems, was found to enhance the imagination in the dancers. Besides being able to analyse their movement trajectories and speed, the contemporary and ballet dancers were also able to get the 'feeling of the motion'. Infact, a detailed work done by Stergiou et al summarises that visual metaphors can be implemented in the form of geometrical shapes, tracing lines, avatars, environment and using actions as metaphors [35].

Archives and technologies

Archives are important to preserve movement knowledge over years. Technologies have also been extensively used to document and archive movements. Motion bank is a product of four year long project which aimed to operate as a 'free library for digital dance scores' and encourage 'peer to peer exchange' of knowledge in the form of ideas and processes among choreographers [9]. Along the same line are more projects like Numeridanse website by Maison de la Danse in Lyon [27], Jerome Robbins Dance Division Audio and Moving Image Archive by New York Public Library [21] and Jacob's Pillow Dance archive [20] have promoted a large number of artists and made their works digitally available for public to experiment with. These repertoires mostly consist of digital media such as audio recordings, videos of performance, photography, annotated timelines etc. and does not deal with the kinaesthetic learning for the dancers.

An example of interactive tool is Knotation, which is a mobile pen-based tool that allows contemporary choreographers to document choreographic ideas by sketching and using their own representations [7].

Inspiring creativity in movements

A considerable number of HCI studies have been carried out to help improvisation in dance. But the key difficulty to support improvisation is that the technological expertise and resources

required to implement while allowing for creative expression is enormous [23]. Research by Hsueh et al shows that the shift between different interaction patterns in a user is where creativity happens. They also offer implications to design interactive systems to inspire creativity in dancers and are identified by four parameters: indeterminacy, discoverability, appropriability and correspondence [17]. Indeterminacy is exploited by using the vagueness in a system to create complex relationships between the system and the dancer; discoverability is achieved by allowing the user to learn the system and the movements progressively; appropriating is defined as configuarability of the system; and implementing correspondence(between the system and the user) allows for users to explore movements.

Though there has been numerous researches in the past years to design for dancers, it is still challenging to design for a moving body [32]. Kristina Höök discusses in detail how designing engaging interactions that consistently coordinates with our movements, non-verbal and social behaviours is challenging [18]. The existing learning technologies are either not specifically created for Isadora Duncan's dance practice or the existing archives (in the form of scores and notations on paper) do not provide an engaging experience to the dancers. Thus, we cease this opportunity to design engaging interactions that transmit Isadora Duncan's movement qualities onto dancers. Our work aims to contribute not only to Duncan's dance practitioners, but also to movement and dance-based researchers.

In the following section, movements vocabulary specific to Isadora Duncan's dance used in this research will be presented.

CHAPTER 3

Isaodra Duncan Movement Vocabulary

Movement vocabulary is important to establish a common language among the dancers (teachers and learners), technologists and designers while they collaborate together. It can consist of a range of forms, qualities, actions, techniques or body parts involved in the movements in a particular language.

Duncan's philosophy of beauty is ingrained in its simplicity - being one with the nature. In the book "Art of Dance", a collection of Isadora Duncan's essays, she writes:

"Man has not invented the harmony of music. It is one of the underlying principles of life. Neither could the harmony of movement be invented: it is essential to draw one's conception of it from Nature herself, and to seek the rhythm of human movement from the rhythm of water in motion, from the blowing of the winds on the world, in all the earth's movements, in the motions of animals, fish, birds, reptiles, and even in primitive man, whose body still moved in harmony with nature." [10]

It is thus evident that her notion of 'social' goes beyond just being communal and refers to the harmony between human and non-human beings. One of the insightful writers, Ann Daly, writes Duncan's dance theory has both aesthetic and social factors as its basis [8].

Duncan also explores about cosmic vibrations that connect to creativity in her movements. Bresciani, artist director of the Isadora Duncan International Institute, explains that this rhythm begins "from the solar plexus, runs through and beyond fingers, toes, and eyelashes, and then through the head, which tilts back" [31]. Solar Plexus (or celiac plexus), located between the chest and stomach, is one of the focal points on the body that is often used in Duncan's movement vocabulary.

The Isadora Duncan's movement principles used in this research was developed by working closely with Elisabeth Schwartz, the connoisseur of Isadora Duncan's movements. The four important principles based on Duncan's movement are given below:

- Simple and natural - Duncan's dance movements are inspired from natural phenomenon and rediscovers the classical principles such as form, beauty and motion.
- Abandoning gravity - exploiting gravity to create movements that shows lightness.
- Wave propagation - They're like the sea waves that goes back and forth, indicating the 'vibrations'.
- Continuity - the movements look as if they are never ending and continuous.

The next chapter covers the design methodologies followed in this study.

CHAPTER 4

Methodology

We primarily followed a participatory design approach in this research study. The methodology we followed is centered on humans and involves the users actively in the different stages of design. Moreover, we chose to do a qualitative study and worked with a small user sample because "smaller studies with a significant qualitative component can address many serious design problems" [22].

The design methods followed are described below in detail.

User-Centered Design

User-centered design is "a process in which end-users influence how a design takes place" [1]. This perspective allows for placing the users at the centre of the design process and understand their needs better in order to develop more appropriate systems [2]. Feedback from participants can be collected through usability testing, sequence of tasks interview and questionnaires, on-site observation and group discussions to amplify our understanding of the end user's requirements [1].

Participatory Design

In participatory design, users are involved more actively in the design, where users act more than just informants and help in shaping the design of the system [28]. This design approach argues that the partnership between design researchers and participants allows the invisible, implicit details to be investigated productively [34]. Participatory design is infact a type of user-centered design, that bridges the domain knowledge in design and that of work practices [28].

Working with participants together on low-tech prototypes also allows them to reshape the technologies with low-tech materials [25]. According to Beaudouin-Lafon and Mackay, asking for users feedback at every stage of the design process is one way to implement participatory design [3].

Iterative Design

Considering the inability of designers in accurately predicting system requirements and performance in real world scenarios, it is highly improbable that the first design implementation would be successful [6]. Thus, an iterative approach to design is inevitable. Verschuren et al further argues in 'Designing a Research Project' book that "design process is a logical sequence and not a sequence of time" [37]. In an iterative design process, the designer constantly switches between different parts of the design process to reconsider the decisions made and the final effects it can result. And more number of times it is refined iterative, the system will be better that much [26].

To address the research question, "how can we design interactive technologies that transmit Isadora Duncan's dance movement qualities?", we conducted a series of four participatory workshops involving dancers, a team of technologists from Grenoble and designers at the dance studio in Central National de la Danse (CND), Paris, each lasting for about 7-8 hours. Technological prototypes were tested and iteratively improved to suit the users' needs in these sessions. We relied on the teaching and experiential knowledge of a Duncan's movement expert to create these prototypes. Bearing the CoVID 19 measures in mind, the participants wore their masks during the workshop and the technologies used were also disinfected with sanitary wipes before passing on to the next participant. All the participants signed a consent form and agreed to participate in the experiments. They also agreed for the use of materials gathered during these workshops, including pictures and videos.

My role was to organise and conduct these research workshops, actively collaborate between the dancers, technologists and the movement expert while playing the role of a designer, developing the audio instructor, building the Virtual Reality prototype and designing the Mixed Reality experience. My supervisor, who is also a HCI researcher, designer and a dancer, participated in these workshops.
The next chapters present the workshops conducted and closely discusses the technological prototypes developed, data collected and the results inferred.

CHAPTER 5

Workshop 1: Bodystorming and Co-ideation

The objective of this co-design workshop was to ideate for interactions through which the users can learn, explore and play with the qualities of Isadora Duncan's dance. There was no technology involved in the first workshop, rather we gave them various probes and activities to sparkle their creativity as discussed in detail below. The following sections refer to the participants as P1, P2, P3 and so on.

Participants

We recruited 4 French dancers (all women) who were either new or beginners in learning Duncanian movements, besides our expert, Elisabeth Schwartz(P4) and my supervisor(P5). The participants were between 30 and 70 years old and spoke French language. They have been practicing other forms of dance for more than 5 years. The participants were recruited through our contacts and they were not financially compensated. One of the participants (P6) joined late and took part only in the role play and de-brief activities.

Procedure

We designed and conducted four different activities (in the same order) during the workshop, namely

- Learning and documentation: The dancers learnt a Duncan's choreography piece, namely 'Prelude', from Elisabeth during this activity. We instructed the participants to use paper to document their experience and the challenges they face while performing and think about how technology can help them in these stages. We also gave them body maps to draw and sketch their bodily experiences.

  The knowledge of Isadora Duncan's movement principles were also explained to the participants in this session.

- Bodystorming: To explore the physical and social aspects as design resources, we used bodystorming as an activity to spur creativity among participants with different artifacts [32]. We gave them a lot of props like elastic bands, feather-like light materials, woolen threads, balloons, silk cloth and some craft stuff as in fig 5.1. They were asked to use these materials on their body to enhance the application of Duncan's movement principles in their dance. At the end, they were given a few questions to answer on a paper as in Appendix 1.

- Roleplay: We gave them the same set of props and we asked them to team up in groups of two to do the roleplay. One person took the role of technology and the other one was the dancer interacting with the technology, and they both had to enact a scenario such that the technology helps the dancer. The technology character was considered to be a

Figure 5.1: Props used in Bodystorming and Roleplay activities

superpower that can take any form and it doesn't have any humanly constraints. They again answered a few questions at the end of the activity as in Appendix 1.

- Debriefing session: In this final activity, we sat together and discussed more about the ideas and if they'd use these systems in their everyday lives.

Data collection and analysis

We recorded audio and videos during the activities, and took handwritten notes from the participants. The collected data was translated from French to English later.
We color coded the participants data and numbered them as P1, P2 and so on. We organised these data on the Miro board and grouped them in different categories. Clustering these data on the Miro board facilitated for better collaboration and to blend ideas together. We further performed a thematic analysis[16] on the collected data. In thematic analysis, the data was grouped into concepts based on the words used by the participants as seen in the Results module.

Results

Our analysis resulted in six categories: feelings that generates movements, body parts, qualities of expression, actions, learning movements with guidance and tracing lines. Each category is discussed in detail below.

Feelings that generate Movements

Emotions play an important role in the movements of the dancers. Each of Isadora Duncan's dance pieces have different emotions attached to it.

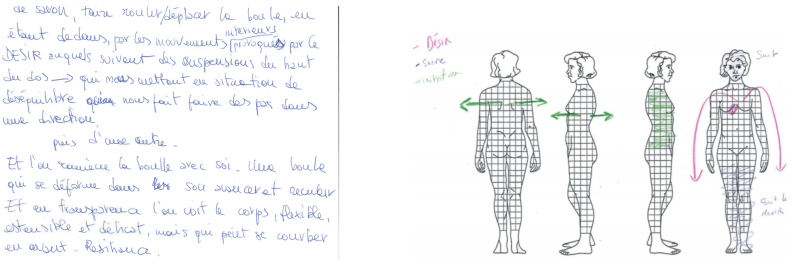
P3 (in the learning session) noted that ***desire, following*** *and* ***initiation*** are the sequence of feelings they feel during this dance. P5 also mentioned the same in body maps as in fig 5.2.

*"..a dance of the inner emotions and of lived experience...****exploration of us towards space****..I* ***feel*** *part of* ***space and time*** *with this dance"* (P2). (see fig 5.3)

P3 also proposed an idea to *sculpt the space with your hands* using *material like soft wax...* As in fig 5.4, P3 noted in the Body maps that they feel ***anxiety*** in their upper body.

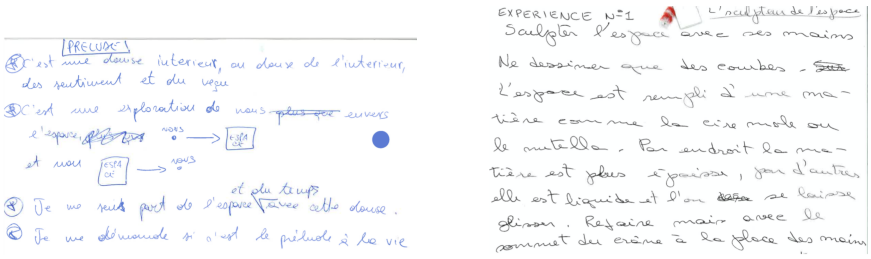
Awareness of Body Parts

Different body parts were either highlighted or used extensively by the dancers in this session.



(a) Documentation by P3 (b) Body map by P5

Figure 5.2: Desire, following and initiation



(a) Documentation by P2 (b) Roleplay activity by P3

Figure 5.3: Exploration of space and time

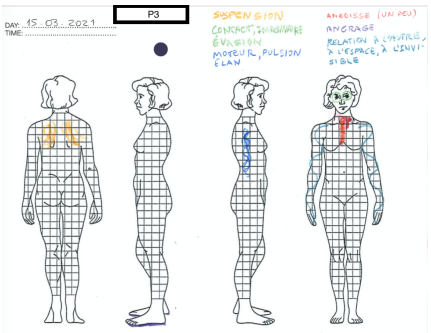


Figure 5.4: Bodymap as noted by P3

P2 highlighted the movement of the ***spinal cord*** and mentioned ***skin of the hands*** to be important in her movements as in fig 5.7.

P2 connected her ***ankles*** with an elastic band as in fig 5.5 while body storming.
P3 used elastic bands on her ***arms*** *and nails to highlight extremities on her* ***hands*** as in fig 5.6.
Use of ***solar plexus*** is another important part of the movement as denoted by P3 (see fig 5.6), P5 (see fig 5.9) and P1 as in fig 5.8.

Qualities of Expression

They also expressed Duncan's qualities in their movements and using the materials.

As noted by P3 on Body maps in fig 5.4, ***imaginary contact, grounding and evasion*** were some of the experiences subjected by their body.

Figure 5.5: Ankles: Body storming by P2

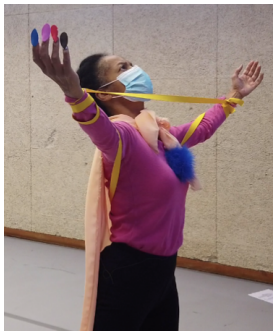


Figure 5.6: Arms and hands: Body storming by P3

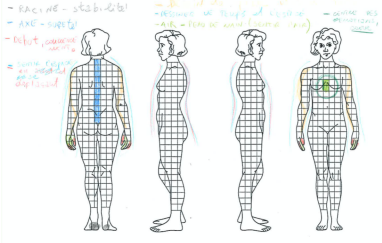


Figure 5.7: Spinal cord and skin of hands

Figure 5.8: Solar plexus: Body storming by P1

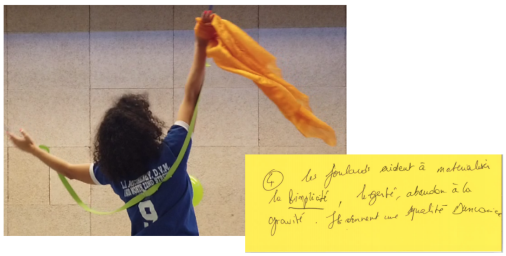


Figure 5.9: Simplicity and lightness

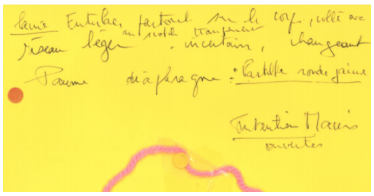


Figure 5.10: Uncertainty and change

P5 used *scarves to materialise* ***simplicity, lightness.***. as seen in fig 5.9.
P4 used woolen thread to represent ***uncertainty and change*** as in fig 5.10.

P6 proposed to use an elastic band *to play with the* ***imbalance and the suspension*** *that precedes it.*

Figure 5.11: Imbalance and suspension

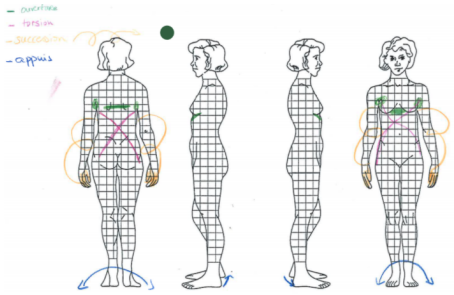


Figure 5.12: Succession, rotation and openness or stretch

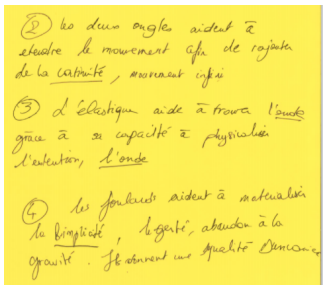


Figure 5.13: Continuity, abandoning gravity and wave propagation

Figure 5.14: Continuiity

Actions

Some of the notable actions were also denoted by the participants.

P5 mentioned **succession, rotation and openness or stretch** on BodyMaps (see fig 5.12).

P4 referred to **continuity, abandoning gravity and wave propagation** in fig 5.13 in the Bodystorming exercise.
P4 also used the ***fluid-like*** *motion* of the fabric in the RolePlay activity as in fig 5.14.

Learning movements with guidance

The participants came up with different ideas on transmitting Isadora Duncan's movements onto their partners while acting as technologies.

"the rubber band", wherein "(they) surround, grab the dancer's body with the rubber band and hold its weight back, like a puppeteer...(the technology's) role is to (re)hold the dancer and to induce a body imbalance, either releasing the attraction or pulling the dancer in different directions" (P6) (refer fig 5.15).

As in fig 5.16, a woolen ball was used to give the dancer *"gentle pressure, accept it and then gradually give in to this point of contact, become aware of it and pay attention to the direction of the pressure"* (P4).

On the other hand, P1 gave *"cues...about the type of dance, through the visual suggestion of color"* to guide their partner. Each part of the body was color-coded and depending on what color is shown by the 'technology', the dancer has to move the corresponding part of their body as in fig 5.17.

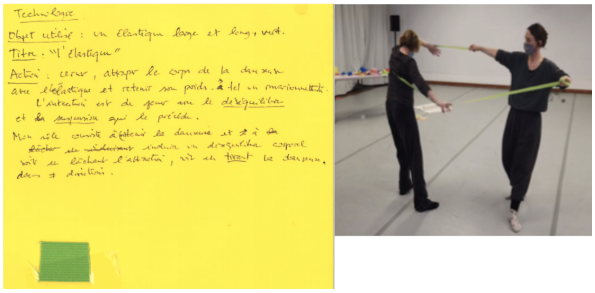


Figure 5.15: Controlling the dancer's body like a puppeteer using elastic band

Figure 5.16: Pressure points

Figure 5.17: Guiding the dancer with visual cues

Figure 5.18: Guiding the movements of dancer and avatar with fabric

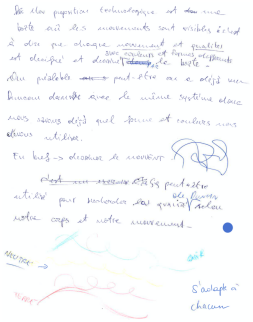


Figure 5.19: Tracing lines by P2

P5 used a fabric to guide the movement of the dancer using *fluids* or fluid-like fabric. A digital avatar, in turn partners with the dancer to co-create performance in the virtual and real world (see fig 5.18).

Using tracing lines to highlight the movement

P2 proposed an idea to trace the movements of the dancer as in fig 5.19.
"a box where the movements are visible, that is to say that each movement...is...drawn by the box".

CHAPTER 6

Workshop 2: Experimenting with the 3D Avatar on HTC Vive and Audio Prototype

The data from the previous workshop was further discussed with a team of engineers from INRIA, Grenoble to find practical solutions with available technology. We finally narrowed down to three prototypes, namely, VR prototype, audio instructor and on-screen visual guide. The rationality behind these workshops are explained below. These lo-fi prototypes were tested in this workshop for their functionalities and the ease of use among the participants.

Participants

Seven stakeholders participated in the workshop - including four dancers, Elisabeth Schwartz (P6), a PhD student in computer graphics from the INRIA Grenoble team who also created the on-screen visual guide (P7) and my supervisor (P3). The participants' age ranged from 30 to 70 years old and they all spoke French language. They have been practicing different dance forms professionally for more than 5 years. The participants were not financially compensated and the dancers were recruited through our contacts. P7 did not participate in testing the on-screen animation prototype.

Prototypes

In order to involve the users in the early stage of design, the following lo-fi prototypes were developed and tested.

Virtual reality prototype

Inspired by our previous ideation workshop, a Virtual Reality (VR) prototype was developed involving the use of a digital avatar(see fig6.1) in it. We used the filmbox animation created by MoCAPLab and the animator controller of Unity3D to devise the digital avatar's animation. To see the avatar from different angles in the 3D virtual space, a viewer can move around using the buttons on hand controllers and they also have the capability to slow down/speed up the animation according to their preference.

Audio instructor

The aim of this prototype was to encourage the dancers to learn the Duncanian movements through play and exploration. Instead of color-coded instructions from Workshop-1 in fig 5.17, we generated audio-coded instructions formulated on Isadora Dunacan's movement principles. Based on our analysis from previous workshop, we combined the three categories, namely: body part, action and qualities of expression to create the audio instructions. For example, the instruction could be "Let your *ankle rotate* with *lightness*". With Elisabeth's guidance,

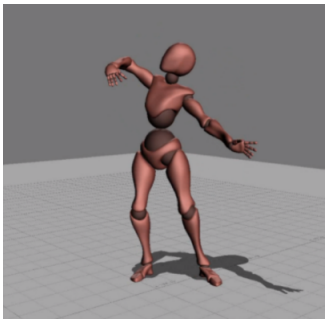


Figure 6.1: Digital avatar in VR prototype

Body Parts	**Actions**	**Qualities of Expression**
Ankles	Rotation	Lightness
Spinal cord	Succession	Suspension
Solar Plexus	Stretch or Openness	Evasion
Arms	Abandoning gravity	Grounding
Palms	Wave propagation	Imaginary contact
Shoulder	Continuous movements	Simple & Natural

Table 6.1: Audio Instructor lo-fi prototype

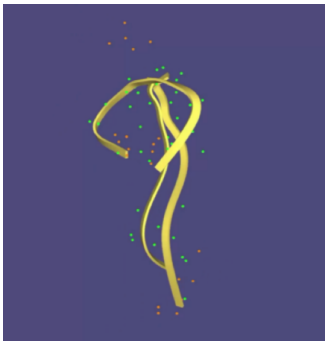


Figure 6.2: On-screen visual guide

we created and elaborated a table of such parameters (see table 6.1). Finally, the lo-fi audio prototype was built by recording her voice to create the instructions, then edited using Audacity to play an instruction for every 20 seconds.

On-screen visual guide

Unlike the VR prototype, the other two ideas are indirect manifestations of the participants' ideas. This prototype implements a ribbon-like elastic abstract model, created by the MoCAP Lab and INRIA Grenoble team, and acts as a visual guide for the dancers as shown in the figure 6.2. This abstract(or ribbon) model and its animations was created by capturing Elisabeth's movements ahead of the workshops. It was also developed based on her knowledge of Duncan's movement qualities. The mirror image of the animation was finally projected on a screen.

Figure 6.3: Participants using on-screen avatar guide

Figure 6.4: Participant dancing with the VR headset and hand controllers

Procedure

The workshop session started with the dancers learning 'Moment Musical', one of the notable Duncan's dances, from Elisabeth Schwartz. The learning activity lasted for about one-and-half hours. Subsequently, we asked a set of questions to the participants after introducing each of the prototypes one by one.

- **On-screen animation:** The ribbon model was projected on a white screen in front of the dancers as in fig 6.3. The dancers were asked to imitate the model and practice their movements. Later on, they were also asked to write down answers to a few questions as in Appendix 2 in the group discussion.
- **Virtual Reality:** Each participant was given 10 minutes to use the HTC Vive and go through the VR experience. In addition to wearing the VR headset, they were also given two hand controllers as in fig 6.4 with which they could control the perspective and distance they chose to see the digital avatar from. They could also slow down or speed up the dance animation with the buttons on the side of the controllers. After the experience, they were asked to write down the answers for a few questions in the group discussion.
- **Audio Prototype:** Each participant was given a wireless headphone(see fig 6.5) through which the audio instructions were played at regular intervals. They were asked to incorporate the instructions they hear in their movements, till they hear the next one. After this activity, the questions in Appendix 2 were given to the participants and were discussed in a group.

Figure 6.5: Participant with headphones using the audio prototype

Data collection and analysis

The participants documented their bodily experiences using Body Maps during the learning session by Elisabeth. Images and videos were captured throughout the workshop. Audio was recorded during the group discussions. Later, the collected data was translated from French to English. Similar to the analysis done in Workshop 1, the data was organised on Miro board and analysed using thematic analysis [16].

Results

The data was analysed in different categories from the last workshop, as the objective of the research workshops changed. The users' data was now analysed under 6 separate themes to study how technology supports transmission, how technology constrins dancer's body, how technology conveys Duncan's movement qualities, emergence of possibilities through improvisation, contemplation in immersion and how technology disembodies.

How technology supports transmission?

As in fig B.1, the VR experience overall helped them to grasp the Duncan's movements better.

"...slowing down, speeding up, changing position in space(virtual space) *which enabled me to understand and see movements which before*(from Elisabeth's workshop) *were unclear".*(P4)

"I slowed down the movement and this was dilating time. This led to a better understanding of the movement, a better feeling of the movement" (P1).
"The teleportation option can be really useful to learn a choreography" (P7).

Compared to the visual cues, audio instruction was perceived to work better in transmitting the movements onto the learners.
"creating movement from spoken words is a better way to make us dance than the visual representation..." (P1)

How technology conveys Duncan's movement qualities?

The audio instructor blended well in the dancers' learning process and was appreciated by them.
"...the audio orders were very useful to incorporate certain movement quality of the Duncanian dance"(P4).
"...engages to put our focus on a certain part of the body which is inducing the movement, (and) we question the movement quality" (P1).

"...helped me to better understand some of the root of the movement, starting for the solar plexus, to be aware of the imaginary "dream curves" or the succession of the movements in the spine, transfer of floor contact etc" (P2).

"I really likes this experiment and would like to use it(audio prototype) *to teach a technique or a style*(referring to movement qualities)" (P5).

The VR experience was described as *"metaphorical"* by P3 (see fig B.4) and further mentioned how changing positions helped *"to observe her energy (and) her emotion from close"*.

Emergence of possibilities through improvisation

The audio instructor helped them to explore Duncan's movements outside a fixed choreography.

"..really helped me discover Duncan's style because I was able to experience the movement outside of a set choreography"(P7) (see fig B.2).

"..to get out of the form and find the meaning and the intention of the Duncanian dances" (P5).

How technology constraints dancer's body?

Difficulties at the practical level were faced by the participants while dancing with the on-screen animation.

"- turning around and not seeing the screen" (P3).
"bouncing movement was really not visible in the ribbon (model)"(P3) (refer fig B.3).

"The missing head on the abstract model was also a problem since head/eye movements are important for expressing emotions" (feedback from recorded audio by P1).

Though the VR setup was installed at a safe distance from the obstacles in the room, their sudden movements during the dance sometimes posed a risk for them to get injured on the wall. During such circumstances, I gave them a warning to move away from the wall.
It also constrained their head and hands movements. The direction in which the avatar moved was also confusing to them.
"..constraints on the hands an the head ...headset too heavy, cord and controller => not possible to dance => difficult to understand the direction of the avatar" (P4) (see fig B.1).

There was also a mismatch between what they saw and the music they heard in the VR experience.
the music doesn't slow down when we slow down the animation (P7).

In the audio prototype, the participants were bothered by the use of headphones on their head.
"when I was moving my head towards the floor because I was sacred it was going to fall down" (P7). *"I would like to have much more different different combinations.."*(of instructions) (P3).

Contemplation in Immersion

The immersive nature of VR made them *"to look more than moving, to soak up more than moving"* according to P6.
As in fig B.4, *"I didn't feel like dancing. I focused on contemplating a wonderful work of art"* (P3).

On the other hand, the audio prototype inspired them to move while being immersive.
"..sound inspires me to move, makes me dance, it is much more embodied and in a way immersive"(P3).

How technology disembodies?

Though the dancers were immersed in the experience, they could not see themselves as the VR experience obstructs the sight of the real world. This, in turn causes a split between their body and mind.
"experience where we observe, look, feel, without being fully in our body."(P1)
Interacting with the Vive and the controllers, *"I do not exist in VR, only rootless hands."* (P3)

CHAPTER 7

Workshop 3: Experimenting with the 3D Avatar on HoloLens and Audio Prototype

In the last workshop, we found that the audio prototype was appreciated by the participants. In contrast, the VR experience did not blend effortlessly with the users' dance practice, though it inspired their learning. So, a Mixed Reality(MR) prototype using HoloLens was developed for this workshop. Further, the on-screen projection prototype was discontinued as the participants did not find it practically useful. The prototypes are additionally explained below.

The objective of this experiment is to test the improved prototypes and the details of the workshop are discussed below.

Participants

Four dancers (all women) participated in this workshop and their age ranged from 30 to 70 years. All of them spoke French language and they have been practicing dance professionally for more than 5 years. All the dancers were recruited through our contacts and the participants were not financially compensated. Besides Elisabeth Schwartz (P5), one(P2) was a new participant while the other three already participated in our previous sessions.

Prototypes

Mixed Reality Prototype in HoloLens

Since the HoloLens does not have cables nor hand controllers and gives more space for the dancers to move around, HTC Vive was replaced with the HoloLens headset. The MR experience was developed using Unity 3D and Visual Studio Code editor. In this experience, all the six Duncan's dance pieces were included for the participants to navigate using air-tap interactions. Besides adjusting the size and orientation of the avatar, users can also slow down/speed up the animation using a slider as in fig 7.1.

Randomized audio instructor

To get rid of the headphones (based on feedback from Workshop-2), the audio instructor was further developed using Python to give different instructions every time, so that the participants will not find it monotonous. Two levels of the audio prototype were developed - easy6.1 and difficult. The difference between the two levels is that a new column was added in the difficult level - namely movement - as shown in the table 7.1 to challenge the learner's creativity. With these tables, one word from each of its columns will be selected at random to generate a new instruction in that level.

(a) Air-tap interactions

(b) UI screen on the mixed reality experience

Figure 7.1: Participant interacting with the HoloLens prototype

Body Parts	Actions	Qualities of Expression	Movement
Sole of the feet	Ondulate	with lightness	while walking
Spinal cord	Sway	in succession	while hopping
Solar Plexus	Open	in evasion	while rocking
Arms	Abandon gravity	with simplicity	while running
Palms	Reach forward	slowly	while waltzing
Body	Curve	continuously	while skipping
Elbow	Close	with force	while turning
Knees	Lift	with liveliness	while leaping
neck	Throw	with resistance	while twirling
Leg	Fall	freely	while swinging

Table 7.1: Constituents of audio instructor

Procedure

The session was divided into four parts. Firstly, it started with a brief introduction to the HoloLens experience. Each participant was given 15-20 minutes to try out any of the six Duncan's dance pieces and learn by imitating the avatar's movements. After that, activity sheets (as found in Appendix 3) were distributed to the participants with questions to investigate their learning experience.

Secondly, Elisabeth taught them the 'Water Study' dance piece for about 1 hour, when they also documented their emotions and other bodily experiences on Bodymaps.

After Elisabeth's session, they again went through the Mixed Reality experience and everyone was given 10 minutes to particularly. We conducted a group discussion to understand if HoloLens helped them with their movements (see appendix 3 for probes used in the discussion). This activity also covered brainstorming for how to improve the Mixed Reality experience further, using sticky notes.

Finally, the last audio prototype, was played to the participants with both the easy and difficult

Figure 7.2: Participants moving to the audio instructions

levels. They were asked to incorporate the instructions in their movements, even if it sounds absurd (refer fig 7.2). Participants were asked to fill out activity sheets and a group discussion was conducted with the probes similar to the previous activity.

Data collection and analysis

Videos and images were captured throughout the workshop and audios were recorded during the group discussions. Activity sheets and body maps (as in Appendix 3) were distributed and collected from participants after each activity.

The collected data was then organised on Miro board and a thematic analysis was performed, similar to Workshop 1 [16]. The following Results section doesn't cover the participants' data from BodyMaps since it is repetitive of the data as in table 7.1.

Results

How technology supports transmission?

The users felt that the HoloLens contributed positively to their experience, without the hassle of cables and controllers (from group discussions). It also helps them to observe and imitate the movement.

"Nice, amusing, discovering, state of observation, astonishing, new, game, early stage, playful, acute attention, identify the part of movement, being at the real and virtual at the same time" (P4).

Moreover, on a scale from 1 to 10, the average rating of the participants' understanding of the qualities embodied by Duncan for this HoloLens prototype was found to be 6.3.

Imagination in movement learning

The brainstorming session revealed interesting suggestions related to creativity in their learning sessions. Some expressed their interest and the need for scenic virtual spaces to "play" and "recall the imagination".

"Play with the spaces of immersion, change of scenery, to recall the imagination put in play by this or that dance."
"Try the experience with the entire space re-live like a beach, the sea or another landscape."

How technology constraints dancer's movements?

Participants found it challenging to get used to the HoloLens as compared to the audio prototype since the latter was not complicated. Throughout this workshop, we saw that the users needed more time to adapt to new, unfamiliar technologies.

For example, *"There is always a time for adaptation. 'Understand how it works' - this second experience is very easy to use. My difficulty rest in the relation at the space because the avatar is far far away from me."* (P3)

"I try to have a good relation, but it(the HoloLens) *does not work everytime. My visual perception has not been trained to this. But I love to discover and acquire the new competences."* (P1)

"...Playful, strange : while being in the real space and the virtual space. The time of experimentation is very brief to adjust to the different settings (size of the avatar, of the intensity). First of all, a time of observation, then a very immediate desire to immerse herself(myself) *"entirely in the dance " with the avatar. I feel the need to adapt the space of the avatar while re-appropriating my hand. It takes a little time to familiarise"* (P2).

Another constraint was that the HoloLens wasn't particularly designed to handle the rugged head movements of the dancer. The headset fell down from P1's head during the experiment, after which she had to restrict her neck movements while using it.

Emergence of new opportunities

Like the previous workshop, participants thought the audio prototype encouraged them to go beyond a structured dance piece and explore the Duncanian movements outside its choreography. They liked the different levels as the 'difficulty level' demanded their physical and mental effort.

"It changes the perspectives about the Duncanian movements." (P3)
"Different levels: sometimes it was absurd, but interesting. Even if it is contradictory, I was like "lets try it"." (P4)

The "togetherness" factor further attracts them to play with the audio instructor.

"..the connection between us is better while dancing together (for the audio prototype). *I like it that way"* (P1).

How technology disembodies users?

The Mixed Reality experience, though immersive, participants felt it disconnected from their real world experience.

"The experience was more cerebral than really corporeal." (P1)

"The experience was very short to feel something at the physical level. But with this second realisation(HoloLens)*, I feel like I will be able to learn the dance with the real physical qualities."* (P3)

How far can we customize technology?

The participants gave different, sometimes even contrary feedback when it came to personal preferences. For example, the perception of time gap between the instructions varied from individual to individual.

"always trying to match (the instructions) but there is too much time in between the instructions" (P2)

On the other hand, *"Too quick and not able to get into the poetry of movements. Otherwise, it gets mechanical."* (P3)

"Not too many sentences. It's better if it is lesser." (P4)

Talking about the voice of the recordings,
"...the device is a little "robotic" and leaves room for improvement". (P2)

"the relationship between a recorded voice and a real life voice does not change much".(P3)

CHAPTER 8

Workshop 4: Visualization on HoloLens and Comparative study of 3D Avatars

Following the suggestions given by some of the participants in the previous workshop, different visualisations were added to in the virtual experience to stimulate their imagination levels. Moreover, a distinct experience was created to carry out a comparative study using two different avatars as explained below.

The objective of this workshop is to test how virtual objects can influence emotions in Duncan's dancers and probe on how an abstract form of the avatar can affect their learning. The experiment and the insights gained from the workshop are described below.

Participants

Including Elisabeth Schwartz (P6), 7 users participated in this workshop. The participants (all females) were between the ages 30 and 70 years. P7 is my supervisor and out of the remaining five dancers, four have already participated in our previous workshops and, two(P5, P6) were new to the technologies and the Duncanian movements. All of them have been practicing dance professionally for more than 5 years and they all spoke French language. The dancers were recruited through our contacts and the participants were not financially compensated.

Prototypes

Two prototypes were created to be tested in this workshop. Firstly, the MR experience from the previous workshop was upgraded with visualisations. In the second prototype, two avatar experiences were created for Folâtrerie, a Duncan's dance piece, without any added visualisations.

Mixed Reality experience with visualisations

Going back to the results from Workshop 1, we understand that dancers attach strong meanings and emotions to the objects around them. In Workshop 3, their need for a space for creativity also became explicit. Hence, we re-designed MR experience and added different meaningful virtual objects in each dance piece. We relied on Elisabeth Schwartz, the Duncanian movement expert and teacher, to decide which objects can serve as metaphors and aid the learners' imagination. These ideas were then discussed with the technical team to find possible methods to implement them without losing the context.

Finally, carefully chosen paintings, colors, textures and other virtual objects(like flowers, celestial objects, etc) were used to emphasize the emotions and 'feel' in all the dance pieces. For example, flowers represented happiness and joy while moon and sky represented the mystery in the Universe. Unlike all other dance pieces, the 'Mother' choreographic work depicted a story. Hence, sculptures were added to enhance the story experience.

Based on Workshop 1 (see fig 5.19), the feature of tracing the path of a point on the Avatar's body was introduced as shown in fig 8.2. For this purpose, seventeen important body parts (see

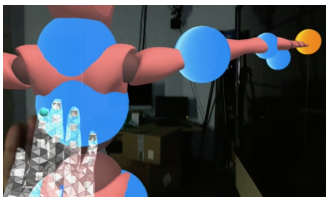


Figure 8.1: Selecting points on body to trace

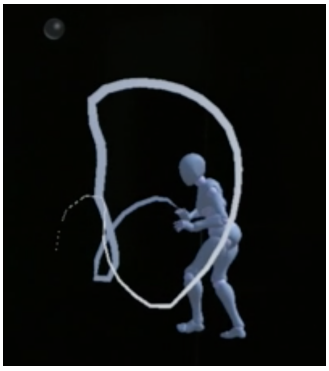


Figure 8.2: Tracing the finger in 'Water Study' dance piece with bubbles as visualisation

Body Parts	Number of points
Solar Plexus	3
Left wrist	1
Right wrist	1
Left elbow	1
Right elbow	1
Left knee	1
Right knee	1
Neck/head	1
Left ankle joint	1
Right ankle joint	1
Hip	1
Left thumb	1
Right thumb	1
Left middle finger	1
Right middle finger	1

Table 8.1: List of traceable body parts

table 8.1) from the Avatar System [36] in Unity 3D were selected by Elisabeth. It was chosen to allow the learners to focus on the movements of these body parts and hence make progress in their learning process. Users can select one of these points to trace by touching the "blue ball" as seen in the fig 8.1. As seen in the images, once the finger is selected, the path of that body part is appears as tracing line. The texture of the tracing lines differed depending on the emotion in the dance piece. For example, the lines were bold in 'Révolutionnaire' dance piece to strength and represent boldness, as compared to thin blue lines in 'Water Study' symbolizing water streams.

Prototype for comparative study

In the on-screen animation prototype presented in Workshop-2 , we could not study the effects of the abstract(or ribbon) model. Hence, a separate experience was created in HoloLens to investigate the use of abstract model(see fig 8.3) and humanoid model(see fig 6.1) in their

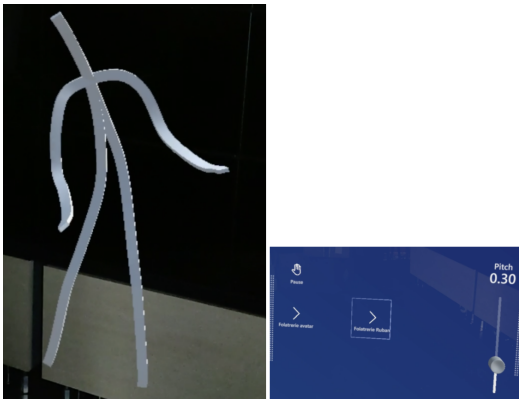


Figure 8.3: Abstract model and the UI window for 'Folâtrerie'

Figure 8.4: Participants interacting with the HoloLens experience

learning process.

The experience involves navigating between the two models for 'Folâtrerie' dance piece as shown in the fig 8.3 without any of the visualisations.

Procedure

The workshop consists of 3 sections. It started with a workshop brief, followed by an introduction to the new visualisations added in the MR experience. Each participant was given 10-15 minutes to go through any dance piece of their choice(see fig 8.4). Activity sheets (see appendix 4) were then distributed to be filled out by the participants to understand the transmission of Duncan's qualities with the new visualisations.

Group discussions were also conducted to further comprehend their learning experience (refer fig 8.5) with questions as given in Appendix 4.

Secondly, a teaching session led by Elisabeth Schwartz was organized for the dancers to learn the 'Folâtrerie' dance piece for about an hour.

Thirdly, the virtual experience for comparative study was deployed. We divided the participants into two groups randomly with the new learners in different groups, and conducted two rounds of experiment. In the first round, one group went through the humanoid model while the other group experienced the abstract model, and vice-versa in the second round. Each participant was given about 8 minutes in every round. After the first and second rounds, the participants also

Figure 8.5: Group discussions

answered a set of questions that probes on their understanding and appreciation for choreography with both the avatars (see appendix 4 for all the list of questions). Finally, two group discussions were conducted to further explore their learning with abstract model and the comparison between two models, before a small debriefing session.

Data collection and analysis

Videos and audios were recorded during the session and we also took photographs. The data was later translated from French to English. Then we organised and grouped the data on Miro board to analyse them further. A thematic analysis was also performed [16] similar to Workshop 1.

Results

How technology supports transmission?

The feedback below show that this virtual experience helped the dancers largely to move better. It inspired visions in their mind, which in turn allowed them to imbibe the movement qualities. *"..except for the plants! the rest*(of the visualisation) *enables to contextualize or to relocate, precise the intention" "It's difficult to really know if it*(virtual objects) *gave more sense, but it created an imaginary which I suppose brings lightness to the movement (bubbles)..."* (P5)
"Mobility and engagement of the spine...Mother (virtual experience of the Mother dance piece) *:touched to do those movements"*(P4).

Some learners also reported that it made the emotional experience more accessible to them.
"My emotional experience was more visual, thanks to the trace, and to the elements added to the space (moon and rose. Emotion : tenderness" (P1).
"If there is any emotion, it is through...the one created by the view of the curves" (P2).

Moreover, the tracing lines helped them to shift the focus of their movement to one body part in their practice.
A green trace...puts the attention on this area of the body and let's us see how the movement moves starting from this area..." (P2)

How technology conveys Duncan's qualities?

On a scale from 1 to 10, four participants rated their understanding of the qualities embodied by Duncan for the HoloLens(visualisation) prototype as 8 while two of them did not answer this question. P4 gave 7-8 particularly for the Mother dance piece, but only 6-7 for other dance piece.

Pointing to the Moment Musical MR experience, P3 said *"...brought an atmosphere of festivity and lightness.. colors are really soothing and clear, give a feeling of warmth..and I was able to learn easily."*.

The tracing lines turned out to be very useful in the users' learning process.
"The trace enables to see the quality and the spaces of the movements." (P7)
"...trace helped me understand the directions and also the movement quality" (P1).

Tracing of each body part also helped them to clearly analyse their movements in comparison with the avatar's. This showed them the room for improvement and to grasp the Duncanian qualities in their own movements.
"Looking for an organic fusion with the trace of the movement...The fluidity is readable in the avatar and more difficult to find within ourselves." (P2)

How technology constraints dancer's body?

It was a struggle for most participants, especially the new ones, to get the air-tap interactions(button clicks or pinch-and-move in slider) in HoloLens working. Their constant battle with technologies, not only consumed more time and effort, but also caused irritability during the learning process.
"There is a need to understand how to click with the interface, but also the constraint of looking in the vision field. Once these difficulties were overcome, it was interesting to see the avatar in the space, following him, the details of the movement were visible, the hands, the head" (P7).

As the dancers constantly moved their head, the HoloLens was not designed to strap on tightly to their head. This also resulted in obstructing their field of view of the avatar.
"I was bothered by the visual field that was too narrow which cuts either the feet or the head of the avatar and by a big red axis in the extension of my right index.I think that during the time to get used to the technology, the body stiffens" (P5).
"Drawback: not seeing the avatar in full size" (P1).

The poetics of abstraction

Many dancers preferred the abstract model for the humanoid form since the abstract (or ribbon) model was also perceived to express "fluid" motions, besides its simplicity.
"the simple line of the ribbon gives me more nuances (compared to humanoid model)*, I like this abstraction better"*(P4). On the other hand, the humanoid model was perceived to be *"less readable"* by the same participant.

"I preferred the ribbon which gives to see the lines in action and in movement" (P2)

"I read better the relationship (with the ribbon model) *to the ground and to the wave propagation from the ground to the hips. The movement propagation* (is) *more visible from the feet to the*

hand" (P6).

Choreography was also appreciated more with the abstract model than the other avatar.
"I appreciate the choreography with the ribbon, maybe because the image of the ribbon is more poetic than the (other) *avatar, more aesthetic and because we can see better with more precision, the fluidity of the movements and motions"* (P5).
Though P1 perceived the humanoid model to reveal more details, they still mentioned "(the ribbon)*model let me appreciate the quality of fluidity of the choreography"*.

CHAPTER 9

Discussion and Future Works

In the course of this research, we ran a set of participatory workshops with dancers, technologists and designers to investigate on how technologies can support and constrain the transmission of Duncan's movement qualities onto the learners. This study was carried out by closely working with Elisabeth Schwartz, the *connoisseur* of Duncan's movements, , and all our prototypes were developed based on her movements and her 40+ years of experiential knowledge in the domain.

This exploration analysed the effects of using different new media technologies, including mixed reality, virtual reality, audio and screen-based systems in the transmission of movement qualities. Rivière et al found that dancers consistently use three steps to learn dance, namely, analysis, integration and personalization [30]. The MR experience allows the dancers to analyse and integrate the dance through the Avatar and use observation, repetition and imitation as learning techniques to acquire Duncan's movements. On the other hand, the audio instructor helps them to personalise the movements by "stepping outside the framework of dance class and take liberties". Thus, in turn, it intends to support the dancers to creatively add expressive variations [30].

It was revealed in Workshop-2 that watching a visual guide on-screen is not the best way to imitate and learn movements, which includes traditional interfaces such as laptops and projector screens in the current times. Because of this difficulty, the users found the abstract model not-so-relatable. Nonetheless, when it was changed to Mixed Reality experience, they described the same model as "poetic". This is in accordance with the research carried out by Raheb et al[29] where the dancers perceived an abstract avatar to be closer to "a reflection or shadow" and it was found to have created "more mysterious and esoteric mood". We also found that the dancers could not only better read the movement propagation, but also were able to appreciate the quality of 'fluidity' with the abstract model, besides its 'simplicity'. Therefore, for Isadora Duncan's dance, we infer that an elastic abstract avatar suits better for transmitting the movement qualities onto the dancers.

Throughout the workshops, it was noted that the dancers perceive the world in a different perspective. In the realms of dance, they use their imagination to attach emotions and other meanings to both physical(in Workshop-1) and virtual(Workshop-4) objects. Average rating for their understanding of Duncan's movement qualities raised from 6.3(in Workshop-3) to 7.8(in Workshop-4) with visualisations implemented in the MR experience. Confirming the analysis of Stergiou et al, tracing lines(color and its texture) and environmental objects like flowers inspired imagination in the dancers and thus move better [35]. In addition to that, we also found that the elements used to connect the users to the story experience of the dance piece also had a considerable impact in their movements. However, it is also noted that all the users' imaginations were not stimulated by the same imagery and they did not work the same way for everyone. For example, many dancers mentioned that the paintings did not *"make sense"* for them. Since art can be interpreted differently by each individual [24] and the paintings were chosen by the dance teacher, it may not relatable to everyone. This can also be explained by the lack of indeterminacy to develop meaningful relationships with the paintings [17]. In the future, we want to give more flexibility to the users to choose and customize their experience

by themselves. Moreover, combining the visualisations with the abstract model could result in interesting directions for the research. Stergiou et al demonstrated that using imagery and tracing lines also helps in implementing metaphors in digital applications with the context of dance.

In Workshop-3, we found that Augmented Reality(AR) worked better for movement learning as compared to Virtual Reality. Unlike the VR experience, where the dancers couldn't see the physical world nor move their head freely, AR was much closer to their real-world scenario where they weren't 'blinded' from the real world while interacting with the virtual objects. With the air-tap interactions in HoloLens, it also freed their hands from the constraint of holding the Vive controllers. The first-time users found the air-tap interactions difficult to use and with time, it was observed that they grew accustomed to the interaction. However, this unpredictable issue with the air-tap interactions in HoloLens was at the system level, and thus it was out-of-scope for our study.

Furthermore, the audio instructor was found to be quite successful among the dancers because of its capability to go beyond the structured choreography while preserving Duncan's qualities in their movements (from Workshop-3). The audio prototype is also similar to the segmentation learning technique presented by Rivière et al [30]. In the segmentation technique, problematic isolated sequences are practiced repeatedly by the dancers to learn the movements better. But in our audio prototype, our aim is to segment and focus on one body part and one movement quality at a time so that dancers can grasp the movement quality instead of the movement sequence itself.

Movements created with the audio instructor is quite fascinating as they are produced from the dancer within the users. The users often mentioned they need more time to "get into the movement to explore". This could be explained by the time required to shift their focus from hearing an instruction to focusing on themselves and moving more in the physical space [17]. Thus, we can understand that by allowing the dancers to interact with systems that retains and transmits movement qualities(without the movement sequence), it can also help in developing kinaesthetic creativity in them as it changes their perspective of how they use their body.

Unlike the other experiences, it can be observed that the audio instructor was not technologically complicated for the users to interact with, and at the same time they could use their creativity to expand and engage in difficult movements. It was observed that instructions in French language also made it easy for the participants to follow. However, it was a clear limitation for the study that the main researcher could not communicate with the participants in their mother tongue. Hence, the time required to do the translations did not allow us to interview and probe the participants on their answers during the workshops. In the future, we also want to host this audio instructor on a website so that the dancers can access it remotely in this relevant CoVID-19 times. It will be interesting as well to incorporate audio metaphors and investigate how this might further encourage the imagination in the dancers.

CHAPTER 10

Conclusion

We experimented with different media technologies, while taking a participatory approach, to show how interactive systems can transmit Isadora Duncan's movement qualities on to the dancers. We found that an elastic abstract avatar conveys the Duncan's qualities better than a non-elastic humanoid avatar. We also learned that a mixed reality experience is more suitable for dancers as compared to virtual reality.

Our mixed reality experience sparked imagination in the dancers while the audio instructor aided them to explore Duncanian movements beyond a choreographic piece. We infer that systems that retains and transmits the movement qualities, instead of movement sequences, can help in developing kinaesthetic creativity in dancers as it changes their perspective on how they use their body.

We believe that our work would serve as a basis and be useful for movement and dance based researchers to further probe on implementing visualisations and improvising movements using digital technologies.

Acknowledgments

We thank all our participants for their energy, time and feedback during the workshops. We especially want to extend our heartfelt gratitude to Elisabeth Schwartz, who naturally imparted her knowledge and enthusiasm on Dunacan's philosophy and movements onto all of us. Thanks to INRIA Grenoble team for assisting us with developing the abstract avatar and their support in the research workshops. A debt of gratitude is also owed to Olivier Gladin, research engineer at INRIA, Saclay for helping us build the Mixed Reality experiences, without whom the study wouldn't have been possible.

I'm immensely thankful to my supervisor, Sarah Fdili Alaoui, associate professor at University of Paris Saclay and Ex)Situ INRIA research team, for giving me the opportunity to do this thesis and, her constant support and encouragement to explore the lesser known HCI territories. I also owe my gratitude to assistant professor Robby Van Delden, University of Twente, for his timely feedback and constant support in writing my thesis. I would also like to thank our colleagues at Ex-Situ lab, University of Paris Saclay and my friends for for their useful feedback and translating the users' words from French to English. Lastly, my sincere thanks to the University of Paris-Saclay, France and the University of Twente, Netherlands for supporting me in the background throughout my course of study. Thank you everyone.

Bibliography

[1] Chadia Abras, Diane Maloney-Krichmar, Jenny Preece, et al. User-centered design. *Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications*, 37(4):445–456, 2004.

[2] Liam Bannon. Reimagining hci: toward a more human-centered perspective. *interactions*, 18(4):50–57, 2011.

[3] Michel Beaudouin-Lafon and Wendy Mackay. Prototyping tools and techniques. *The human-computer interaction handbook: fundamentals, evolving technologies and emerging applications*, pages 1006–1031, 03 2009.

[4] Johannes Birringer. Dance and media technologies. *PAJ: A Journal of Performance and Art*, 24(1):84–93, 2002.

[5] Susanne Bødker. Third-wave hci, 10 years later—participation and sharing. *interactions*, 22(5):24–31, 2015.

[6] William Buxton and Richard Sniderman. Iteration in the design of the human-computer interface. In *Proc. of the 13th Annual Meeting, Human Factors Association of Canada*, pages 72–81, 1980.

[7] Marianela Ciolfi Felice, Sarah Fdili Alaoui, and Wendy E Mackay. Knotation: exploring and documenting choreographic processes. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2018.

[8] Ann Daly. Isadora duncan's dance theory. *Dance Research Journal*, 26(2):24–31, 1994.

[9] Scott deLahunta. Motion bank. *Transmission in Motion: The Technologizing of Dance*, page 128, 2016.

[10] Isadora Duncan and Sheldon Cheney. *The art of the dance*. Theatre arts, Incorporated, 1928.

[11] Sarah Fdili Alaoui. Making an interactive dance piece: tensions in integrating technology in art. In *Proceedings of the 2019 on Designing Interactive Systems Conference*, pages 1195–1208, 2019.

[12] Sarah Fdili Alaoui, Frédéric Bevilacqua, Bertha Bermudez Pascual, and Christian Jacquemin. Dance interaction with physical model visuals based on movement qualities. *International Journal of Arts and Technology*, 6(4):357–387, 2013.

[13] William Forsythe. Lectures from improvisation technologies. https://www.williamforsythe.com/filmspaces.html?&no_cache=1&detail=1&uid=42.

[14] William Forsythe. *Improvisation technologies: a tool for the analytical dance eye*. Hatje Cantz, 2004.

[15] Ruth Gibson. Capturing stillness: visualisations of dance through motion/performance capture. In *EVA*, 2011.

[16] Greg Guest, Kathleen M MacQueen, and Emily E Namey. *Applied thematic analysis*. sage publications, 2011.

[17] Stacy Hsueh, Sarah Fdili Alaoui, and Wendy E Mackay. Understanding kinaesthetic creativity in dance. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2019.

[18] Kristina Höök. *Designing with the Body: Somaesthetic Interaction Design*. The MIT Press, 01 2018.

[19] The isadora duncan archive. https://www.isadoraduncanarchive.org/. Accessed: 2021-08-10.

[20] Jacob's pillow dance interactive archive. https://archives.jacobspillow.org/, 1993.

[21] Jerome robbins dance division audio and moving image archive. https://digitalcollections.nypl.org/danceaudiovideo.

[22] Predrag Klasnja, Sunny Consolvo, and Wanda Pratt. How to evaluate technologies for health behavior change in hci research. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 3063–3072, 2011.

[23] Jerrold Levinson. *The Oxford handbook of aesthetics*. Oxford University Press, 2003.

[24] Robert J Matthews. Describing and interpreting a work of art. *The Journal of Aesthetics and Art Criticism*, 36(1):5–14, 1977.

[25] Michael Muller and A. Druin. Participatory design: The third space in human-computer interaction. *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*, pages 1125–1154, 01 2012.

[26] Brad Myers. Challenges of hci design and implementation. *interactions*, 1(1):73–83, 1994.

[27] Numeridanse tv. https://www.numeridanse.tv/en/home.

[28] Eva Olsson. What active users and designers contribute in the design process. *Interacting with computers*, 16(2):377–401, 2004.

[29] Katerina El Raheb, George Tsampounaris, Akrivi Katifori, and Yannis Ioannidis. Choreomorphy: A whole-body interaction experience for dance improvisation and visual experimentation. In *Proceedings of the 2018 International Conference on Advanced Visual Interfaces*, pages 1–9, 2018.

[30] Jean-Philippe Rivière, Sarah Fdili Alaoui, Baptiste Caramiaux, and Wendy E Mackay. How do dancers learn to dance? a first-person perspective of dance acquisition by expert contemporary dancers. In *Proceedings of the 5th International Conference on Movement and Computing*, pages 1–7, 2018.

[31] Carrie Rohman. Nude vibrations: Isadora duncan's creatural aesthetic. *Modernism/modernity Print Plus*, 2017.

[32] Elena Márquez Segura, Laia Turmo Vidal, and Asreen Rostami. Bodystorming for movement-based interaction design. *Human Technology*, 12(2), 2016.

[33] Phoebe Sengers and Chris Csikszentmihályi. Hci and the arts: a conflicted convergence? In *CHI'03 extended abstracts on Human factors in computing systems*, pages 876–877, 2003.

[34] Clay Spinuzzi. The methodology of participatory design. *Technical communication*, 52(2):163–174, 2005.

[35] Marina Stergiou, Katerina El Raheb, and Yannis Ioannidis. Imagery and metaphors: from movement practices to digital and immersive environments. In *Proceedings of the 6th International Conference on Movement and Computing*, pages 1–8, 10 2019.

[36] Humanoid avatars. https://docs.unity3d.com/Manual/AvatarCreationandSetup.html.

[37] Piet Verschuren, Hans Doorewaard, and Michelle Mellion. *Designing a research project*, volume 2. Eleven International Publishing The Hague, 2010.

[38] Elizabeth Waterhouse, Florian Jenett, Monika Hager, and Mark Coniglio. 'i gave that cue.'integrating dance studies, praxeology, and computational perspectives to model change in the case study of william forsythe's duo. *International Journal of Performance Arts and Digital Media*, 17(1):160–181, 2021.

APPENDIX A

Workshop-1 materials

Questions and Probes

Questions for Bodystorming activity:

- What materials did you use?
- On which body part did you use each material?
- Which of the 4 principles does it relate to (if it does)-
  - wave propagation
  - abandoning gravity
  - simple and natural
  - continuity
- How does it help you in your performance?

Questions for Roleplay activity:

- Did you allocate any super power to the 'technology' character? If yes, what is their superpower?
- How would you describe the relationship between the dancer and the technology character?
- How would this 'technology' help the dancer in their performance?

APPENDIX B

Workshop-2 materials

Questions and Probes

On-screen Animation activity:

- How would you describe your experience with this system? Please specify 5 words.
- Did the experience help you to learn the dance sequences and Duncan's techniques? Rate it out of 10.
  - If yes, how? What did you learn about Duncanian's movements, in specific from this activity?(Describe your answer)
  - If not, explain the problem faced? (Describe your answer)
- What do you think about the appearance (ribbon model) of the avatar? Did the abstract model help/hinder your learning?
- Did this experience hinder your movements? How?

Virtual Reality activity:

- How would you describe your experience with this system? Please specify 5 words.
- Did the experience help you to learn the dance sequences and Duncan's techniques? Rate it out of 10.
  - If yes, how? What did you learn about Duncanian's movements, in specific from this activity?(Describe your answer)
  - If not, explain the problem faced? (Describe your answer)
- Which of the functions (speeding up, slowing or teleporting) did you use the most?
- Which function helped you the most to learn? And why?
- Did this experience hinder your movements? How?

Audio Prototype activity:

- How would you describe your experience? Use 5 words to describe it.
- Did the experience help you to learn and implement Duncan's techniques? Rate it out of 10.
  - If yes, how? (Describe your answer)
  - If not, explain the problem faced? (Describe your answer)

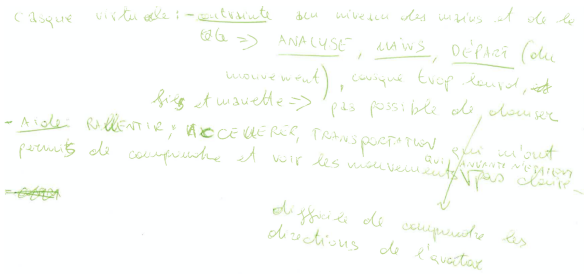


Figure B.1: Feedback of 4 after the VR experience

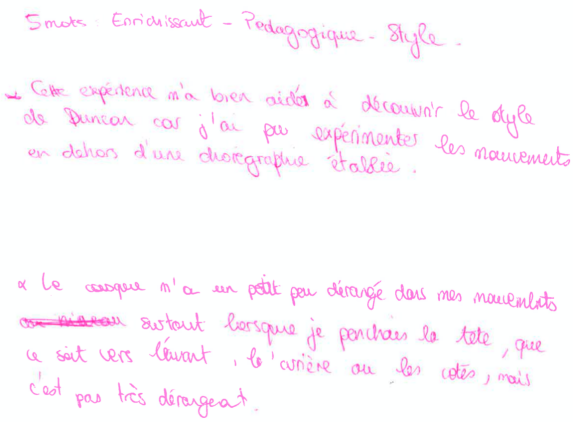


Figure B.2: Feedback of P6 after experiencing the audio prototype

- Did you enjoy this learning experience using audio instructions?
  - If positive: Do you think you'll use it in your regular practice and play with your moves?
  - If negative: Why didn't you like it?
- Did the experience or the headphone hinder your movements?
- If you face any other problems, elaborate on it.

Results

Figures B.1, B.2, B.3 and B.4 show some of the participants' data collected during the study in Workshop 2, as explained in the results of Chapter 6.

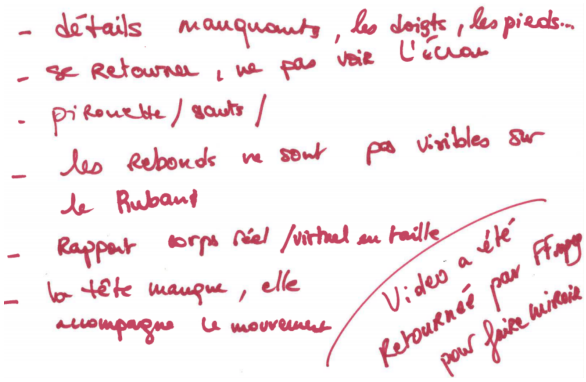


Figure B.3: Feedback of P3 after using on-screen visual guide

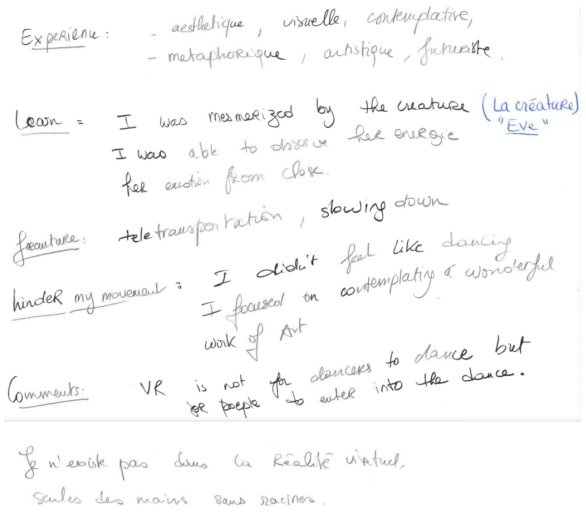


Figure B.4: Feedback of P3 after the VR experience

APPENDIX C

Workshop-3 materials

Questions and Probes

Activity sheet: Mixed Reality experience

Figures C.1 and C.2 show the activity sheets distributed to collect the participants' data in Workshop 3.

Group Discussion: Mixed Reality experience

- Did it make a difference from what you used last time? How and what changed?
- What are the limitations you experienced while going through the experience?

Question and probe: Brainstorming for improving MR experience

Imaginez et spéculez sur des scénarios sur la manière dont vous souhaitez améliorer / modifier cette expérience.
Vous pouvez commencer par écrire 3 de ces idées.

Activity sheet: Audio Instructor

Figures C.3 and C.4 show the activity sheets distributed to the participants after they experienced the audio prototype.

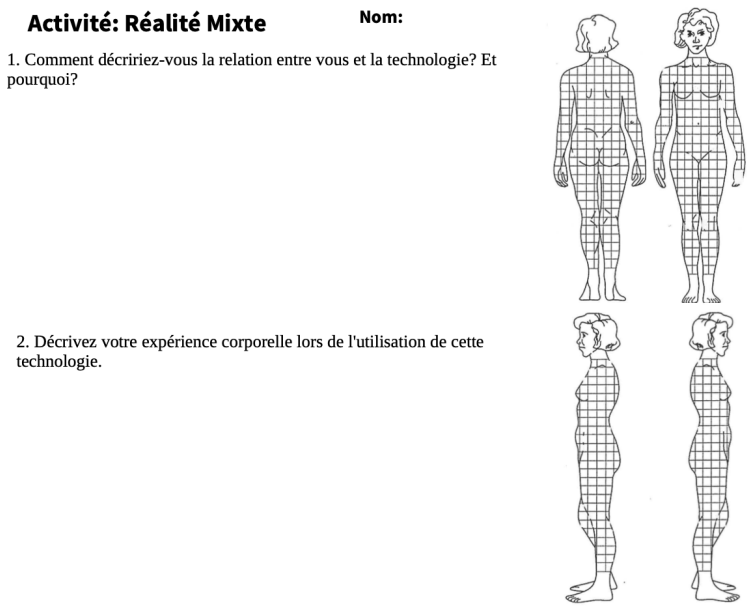


Figure C.1: Mixed Reality activity sheet - Page 1

3. Comment évalueriez-vous votre compréhension des qualités incarnées de Duncan dans ce prototype? Donnez-lui une note de 1 à 10. (1 étant le plus bas et 10 le plus)

Figure C.2: Mixed Reality activity sheet - Page 2

Activité: Suivez mon invite **Nom:**

1. Comment décririez-vous la relation entre vous et la technologie? Et pourquoi?

2. Décrivez votre expérience corporelle lors de l'utilisation de cette technologie.

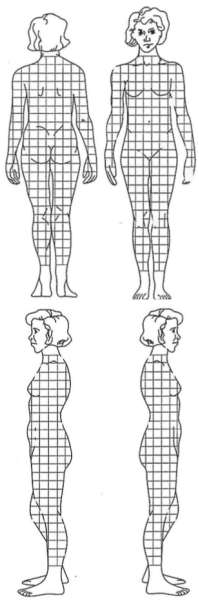


Figure C.3: Audio Instructor activity sheet - Page 1

3. Comment évalueriez-vous votre compréhension des qualités incarnées de Duncan dans ce prototype? Donnez-lui une note de 1 à 10. (1 étant le plus bas et 10 le plus)

Figure C.4: Audio Instructor activity sheet - Page 2

Group Discussion: Audio Instructor

- Did you face any limitations while going through the experience? If yes, what are they?
- Do you think the technology is interacting with you? If not, how can we make it more interactive?

APPENDIX D

Workshop-4 materials

Questions and Probes: Testing the visualisations

Images D.1 and D.2 show the activity sheets used by the participants to give their feedback after the HoloLens (visualisation) experience.

Group Discussion: Testing the visualisations)

- Did this experience help you to learn the choreography? (Not at all/ I'm familiar with some steps/ I learnt a lot/ I now know the full sequence)
- Did the experience add any meaning to you?
- What emotions did the dance experience elicit in you, if you felt any?
- Did you like this experience?

Questions and Probes: Comparative study

Round 1

- Ce model vous aide-t-il à apprendre la chorégraphie ? Si oui, comment ?
- Ce model vous aide-t-il à apprécier la chorégraphie ? Si oui, comment ?

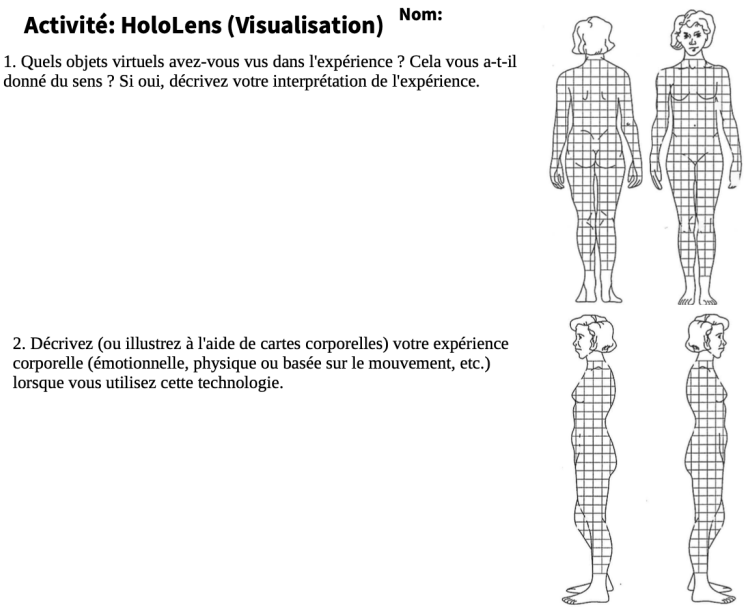


Figure D.1: Page 1 of Activity sheet

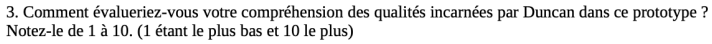


Figure D.2: Page 2 of Activity sheet

- Pouvez-vous préciser quels aspects de la danse vous avez appris de ce modèle ?

Round 2

- Votre apprentissage de la chorégraphie était-il différent du premier modèle ? Comment?
- Votre appreciration de la chorégraphie a-t-il changé avec ce modèle ? Comment?
- Y a-t-il des aspects de la danse que vous avez appris/manqués de ce modèle, par rapport au précédent ?

Group discussion: More on Abstract model

- Does the arrangement of the ribbons seem relevant to you ("starfish" arrangement, which meets at the plexus)?
- Would you change this representation? If yes, how?
- For the ribbon model - Is the lack of detail at the ends (feet, hand, head) acceptable? Disturbing?

Group Discussion: Comparative study

- Does the arrangement of the ribbons seem relevant to you ("starfish" arrangement, which meets at the plexus)?
- Would you change this representation? If yes, how?
- For the ribbon model - Is the lack of detail at the ends (feet, hand, head) acceptable? Disturbing?