Dance-Led Research

Sarah Fdili Alaoui

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Université Paris-Saclay, ED STIC

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0.1 How to read this manuscript

I wrote this "Habilitation" manuscript in a narrative form, from my first-person perspective. I chose narrative as a way to reflect on the work I have been developing for the past ten past years of research in human-computer interaction, interaction design, and dance. While this manuscript represents my voice (hence the use of the first person), by no means did I aim to ignore that of my collaborators. I acknowledged the collaborators, be they the researchers and Ph.D. students or the artists, choreographers, and dancers with whom I worked for each piece or study that I wrote about. I named them explicitly to credit their work, avoiding the generic "we" frequently used in academic writing. Thus, this manuscript is an attempt to honestly relate my journey as a researcher and an artist to both my academic and artistic communities, cautious to faithfully include the perspectives and contributions of my collaborators.

There are six chapters in this manuscript. The first chapter is an autobiographical narrative where I situate myself, who I am and how I came to work at the intersection of interactive technologies and dance. In the second chapter, I situate my work within the literature on dance and human-computer interaction. In the third chapter, I describe how I sought to use a universal method such as Laban Movement Analysis to study and model dance movement. In the fourth chapter, I explain how moved away from such a universal view of movement and sought to design systems with and for dancers by studying their personal practice and by involving them in the design and assessment of the systems. In the fifth chapter, I present how I use research-creation and research through practice methods to bridge my own personal practice as a choreographer and dancer and my research in interaction design. Finally, the sixth chapter discusses what I learned from the work that I have done and how it opens up new avenues in research and creation to dream about.

1

Auto-biographical preamble: Situating who I am and how I came to do the work I do

I grew up in Morocco, in the city of Rabat, where I started dancing at the age of 5. In Morocco, we dance on many occasions: weddings, parties, circumcisions, eid, etc. However, I was considered a dancer only once I had enrolled in the classical ballet program at the national conservatory in Rabat. In retrospect, the fact that the conservatory is seen as the only legitimate space to acquire dance knowledge appears to be an effect of the remains of French colonial heritage that perpetuate cultural hierarchies separating valid art forms (such as ballet) from other less valid art forms (such as traditional Moroccan dance).

I grew up going to a school within the Moroccan public school system. However, my family was determined to provide better opportunities to their children, so my sisters and I had the privilege of accessing dance or music programs at the conservatory. Because my sisters went to French middle and high schools, which for Moroccans is expensive and exclusive, my parents decided to balance things out for me (the third daughter who went to public school) by taking me to many private classes, from French spelling philosophy. They also paid for my yearly subscription to the "Institut Français", which back then was the only library and theater space where knowledge and culture (at least, French culture) were accessible.

By the time I was in high school, I was spending all my Saturday mornings at Madame Deborn's home. She was a French woman in her 70s living with another woman in Rabat. My mother hired her to give me spelling and French classes so that I master French as my sisters had. Mastering French was a sign of distinction and class. Instead, Madame

Deborn gave me a taste of what she liked and what she had studied, which was poetry and philosophy. She told me that she had studied with a philosophy professor called Maurice Merleau-Ponty. I was 15 and had no idea who that was. Nonetheless, I admired my professor's past. An unmarried woman in her 70s, smoking many cigarettes that she kept in an elegant silver case, living in a sunny house with her friend of the same gender and age. Perhaps they were lovers. I was too young and immersed in a society that ignored the existence of same-sex love, so I didn't consider it. Madame Deborn's classes consisted in giving me books to read books that were challenging for me, like Michel de Montaigne's "Essais" or Pierre de Ronsard's "Sonnets" and then talking about them. She had a massive library in her home where we sat during our Saturday mornings together. She lent me some of her old books and sometimes told me to keep them. She had the kind of book collection no Moroccan had or thought of having. I have kept these books with me until now. They were my first steps into a world that inspired me and changed my perspectives and desires. I became interested in philosophy and poetry. I was fascinated by such beauty and depth of thought and experience early in my adolescence. I would not miss a conference at the "Institut Français", where they would invite French writers or scholars to talk about their research. My mother realized it only when she came with me to a conference on Spinoza that I had begged her to let me attend, where she saw me frantically asking questions to the scholar after his talk. She said, "I thought you liked science; I didn't know you could be into literature or philosophy." Back then, for all of us, "knowledge" meant French knowledge, and "culture" meant French culture. There weren't spaces where local Arab or Amazigh cultures were shown and valued.

By the end of high school, I had decided to drop out of ballet classes. I didn't like to go onto pointe. I had finally hit puberty, and my body had changed and gotten heavier. Being light and enduring the pain of ballet's constraints with a smile on my face became difficult. So I quit. My mother was disappointed. She had invested time and money to support me through 10 years of classes, importing ballet shoes from France every year and driving me to classes multiple times a week. Moreover, she didn't like to see people dropping out or abandoning anything mid-way. But despite her insistence on me continuing, I dropped out and never passed the final ballet exam at the conservatory.

I was a good student, a competitive student. I had not always been that way. We lived in a big building until I was 12. And while we were there, all I was interested in was playing in the street with my girlfriends. My parents decided to move when I was 12 years old, specifically so that I would focus on school. And it worked. We moved to the furthest possible neighborhood with massive houses and neighbors that don't know each other. Suddenly, I was isolated and bored. My oldest sister started reading "Les fourberies de Scapin" by Molière to me as an initiation to literature. Weirdly, I liked it. My parents' strategy worked. That coincided with the time I started the classes with Madame Deborn. As I became interested in reading, I also became a good student. I got hooked on mathematics and French. These were the classes that I was the best at. I wrote poems and essays, and mathematics had no difficulty for me as if it was a puzzle that I figured out with ease. So I graduated from my public Moroccan high school with the best grades in mathematics, French, and philosophy. I then asked my parents to let me study philosophy. My parents came from poor backgrounds and could climb the social and economic ladder of a North African country only by making "responsible and serious career choices" such as studying law and political science and enrolling as civil servants in the Moroccan government. They laughed at me because philosophy did not provide jobs. Because I graduated best in mathematics, I would instead go to a "grande école" in Paris and be an engineer. That was a real job. I would be safer working in a big company, getting married, and having a family. Science was the only way towards that. Science, for them, was better than anything. I guess that's also part of the French colonial heritage that institutionalizes hierarchies between desirable and less desirable forms of knowledge.

And so I did. I went to Paris and studied in a French "classe préparatoire" and later at an engineering "grande école". I studied applied mathematics and computer science. In parallel, I got back into dance, contemporary dance instead of ballet, and enrolled in a yearly training program. I also audited the philosophy classes at the university nearby. I started doing yoga and contact improvisation. I started performing with various small-scale dance companies, in the street or in small venues. My studies, however, did not interest me much. And as much as I loved fundamental mathematics, I disliked applied mathematics and computer science altogether. The only time I felt any sort of flow while programming was when I built (with a group of students) a compiler. It felt as if I had figured out the inside of a machine and overcome the difficulty of an almost impossible task (computing). I felt like I finally understood what programming was. I was in a school with 5% women and 95% men, most of whom didn't understand what these women were doing there. I often overhear that "women are not able to do computer science". There was also a minority of students from North Africa, most of whom did not interact with the French students from European backgrounds. It was somehow a segregated environment and a patriarchal one. And the only time I enjoyed finishing a coding project was when I had to defend myself as a North African woman who did well in the hardest project, which was to build a compiler. Other than that, my relationship with computer science has never been passionate. I never cared about computers. It has only been a way for me to care about the body and people.

After finishing my engineering school and master's in applied mathematics, where I did some statistics and machine learning, which ultimately was still quite boring for me, I was contacted by IT consulting companies. It was in 2007, right before the economic crisis, and companies were hiring. I had no French citizenship, and the only way to stay in France was to get a highly-paid job. So I did not have the luxury of taking the time to figure things out or wonder what I liked or wanted to do. I just took the best option. And that was working for two years as a junior IT consultant for a major international company called Accenture. That work environment was competitive, exploitative, and toxic. After a couple of months on the job, I knew I would not endure it for long. I kept on dancing during my very little spare time. I also joined "Friends of the Earth", an activist organization that does environmental work. I stayed in the company for about 18 months. I did not know what my way out would be. Eventually, my partner at the time found it for me. A total coincidence. He was at IRCAM, enrolled in a second master's in Music and Technology. A field he knew of through an exchange program in mathematics at the university of Pompeu Fabra in Barcelona, where he took a class called "Mathematics and Music" by chance. At IRCAM, he saw an upcoming conference given by Frédéric Bevilacqua and Scott De la Hunta on using technology to document the gestures of the Emio Grecco | PC dance company. He then borrowed the book "Capturing Intention" [deLahunta, 2007] and brought it back home. I looked at this work combining science and dance and became fascinated by it. It was at the intersections of fields, skills, and interests that I had. So I contacted Frédéric Bevilacqua and looked for other academics in Paris working in a similar interdisciplinary manner. Christian Jacquemin was one of them, and I contacted him too. Christian and Frédéric were nice enough to accept to meet me. I was so determined to quit Accenture and start a Ph.D. that I had already started what I thought was a state-of-the-art and sketched some ideas of what my possible Ph.D. could be. And weirdly enough, they trusted me even though they didn't know me. I left Accenture and started my Ph.D. at Paris-Sud University, and IRCAM on movement qualities in dance applied to the vocabulary of Emio Grecco PC company. From that time on, I was convinced that I had landed in the right place.

My Ph.D. was a fantastic time of learning. I was allowed to be creative. My professors were supportive and caring. They gave me the best model anyone could have in academia, and I am forever grateful to them for that. They are now my friends, and I still collaborate with Frédéric in IRCAM. I consider him an academic inspiration, always affable, wise, and with the best advice. I defended my Ph.D. and set a more solid foot into academia in the intersection of dance studies and human-computer interaction (HCI) and interaction design. I also acquired French citizenship, which made it easier to consider going abroad for a post-doc while still having the possibility of coming back to France anytime. I contacted Thecla Schiphorst, whose work I had admired since the beginning of my Ph.D. She was a pioneer. One of the scientists and artists who designed LifeForms with Merce Cunningham [Schiphorst, 1993]. She was also actively involved in the HCI community. She was both an artist and an academic. And she had just received a major grant in Canada bridging Laban Movement Analysis and interaction design and arts. So she hired me as a post-doctoral fellow at the School of Interactive Arts and Technologies in Vancouver, Canada. A place far from my second home, Paris, and even farther from my first home, Rabat. And thus, I left everything behind and went to work with her on the MovingStories project.

This "habilitation" manuscript will narrate the journey that I have been undertaking since I started working within the MovingStories project in 2013 up to today.

2

Situating my work in the literature

This chapter is dedicated to situating my work within the literature on dance and human-computer interaction. I will revisit notorious existing works that integrate technologies in dance to "augment" the dance stage, to "enable" learning, documentation, and archiving of dance, or to "support" the choreographic process.

Figure 2.1. One of the Experiments in Art and Technology (E.A.T.) during the 9 Evenings.

Interdisciplinary approaches linking dance to computer technologies have existed for almost as long as computers. Some of the earliest experiments illustrating such approaches are the 9 Evenings interactive performances that linked prominent performance and sound artists and engineers from Bell Labs in 1966 (see figure 2.1). In "Entangled", Christopher Salter reflects on how technologies are "entangled" with performance from early works such as Diaghilev's "Ballets Russes" in

1917 to current digital and interactive art as seen in massive festivals and conferences such as MUTEK[1] or Ars Electronica[2] [Salter, 2010].

[1] http://www.mutek.org/fr

[2] https://ars.electronica.art/news/

Merce Cunningham is a major figure in modern and contemporary dance who explored computer-based visualization on stage in the 1990s [Schiphorst et al., 1990, Schiphorst, 1993]. Thecla Schiphorst, with whom I worked for two years as a post-doctoral fellow, was among the scientists and designers who co-designed the Lifeforms software with Merce Cunningham, to support his choreographic process. Since then, human-computer interaction (HCI) has become one of the multidisciplinary fields within which researchers use computation in performance through art and science collaborations. There are also hybrid personalities in HCI that are both researchers and artists and that produce interactive performances, such as Thecla Schiphorst, Lian Loke, Atau Tanaka, Marco Donnaruma, or myself (humbly). The culmination of such "entanglement" is visible in the emergence of conferences such as "Movement and Computing" (MOCO) [3] in 2013, bringing together a community of art and science practitioners and academics around the emergent field of digital and augmented performance. MOCO was a conference that I co-founded with Frédéric Bevilacqua. It started from a small workshop that we organized during my Ph.D. on the topic of "Analyzing and Representing Movement Qualities in Dance". This modest workshop hosted 75 researchers and artists from around the world. The keen interest of these people was proof that there was a gap to fill and a community to build, uniting people around dance, movement, computing, and science. Two years later, when I was in Vancouver, Frédéric and I, along with researchers in both of our teams in SIAT and at IRCAM, collaborated to create MOCO as an international conference with peer-reviewed papers, performances, and artworks. We organized it first in Paris, where I was a Ph.D. student, and second in Vancouver, where I was a Post-doctoral fellow.

[3] https://www.movementcomputing.org

At the heart of such a community is work on digital performance, which Dixon define as a performance in which computer technologies play a central role in terms of content, techniques, aesthetics, or delivered forms [Dixon, 2007]. Augmented performance, by analogy with the term, "augmented reality", designates digital performances that explore the possibilities offered by computer technologies to extend the language of dance, choreography, theatre, performance, or set design. The goal is not to suggest ways to replace the actual performer with a virtual one but to enrich the performance through digital artifacts that are used on stage or during the creative process. This echoes Mark Coniglio's motivation behind the use of technology and computation in the Troika Ranch company's performances:

> "[...] To create dynamics, challenging artworks that fused traditional elements of dance, music, and theatre with interactive digital media. We believed that by directly linking the actions of a performer to the sound and imagery that accompanied them, we would be led to new modes of creation and performance and, eventually, to a new form of live artwork. While we cannot yet claim to have reached this latter, rather lofty, goal we have firmly established our views about interactive performance and its importance to the performer and audience. [...] I think it is worth answering a simple question: why would one want to create such artwork in the first place?"[4]

[4] http://digicult.it/digimag/issue-030/the-importance-of-being-interactive/

In the next sections, I will revisit notorious existing works that integrate technologies in dance. I will address the question "why would one need to create such augmented performance in the first place?"

2.1 Augmented performance

The premises of augmented performance experiments using technologies date back to 1966 in the series of Experiments in Art and Technology (E.A.T.) that culminated in the 9 Evenings [Morris, 2006]. This is the first collaboration between engineers and scientists from Bell Laboratories and visual artists such as Robert Rauschenberg, composers such as John Cage, and choreographers such as Steve Paxton and Lucinda Childs. The goal of this collaboration was to incorporate technological development in artistic performances. They used projection, video and television, wireless transmission, and infrared camera to augment performers' movements on stage. These performances are legendary. They emerged from a period of amazing creative energy, experimentation, and risk-taking to re-invent art in the early 1960s. They imagined a possible future where artists would use technology in their work. Subsequently, choreographer Merce Cunningham, who participated in the E.A.T., is one of the most famous figures in dance that have explored motion capture tools or computer visualization since the 90s. In his famous augmented dance piece, BIPED (1999)[5], images of virtual characters are projected on stage. These animations are made from the pre-recorded movements of the company's dancers.

[5] http://www.gavinbryars.com/Pages/biped.html

Another trailblazer in digital art and performance, known for his hybrid status as an artist and a researcher, is David Rokeby [6]. In 1986, he developed an interactive system called Very Nervous System, which

[6] http://www.davidrokeby.com/vns.html

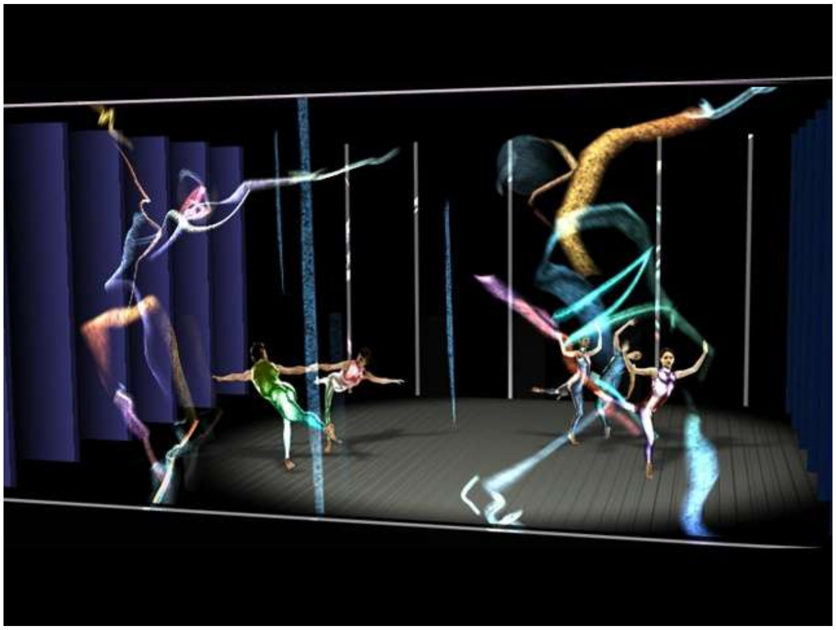

Figure 2.2. Merce Cunningham's augmented performance BIPED

invites participants to move in their everyday environment while generating sound from their movements. This interface explores the resonant nature of interaction and its ability to reflect participants' movements in their own environment. David Rokeby strongly engages the whole body of the participant in the interaction while composing its "disappearance" in the computer. He laid the foundation for what will later be labeled as "interactive installations".

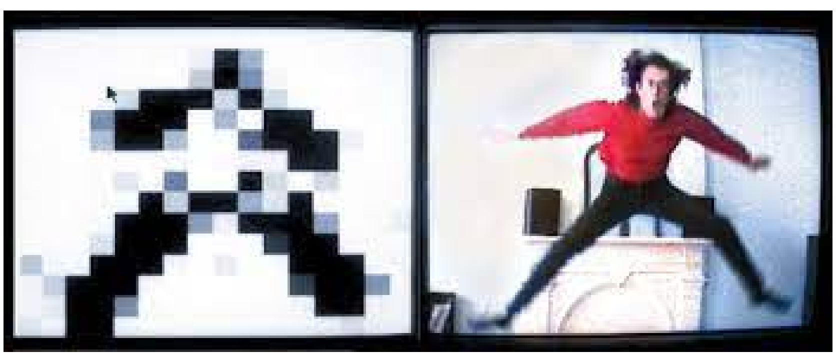

Figure 2.3. David Rokeby's Very Nervous System

The use of interactive systems for augmented dance peaked in the 1990s and 2000s with companies such as Palindrome[7] or Troika Ranch[8]. The Palindrome Company defines itself as a performance group using motion captures technologies for dancers or actors to control music, light, or video projections in real-time. Its founder and artistic director, Robert Wechsler applies his fascination with science and technology to

[7] `http://www.palindrome.de/`

[8] `https://troikaranch.org/`

the art of dance. The dance company Troika Ranch was founded by Mark Coniglio and Dawn Stoppiello with the goal of using interactive systems on stage. They developed a motion capture system called MidiDancer and a software platform called Isadora to control light, music, or video with the movements of the dancers in real-time.

Figure 2.4. Palindrome's piece Talking Bodies (2005)

Following that, several augmented dance experiments have appeared using tools including 3D motion capture, avatars, abstract rendering simulation, robotics, or image processing. For example, in 2000, Susan Kozel used motion capture in her performance Contours [9]. She used infrared cameras and translated kinetic information derived from the movement of dancers in real-time into digital images [Kozel, 2007]. Depending on the case, the digital image can be seen as an interactive scenography or as an abstract element of the show creating a duet and a dialogue with the dancers. This idea of a visual duo is also present in the work of choreographer Trisha Brown who collaborated with digital artists Paul Kaiser, Shelley Eshkar, and Marc Downie in 2005 for “How long does the subject matter linger on the edge of the volume" [10]. They developed a system that uses data from 3D motion capture to nurture agents' behaviors and generate dance partners in the form of semi-autonomous interactive abstract visuals. The company's motivation in employing motion capture as well as the generative agent was its capacity “to weave the movement, music, and visual elements into one beautifully integrated design. Brown's multi-media collaboration [...], through its exhilarating amalgamation of dance, music, and set,

[9] http://www.meshperformance.org/contourtext.html

[10] https://trishabrowncompany.org/repertory/how-long-does-the-subject-linger-on-the-edge-of-t html?ctx=title

challenges the future of dance presentation."

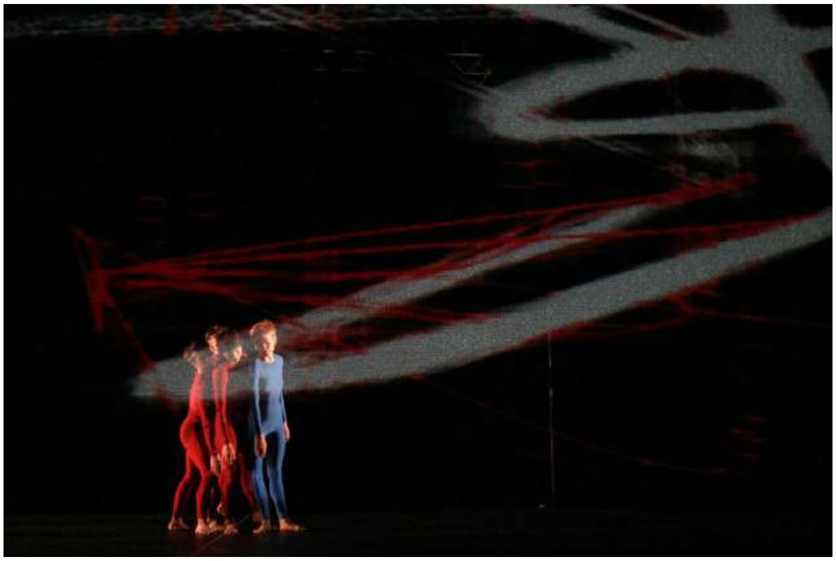

Figure 2.5. Trisha Brown, in collaboration with Paul Kaiser, Shelley Eshkar, and Marc Downie, created the augmented performance, "How long does the subject matter linger on the edge of the volume"

Inspired by these major figures in dance, there has been a multitude of artistic initiatives that integrated digital and interactive visuals or sonic artifacts as scenography on stage, such as Australian Choreographer Gideon Orbazanek [11] or the French company Adrien M Claire B [12]. The latter famously use images and particle systems as "trompe l'oeil". They claimed: "We want to deform perception, blur the lines between what is true and what is false, cross the daily boundaries of reality, and reveal things that are not possible (i.e., through interactive digital visuals on stage). [...] the quest for illusion."

[11] http://www.frieder-weiss.de/works/all/Mortal-Engine.php

[12] https://www.am-cb.net

2.2 Technology for dance documentation

Besides its use on stage, technological augmentation in dance has also aimed to support notation, annotation, documentation, or archiving of the artwork. These kinds of applications are what brought me into this work when I discovered the early collaborations between Frédéric Bevilaqua and Scott Delahunta. Very early on in my work, I was aware that dance is challenging to document because it encompasses a complex and tacit form of embodied knowledge. Too much is going on when one is dancing. The body performs a movement in an embodied way that is often hard to describe, articulate, or even decompose fully [Noë, 2004, Wilson and Foglia, 2013, Varela et al., 2016, Purser,

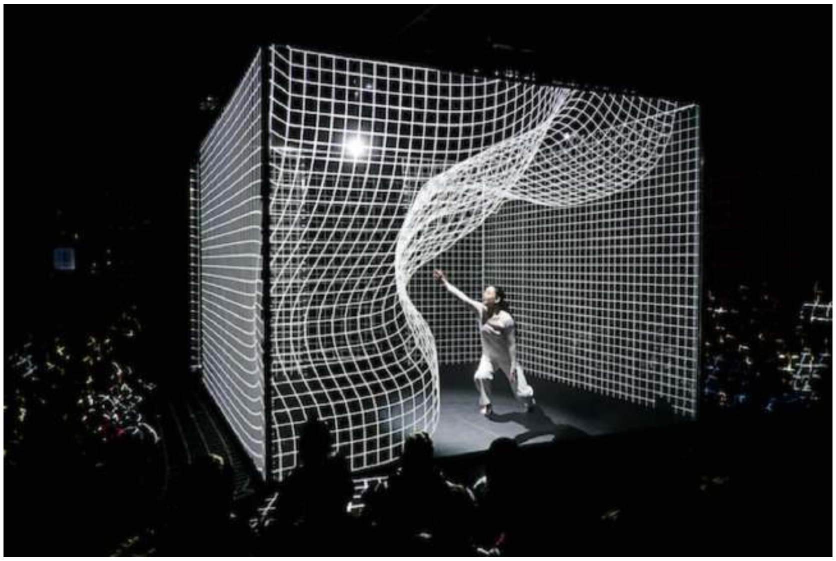

Figure 2.6. Augmented performance Hakanai by Adrien M Claire B

2018]. Additionally, dance scholars have described dance as being an ephemeral form. A dance show happens on stage and as soon as it is over, nothing is left of it. In the best-case scenario, it is captured through video. Dance is thus often perceived as a metaphor for life, constantly changing from one piece to another, leaving no tangible trace after the show [Delahunta and Shaw, 2008].

Up until now, dance has mainly been recorded through video, resulting in an unimaginable quantity of dance videos currently available on streaming websites such as YouTube or Vimeo. Few major dance companies use notation systems such as Laban [Guest, 2005] or Benesh [Benesh, 1969] notations to archive their repertoire. But neither video nor dance notation systems do it justice. Mere video recordings do not inform on aspects such as cultural context, movement qualities, or kinaesthetic sensations, among others. Formal systems such as Laban or Benesh notations impose a standard language to characterize movement that emphasizes certain aspects of it and ignores others. In fact, these notation systems, unlike the ones used in Western music, remain rarely used by choreographers and dancers because they do not adapt well to the practitioners' approaches to movement. They also require too much time to write or read the score, time that the practitioners don't have or can't afford to spend on documentation.

For all these reasons many dance scholars have been grappling with the following questions: What are the ways in which dance can be documented and therefore preserved and archived? What models should be adopted in order to codify dance? What level of detail is needed to describe it? The gesture, the rhythm, the phrasing, the sequence, or the whole piece? Beyond video, how to capture characteristics that are essential to dance that may not be visible on video (intentions, movement qualities, etc)? How to manage the substantial amount of information contained in dance due to its complexity and embodied nature?

In the literature, the problem of the codification of dance movement remains an open question. Several academic projects have addressed this question and no methodological consensus has yet been found [Camurri et al., 2016]. Essentially, there have been two main divergent approaches to tackling this question. The first one employs the Laban Movement Analysis (LMA) framework as a general "universal" way to analyze movement. The second one is based on studying the specific vocabularies of a single choreographer. The latter have produced extensive documentation and archives in the form of CD-ROMs, DVDs, websites, articles, or books. I have been tempted by both approaches and worked on the specificity of a single practitioner and looked at the possible universality and generalizability of LMA. Both approaches have shown interesting results but also technical, empirical, and ethical limitations. I will reflect on the opportunities and limitations of these two approaches later in this manuscript.

The questions about how to document dance have allowed the emergence of burgeoning technological experimentations that have evolved since the 1990s into experiments with more elaborate technologies such as motion capture, video augmentation, and interactive animation to document notable choreographers' practices. DeLahunta and Shaw offer an in-depth reflection on the use of digital technologies to address the dance documentation problem [Delahunta and Shaw, 2008].

In the literature, there are many systems that target specific choreographers' approaches to movement. Among them, I can cite Christian Ziegler's CD-ROM "Improvisation Technologies" [13]. It aimed to present, in a pedagogical way, the essential principles of the improvisation techniques of choreographer William Forsythe. This CD-ROM provides graphically enhanced demonstrative images and videos with geometric elements. From the same choreographer, the piece "One Flat Thing Reproduced" was studied by Palazzi et al. who developed the Synchronous Object website[14]. In the interactive website, videos of the show are augmented with visualizations of clues and impulses that are communicated between dancers and reveal the choreographic struc-

[13] http://www.movingimages.de

[14] http://synchronousobjects.osu.edu/

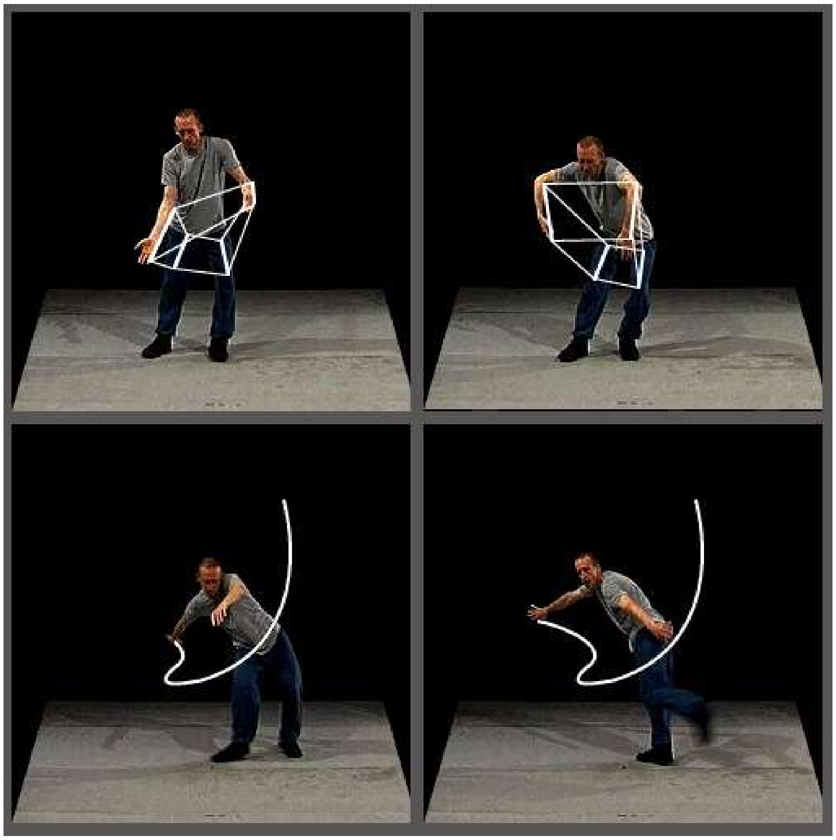

Figure 2.7. The CD-ROM improvisation technology augmenting videos of William Forsythe for pedagogical purposes

tures of the piece [Palazzi et al., 2009]. Choreographer Bud Blumenthal developed a website called "DANCERS!" that includes a database of short improvised choreographic sequences performed by several choreographers or dancers. Tardieu et al. have contributed to the website through a navigation tool with an automatic classifier that clusters performances according to their styles using computational criteria derived from the analysis of the dances through gestural descriptors [Tardieu et al., 2010].

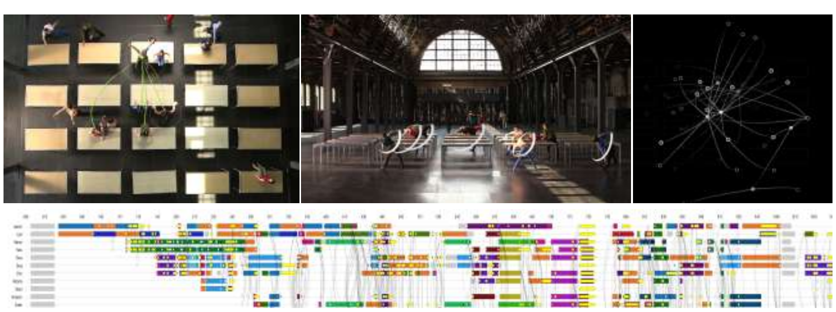

Figure 2.8. The Synchronous Object website proposes augmented visualizations revealing the choreographic structures of William Forsythe's piece One Flat Thing Reproduced.

The Emio Greco | PC dance company has investigated the question of the documentation of their dance vocabulary for almost 10 years. They initiated a first project to use new media as a potential way to document their repertoire. The result was the book and DVD-ROM "Capturing Intention" [deLahunta, 2007], The very same book that I read that introduced me to this multi-disciplinary field. The project provided, for each element of the vocabulary studied, linguistic descriptions, Laban and Benesh notations, and demonstrative video extracts. The company continued with a second project that they called Inside Movement Knowledge, to which I contributed[15]. Various disciplines (with their specific tools) such as linguistics, dance notation (Laban and Benesh), motion capture, and sound and graphical synthesis, were involved in this project with the case study of the company's workshop Double Skin / Double Mind (DS / DM). The project aimed to describe, record, and document the vocabulary of the workshop using text and digital media. For example, the project produced a comprehensive and detailed glossary qualitatively describing the vocabulary of DS / DM [Fernandes, 2010]. It also produced an interactive installation, also called DS / DM, that used interactive technologies to transmit the workshop to dancers and dance students. I contributed to the design and development of the DS / DM interactive installation [Fdili Alaoui et al., 2013] during my Ph.D. Along with a team of designers and computer scientists, we followed an ethnographic method where we studied the vocabulary of the company and used the glossary that they made to design the interaction. Moreover, we built upon the multi-disciplinary knowledge provided by the other disciplines in the project, including Laban notation. I was interested in the notion of movement qualities and how Emio Greco articulated them. I studied the movement qualities of the company in order to design the interactive system. The installation allowed the dancer to follow the DS / DM workshop with voice and video instructions given by Emio Greco. The dancers could perform the movement according to these instructions, and their movements were captured by a video camera and analyzed in real-time by a gesture recognition algorithm. An interactive visual and sonic feedback would then be given to the dancers to indicate how the machine "reads" their movements and the concordance between what they performed and the vocabulary of the company. The installation had dual goals: it was made to document the movement repertoire of the company, but it also had a pedagogical goal of teaching outside dancers the inside knowledge of the company.

[15] http://www.ickamsterdam.com

The Transmedia Knowledge-Base for contemporary dance (TKB)[16] is another example of a project where researchers developed a multimodal video annotation tool for contemporary dance [Cabral et al.,

[16] https://tkb.fcsh.unl.pt

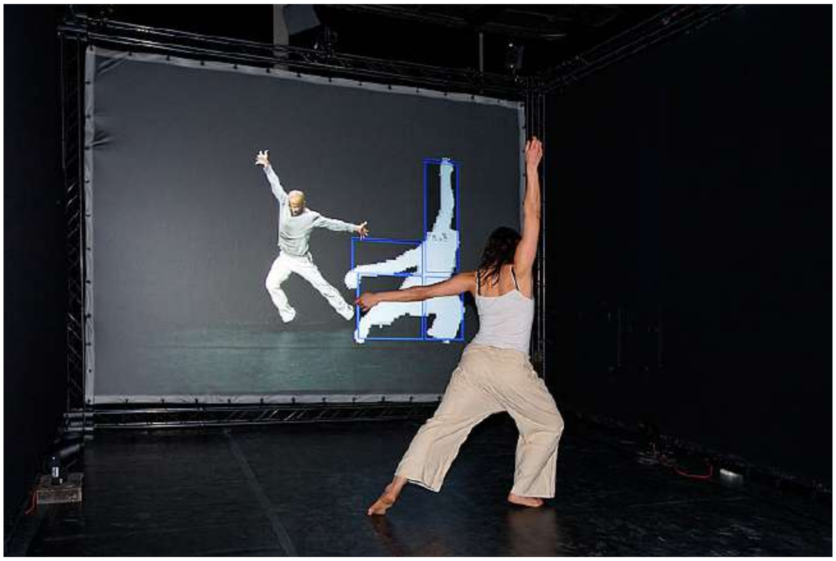

Figure 2.9. The interactive installation DS / DM designed with the company Emio Greco | PC

2011]. This tool was designed with and for choreographer Rui Horta to assist him during his compositional process. This tool has also been used for the documentation of his dance repertoire [Fernandes, 2013]. The project's researchers set out to microscopically document some of the choreographer's works using methods and software used in linguistics and through the annotation tool that they developed. The linguistic methods upon which their results are based are the same (in part) as those used by the dance company Emio Greco | PC to develop a detailed glossary of their choreographic elements [Fernandes, 2010].

Figure 2.10. The website Motion Bank provides a platform to document the choreographic knowledge of choreographers such as Thomas Hauert and Bebe Miller.

A multi-disciplinary group called Motion Bank[17] has formed around choreographers such as William Forsythe or Deborah Hay. Guided by Scott DeLahunta's research, Motion Bank, which is still active to

[17] `http://motionbank.org`

date, explores ways to develop online digital scores and related choreographic resources produced by and with the choreographers [deLahunta, 2016]. The idea is to use technologies such as motion capture and movement visualization to invent new ways of documenting, explaining, and revealing the choreographic process. This is embodied in a set of choreographic resources and publications that use online text, images, and videos as well as a digital annotation platform for documenting the movement.

The examples that I gave above are of projects that are highly interdisciplinary, bringing together artists, scholars, and scientists to invent new ways of archiving dance through digital technologies. Although these research consortia were a great source of creativity and innovation in dance, they did not yield results that had an impact on the dance field as a whole. Apart from the video documentation of the resulting artifacts produced that dancers can find on YouTube or on the projects' websites, the computational archives all emerged from heavy platform deployment that is difficultly accessible to the public. The scale of these experimentations is what made them scarce and hindered their adoption by dance artists outside of their research consortia. Indeed, because they involved a large number of academics, large technological platforms, and substantial funding, they could hardly be replicated or applied to other artists' work.

Retrospectively, I also started questioning the interventionist nature of the methods deployed, relying on outside expertise to document inside knowledge. It would be interesting to co-develop systems that would encourage the practitioners to find easy ways to document their dance on their own, rather than relying on designers, developers, notators, or linguists to do it for them. What would that look like? What would be the role of the researcher in projects where the technology would give such agency and responsibility back to the practitioner? This is one direction that I aim to pursue in the near future and for which I have received funding from the Agence Nationale de la Recherche in 2021.

2.3 Systems for supporting creativity in dance

Most development of interactive systems for dance that intervene either on stage, in composition, for learning, or for documentation, falls under the category of what researchers call creativity support tools (CSTs). These tools are designed to support practitioners, particularly choreographers, in creating and transmitting their ideas [Shneiderman, 2000]. A complete literature review of the past twenty years of CSTs in HCI is available in [Frich et al., 2018].

In the context of dance, CSTs usually focus on allowing kinaesthetic creativity to unfold and supporting the generation of creative ideas in the choreographic process through the use of interactive technologies. In this quest, choreographic and dance practices are often presented as a challenging design space because they are made of personal and idiosyncratic methods as well as non-linear and messy processes [Ciolfi Felice et al., 2016, Fdili Alaoui, 2019, Hsueh et al., 2019a].

Figure 2.11. Lucinda Childs' postmodern dance piece "Carnation"

Choreography is usually defined as the crafting of movement [Cvejic and Keersmaeker, 2015]. Like other compositional processes, it is a complex creative practice that explores a variety of formal and personal procedures that can lead to a unique artistic creation [Blom and Chaplin, 1982]. When choreographers are provided with technologies, they sometimes respond with a fascination for the creative possibilities that they allow. Other times, they resist the idea of a technological intervention or delegating their choreographic thinking to a "machine". In my many experiences collaborating with choreographers to understand the potential of technology to support the choreographic process, I saw in their responses an openness to reflect on the use of technology even when it was not adapted to their practice. Oftentimes, a technology that was not designed for a specific practice can still prove its potential to accidentally provide inspirations for the creative space to be renewed. This is similar to the experiments done in the 70s where even random everyday objects sparked the creativity of the post-modern Judson Church choreographers. Between 1963 and 1966, Lucinda Childs created thirteen pieces that could be seen somewhere between performance, sculpture, and daily rituals, where she used mundane objects of everyday life as dance probes. Yvonne Rainer reports on the feeling of strangeness to see this woman engaging in these operations with her body, as in the famous performance "Carnation" where she morphs into ready-made decorated with household objects (see picture 2.11). For Lucinda Childs, these pieces were experiments aimed at freeing oneself from the academic way of making dance while questioning the theatrical space and rejecting the usual trend of "spectacular" dance. She showed compositional rigor through the use of repetition and accumulation of elementary actions as bases of composition. Lucinda Childs, Yvonne Rainer, and other pioneers of post-modern dance used external random objects and sometimes technologies (in the case of Merce Cunningam or Trisha Brown) to invent new dance forms and languages. In fact, they experimented with anything at hand. I argue that just like post-modern choreographers re-appropriated all kinds of objects, contemporary choreographers re-appropriate all kinds of digital systems creatively.

The fact that creative people do creative things with objects or technology does not prove that these artifacts are suitably designed to support or enhance their creativity. If you take creative people, they will make creative things with a system no matter what the system affords. A good example of that is all the experiments that emerged from using particle systems and asking dancers to move in front of them. Most of the people conducting these experiments argued that their systems sparked dancers' creativity and made them move in interesting fashions when all they proved was that dancers are creative no matter what they are given and that they are always capable of imagining interesting ways of moving. I plead guilty, having given dancers particle systems to dance with in the past. This trend also showed how a field (computer science) was comfortable exploiting the creativity of another field (dance) to motivate its agenda for pushing forward a specific technology (particle systems) that none of the dancers asked for to start with. I will cite the personal response of Kate Sicchio, a colleague, dancer, and developer from Virginia Commonwealth University, who once tweeted: "STOP MAKING DANCERS MOVE IN FRONT OF YOUR INTERACTIVE PARTICLE SYSTEM. It's so stale at this point. I just can't anymore."[18]

[18] https://www.sicchio.com

The proliferation of particle systems in experiments around CSTs in dance is further proof of how these systems were designed according to the technologies that were “trendy" at the time. They were also designed according to their developers’ understanding of movement and creativity which in most cases did not fit the practitioners’ approach nor their desires or needs. There are just too many systems in the literature that provide elaborate visualizations of dancers’ bodies based on some motion capture data that nobody asked for except the developer who thought it was a good idea to develop them. These systems are usually not designed with practitioners, nor are they fully assessed by them [Jürgens et al., 2021]. Moreover, their design is full of hidden assumptions about what dance practitioners do, like, or need that have nothing to do with reality.

If I look back into all existing CSTs for dance in the literature, there are very few that served practitioners in the field, supporting their methods and creative vision. The system that comes to mind that was developed originally to support a specific choreographic use was LifeForms. It was tailored for Merce Cunningham’s choreographic writing. It is one of the first choreographic assistive software designed by Thecla Schiphorst and her colleagues. The idea behind it was to feed the choreographic work of Merce Cunningham through the generation of sequences of fixed postures [Schiphorst et al., 1990, Schiphorst, 1993]. LifeForms animated a skeleton in 3D and generated postures and sequences that Cunningham asked his dancers to reproduce. These postures were not always realistic nor biomechanically reproducible, which appealed to Merce Cunningham and repelled his dancers.

The same researchers, years later, explored choreographic writing methods such as those disrupting habits [Carlson and Schiphorst, 2013]. The argument behind such exploration is that there are strong cognitive overlaps between movement processes, decision-making, and creativity that can provide unique opportunities for designing technologies to support choreographic creativity. They observed that current systems for dance usually use computers to accompany the scenography of the performance (background video, lighting, and sound) and that although these uses necessarily have an impact on choreographic decisions, choreographers often respond to these external constraints with a stronger use of their own habits [Carlson et al., 2019]. Researcher and dancer Kristin Carlson in particular focused her doctoral work on technologies that enable computers to be engaged in the choreographic process to influence habits and style, divert attention from particular aspects of the experience, and propose new

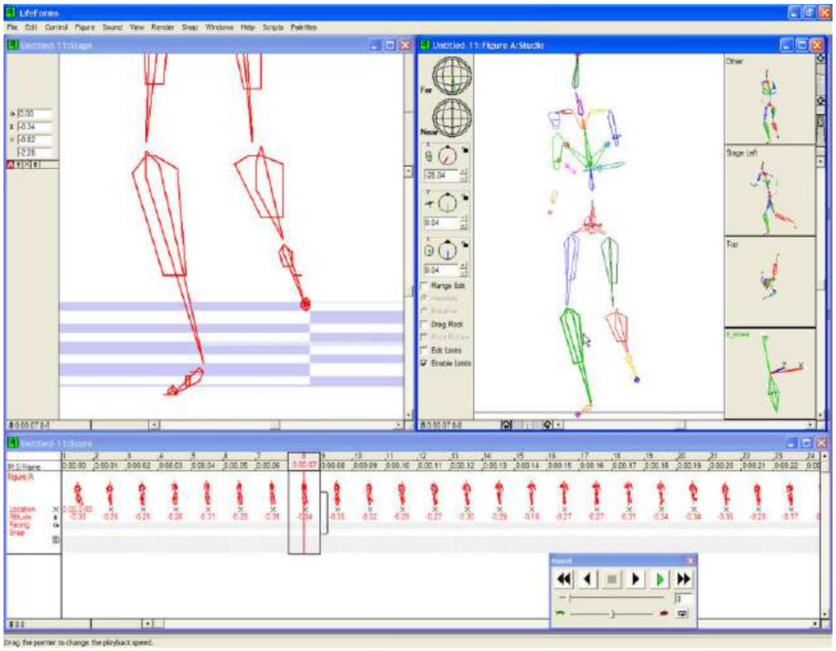

Figure 2.12. LifeForms created with and for Merce Cunnigham to support his choreographic process

choreographic choices. Her work is based on a technique called "defamiliarization", introduced in HCI by Lian Loke under the name of "making strange" [Loke and Robertson, 2013b]. By making the familiar a strange material, technology is used to bring a new awareness of known practices, and thus destabilize the choices of the choreographer and dancers. This form of "disorientation" encourages the choreographer to engage in a scenario of reflections, analysis, and evaluation of a given situation in order to propose unfamiliar improvisations generating new choreographic material. This principle underlies the design of the improvisation system called "Scuddle", developed and used by Kristin Carlson [Carlson et al., 2011].

Analogous to this approach, DaNcing is a system that generates sets of rules resulting in sequences of dance steps represented as superimposed ASCII symbols. The system uses a series of music-related parameters, rules, and a predefined library of traditional movements to generate syntactically correct waltz choreography using a genetic algorithm [Nakazawa and Paezold-Ruehl, 2009]. The dancer then receives a printout of the spatial steps from the system. "Web3D Composer" is another system that creates sequences of ballet movements based on a predefined library of movement material, as a tutoring tool for ballet students [Soga et al., 2006]. The system allows the choreographer to select movements from a pool of possibilities based on structural ballet syntax using a markovian probability algorithm. The beginning and ending positions of each movement are cataloged so that the system can choose a sequence based on transition possibilities for the dancer. "Viewpoints AI", a system developed by Jacobs and Magerko using the SOAR cognitive framework, captures and manipulates improvised movement based on the Viewpoints approach [Jacob and Magerko, 2015]. It plays back the movement after being manipulated, by repeating the movement, transforming it, reversing it, etc. Finally, another example of a system that interacts cognitively with dancers is the 3.5-meter tall robot spider that was developed by Wallis et al. to act as a dance improvisation partner by exploring themes of composition, embodiment, and play [Wallis et al., 2010]. The robot is suspended in the air and is controlled using information gathered from multiple sensory inputs. The robot follows four interaction scenarios: mimic, follow, oppose and innovate. This work addresses habits by revealing the dancer's own habitual patterns through the robot who reflects these movement preferences back to the dancers in its own movement.

It is true that such literature in HCI shows an encouraging history of CSTs applied to dance and choreography. However, many of these successful experiments are specific to superstars in dance such as Emio Greco or William Forsythe who can afford to gather massive groups of academics and developers to investigate their choreographic approach and vision. The other types of experiments are those driven by computer science labs whose researchers care about their technologies. Their goal is first to develop a tool and then to present a proof of concept to their computing communities. When a dancer tries their system and succeeds in the task originally targeted by the tool during a lab experiment, the tool is considered to be evaluated and assessed. This type of artificial context with an artificial task validates the systems as supporting practitioners' performance. But we can see that there are just too many biases and assumptions in such approaches. That certainly explains why most experiments that are born in research labs never percolate into the broader field of dance, in classes, or in rehearsal studios.

The other reason why CSTs somehow fail to convince the broader dance field is the fact that there are very few commercial systems that emerged to support dance because dance is a niche market with low economic potential. Traditionally, computer science is an applied discipline whose impact, relevance, and development are closely related to that of industry. And an application field such as dance that does not appeal to industry would stay in the academic community as the focus of marginal researchers who are passionate about the subject. The exceptions to that include major dance figures such as Wayne Mc-

Gregor whose collaboration with Google magnifies the results of the company's latest innovation in AI. In other words, innovating with technology in dance mostly emerges in academic labs. This surely doesn't produce robust and usable CSTs that practitioners can have access to. As a result, dance studios do not include technologies other than video cameras in addition to paper to record dance, take notes and sketch personal scores.

Over the past 3 years, the early experiments with intelligent systems that I mentioned in the previous paragraphs found a new beginning. A new generation of CSTs appeared and made use of the rapid rise of artificial intelligence and particularly deep learning. Beyond designing to facilitate task-oriented interaction through specific functionalities, these CSTs moved towards adding intelligent features. More emphasis was put on augmenting CSTs with features that can support system collaboration via an intelligent autonomous system. The trend became to explore generative systems that produce creative results autonomously or that behave as a creative agents in a collaborative process with a practitioner. To illustrate this trend, I can cite the massive collaborative experiment between Studio Wayne McGregor and Google Arts and Culture Lab called Living Archive[19], released in 2019. It is a tool for choreography "powered" by deep learning. The tool is trained on the repertoire of McGregor's movements and generates new movement sequences that are inspired by it, creating a "live dialogue between dancers and his body of work". It is based on the latest deep learning experiments developed by Google that perform sequence generation and that can reproduce the style developed by the choreographer. Wayne McGregor said, in Wired magazine[20]:

[19] https://artsexperiments.withgoogle.com/living-archive

[20] https://www.wired.co.uk/article/google-ai-wayne-mcgregor-dance-choreography

> I wanted to make use of this massive archive of work in an interesting way, so I asked Damien [technical program manager at Google's Arts & Culture in Paris] if he could use it to generate something new. It all goes down to the same question that is crucial in choreography: how do you keep creating fresh content?

While the discourse of how much technology enables creativity to unfold is thriving in engineering and computer science environments, I have doubts about the impact that such technologies and particularly artificial intelligence, have on the "democratization and escalation of creativity" where "anyone can write at the level of Shakespeare, compose music with Bach, and paint in the style of Van Gogh" [21]. These same narratives have been propagated by the World Economic Forum, which recently published a report [Forum., 2018] on the impact of AI in the creative sector, providing a timeline where AI will autonomously manage to perform complex tasks such as composing pop songs, gen-

[21] https://medium.com/@creativeai/creativeai-9d4b2346faf3

Figure 2.13. Living Archive experiment between Studio Wayne McGregor and Google Arts and Culture Lab

erating creative videos or writing a bestseller book.

Dance is no exception. It inspires discourses that hand out a special power to technology as empowering and augmenting dancers and performers or even autonomously doing their job. Such discourse on technological enhancement is due to the over-enthusiasm and tech chauvinism that is burgeoning in specialized media and Silicon Valley-type cultures [Bardzell and Bardzell, 2013]. Applied to art, technology is expected to allow for the emergence of what seemed like a new form and aesthetics and even a new art discipline. The origin of this discourse dates back to when computer science researchers and technological innovators applied technologies to enhance the home and work contexts. These academic and business-oriented communities are closely connected economically, politically, and philosophically. Their main advocates see themselves as the "heroes" of the current era, solving people's issues and assuming that users are weak or inefficient and technology is the remedy that will enable them to live comfortably, work efficiently and express themselves in times of leisure [Blythe, 2017]. This would also casually generate income and create jobs. We know now that technology does not act neutrally as an enabler only. It rather operates on a series of value systems, biases, and economic and political agendas [Broussard, 2019]. We also know that as much as technology empowers, it also disempowers, and examples of the use of technologies in surveillance or political manipulation, among others, do not dry up.

In their article, MacCallum and Naccarato argues that the intersection between computation and dance suffers from one voice necessarily taking over the other [MacCallum and Naccarato, 2019]. They argue that knowledge and ideas suffer from a degree of loss when they are translated from art to computation, for example, in order to be made visible through the lens of the second discipline's discourse, which creates tensions related to one discipline dominating the other. Mark Coniglio's question then remains: "Why would one want to create such artworks (i.e. digital performance) in the first place?" I would add to that: How does the integration of technologies in dance operate? What type of opportunities, understandings, tensions, and discourses emerge from such integration?

These questions are at the core of the dance-led research that I have been doing for the past ten years. I hope to provide some honest reflections and thoughts on how these questions led my inquiries and the motivations that I had in looking at the crossroads of two fields, such as dance and HCI.

3

A system for movement modeling

As I said in the previous chapter, I have explored the two approaches to characterize dance movement, the one based on studying the specific vocabularies of choreographers and the one that employs the Laban Movement Analysis (LMA) framework as a general "universal" way to analyze movement. For the two years that I spent in the MovingStories project in Vancouver as a post-doctoral fellow, I focused on the possible use of LMA as a generalizable system to articulate movement, particularly dance movement. Thecla Schiphorst funded my training to become a certified Laban Movement Analyst (CMA). This allowed me to dig into LMA and use it in computational methods to analyze movement and study its reliability. This chapter is dedicated to my experiments and design process involving LMA as a system for analyzing movement.

3.1 Laban Movement Analysis

I started my postdoctoral research in HCI, looking at ways to model dance movement. I was interested at the time in finding scientific ways to describe dance and characterize it. I thought that I was expected to produce science and therefore seek generalizability as one of the main values of my research. So, I was interested in developing technologies that can be seen as general tools that all choreographers can use to analyze their repertoires and create mappings between semantic units of movement that they invent and other media such as sound, visuals, or light. The underlying assumption here is that there must be something common to all dance artists in modern and contemporary dance. Just like musicologists have attempted to find common patterns that can provide a universal vocabulary that describes any music produced in western cultures, dance should attempt to formalize a common vocabulary made of movement units that compose the basis of modern and contemporary dance.

The most renowned framework that I found that aims at describing movement, and dance movement in particular, is Laban Movement Analysis (LMA) [Laban, 1975]. This framework was invented by Rudolf Laban, a movement theorist and choreographer [Laban and Lawrence, 1947]. LMA has a rich history of being applied to various disciplines, including psychology [Levy and Duke, 2003], sports [Hamburg, 1995], and STEM areas such as HCI [Maranan et al., 2014], and Human-Robot-Interaction [LaViers and Egerstedt, 2012, Masuda et al., 2009., Lourens et al., 2010]. During my two years in Vancouver as a post-doctoral fellow at the MovingStories project, I followed a training in LMA with the Laban and Bartenieff Institute of Movement Studies, both in New York City and in the Belgian countryside. I soon discovered that LMA was not only a theory that describes movement, nor was it viewed in the same way as practices that are primarily somatic such as Alexander Technique or Feldenkrais. It has a broader scope because it provides a rigorous use of language to analyze movement based on experiential knowledge. It bridges both theory and personal intimate kinaesthetic experience. It allows its practitioners to develop a personal somatic knowledge of movement and to describe movement according to various “objective” analytical categories. The training consists mostly of somatic work during which one experiences the categories of LMA through movement, as well as a few theoretical and historical lectures. The training also provides methods to perform observations and analyses of movement. To analyze movement, LMA training teaches students to attune to it and to use their own body as a lens through which to recognize the patterns of change that best describe it according to LMA categories. Many classes consist in observing videos of people’s movements, analyzing them according to the LMA categories, and notating them with the symbols of Labanotation (or a simplified version of that called Motif Writing) [Guest, 2005].

While most of the knowledge is framed within defined categories of movement, the method to acquire such knowledge is based on somatic and experiential practice where students experience and articulate movement patterns according to LMA categories with their own body.

In LMA, movement is observed as a pattern of change that occurs in terms of four components, defined as Body, Effort, Space, and Shape (referred to collectively as BESS):

Body represents *what* is moving. The Body category in LMA describes the body parts, and body actions responsible for the movement. Body parts are a sub-category that describes the parts of the body that are responsible for movement. Actions are another sub-category of Body that describes specific actions and gestures that can be performed.

Effort represents *how* the body is moving. LMA considers Effort to be what can be observed and experienced in terms of the shift that reveals the mover's attitude and intent, as well as how the mover exerts and organizes their energy [Laban and Lawrence, 1974]. Karen Studd, one of the main educators in my LMA training, describes Effort as "the dynamic or qualitative aspects of the movement. Dynamics give the feel, texture, tone, or color of the movement and illuminate the mover's attitude, inner intent, and how they exert and organize their energy. Effort is in constant flux and modulation, with Factors combining together in different combinations of two or three, and shifting in intensity throughout the progression of movement" [Studd and Cox, 2013]. Effort encompasses four Factors: Weight, Time, Space and Flow [Laban, 1975]. Space is related to how the mover orients their attention to the environment, Time encodes the mover's sense of urgency, Weight encodes the mover's impact on the world and Flow captures the mover's attitude toward bodily control [Bartenieff, 1970]. Each Effort Factor is a continuum with two opposite ends referred to as "Elements" (Space: Direct/Indirect, Time: Sudden/Sustained, Weight: Light/Strong, Flow: Bound/ Free), while "Effort qualities" indicate where a movement lies on the continuum between these poles (See Figure 3.1).

Space represents *where* the body is moving. LMA formalizes the Space component by modeling space in what is called the "Kinesphere", i.e., the volume defined by the 27 reaching possibilities of the limbs in the 3-dimensional Cartesian space with oneself at its center as shown in figure 3.2. We can move in a Far Reach Space using large movements, in Near Reach Space by moving close to ourselves, or in between (Mid Reach Space). Laban also defined different zones in the Kinesphere in which movement can occur: Up, Down, Forward, Backward, Side-Open, and Side-Across.

Shape represents the *relationship* of the body shape and how it changes in the environment. It describes the change in the body's form. Within

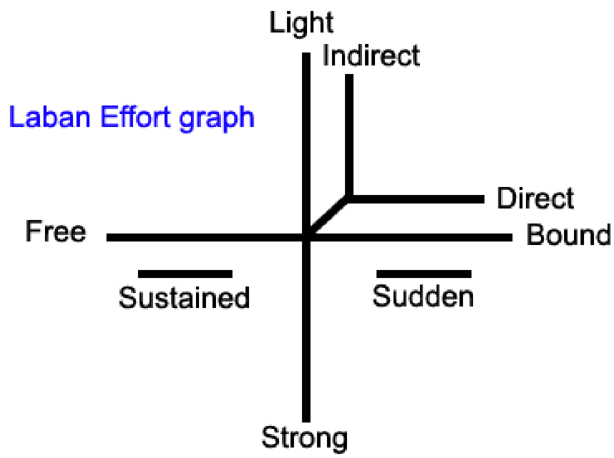

Figure 3.1. A diagram showing the Effort Factors with two opposing Elements

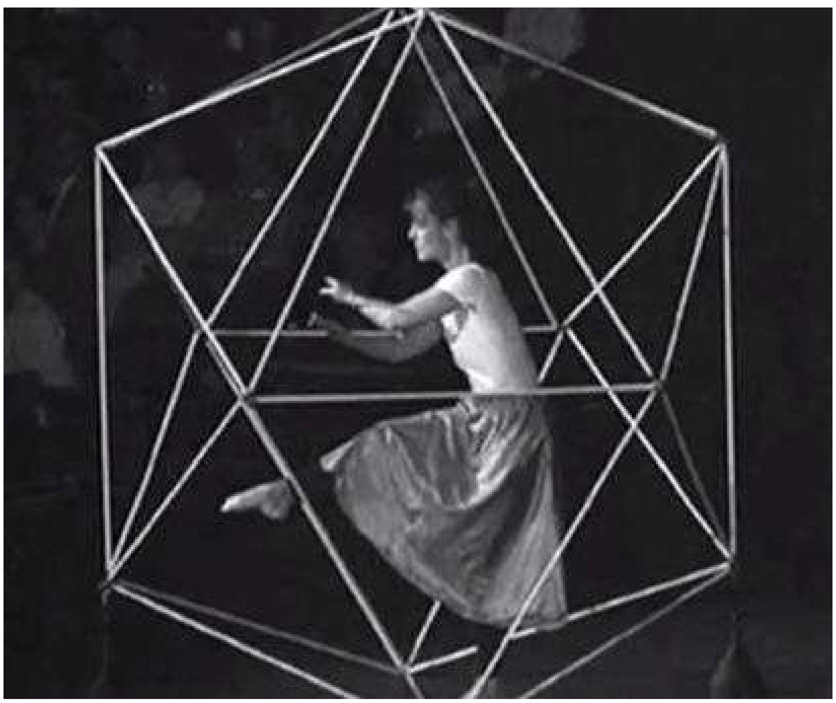

Figure 3.2. A dancer exploring the 27 directions of the Kinesphere

the Shape category, the Shape Qualities are related to the sensation, experience, and articulation of the Inner Space of the Body. Shape Qualities can be described with a horizontal change (Spreading or Enclosing), a vertical change (Rising or Sinking), or a sagittal change (Advancing or Retreating).

Additionally, LMA defines the meta-category of Phrasing. It represents the rhythm of the action. This category looks at what aspect is emphasized in movement and how this contributes to its perceived meaning. It corresponds to where the emphasis is placed in the phrasing of the movement. Impulsive Phrasing encodes an emphasis at the beginning of the phrase, while Swing Phrasing denotes an emphasis in the middle of the phrase. An emphasis in the conclusion of the phrase corresponds to an impactive movement.

3.2 Related works using movement and embodiment in human-computer interaction

3.2.1 Somatic practices in human-computer interaction

Researchers in HCI have developed computational systems to characterize dance movement through LMA. LMA has been chosen by many as a framework in order to favor a standard language to describe movement [Maranan et al., 2014]. Some of the earliest works relying on LMA date back to systems developed at Norman Badler's research group [Bouchard and Badler, 2007, Zhao and Badler, 2005]. These works focused on Efforts and Shape in particular. For example, Chi et al. developed EMOTE, a system that integrates Effort and Shape categories to animate a 3D character using motion capture data with the aim of producing more expressive and natural simulated movements [Chi et al., 2000]. Eyesweb is another notable platform that uses data from video streaming to analyze and classify the expressivity of gestures along the Laban Effort Factors [Camurri et al., 2004]. Mentis and Johansson built a system using the Microsoft Kinect in which users' Effort qualities were used to trigger musical events [Mentis and Johansson, 2013]. Most of these LMA-based recognition systems are applied to designing expressive movement-based interactions. Although not necessarily deployed in real-world contexts, they often suggest potential applications in dance learning or performance [Camurri et al., 2004].

In HCI, movement-based interaction researchers have explored other somatic practices for designing for and with the body. The term "somatics" refers to body-based practices that use a first-person perspective to develop embodied awareness of bodily sensations and capacities as experienced and regulated from within. Schiphorst argues for developing somatic connoisseurship that lays the ground for an aesthetic and embodied appreciation of movement in designing interactive systems through enriched experiences and attention to the self [Schiphorst, 2011]. Höök developed what she calls "soma design", a method inspired by the somaesthetic philosophy of Shusterman. Somaesthetics finds its sources in pragmatist aesthetics and Shusterman's own Feldenkrais practice. It considers "the soma - the living, sentient, purposive body - as an indispensable medium for all perception" [Shusterman, 2008]. According to Shusterman, somaesthetics is the "critical study and meliorative cultivation of the experience and use of the soma as a site of sensory appreciation" [Shusterman, 1999]. Unlike most philosophical schools of thought, it includes both theory and practical exercises that allow designers to cultivate, attend to and ameliorate the soma.

These premises allowed Höök et al. to develop over the years a method for designing interactive systems. Rooted in the interdisciplinary endeavors of somaesthetics, soma design incorporates the embodied lived experiences of both the designers and the users as articulated through their first-person perspectives [Höök et al., 2016, Höök et al., 2018a, Höök, 2018]. To do so, soma design includes various processes such as somatic introspection, meaning "an organized inward-looking inquiry by the individual about their bodily perception and its related affective experiences" [Shusterman, 2008]. It also includes estrangement, where one disrupts habitual patterns and engages with unfamiliar ones –through slowing down, for example – in order to access a large repertoire of experiences [Loke and Robertson, 2013a, Wilde et al., 2017]. Soma design puts the emphasis on somatic experiences at the core of the design decisions taken throughout the process [Ståhl et al., 2022]. Finally, soma design includes inviting others into the design process. This allows the designers to assess whether their own first-person experiences translate to other people's experiences. Sharing and inviting others into the process lets designers critique and reflect on their design decisions, producing knowledge that can benefit others beyond the scope of the specific experiences that their system affords [Ståhl et al., 2021].

Aside from Kia Hook and her collaborators, Loke and Khut also use their somatic practice of Feldenkrais as a method to design technologies that enable users to gain awareness of their inner bodily sensations [Loke and Khut, 2010]. Other approaches accounting for the body in design have also emerged. I can cite move to get moved [Hummels et al., 2007], moving and making strange [Loke and Robertson, 2013a], embodied sketching [Márquez Segura et al., 2016], designing for movement and through movement [Wilde et al., 2011]. In these approaches, researchers have emphasized the role of embodied knowledge and expertise in designing interaction. Most of these works are framed within embodied interaction [Dourish, 2004, Kirsh, 2013], a method for designing interactive systems leveraging on embodied human experiences. Some approaches in embodied interaction spur out of phenomenology [Dourish, 2004] and others out of embodied cognition and its critique of the dualism between mind and body [Kirsh, 2013].

3.2.2 The embodied and phenomenological turn

In this section, I will trace some of the heritage of embodied interaction, starting with phenomenology. Phenomenology is the study of structures of consciousness as experienced from the first-person point of view. The modern founder of phenomenology is German philosopher Edmund Husserl, who rejected the primacy of abstract, decontextualized entities of cognition as present in the Cartesian view of the world. While Husserl had conceived of a progression from perception to meaning to action, Heidegger considered that we originally act in a world that is already organized in terms of meaning and purpose. To illustrate that, he describes the notion of "ready-to-hand" and "present-at-hand". While ready-to-hand describes our relationship to things that are "ready", meaning "handy", present-at-hand refers to our theoretical apprehension of a world made up of objects [Heidegger, 1962]. Merleau-Ponty pushes this view further, claiming that things cannot be separated from whoever perceives them. According to him, "our bodily experience of movement is not a particular case of knowledge; it provides us with a way of accessing the world and the object, with a 'praktognosia' (practical knowledge) which has to be recognized as original and perhaps as primary." [Merleau-Ponty, 2013] Thus he started forming a phenomenological embodied view of perception [Merleau-Ponty, 2013]. Contemporary philosopher Maxine Sheets-Johnstone has linked phenomenological accounts of the moving body to the kinaesthetic sense that she considers vital to our perception. She links perception with the experience of self-movement mediated by the phenomenon of kinaesthesia: "To separate myself into a mind and a body would be to perform a radical surgery upon myself such that a vibrant kinetic reality is reduced to faint and impotent pulp, or excised altogether" [Sheets-Johnstone, 2011].

Embodied cognition, inspired by phenomenology, considers that many features of human cognition are shaped by aspects of the body beyond the brain. It challenges previous views of cognition, such as cognitivism, computationalism, and dualism. There have been multiple approaches that contribute to building the foundations of embodied cognition. One of the most notable ones is Varela's Enactive approach that encompasses the biological, psychological, and cultural context: "By using the term embodied we mean to highlight two points: first that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological and cultural context" [Varela et al., 2016]. Another approach that contributed to embodied cognition is the extended mind theory, which extends the cognitive process beyond the brain and the body outward into the agent's world [Clark and Chalmers, 1998]. Situated cognition, on the other hand, emphasizes that this extension is not just a matter of including resources outside, but stresses the role of the agent in interacting, probing, and modifying their world. Lucy Suchman's work at Xerox Labs was fundamental to show how the agent's understanding of how to perform an action results from reflecting on their interactions with the social, material, and technologically-mediated situation in which they act. In her book "Plans and Situated Actions", Suchman shows the flaws in the view of human action as one based on a planning model. She provides an alternative view of understanding human action as situated, meaning "taken in the context of particular, concrete circumstances" [Suchman, 1987]. Another theory that emerged from the embodied turn and that has been particularly generative in HCI is that of Gibson's affordances. Gibson considers that visual perception is located in the relationship between the person and their environment [Gibson, 2014]. This gave birth to the notion of "affordances" as properties of the environment that afford action to individuals. Finally, distributed cognition is another theory that HCI researchers have also used. It views "a collection of individuals and artifacts and their relations to each other" as a fundamental unit of analysis [Zhang and Norman, 1994]. It emphasizes how cognition is off-loaded into the environment through social and technological means.

Embodied interaction derives directly from these theories of embodiment. It engages the body in interaction with technology, going beyond traditional design methods that have privileged language and logic solely [Dourish, 2004, Kirsh, 2013]. According to Paul Dourish: "when I talk of 'embodied interaction', I mean that interaction is an embodied phenomenon. It happens in the world, and that world (a physical world and a social world) lends form, substance, and meaning to the interaction." [Dourish, 2004]. Kirsh summarizes key principles that describe how humans interact with tools in an embodied way. These principles can be seen as guidelines for HCI researchers designing embodied interactive systems [Kirsh, 2013]:

- Interacting with tools changes the way we think and perceive.
- Tools, when manipulated, are absorbed into the body schema, and this absorption leads to fundamental changes in the way we perceive and conceive of our environments.
- We think with our bodies.
- We know more by doing than by seeing
- There are times when we think with things.

3.3 Studying movement observation in design

In an early study that I did during my post-doctoral fellowship within the MovingStories project, I was interested in understanding ways in which movement was articulated in the design of embodied interactions. There seems to be a gap between the experiences that I was having as I was training as a Laban movement analyst, feeling my body and putting words onto those experiences, and what I was able to inspire in the design of technologies. Looking at the literature, I became convinced that the other researchers within HCI that inspired me also lacked ways to describe, translate and apply their movement experience to their design process [Dourish, 2004]. To identify this gap and understand how to bridge it, I interviewed three design researchers, namely Kia Höök, Georges Khut, and Helena Mentis, that organized the CHI2014 panel titled "Designing for the Experiential Body" [Mentis et al., 2014]. I asked them how they performed observation to collect movement experiences and how they articulated these experiences in their design process. I correlated their individual responses with a key publication they had each written that emphasized the use of observation in their design process. For Kia Höök, I looked at her work on "Transferring qualities from horseback riding to design" [Höök, 2010] where she analyzed through an auto-ethnographic method her experience of learning horseback riding. For Georges Khut, I looked at the work he did with Lian Loke applying the Feldenkrais method to explore touch and proprioception in the interactive artwork, *Surging Vertically* [Loke and Khut, 2010]. For Helena Mentis, I looked at her work where she utilized LMA to design for the detection of Effort Qualities [Mentis and Johansson, 2013].

In my interviews, I was particularly interested in how these researchers used the following techniques that I was learning in my LMA training and that are present in other somatic practices as an integral part of movement observation [Moore and Yamamoto, (1988, Alexander, 1932, Feldenkrais, 2009] :

- Attunement: The preparation to perceive sensory information. It is an operation in which the observer accommodates herself to another by shifting her behavior to the situation, process, or qualities of the other [Balzarotti et al., 2014]. Many people implicitly attune as a preparation to engage in everyday activities and to make themselves ready to receive information. Examples could include a surgeon taking a deep breath before beginning surgery or a runner closing her eyes before beginning a race.

- Attention: The "flashlight" used to bring awareness to facets of experience. Schiphorst describes attention as the operator on experience [Schiphorst, 2011]. What people pay attention to and how they guide their attention directly affects what they will see.

- Kinaesthetic Empathy: The phenomenon related to how the body physically responds when observing movement. What the observer's own physical response is to someone else's movements, and how it guides her attention into someone else's patterns.

My findings showed that the researchers adopt a first-person perspective to design embodied technology. Precisely, their design process takes as a first stance their own felt experience which supports self-connection, affords kinaesthetic self-awareness, and opens for new embodied experiences that enable "great" design qualities to emerge. To do so, they pay attention to their own bodily felt experiences by attuning to themselves first. My findings showed that the researchers also adopt a second-person perspective to design embodied technology. They observe the participants in the system by attuning to others. Researchers use kinaesthetic empathy which means they use their bodies to feel the participants' bodies. Finally, my findings showed that the researchers also adopt a third-person perspective to design embodied technology. In order to observe the participants' experience in the system, researchers pay attention to the larger patterns: the participants' backgrounds or their micro-movements as indicators of their state.

The interviews confirmed the challenges that I was intuiting as inherent to designing with the body. The first challenge is to maintain the inner embodied state during the design process. The second challenge is to articulate the inner felt experience using language. The third challenge is to share the inner felt experience with participants and collaborators.

This work allowed me to describe explicitly the tools that embodied interaction researchers use, inspired by somatic practices, which are attunement, directing attention, and kinaesthetic empathy. I also described more precisely how one could take a first, second, or third-person perspective while observing movement. Finally, I pointed out the challenges that embodied interaction poses in articulating and translating and sharing embodied experiences. I addressed these challenges by arguing that there is a need in HCI to further develop movement literacy and deepen the physical and theoretical movement knowledge and related design strategies. Such knowledge can come from integrating somatic practices and movement studies in the domain of interaction design [Feldenkrais, 2009, Schiphorst, 2009].

3.4 Computing movement with Laban Movement Analysis

In parallel with the study on observation, and in an attempt to model dance movement in a generalizable way, I explored along with my collaborators from the MovingStories project the use of LMA as a framework for a computational model that would recognize movement qualities. To do so, we looked specifically at the category of Effort as the one that describes how movement is performed along the elements of Time, Weight, Space, and Flow. The interest in Effort as the qualitative category in LMA was a natural continuation of my Ph.D. where I looked at how to analyze movement qualities in dance using computational systems and in particular movement recognition and machine learning algorithms.

3.4.1 Computing Efforts from a single accelerometer's data

My co-author Diego Silang Maranan designed and evaluated a prototype of a system for Effort analysis called EffortDetect that uses a single-accelerometer data fed to a machine learning software to recognize in real-time and classify Laban Effort qualities[Maranan et al., 2014]. The specificity of this system is that it is based on a single-accelerometer to perform continuous movement qualities classifications, while most of the movement qualities recognition techniques rely on motion capture or video data. The advantage of using accelerometers is that they are small and thus highly portable and can be used under a wide range of environmental conditions, including interactive installations targeting the general public audience, interactive performances, or mobile applications.

EffortDetect is based on a supervised learning system built using Max/MSP and Java and using a classifier implemented in Weka[1], an open-source collection of machine learning algorithms. The stream of incoming movement feature vectors is fed to the classifier that operates in a training phase and a performance phase. During the training phase, an expert Laban Certified Movement Analyst (CMA) recorded examples of the Basic Effort Actions in LMA (BEAs). The BEAs are a set of eight effortful actions that combine 3 Effort elements from the Weight, Time, and Space Effort Factors as shown in table 3.1. During the performance phase, the recognition process would evaluate other dancers' execution of the BEAs. Based on the examples recorded during the training, the recognition process is able, during the performance phase, to estimate in real-time the similarities between the BEAs performed by the user and the pre-recorded examples and decide on the BEA that is most likely to be performed by the user. To evaluate this prototype, Diego collected 80 profile streams that they recorded using a custom tool built in Max/MSP. They measured the accuracy of the recognition (i.e., how accurately the system chooses the dominant BEA in a movement from the eight possible BEAs) and the confidence of that recognition.

[1] WekaSoftwarehttp://www.cs.waikato.ac.nz/ml/weka/

The analysis of the data indicates that the model recognizes movement qualities to various degrees of accuracy and confidence, going from very low to fairly high (75%) and that in most cases, both the system's level of accuracy and performance could be described and rationalized by the Laban analyst.

Effort Actions	Space	Time	Weight
Float	Indirect	Sustained	Light
Punch	Direct	Quick	Strong
Glide	Direct	Sustained	Light
Slash	Indirect	Quick	Strong
Dab	Direct	Quick	Light
Wring	Indirect	Sustained	Strong
Flick	Indirect	Quick	Light
Press	Direct	Sustained	Strong

Table 3.1. Overview of the BEAs with the corresponding Effort Factors.

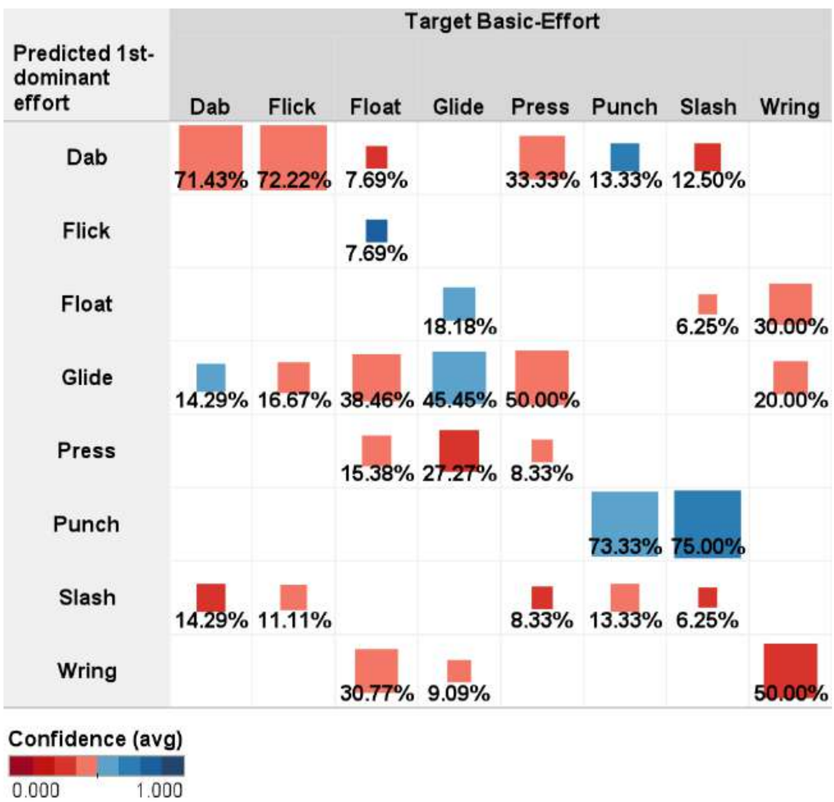

Figure 3.3. The percentage of confidence and accuracy of the recognition of the first dominant Basic Effort Action

3.4.2 Computing Efforts from multimodal data

Following this first contribution, I continued to work on ameliorating the computational models for Laban Efforts recognition. In a follow-up paper with my co-author Jules Françoise, we followed an expert-centered design of computational models of Effort analysis by including movement expertise from certified Laban Movement Analysts (CMAs). Our hypothesis is that putting experts at the center of the process would ameliorate the performance and the accuracy of the models [Fdili Alaoui et al., 2017]. So we included expert CMAs in order to select a set of suitable multimodal sensors as well as to compute features that closely correlate to their definitions of Efforts in LMA.

First, we interviewed two CMAs from the Laban Institute of Movement Studies. Our research goal was to elicit "how" they observe Efforts and articulate the visual and kinaesthetic cues used in their observational process. This process drove us to the selection of an appropriate set of multimodal sensors, their number and their disposition on the body, and the design of high-level movement features that correlate with the Effort Factors of Weight, Time, and Space that compose the Basics Effort Actions as such :

- For Space Effort: A feature based on spatial variation of the distance between the right elbow and the chest obtained. This feature is computed from *positional* data acquired through a 3D Vicon Motion Capture system.

- For Time Effort: A temporal feature based on the norm of the jerk extracted from *dynamic* data obtained with one accelerometer placed on the right wrist.

- For weight Effort: A feature based on the estimation of the muscle activation. This feature is computed from *physiological* data recorded with 2 EMGs placed on the core and the forearm and filtered through a non-linear Bayesian filter.

We ran a multimodal data acquisition session with two different expert CMAs that were not part of the interview: one male and one female that both had over 15 years of experience in LMA (see Figure 3.4). We ask them to perform 12 sequences of 8 BEAs specially ordered in the order defined by Table 3.1 and 3×8 sequences of non-ordered BEAs.

I manually annotated the data using a custom data annotation interface shown in Figure 3.5 and defined labeled segments according to Laban's definitions of BEA. At this point of my postdoc, I had been through half of the certification program in LMA and had delved into Efforts and embodied them enough to recognize them in the data we collected. My annotations were the ground truth to which the Effort recognition outputs were compared.

We evaluated our features' performance on a task of Effort recogni-

Figure 3.4. The data collection using EMGs, an accelerometer, and a Vicon Motion Capture

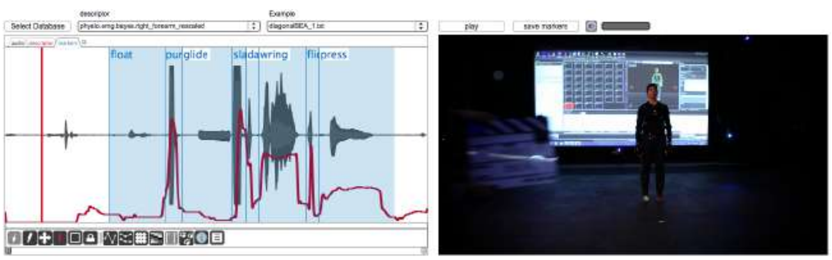

Figure 3.5. We build a data annotation interface using MuBu.

tion. We used a machine learning model based on Hierarchical Hidden Markov Models (HHMM) that continuously estimates the likeliest Effort at each time step using the partial observation sequence up to the current frame [Françoise et al., 2014]. The HHMMs can train each model from a single example. The testing phase consists of evaluating the likeliest Effort for each frame of the test sequence. This is performed in real-time using a forward algorithm. The HHMM library is available online and comes with Python bindings, and is also implemented as a set of externals for MaxMSP using the MuBu library[2].

[2] `https://github.com/Ircam-RnD/xmm`

The results shown in Figure 3.6 confirm the relevance of the features designed for the Time and Weight Effort Factors. Indeed, the best result for the recognition of the Time Effort is obtained with the dynamic feature of the norm of the jerk (B) with 80% accuracy. With one-way ANOVA, we found a significant effect of the features on the recognition accuracy (F(4;655) = 221, p < 0:001, partial=0.57). A Tukey's pair-

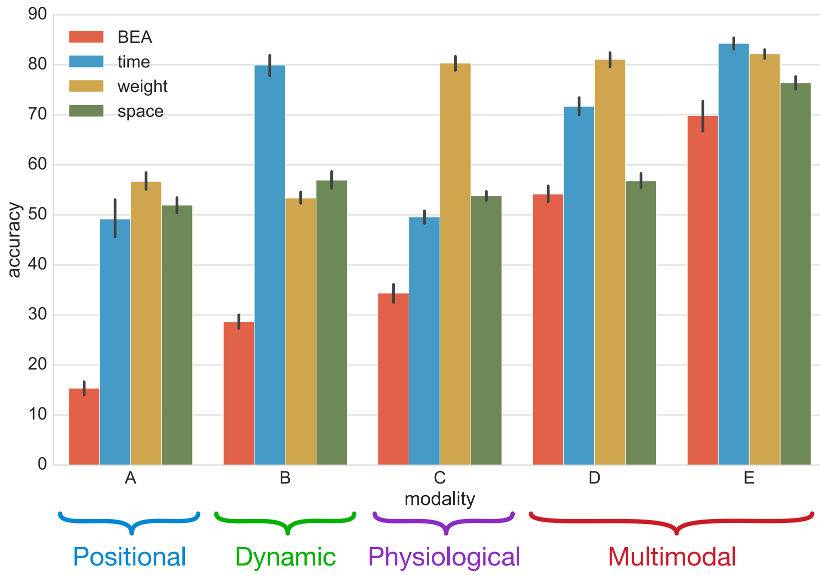

Figure 3.6. The overall results of the recognition of the BEAs and their three Effort Factors, depending on the various combinations of high-level features. ***A:*** **elbow-chest distance variation,** ***B:*** **norm of the jerk (right wrist),** ***C:*** **envelope of the EMG (right forearm),** ***D:*** **combination of the three features,** ***E:*** **combination of the three features + speed & acceleration**

wise comparison revealed the significant differences between B and A, C, and D ($p < 0{:}01$), but no significant difference was found between B, and E.

The recognition rate of the Weight Effort is significantly higher for the physiological feature of the EMGs envelope (C) with 80% accuracy. With one-way ANOVA, we found a significant effect of the features on the recognition accuracy ($F(4;655) = 437$, $p<0{:}001$, partial=0.73). A Tukey's pairwise comparison revealed the significant differences between C and A, B ($p < 0{:}01$), but no significant difference was found between C, D, and E.

However, the feature designed for the Space Effort Factor did not perform significantly better than other features. With one-way ANOVA, we found a significant effect of the features on the recognition accuracy ($F(4;655) = 198$, $p < 0{:}001$, partial= 0.55). A Tukey's pairwise comparison revealed the significant differences between the multimodal features E and A, B, C, D ($p < 0{:}01$). This result reveals that the addition of speed and acceleration information helped recognize the spatial directionality. It is interesting that the Space Effort was the hardest to characterize with the algorithm as that correlates with the interviews with the CMAs that revealed the difficulty to observe Space Effort from the positional aspect of the body. These results also echo limitations found in the literature and reported in the Eyesweb system, for example [Camurri et al., 2004].

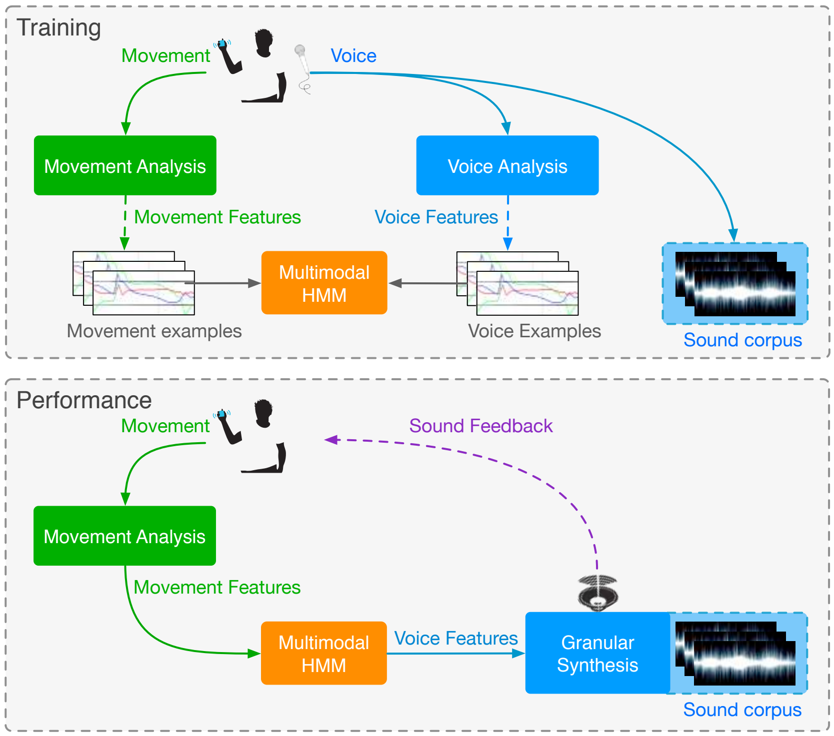

Figure 3.7. Overview of the Effort vocalization system.

3.4.3 Applying Efforts recognition to movement sonification

Along with Jules Françoise, we applied what we learned from our Effort recognition study to provide interactive sound feedback for an application in dance pedagogy. We proposed a methodology for the sonification of Effort Factors based on interactive vocalizations performed by the two movement experts that we recorded. Our goal was to allow dancers to access a greater range of expressive movement qualities through such interactive vocalization [Françoise et al., 2014].

We designed an interactive system built upon the machine learning method and features selected in the previous study. Our system learns the mapping between the movement and vocalization performed by the experts that we recorded using a 3D accelerometer attached to the right wrist and an electromyography sensor (EMG) attached to the forearm (see Figure 3.7). Precisely, it trains a Multimodal Hidden Markov machine learning model on examples of movements associated with their vocalization in order to learn the motion-sound mapping. During the testing phase, the dancer's movement is recognized, and the system produces the corresponding sound according to the learned mapping.

Figure 3.8. A dancer exploring the sonification during the workshop.

We organized a workshop where dancers were taught to perform and experience Laban's Effort Factors from a CMA. Each of the 5 participants that we recruited was guided by a CMA to improvise with the interactive sonic feedback in order to experience and perform Laban Effort factors through vocalization. The workshop used bodystorming and open-ended interviewing techniques to elicit participants' experience of the voice-based sonic interactions [Schleicher et al., 2010, Márquez Segura et al., 2016]. Overall, our experiment revealed the potential of such an interactive sonification system to allow for a new understanding of movement, support such a pedagogical activity and create a reflective space for learning Effort through sound.

3.5 Studying the reliability of Laban Movement Analysis

While I was learning LMA and using it to train computational models, a recurrent question that was central in the MovingStories discussions was about the level of reliability of such a system. We realized early on that although the LMA system is widely used for the description of human movement, there was a yawning gap in the literature: there was no study that assessed the inter-rater reliability for LMA as a whole. So if we don't know if two expert raters can agree when coding a movement using LMA, how can we rely on any ground truth when designing LMA based computational system? Reliability seems to play a pivotal role insofar as the assumption that LMA is reliable builds the foundation on which studies of the validity and the application of LMA in a technological context rest. Yet it was lacking.

Along with my colleague Ulysses Bernardet who is trained as a psychologist, we studied the reliability of the LMA system by assessing the consistency of LMA within and between different expert coders [Bernardet et al., 2019].

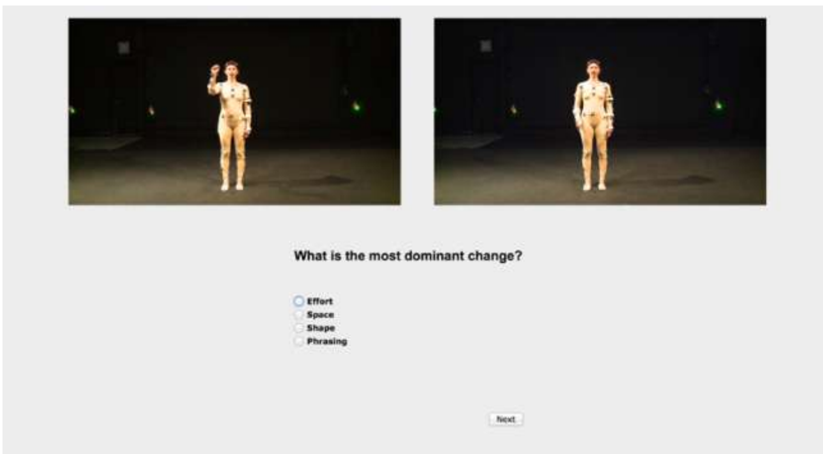

Figure 3.9. the video annotation tool where the participants could annotate the difference between neutral and variation through the LMA graph

Figure 3.10. The neutral version of the Knocking gesture

Prior to the experiment, we implemented a custom video annotation tool for stimulus presentation and annotation of movement using LMA shown in Figure 3.9. We then conducted an experimental assessment of LMA reliability where Certified Laban Movement Analysts (CMAs) were tasked with identifying the differences between a "neutral" movement and the same movement executed with a specific variation in one of the dimensions of LMA. The videos represented variations on the pantomimed movement of knocking at a door or giving directions.

Figure 3.11. The neutral version of the giving directions gesture

Figure 3.12. Example of a variation on the giving directions gesture using a near reach space

Figures 3.10 and 3.11 show the neutral version of the two gestures of knocking and respectively giving direction and figure 3.12 shows an example of a variation in space of the gesture of giving directions. To be as close as possible to the annotation practice of CMAs, participants were given full control over the number of times and order in which they viewed the videos. CMAs had multiple-choice questions. They were asked to first annotate the most salient difference (round 1), and then the second most salient one (round 2) between a neutral gesture and its variation. To quantify the overall reliability of LMA, we computed Krippendorff's α [Hayes and Krippendorff, 2007].

Our quantitative results show that the reliability of LMA, depending on how the two rounds are integrated, ranges between weak and acceptable. Table 3.2 summarizes the α values computed using the different combination methods. It shows that neither method of combining round 1 and round two, order dependent or order independent, yielded an α higher than round 1 alone. This can also be seen in the coincidence matrices Figure 3.13. When including the best of both rounds, we do observe a higher α. Comparing round 1 alone with the "R optimal" combination strategy, we see an increase of α

Table 3.2. Krippendorff's α computed for different ways of combining rounds 1 and 2

Subset	α
R1 only	0.473
R1xR2 order dependent	0.219
R1xR2 order independent	0.305
R optimal	0.676

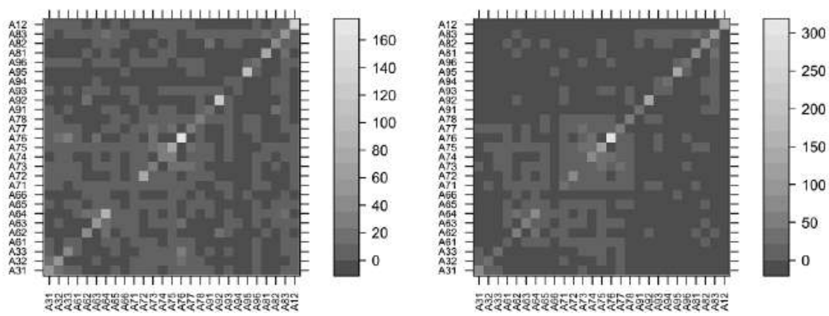

Figure 3.13. Coincidence matrices for round 1 only (a) compared to "best of" round 1 and round 2 (b). Hits on the diagonal axis indicate agreement between two raters.

We calculated Krippendorff's α for the two gesture types on the one hand, and for the different variations on the other hand. As we can see from Table 3.3, there is no marked difference in the reliability with which the two gestures are encoded. The results in Table 3.4 show however that while Space and Phrasing are rated the most reliably, the Effort and Shape categories are the most difficult ones to agree on. This can be related to the fact that Effort and Shape characterize the qualitative aspects of movement versus Space and Phrasing which are usually considered more "objective" categories.

Table 3.3. Krippendorff's' α values per gesture based on "R optimal" combination method

Gesture	α
direction	0.65
knocking	0.69

The results of our study emphasized that LMA is a practice-based method that allows to articulate movement both objectively and subjectively (third and first-person perspectives) as two of the categories

Table 3.4. Krippendorff's' α values per category based on "R optimal" combination method

Variation	α
Space	0.66
Effort	0.46
Shape	0.50
Phrasing	0.66

that are considered more objective seem to be fairly reliable (Space and Phrasing), and the two others that are considered more qualitative are only weakly reliable (Effort and Shape). Interestingly, scientific literature using LMA in computational systems assumes its objectivity as a third-person coding method only. In such literature, LMA experts are usually the authority that provides the ground truth against which automation is tested. But to be valid, this ground truth needs to be established in a rater-independent fashion. Our study showed the precarious reliability of such a system and thus questions its use by default as a universal generalizable reliable way of analyzing movement and particularly movement qualities.

3.6 Limitations of Laban Movement Analysis

In the reliability study that I presented, we can see that there is an ongoing ambiguity around how the system is both a somatic practice made for each person to make sense of the categories experientially using their body and an objective system that can accurately describe any movement using a set of given categories and on which engineers can build on to make their algorithms more efficient in recognizing or synthesizing movement. In either case, there needs to be an acknowledgment of whether the system is used objectively or subjectively and the limitations that come from both in terms of reliability and generalizability.

Beyond the reliability issue of LMA, another limitation that I was able to witness while experimenting with practitioners in the studio is that LMA is often seen as too contriving. Practitioners resist such standardization, going as far as to consider it as an act of violence towards their personal voices [Heyward, 2015]. In response to MOCO's call for provocations on the question, "What aspects of your practice/research are invisible to your collaborators?"[3], Hannah Kosstrin from Ohio State University posted the following:

[3] https://provocations.online/invisibilityincollaboration/kosstrin/

> The invisible aspect of my practice/research is my critique of the Laban systems of movement notation and analysis even as I use them as research tools. I am critical of these systems because of their kinaesthetic residue from their progenitors' historical actions related to Nazism; the ways practitioners uncritically employed them during the past century as ways to capture dances from outside their cultural context; the aesthetic gatekeeping they engender; and the ways that applying them uncritically as analytical frames inflicts violence onto dance-objects of analysis. Once I recognized that my extensive training in them so disciplined how I analyze movement that I could not extricate myself from them, I had to reconcile the ways they have colonized my analytical seeing techniques and figure out how to harness those skills for good. In many ways, the elements of these systems I find most useful are the ones that become invisible because of the kind of critical approach I engage to use them. When employing the usable parts of these systems and recognizing their biases, they can be efficient and nuanced tools for harnessing kinaesthetic ways of knowing. This critical distance has been most generative for how I consider ways of analyzing movement within analog, digital, and computing modalities. My provocation is: How do the ways we critique our tools affect our work in parallel or divergent ways from the manner(s) in which we use them?

What Hanna Kosstrin is pointing out is not only the questionable historical background of Rudolf Laban himself but also the way in which LMA as a system, aspires to provide a universal view of movement that disregards specific cultural contexts. That in itself can be a normative and harmful endeavor. We can cite as an example the application of LMA in Alan Lomax and Faustine Paulay's controversial Choreometric project[4]. The LMA-inspired Choreometric system was invented to quantitatively analyze the dance recordings collected by Allan Lomax across various cultures. It has been critically described as a "pseudo-scientific" theory of dance [Williams, 2007]. Choreometrics was seen as problematic because it imposed a positivist approach to dance and science. It was also seen as imposing a western-centered view of other cultures without situating the positionalities of its investigators. The project consisted essentially of a group of North American CMAs that observed and characterized dances from around the world, dances that they had no knowledge nor experience of [Hanna, 2019]. Anthropology has long shifted away from such observationist viewpoints by embracing an agent-centered perspective. Thus, the Choreometrics project represents a "white gaze" attempting to produce knowledge about others' distant cultures [Fanon, 1952]. One can go so far as to say that this is a textbook case of what to avoid in anthropological research. Irmgard Bartenieff's position, however, deserves to

[4] https://www.reimaginechoreometrics.com

be acknowledged as she quit the project long before its completion, stating that: "Dance cannot profitably stretch its concepts to fit the mold of existing scientific models." [Irmgard Bartenieff]

Figure 3.14. Alan Lomax discussing the Choreometrics system. Alan Lomax Collection, American Folklife Center.

Another limitation that I will cite is how, in practice, dance artists rarely use LMA because it requires substantial training, which is not provided in conservatories or dance institutions. While building a system that relies on a defined system like LMA appeals to computer scientists because it seems like the most computationally-suitable and generalizable approach to dance movement, such a system would certainly force the dancers to express their own movements through a standard language that might not correspond to their practice, or worse, hinders their creative choices. We found that practitioners have heterogeneous creative processes and personal ways of representing their ideas that are hard to generalize [Ciolfi Felice et al., 2016]. The idiosyncrasy of choreographic writing implies that every attempt to formalize a universal way to characterize dance knowledge, which would lead to designing one system for all, will surely have limited success and adoption [Fdili Alaoui et al., 2014].

In the following chapter, I illustrate how I began to move away from LMA as an all-encompassing system when I moved back to Paris as an assistant professor at Paris Saclay University. I describe how I collaborated with various practitioners by honoring and celebrating the diversity of their methods and approaches.

4

Designing with and for dancers

A contrasting approach to employing a generic framework such as LMA consists of studying dance artists' practices, and their ways of composing or generating ideas or learning movement. This approach usually builds on close collaborations with the artists in order to better align the design with their personal visions of dance. These types of works usually fall under the umbrella of user-centered design methods because they involve the practitioners in different stages of the design process. In this chapter, I will describe the design studies that I did along with my collaborators by putting dance artists at the center of the inquiry.

4.1 A historical perspective on systems supporting dance practice

I have witnessed an increasing number of works in HCI that apply the design of interactive systems to dance, which culminated in the publication of two state-of-the-art papers in 2021 [Zhou et al., 2021, Jürgens et al., 2021]. Zhou et al. presented an extensive literature review of HCI dance research throughout the past two decades that covers publications from SIGCHI, and the movement and computing (MOCO) conferences [Zhou et al., 2021]. They analyzed the literature according to where the technology intervened, e.g. in creating dance, on stage, supporting performance and improvisation, or analyzing, modeling, or annotating movement. In a paper that I wrote along with my colleague Kristin Carlson in 2014, prior to these two state-of-the-art papers, we examined existing systems for supporting choreography and dance practice. However, we grouped these systems by purpose, rather than application context, into four categories: reflection, generation, real-time interaction, and annotation [Fdili Alaoui et al., 2014].

We defined reflective tools as tools that apply various approaches to visualizing movement or choreographic structures in order to allow practitioners to reflect on them. Motion Bank and Synchronuous Object fall into that category. They are websites that reflect on the composition of movement and choreographic structures to enhance the audience's understanding of specific dance pieces [Forsythe and deLahunta, 2011, Palazzi et al., 2009]. While the content of these two systems is different, they all depict movement and structural information to provide different perspectives on the choreographic craft.

We defined generative tools as tools that generate movement material, either autonomously by using an existing corpus of data, or manually by facilitating a human choreographer's creation of material. Generation can be based on either movement simulation, movement sequencing, generation of procedural rules, mutation, or style incorporation. LifeForms falls into this category [Schiphorst, 1993]. Thecla Schiphorst and her colleagues designed it to provide Merce Cunningham with movement sequences made up of 3D skeletal postures. Church et al. developed the Choreographic Language Agent [Church et al., 2012], an autonomous artificially intelligent software agent that generates new movement as "unique solutions to choreographic problems"[1]. The goal of the system was to support Wayne Mcgregor dancers' creative decision-making processes. Living Archive also falls in this category as it uses deep learning algorithms to create movement sequences from a selection of movement postures from Wayne McGregor's repertoire[2].

[1] https://waynemcgregor.com/research/choreographic-language-agent

[2] https://artsexperiments.withgoogle.com/living-archive

We defined interactive tools as those allowing dancers to interact with digital media that responds to their performance in real-time. The digital media can be designed to assist choreography by facilitating improvisation or the exploration of the creative process. The crucial point here is how the link between the dancer's movement and the digital response is designed. In other words, with interactive tools, the mappings between input and output modalities are crucial for creating expressive cause-effect relationships that allow for a rich exploration of movement. Most systems mapping movement to media in dance fall into this category. Camurri et al. designed the Eyesweb platform, one of the earliest systems to provide multimodal interactions based on dance movement qualities [Camurri et al., 2004]. Anderson et al. designed YouMove, a Kinect-based system that aims at helping dancers learn movement by providing guidance and feedback through visualizations displayed on an augmented reality mirror. The system offers guidance that instructs the users on which movement to perform and feedback that suggests corrections to their movement [Anderson et al., 2013]. Brenton et al. presented the design of a system displaying interactive visualizations that respond to dancers' movements. The system is based on interactive machine learning that allows an individual dancer to train the visualizations rather than having preprogrammed rules. The authors claimed that they allowed the dancer to design their own version of the interactive system in an embodied way by moving, rather than by analyzing movement [Brenton et al., 2014]. Molina-Tanco et al. designed and evaluated the Delay Mirror, a system that allows dancers to observe and correct their own movements. Delay Mirror records video streams of dancers' real-time practice and projects them with a delay of a few seconds. The intention of the authors was to augment the mirror, a tool that already exists in dance studios [Molina-Tanco et al., 2017]. Inspired by Oskar Schlemmer's Triadic Ballet costumes, Karpashevich et al. designed an interactive costume in the form of a wired tutu with LEDs that is meant to make the body "strange" by restricting lower body movements. The costume was introduced to a dancer who found novel and evocative forms of expression [Karpashevich et al., 2018]. Kim and Landay presented a system called Aeroquake that allows dancers to control the movement of drones in real-time. The authors claimed that the system aims at augmenting and supporting dancers as they improvise and "explore their creativity" with the drones. Authors collaborated with a dancer to "validate their system by performing with the drone in front of a live audience" [Kim and Landay, 2018]. Jochum and Derks used a user-centered approach involving dancers to generate interactive non-anthropomorphic robot movements inspired by improvisation exercises. This resulted in human-robot performances that augmented dancers' creativity by eliciting unexpected choreographies [Jochum and Derks, 2019]. Lastly, Raheb et al. developed Choreomorphy, an interactive system based on Motion Capture and 3D technologies that allows the users to experiment with different body and movement visualizations in real-time [Raheb et al., 2018]. The system offers a variety of avatars, movement visualizations, and environments. The authors' goal was to allow dancers to explore different "digital selves" that can vary in shape, size, gender, and human versus non-human characteristics in order to inspire their dancing and improvisation.

Finally, we defined annotation tools as those that allow the annotation of dance movements or structures during the rehearsal with a strong potential for assisting choreographic thinking. They allow dance artists to analyze, edit, play, and re-frame material in order to craft it incrementally during the choreographic process. There are many examples of systems for dance annotations. Singh et al. developed the Choreographer's Notebook, which enables choreographers and dancers to annotate video clips of dance rehearsals remotely and asynchronously, providing multimodal input, such as textual comments and video demonstrations [Singh et al., 2011]. The authors evaluated their system in various rehearsal contexts and showed that it increases the efficiency of rehearsal time, helps learning, and enables online communication between the dancers and the choreographer [Carroll et al., 2012]. Cabral et al. designed a system that facilitates multi-modal annotation of dance videos through textual and verbal language as well as touch-pen drawings [Cabral et al., 2011, Fernandes, 2013]. Later on, they developed the BlackBox, a web-based collaborative platform that applies novel visualization techniques to support the documentation of choreographers' compositional processes [Ribeiro et al., 2016]. dos Santos et al. presented a video annotation tool where dance teachers can write comments or use predefined labels to assess a dance performance [dos Santos et al., 2018]. Lastly, El Raheb et al. followed a user-centered design approach involving dance researchers and practitioners in order to develop a web-based dance application with browsing, searching, visualization, personalization, and textual annotation functionalities. Their objective was to provide access to a repository made of annotated motion capture data, video, and audio recordings of dances that they collected [El Raheb et al., 2018]. They then presented the conceptual framework and toolkit that underly the manual movement annotation that they rely on to design their tools and repositories [Raheb et al., 2022].

Analyzing the state-of-the-art of tools supporting dance practice according to these four categories made clear the diversity of the choreographic approach that underlies each system. Each of these systems is distinct in how they consider the body and movement and what they emphasize in dance practice, be it improvisation, creativity, performance, etc. There is also a large scope of technologies used. Regarding methodology, most of these systems involve dancers in the design process. Sometimes one single dancer is asked to evaluate a system at the end of the process. Sometimes multiple dancers participate in the research from the beginning. However, none of these systems is based on a deeply committed engagement with contemporary dancers outside of the lab experiments which allowed for the definition of a design space or the evaluation of the prototypes. In their state-of-the-art, Jürgens et al. identify three opportunities for HCI that can arise through further engagement with the knowledge produced in contemporary dance and performance: 1) to engage with performance research and theory, 2) to employ contemporary dance methods and practices in HCI research, and 3) to integrate contemporary dance choreographers and performers as researchers in interdisciplinary projects [Jürgens et al., 2021]. In the same vein, [Zhou et al., 2021] concluded their state-of-the-art by suggesting that HCI research should learn from the works developed in dance to design interactions that better cultivate the felt dimension of the embodied experience.

The question that I am also left with is: How can these very distinct systems inspire the design of future systems that aim at supporting dance practice? Is there anything common to dance practitioners that allows us to design for more than one context of use?

4.2 Studying dancers' practices

From the previous questions, I embarked on a series of interviews of dance artists in relationship to how they learn or craft, or ideate choreographic ideas. Along with the people with whom I did these studies, my goal was to characterize what is individual and what is common in these practices, and understand how to design systems with and for dance artists, that have interactive capacities yet that can be personalized, customized, appropriated according to one's individual need and creative journey.

4.2.1 Studying how dance artists learn to dance

In studying how practitioners learn to dance, we (my former Ph.D. student Jean-Philippe Rivière, in collaboration with the other co-supervisors Baptiste Caramiaux and Wendy Mckay) realized that the literature on dance pedagogy is primarily focused on the perspective of the teacher. We also found a number of studies in neuroscience characterizing motor skill acquisition in dance [Adams, 1971, Annett, 1985, Allard and Starkes, 1991] with a nice overview in the book of Bläsing et al. [Bläsing et al., 2010]. These studies, however, did not describe the techniques and mechanisms in play when dancers are learning to dance from their own perspective. In order to tackle that, Jean-Philippe performed a series of interviews probing the perspective of professional contemporary dancers on their own learning [Rivière et al., 2018].

Jean-Philippe used a variation of Flanagan's critical incident technique [Flanagan, 1954] introduced by Mackay for HCI [Mackay, 2002]. He asked the participants at the beginning of the interview to recall the last time they had to learn a new dance movement in order to retrieve specific examples and avoid generic answers. The interviews were built around 4 topics through 4 main questions:

- Learning Steps: "Can you explain how you learn a dance movement step by step? What is the most important step?"
- Movement Transformation: "Do you make any changes in your movements during the training and why?"
- Understanding of the learning endpoint: "When do you consider the movement to be learned?"
- Using additional information: "Are you using any cues or feedback to learn the movement?"

Figure 4.1. Jean-Philippe Rivière interviewing a dancer on their learning process

I helped Jean-Philippe recruit 11 professional contemporary dancers (six women; five men) with 7 to 34 years of experience (M=18.3, SD=8.3) from my personal network. Jean-Philippe ran the interviews and recorded the data. He and I performed a grounded theory analysis [Glaser, 2017] from the corpus of the data collected in order to identify larger concepts within the data from the interviews.

The interviews showed that during the learning process, dancers use the following techniques that consist of specific actions that allow them to learn movements: observation, repetition, imitation, marking, segmentation, mental simulation, and personal adaptation (see figure 4.2). All of the participants reported that observation of movement is the very first action of the learning process. Additionally, dancers constantly mentioned repetition as the way to progress in learning. All dancers reported that they try to imitate a reference movement identically. More than half (7/11) of the participants reported that they train on a smaller version of the reference movement to work independently on a specific element of it such as space, time, or energy...Etc. This is what is usually called "marking" [Kirsh, 2013]. More than half (6/11) of the participants reported that they decomposed the reference movement into smaller sequences. Five participants mentioned the use of personal adaptation in the form of explicit variations used to make a movement easier to execute. Finally, Three participants refer to mental simulation to support their movement memorization.

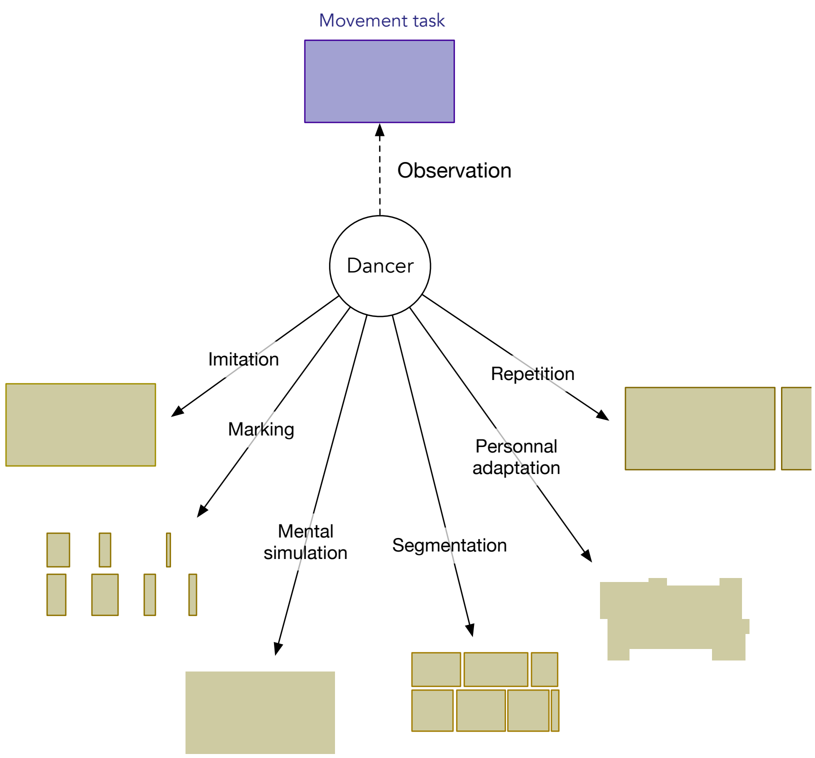

Figure 4.2. The learning techniques used by dancers

The interviews also revealed that there is a progression in learning dance movements. We identified that learning goes from a first step of movement analysis, to gradually integrating movement. This "integration" is related to when the movement is embodied, which means incorporated at the cognitive level but also at the motor level resulting in a more fluid performance of movement [Kirsh, 2013]. Once movement is embodied, dancers progressed into a personalization step, which relies on changes that the dancers apply to appropriate the movement according to their individualities. Finally, almost all participants (8/11) reported that implicit variations appear all along the process of dance movements acquisition which reveals the impact of their habits and personal ways of moving in their dance performance.

These interviews showed the variety of common but also individual tools that the dancers use in their learning as well as the steps that they go through to progress in their learning. It highlights a part of learning that is due to the individual traits of each dancer but also a part that is common between them that suggests that there is a design space for interactive systems to support dancers' learning of movement.

4.2.2 Studying how dance artists choreograph movement

Similarly to studying how dancers learn to dance, I was interested in understanding how they choreograph movement and how they represent it. We (my former Ph.D. student Marianela Ciolfi, in collaboration with the other co-supervisor Wendy Mckay) wanted to identify the elements that dancers manipulate as they create a piece. To do so, Marianela interviewed 6 professional choreographers about their choreographic practices [Felice Ciolfi et al., 2016] using critical incident technique [Mackay, 2002]. She asked each participant to choose a recent piece that they had choreographed and to describe their creative process, step by step. She also asked them to show her the artifacts that they used to explore or record ideas, including notebooks, videos, and digital files. She then probed for specific stories, sparked by their design artifacts, in order to help them provide a grounded reconstruction of the details. These stories helped us to understand what they actually did, rather than how the process "should" work. She collected and anonymized the interview data. Marianela and I then used a grounded theory approach [Glaser, 2017] to analyze the stories. We identified six primary categories: choreographic objects, creative phases, representations, operations, specificity, and focal points.

We defined choreographic objects as objects that represent choreographic ideas that are manipulated throughout the entire process. Choreographers formalize them at various levels of abstraction and detail, at times in their own minds, in the dancers' bodies and memories, or captured via paper, video, or other support tools. We found that choreog-

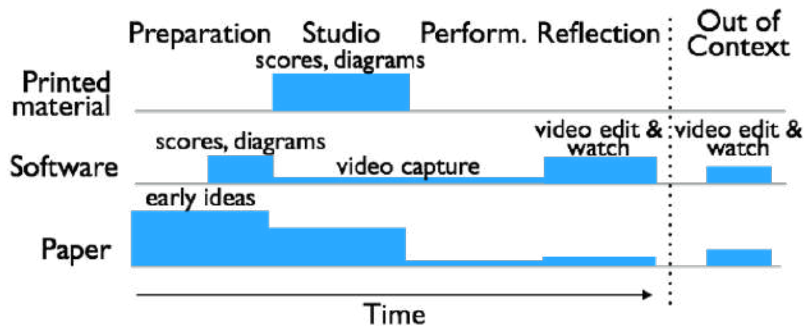

Figure 4.3. The choreographic objects, and the representations used along the creative phases.

raphers' creative processes, despite being highly diverse and personal, pass through a series of creative phases that we called: preparation (before working with the dancers), studio (interacting with the dancers and the support materials), performance (during the shows), reflection (after a studio session or a performance), and out of context (stories not related with their current project). We found that all of the participants represent their choreographic objects with a variety of representations spanning from drawings, text, diagrams, and video to formal notation. Choreographic objects and representations along creative phases are illustrated in the figure4.3.

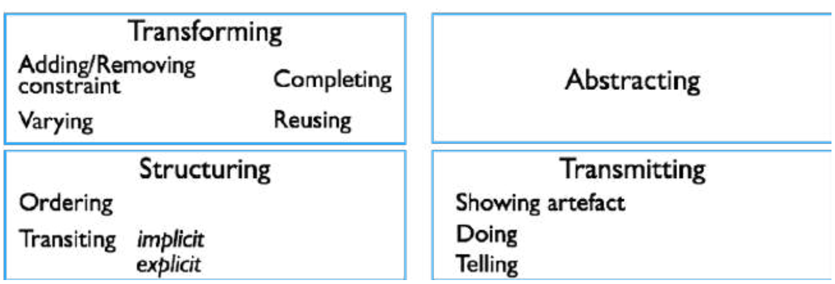

Figure 4.4. The types of operations applied on choreographic objects.

We also found that choreographers apply various operations on their choreographic objects as shown in figure4.4. These operations are actions where the choreographer's skills come into play, resulting in new choreographic objects or refined versions of the existing ones. We identified four categories that are present in at least one story from each participant: transforming, structuring, abstracting, and transmitting.

We also found that choreographers define their choreographic objects with various degrees of specificity going from open (typically improvised movements) to set (typically highly set movement sequences). They also compose their work by shifting between different levels of abstraction: in depth, but also different focal points in width as shown in figure4.5. Choreographers define choreographic objects with attention to the piece as a whole, to the stage, to a particular dancer, to an interaction (between dancers, with an object, with the stage, with an idea), and in temporal patterns.

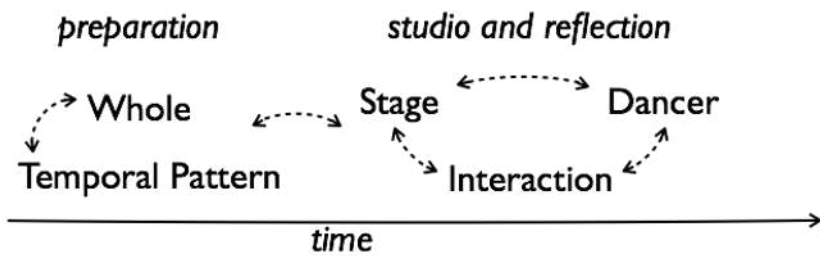

Figure 4.5. The focal points along the creative phases

The above six categories form a framework that captures the key elements common to choreographers' practices. Put simply, choreographic objects serve as the focal point, with a certain degree of specificity. They are expressed via different representations and evolve through several creative phases as the choreographers apply operations to them. Our findings highlighted how practitioners constantly shift choreographic objects and operations, across levels and focus points. They also shift representations and work across various creative phases.

There was a challenge for us to create a framework for a dynamic field such as choreography, which constantly tests and breaks its own rules. Indeed, choreographers have heterogeneous creative processes that are notoriously very hard to generalize. There is an inherent beauty and uniqueness in this field (dance) that might resist, at a first sight, attempts of characterizing or extracting common patterns from it. However, our interviews showed commonalities in what choreographers manipulate (objects, operations, and phases), yet what defines a choreographic object or the type of operations that are applied to it remains idiosyncratic. Our study does not take away from the uniqueness or specificities of each practitioner yet it allowed us to better frame the art of choreographic composition. It is by establishing such a framework that we could begin to design an interactive tool (namely Knotation) that recognizes the special craft of each artist but leverages upon higher-level commonalities.

4.2.3 Studying how dance artists interact with collaborators and artifacts

With my former Ph.D. student Stacy Hsueh and in collaboration with the co-supervisor Wendy Mackay, we were interested in unpacking how the choreographic creative process was driven both by the artifacts that come into play and by the collaboration with performers [Hsueh et al., 2019a]. We used artifacts as a lens into choreographers' creative practices to address two key questions: How do creators relate to performers throughout the creative process? What are the different ways in which creators interact with artifacts during collaboration?

Stacy conducted critical incident interviews [Flanagan, 1954] with 9 choreographers (ages 30-47) at the participant's studio or a location of their choice. She asked each participant to choose a piece, either recently completed or in progress, and bring any work notes, sketches, or other artifacts used during the creation process. She asked participants to describe each step of their creative process, with particular emphasis on the artifacts or strategies they used to capture, represent, and transform their ideas. She anonymized all interviews. After transcribing the audio, Stacy and myself used thematic analysis [Braun and Clarke, 2006] to extract stories related to idea generation and exploration from all participants. We then assigned one or more themes to each story, looking for preliminary trends to emerge.

We identified four types of creator-performer relationships :

- Creator as author, performer as interpreter: This relationship is the most familiar one, where the creator controls the overall structure and content of the piece, and represents and communicates them via a physical medium (e.g. a score). The performer's role is to process and understand the creator's instructions and to develop their own interpretations based on their individual qualities.

- Creator as curator, performer as creator: In this type of relationship, the creator interactively creates content with the performer. Here the performer provides the raw material (such as movement sequences produced during improvisation), and the creator acts as a curator, selecting from the repertoire of materials to gradually form the piece.

- Creator as planner, performer as improviser: This relationship is similar to the above in that they both involve improvisation. However, in this particular relationship, the creator, instead of selecting materials, direct their attention to the construction of the conditions within which materials are generated. Once the conditions are designed and set up, the performer has a comparable level of authorship with the creator over the creative content.

- Creator as researcher, performer as informant: Finally, this type of relationship, usually found at the beginning of the creative process, involves the creator initiating "consultation sessions" with the performer. These are sessions where the creator tries to gather information about an area they are unfamiliar with.

Our results also show that choreographers have three ways in which they interact with artifacts.

- Sculpting: This type of interaction is characterized by the ways in which artifacts serve as sites for sculpting activities. In these scenarios, the artifacts take the form of substrates, providing structures out of which materials may emerge.

- Layering. This type of interaction is characterized by the different ways the creator layers multiple artifacts together. In these scenarios, the creator prepares different types of artifacts separately, and once these artifacts reach a certain level of maturity, the creator begins to weave them together, overlapping them or stitching them together. The creator subsequently composes/improvises at the interstices of these “layers".

- Remixing. The goal of this type of interaction is to generate alternative creative materials. The type of artifacts used here can be of both the content and structure types. It is reminiscent of the collage technique in visual art, in which cut-up scraps of images and texts are re-combined to form a new patchwork.

Our study showed that the creative process can be characterized by the ways in which the creator weaves in and out of different forms of interaction with artifacts and different relationships with performers. In the examples provided by the choreographers that Stacy interviewed, we saw a constant re-definition of roles which creates a constantly evolving practice. Because of the cross-pollination of different expertise in the studio space, the exchange of ideas becomes fluid and incredibly generative.

We also saw how creators move fluidly between the different forms of interactions with artifacts (i.e. sculpting, layering, and remixing) creating content out of structure or structure out of content. The heterogeneity of the artifacts that the practitioners manipulate forms a sort of ecology that provides conditions for fluid transitions between the different interaction styles. Tools in these cases do not necessarily impose a particular way of using them. Instead, creators re-appropriate them and reintegrate them into their existing work practices, performing what Suchman calls artful integrations [Suchman, 1987, 1995].

This study complemented the 2 others on learning and crafting choreographic ideas. It explored the collaborative aspect of creativity in dance through the lens of the artifacts used. It allowed us to go further in the understanding of creativity as an ongoing process that requires divergent viewpoints and negotiation among a complex ecology of people and materials [Barad, 2003] with their boundaries continuously being disrupted, broken, and rejoined. Despite our efforts to grasp the creative process in dance, we uncovered here the slippery nature of the boundaries between artifacts, roles, and interactions. What we became convinced of is that these slippages are not to be avoided by designers. Quite the opposite. We saw how they presented an opportunity to critically call "boundaries" into question in order to drive creativity forward.

One of the technologies that question the boundaries of what art is and who the artist becomes and that is currently viewed as a drive forward for the art field is certainly artificial intelligence. I dedicated another study of creative practitioners to the specificity that AI brings. The study is not specific to dance per se but I see it as illuminating my overall reflection on the specificities and commonalities of creative practices.

4.2.4 Studying how AI artists craft their art

Over the past decade, I have witnessed how Artificial Intelligence (AI) aroused a great interest in both academia and industry, encouraged by public and private incentives. Such growth had a significant impact also on the creative and cultural sectors [Caramiaux et al., 2019]. The HCI field, which has been indifferent to intelligent systems for decades, suddenly organized panels and workshops about human-computer partnerships and interactive machine learning, AI with humans in the loop, and AI for creative practitioners. Everyone wanted their piece of the cake!

But how did such a booming trend affect the art world? what became of the work of the artists who have been engaging with AI since before this technology became viral?

It is striking to observe that the common narrative tends to introduce AI (mainly deep learning) in the creative sector through the complexity of the creative tasks that the technology is capable of performing that were previously reserved for humans. AI is depicted as contributing to the "escalation of creativity" and democratization of artistic talent [Pieters and Winiger, 2016]. Besides the fantasy that AI will acquire human-like artistic genius and supernatural skills, there are complex ways in which artists are currently using AI in visual art, music, or performance. Understanding the use of AI in real-world art practice allows us to consider it as both a material that practitioners can appropriate and a socio-technical object that has political and cultural impacts [Simondon et al., 1980].

Through an interview study with the 5 world-renown contemporary visual artists listed below, Baptiste Caramiaux and I explored how AI and particularly deep learning techniques shape their creative endeavor [Caramiaux and Alaoui, 2022].

- **Memo Akten** is an artist, experimental filmmaker, musician, and computer scientist. He works with emerging technologies and computation as a medium, to create images, sounds, films, large-scale responsive installations, and performances.

- **Jake Elwes** is a media artist. Recent works explore their research into machine learning and artificial intelligence. Their practice looks for poetry and narrative in the success and failures of these systems, while also investigating and questioning the code and ethics behind them.

- **Mario Klingemann** is an artist, who uses algorithms and artificial intelligence to create and investigate systems. He is particularly interested in human perception of art and creativity, researching methods in which machines can augment or emulate these processes.

- **Kyle McDonald** is an artist crafting interactive installations, sneaky interventions, playful websites, workshops, and toolkits for other artists working with code. He explores possibilities of new technologies: to understand how they affect society, to misuse them, and build alternative futures; aiming to share a laugh, spark curiosity, create confusion, and share spaces with magical vibes.

- **Anna Ridler** is an artist and researcher who works with systems of knowledge and how technologies are created in order to better understand the world. She is particularly interested in ideas around measurement and quantification and how this relates to the natural world. Her process often involves working with collections of information or data, particularly datasets, to create a new and unusual narrative.

Baptiste conducted semi-structured interviews where he aimed at collecting stories and testimonies on the way these artists use AI in order to create artworks. To this end, he structured the interviews according to three main points: the way they see AI (definitions, perceptions, and aesthetics), the way they use it (workflows, interpretations, and evaluations), and the way they situate themselves with respect to it (governance and ethics). For each question, he asked the artists to illustrate their responses with concrete examples of their work. We analyzed the interviews together using thematic analysis [Braun and Clarke, 2006].

Our interviews showed how the artists craft AI technology leading to a set of diverse and ad-hoc workflows. The workflows adopted by artists involve tight interactions with the elements of the machine learning pipeline such as editing the dataset or editing the model's architecture or parameters. In addition, the practice of AI in art takes advantage of the inherent capacities of algorithms to generate surprises, glitches, and errors. Artists reported that they build their own tools and instruments based on AI in order to work with such material in an embodied way.

We found from our interviews that from an epistemological point of view, AI-artists distance themselves from AI research culture and objectives. They aim at twisting the AI narrative and at resisting conventions from the AI field. They do not abide by the values that are dominant in the development of AI technology such as accuracy, productivity, and performance. Additionally, AI artists question the ethics behind AI, particularly around its inherent power dynamics, opacity, and lack of inclusivity. They acknowledge that working with AI is not neutral. This inspires them to develop a critical discourse in their artworks about the politics and ethical pitfalls behind this specific technology.

Our interviews showed how working with AI challenges the notion of authorship, aesthetics, and control in creative work. Indeed, AI as opposed to other technologies is rather opaque and leaves little agency and control to the artists over the final outcome. AI-artists recognize the tensions that arise from the current debates about artists' authorship over their artworks generated by AI in the specialized media. They address this tension by emphasizing how their AI-generated pieces involve manual labor. Doing AI-Art is not limited to downloading source code and running it. It involves craft(wo)manship and implies hours of exploration leading to countless failures and few achievements. Thus, the degree of automation in AI does not redefine the artist's role. Artists negotiate constantly between autonomy and control as they define how much freedom they have in this process and how many constraints they work with. They illustrated that by describing their roles with regard to the algorithm and the data sets using the metaphors of documentary filmmakers, doctors looking for syndromes, witnesses, curators of data, or explorers of unknown planets.

This work is very recent and allowed us to start highlighting the characteristics of an emergent art practice using AI and to shed light on the cultural and socio-technical implications of involving AI in artists' practice, in particular with regard to the political stance that they take with a technology that is loaded with political and social meaning [Simondon et al., 1980].

4.3 Designing for and with dancers

Following the interview studies, my collaborators and I embarked on a series of iterative ideation and prototyping processes where we designed systems along with the practitioners to support the documentation, learning, and generation of dance. We assessed these systems with the practitioners at different stages of their development. Along the way, we learned about how they use and appropriate the systems for their specific methods and approaches to dance.

4.3.1 Knotation: Designing a system for dance documentation

In the previous study made with Marianela Ciolfi and Wendy Mackay, we showed that even though each choreographer's creative process is unique, they all define choreographic objects, represent their ideas at different levels of abstraction, and apply operations on these choreographic ideas. This study allowed us to define a design space to create a technological tool for dance documentation [Ciolfi Felice et al., 2018]. To do so, we followed Shneiderman guidelines to designing systems that support creative practitioners through a user-centered approach [Shneiderman, 2000, Hewett et al., 2005, Shneiderman, 2007].

4.3.1.1 Probing practitioners' representation of dance on paper

The first step of our user-centered approach consisted of engaging in an observational study with choreographers and dancers to better understand how they represent their choreographic ideas on paper. I helped Marianela to recruit a professional choreographer with 34 years of experience as the lead choreographer and four of his regular collaborators, including two choreographers, one dance professor, and one dancer. First, the dance artists were asked to compose a choreographic fragment and then capture the dance fragment on paper using A3 paper, colored pens, highlighters, stickers, and post-it notes. Then came the transformation activity which involved transforming the choreographic fragment. Participants choose a set of operations to apply to the fragment, including 1) sequence, 2) reorder, 3) reuse, 4) vary the speed, rhythm, energy, or spatial patterns, 5) define transitions, 6) add details, and 7) abstract a choreographic object. They were asked to then update their annotations. Finally, we went through a debrief at the end of the session and asked for explanations of their annotations from both activities.

We observed considerable variability in how participants represent choreographic objects and operations, even given the same initial constraints. Participants also varied greatly in their choice of which aspects to capture for each fragment. However, several common features emerged. For example, all participants specified movement speed and movement qualities; all drew spatial diagrams (floor plans); and all sketched rules and constraints with respect to the movements, using a combination of sketches, personal sublanguages, diagrams, and text as shown in figures 4.6 and 4.7.

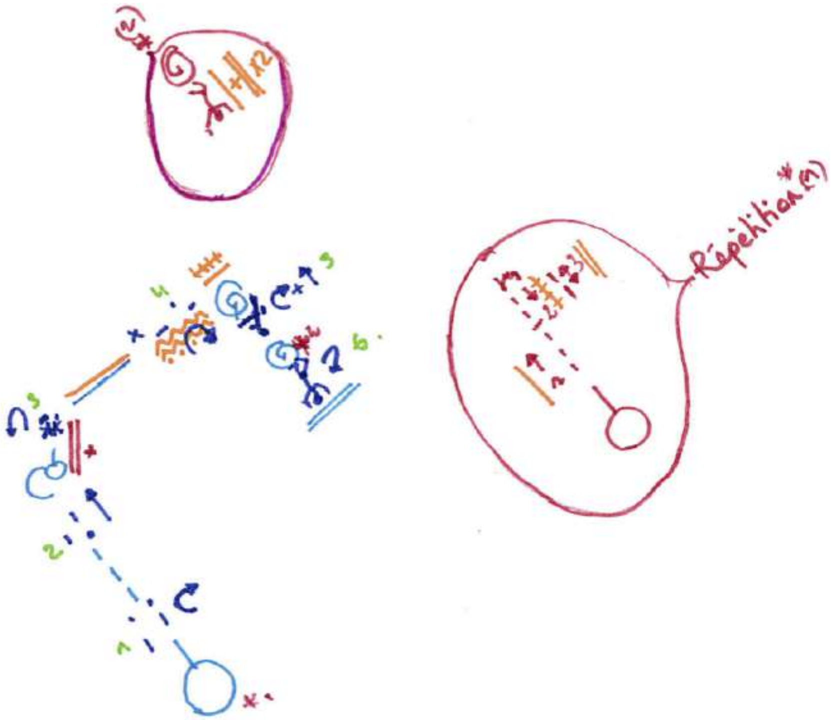

Figure 4.6. A dancer's representation of their choreographic fragment on paper emphasizing floor plans as seen from above.

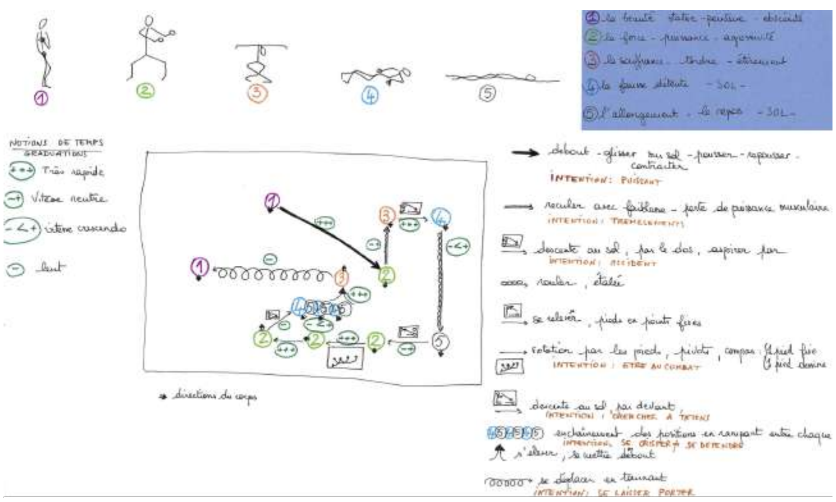

Figure 4.7. A dancer's representation of their choreographic fragment on paper emphasizing floorplan but also gestures that compose the fragment

4.3.1.2 *Designing Knotation*

Following the results of this first study, we engaged in an ideation phase with the goal to let dance artists express choreographic concepts in terms of both space and time, and to represent movement in terms of constraints, through combinations of drawings and text. At the end of the ideation phase, we used paper prototyping to represent our interactions before designing the first version of the tool.

Subsequently, we designed an application called Knotation. Knotation was developed by Marianel Ciolfi to run on IPad Pros [Ciolfi Felice, 2018]. Knotation allows choreographers to define and interact with graphical knots to which they assign the meaning of their choice as shown in figure4.8. Knots can have multiple attributes such as speed, energy, and quality as shown in figure4.9. Users can also incorporate pictures, videos, and pre-recorded material by linking a knot to any file in their photo library. They can also sketch a floor plan as shown in figure4.10. They can also use timelines to define temporal sequences of knots as shown in figure 4.11. Users define floor plans and timelines by attaching the corresponding type of knot to any type of line, including curves, circles, and diagonal lines. They can also create portals that provide a link from the original canvas to a more detailed or more abstracted view of it. When adding and tapping on a portal knot, the user sees the new canvas. The user can return to the original canvas by tapping on the portal knot that appears automatically at the top of the new canvas.

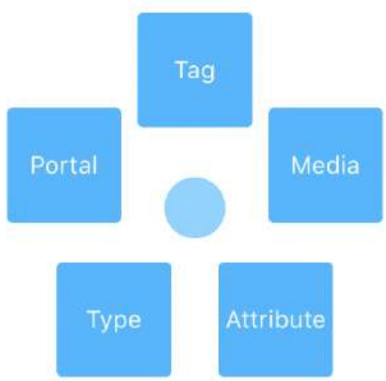

Figure 4.8. A knot and the menu proposed to define it as designed in Knotation

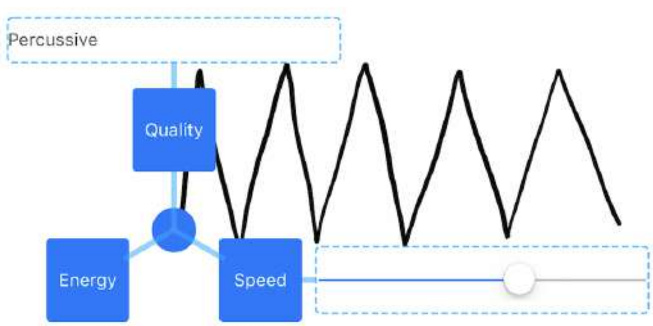

Figure 4.9. A knot and its attributes as designed in Knotation

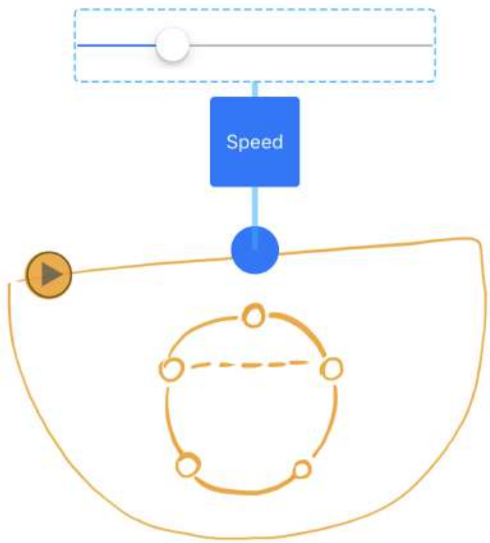

Figure 4.10. A floor plan seen from above with spatial trajectories of movements and a speed knot to define how it can be played in Knotation

Figure 4.11. A media timeline as designed in Knotation

4.3.1.3 Studying how choreographers use Knotation V1

Marianela, Wendy, and I deployed the first version of Knotation and studied how three choreographers used it as a technology probe [Hutchinson et al., 2003]. During the study, we asked the participants to first compose a short fragment of dance and then to transform such a fragment. They could use Knotation as much as they wanted to capture their choreographic ideas. At the end of the study, we had a debriefing session. We captured all the data through video and sound recording and analyzes it using thematic analysis [Braun and Clarke, 2006].

We identified two contrasting strategies among participants who focused either on concrete movements or on the rules that define them (content or structure). For example figure 4.14 shows how the participant only documented and transmitted the constraints the dancers had to meet in order to perform the fragment. Their idea was that two dancers form a "wall" by moving sideways along a diagonal, while the other two close their eyes and move, with the "follower" trying to mirror the movements of the "leader". In addition to these two distinct strategies, choreographers used Knotation with a combination of both strategies, by representing movements and constraints that rule them. Thus, Knotation v1 successfully supported this diversity across participants. Once choreographers were able to express their choreo-

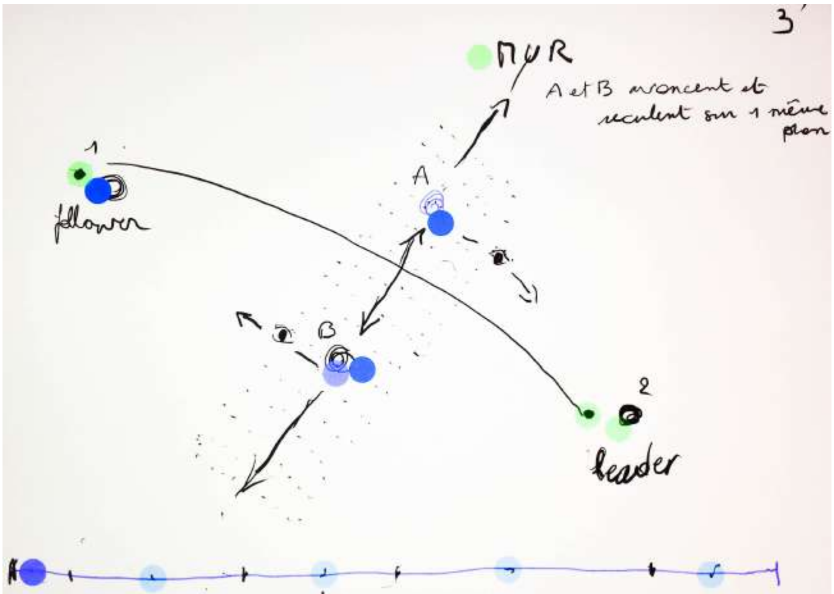

Figure 4.12. A participant's documentation that represents exclusively constraints and rules in Knotation v1.

graphic ideas in Knotation v1, they sought additional ways to interact with them and proposed new features and functionalities.

4.3.1.4 Iterating on Knotation

Following the study, Marianela iterated on the probe and introduced a second version of Knotation. In this version, she focused on turning floor plans and timelines into first-class interactive objects allowing users to move or duplicate any object on the screen. She also made the floor-plan interactive. Users can define a floor-plan by drawing a closed area (within a certain tolerance) and attaching a floor-plan knot. The border then turns orange, indicating that the figure is now interpreted as a floor-plan. Any strokes within this figure are considered trajectories, which are also rendered in orange. Tapping on the floor-plan knot animates each trajectory in the direction in which it was drawn. Users can modify the speed of the trajectories by attaching a speed knot to the floor plan's border, and either entering a numeric speed value or adjusting a slider. Alternatively, users can apply a duration knot to specify the duration of the trajectories. Knotation v2 calculates the speed of each trajectory in the floor-plan such that they all finish at the same time. Users can use a relationship attribute for specifying relative movement, with two examples: mirroring: when two groups of dancers mirror each others' movements and unison: when several dancers perform a movement simultaneously.

Creating an interactive timeline consists of drawing a stroke of any shape and attaching a timeline knot, which turns the stroke violet. Users can then add any type of knot to the timeline. Tapping on the timeline knot displays the video knots in the order specified by the direction in which the timeline was drawn. The timeline plays the videos either at normal speed or at a speed determined by a speed knot. Users can reorder, edit, clone, attach, detach or delete any knot of any type as shown in figure 4.13.

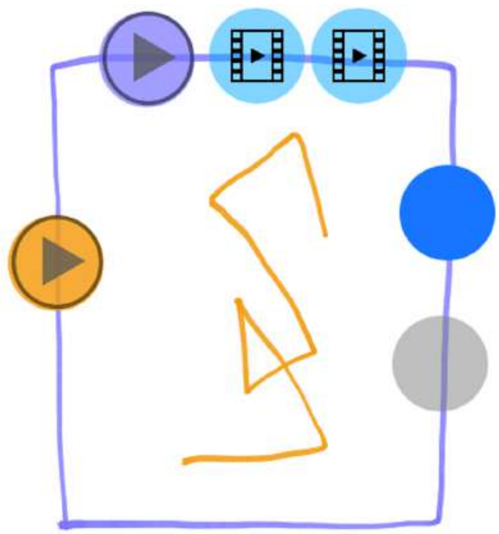

Figure 4.13. Combined floor-plan (orange) and timeline (violet) in Knotation v2.

4.3.1.5 *Studying how choreographers use Knotation V2*

We introduced this second version of Knotation and observed how six choreographers used it and what it enabled them to do [Mackay, 2014]. We organized 3 sessions (2 choreographers per session) that included five activities: training, composition, transmission, transformation, and debriefing. We captured all the data through video and sound recordings and analyzed it using thematic analysis.

We observed that Knotation v2 successfully supported participants with diverse choreographic approaches, including what we called dance-then-record and record-then-dance or a combination of the two, without imposing a particular process. For example, two choreographers first danced the sequences and then captured the result with Knotation v2. Another choreographer sat down and used Knotation v2 to plan different combinations of trajectories and movements. She then asked a volunteer dancer to perform the sequence.

We also observed that participants choose their desired level of for-

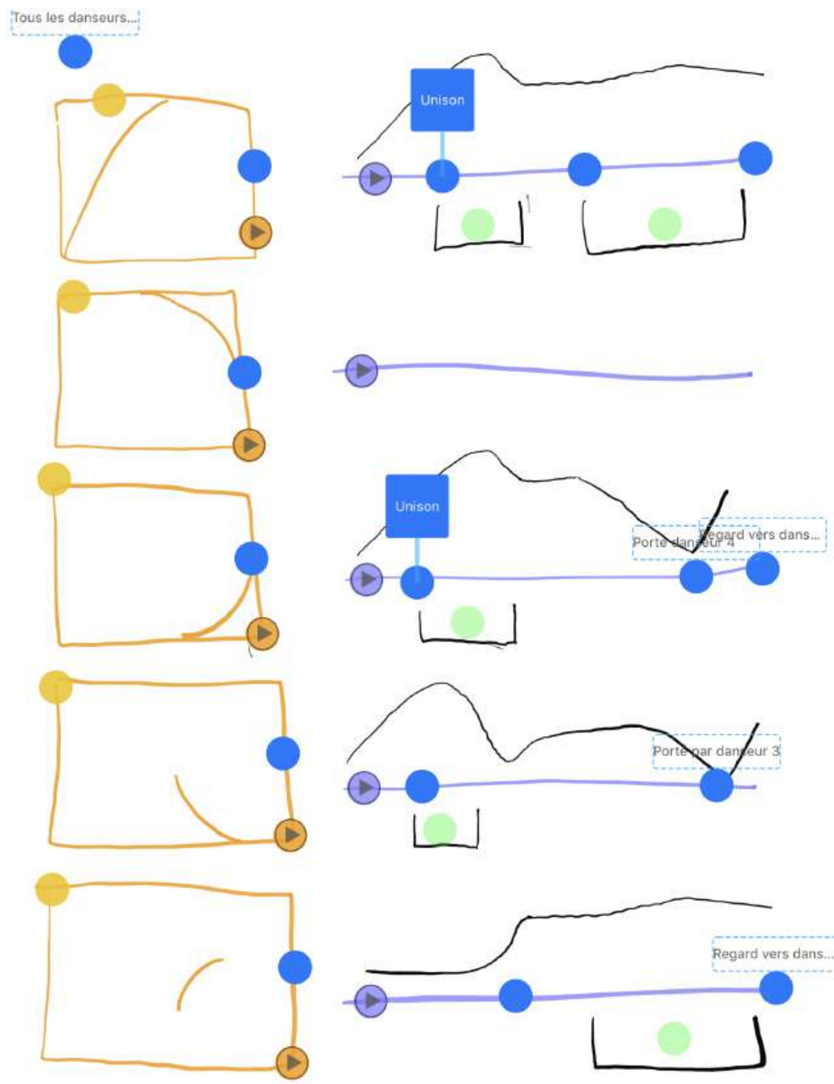

Figure 4.14. A choreographer created pairs of floor plans and timelines, one per dancer, with progressive level changes. She also used knots to mark the scope of a particular constraint over time, and cloned portals to establish relationships among the dancers.

mality, from informal sketches to formal notations. One participant created a complex structure with floor plans and timelines to compose time and space as shown in figure 4.14. She drew one floor plan and one timeline per dancer, with "properties" (e.g. unison relationships) that are read vertically as in a "rhythmic score". She created tagged knots and attributes for each timeline that indicated the scope of specific constraints over time (e.g. the direction of the dancer's gaze). She also cloned portals to define "shared scores" for dancers at the proper locations on their timelines. In addition, she drew a curve over each timeline to represent the levels with respect to the floor. Thus, she created her own sophisticated structure for decomposing and combining the 3 spatial dimensions and time on a 2D surface.

Our study demonstrated the potential of Knotation as a tool for exploring and documenting choreographic ideas in a studio setting that offered new insights into the choreographic creative process. Indeed, we observed that the tool provided enough openness and appropriability to support opposite choreographic approaches which allowed practitioners a wide range of expression at varying levels of formality.

We had designed Knotation for and with choreographers. As much as our studies with choreographers using paper or Knotation V1 or V2 allowed us to understand how choreographers represent their ideas or how they appropriate Knotation to do so, we were lacking the kind of insights that come from deploying the prototype as a fully-fledged tool in real-world settings without artificial tasks and within the ecosystem made of other analog and digital tools that dancers use. That is the gap that the next study aimed at filling.

4.3.1.6 Studying how dance artists use Knotation in the wild

Marianela deployed Knotation in a longitudinal 5-month field study with myself as a choreographer and six pre-professional dance students [Felice et al., 2021], in the frame of a course on dance and technology that I was giving in a conservatory in Paris. During the course, dancers collectively created a contemporary choreographic piece to perform at the conservatory's end-of-the-year show. The final piece included diverse technologies that I brought up such as interactive visuals, vibration sensors, and live electronic music. A total of six dancers followed all parts of the course and performed in the final show.

During the first part of the class, dancers worked in groups physically and using Knotation during a series of 3-hour classes per month over five months. During the second part of the class, which consisted of an intensive week, I instructed dancers to stop working in groups and divided them into pairs. Each pair had to compose their own choreographic fragment. All these sessions were followed by debrief moments and in the middle of the intensive week, Marianela interviewed each dancer for approximately 10 minutes, using a variation of the critical incident technique [Flanagan, 1954]. She captured all the data through video and sound recordings, and we analyzed it together using thematic analysis.

Marianela and I wrote the paper after much time has passed after the implementation of the tool [Felice et al., 2021]. The assumptions

Figure 4.15. 2 Dancers collaborating on Knotation to create a sequence and learn it together

we had when we designed the tool were that it would 1) mediate exploration and documentation, 2) democratize documentation, and 3) generate common annotation practices.

In our study, we found that the technology did not mediate exploration. In most of the 3 hours sessions in the first part of the class, I used the technology to explore creative ideas, while the dancers used it solely to document their final choices. They also used it to individually learn previously created material. However, over time, we observed how dancers' initial conflicted relationship with using the technology changed considerably throughout the process. A horizontal collaboration between dancers emerged, mediated by Knotation. Marianela observed that the dancers' feeling of belonging to the group and to the creative process progressed throughout the course and increased their engagement with the piece and with Knotation. In the second part of the course, dancers incorporated documentation practices into their routines at their own initiative.

Even if dancers became engaged in documenting their creations and in collaborating together, the hierarchical roles were always present, and the technology complied with this hierarchy. In the intensive week, I proposed to centralize the global score on one device and asked the dancers to stop updating their compositions on their own iPads. I then used Knotation intensively, creating a "global score" shown in figure 4.16 and adding each duo's score into it. From that moment on my annotations in Knotation implicitly became the one source of truth, and constituted a shared object (and place) to which the dancers would spontaneously come and sit around on the floor. Thus, the results of this study did not comply with our second assumption. They showed that hierarchical roles, as well as participants' perceptions of such roles, directly impacted their use of and relationship to the technology introduced.

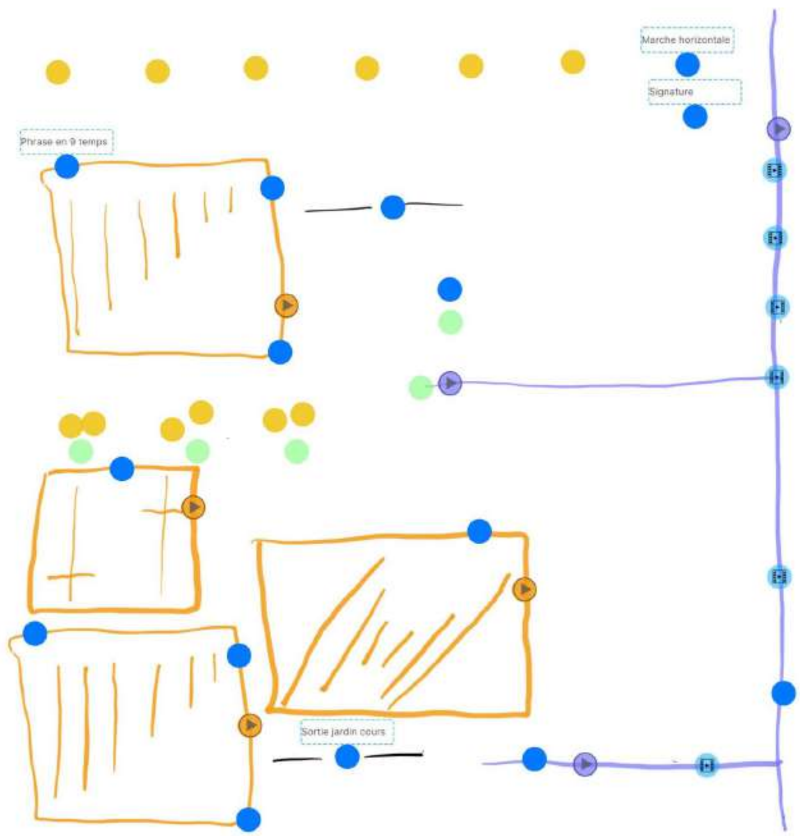

Figure 4.16. The global score of the piece created collaboratively with Knotation

Finally, our results did not comply with our third assumption either. Dancers either did not have a personal way of notating dance, or they had an idiosyncratic one that was different from mine. Still, in both parts of the course, dancers had to share one iPad with their group. Some groups took turns using the pen while others discussed and decided on a common policy for their annotations.

The results of our longitudinal study in the wild described how the reality contradicted our initial assumptions and discourse about Knotation as it has been deployed in the previous lab experiments or short workshops in the studio. Indeed, in the wild, the deployed technology played a wider variety of roles than expected but did not attenuate existing power dynamics or style differences among collaborators.

What our results allowed us to reflect on was that studying choreographic collaboration in the wild mattered and that again, it was messy. Over time, we were able to observe a progression of people's roles, relationships, and needs. This would not have been possible to observe in a lab experiment nor in any other controlled environment with artificial tasks and roles.

Moreover, we were able to accept the fact that the technology did not mediate nor democratize exploration and collaboration and that this is not a problem to solve with CSTs. We became convinced that designers of CSTs need not to poise their tools as "solutions" to for instance hierarchical social dynamics in dance making, as we were able to see how our tools at best simply complied with existing hierarchies. The worst scenario would be to create new ones shifting the power from whoever initially has it to whoever designed the technology.

4.3.2 Move-On: Designing a system for dance learning

In the very same fashion that we probed and designed for choreographic writing, we looked at dance learning as another design space. In the previous study that we run with Jean-Philippe Rivière, Baptiste Caramiaux, and Wendy Mackay, we showed that even though each dancer has a personal learning process, they all use similar techniques to learn dance namely observation, repetition, imitation, marking, segmentation, mental simulation, and personal adaptation. We also showed that there is a progression when learning dance movement that culminates into a perceived fluidity of the movement when it's integrated. This study allowed us to define a generative design space where we ideated on ways to support dancers' in their learning process [Rivière et al., 2019]. Again the idea is to leverage the commonalities that we discovered while allowing practitioners to adapt customize and appropriate the technology to their own specific ways of learning. Just like for Knotation, we were interested in following a user-centered design inspired by the guidelines from Shneiderman [Shneiderman, 2007].

4.3.2.1 Probing dancers' learning process on paper

To start this design process, our first step consisted in investigating how dancers report on their learning process on paper. We run a first study, with the goal to uncover dancers' learning strategies and the actions that they perform, and the problems that they encounter while learning dance from video. We conducted a workshop with 4 expert contemporary dancers where they captured their learning process on paper. During the workshop, dancers learned a solo dance sequence from a video recording using a simple video player software and documented the way they practice the movements at the same time. Documentation was guided by a set of pre-identified learning techniques coming from our previous work [Rivière et al., 2018]:

- Observation of the movement in its entirety or in detail.
- Segmentation of the movement into smaller sequences.
- Mental simulation of the movement.
- Imitation of the movement.
- Marking of the movement in a less than complete manner.
- Personal adaptation of the movement in order to make it easier to execute.
- Repetition

Figure 4.17. A dancer learning the sequence and representing her learning process on paper

Jean-Philippe captured all the data through video and sound recording. We analyzed the data together using thematic analysis. Our results showed how the decomposition of movement was a fundamental aspect of dancers' learning process. They also showed how dancers used the learning techniques in combinations and not in isolation to address their specific needs as these techniques complemented each other. Finally, they showed how dancers' interactions with the video player software are linked to the different learning techniques. This suggested that designing a tool to manipulate video with features reifying the learning techniques that we identified would have great potential to support dance learning.

4.3.2.2 *Designing Move-on*

Based on these findings, we designed a technology probe in the form of a video annotation tool called Move-on applied specifically to support dance learning [Rivière et al., 2019]. First, we went through an ideation process to create the interaction points, then we paper prototyped the tool as seen in figure 4.18. Jean-Philippe then developed Move-on based on the interaction points that we imagined. The tool allows users to edit dance videos by segmenting videos, then annotating, repeating, and controlling the speed of the dance segments. A segment is an interactive object that is associated with a part of a video. During the creation of a segment, the user can define the starting point and the duration of the segment. When a segment is created, it can be played, i.e. playing the associated video part. To create a segment, the user needs to long-press the video's progress bar. This action makes a segment appears below the progress bar. Then the user holds the long press and drags until the desired endpoint as seen in figure 4.19. Once the user drops the progress bar, a segment is created below the video. The user can then annotate the segment, repeat it and speed it up or slow it down as seen in figure 4.20. Thus, Move-on is designed to allow the user to engage with the learning techniques of segmentation, repetition, observation, and imitation.

Additionally, Move-On saves all the segments created by a user in a segment history. A segment history is a time-ordered stack of the different segments created by the user. A newly created segment is placed at the top of the segment history, so the first segment created is always at the bottom as shown in figure 4.21. Jean-Philippe implemented Move-On as a web application on a Node.js server that is compatible with a computer, a tablet, and a phone screen.

Figure 4.18. **Paper prototype of how to create a segment in Move on**

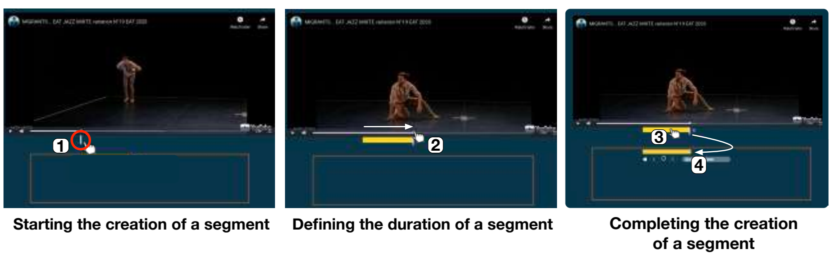

Figure 4.19. **How to create a segment in Move-on**

4.3.2.3 *Studying how dancers learn movement using Move-on*

In a second workshop, we aimed to probe how dancers decompose video into short, repeatable clips using Move-On. I helped Jean-Philippe recruit 6 experienced contemporary dancers from my personal network. We asked them to learn a video-recorded dance excerpt using the technology probe. Afterward, we sat all together and asked each participant to explain their segment history. Jean-Philippe captured all the data through video and sound recording, and we analyzed it together using thematic analysis.

From the second workshop, we found that participants created segments according to various needs for example when a sequence was especially difficult. They also segmented the video based on various foci such as space, quality, speed, orientation, etc. Additionally, we were able to identify two strategies when creating multiple segments:

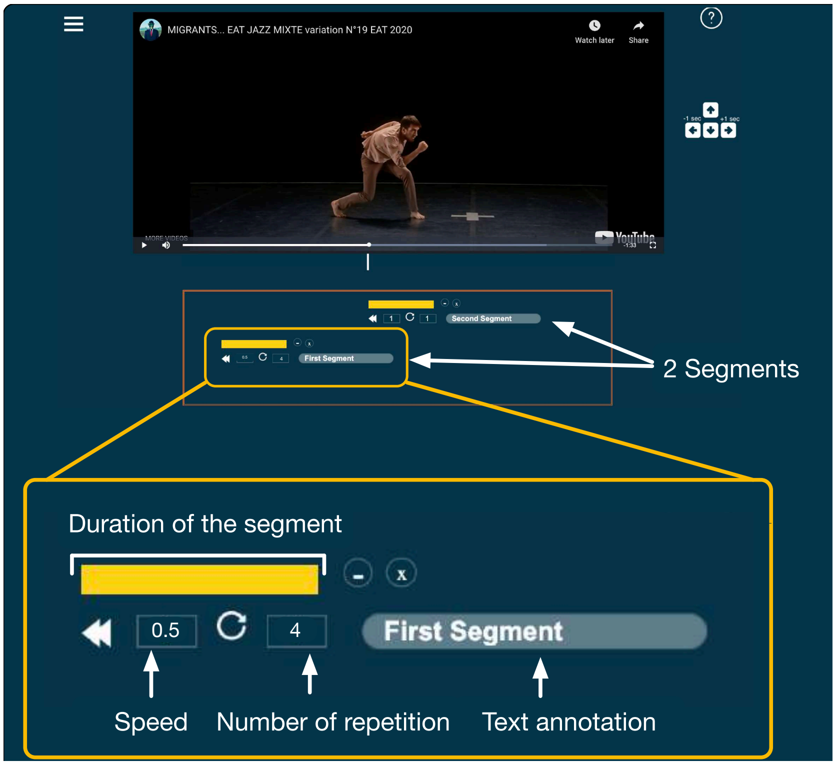

Figure 4.20. The interactions on segments in Move-on allow to annotate it or change its speed and number of repetitions

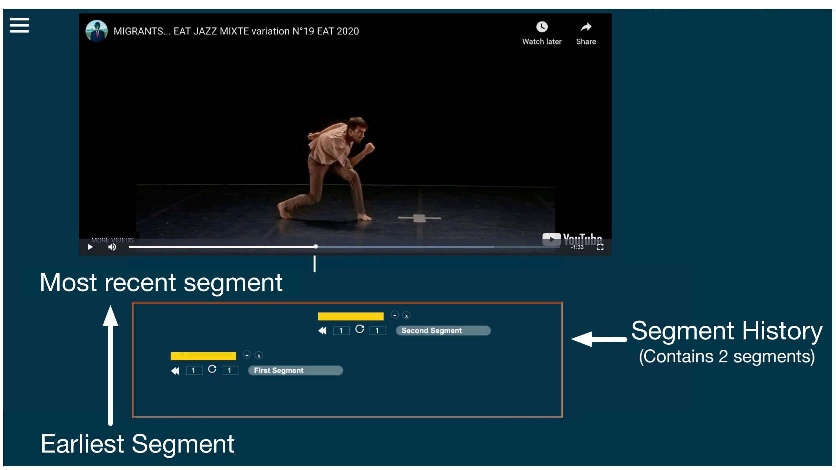

Figure 4.21. The segment history in Move on

regrouping and ungrouping. Regrouping corresponds to the creation of a new segment from multiple previously-created smaller segments. Ungrouping corresponds to exploring smaller chunks within a larger sequence. Finally, a collaborative discussion emerged from the workshop where participants suggested the potential of the technology to be used in movement transmission and pedagogy. This last finding led us to investigate further the technology probe in a context where we could explore the difference between the two typical pedagogical cases: self-scheduled learning by the dancer and learning from a schedule provided by a teacher (transmission).

Figure 4.22. Dancers learning the sequence using the technology probe

4.3.2.4 Comparing teacher versus dancers strategies in Move-on

In a third workshop, Jean-Philippe recruited a dance teacher that he collaborated with, who teaches a contemporary dance class every week for 4 hours with 6 students. These 6 students are the 6 participants in the study. Before the workshop, Jean-Philippe asked the teacher to choose two video excerpts. For each video, the teacher created a decomposition of the dance phrase with Move-On "as she would teach it to her student". She produced a detailed decomposition according to various foci with the same grouping and ungrouping strategies that we identified before (see figure 4.23). During the workshop, in the first activity, we asked the participants to learn the dance phrases from the first video using Move-On. We split the 6 dancers into 2 groups of 3 in a random manner. The first group had to learn the dance phrase using their own decomposition on the Move-on. The second group had to learn the same dance phrase using the decomposition made by the teacher and displayed on Move-on. In the second activity, we inverted the roles with the second video. Finally, in a group discussion, we asked each participant to reflect on their segment history and we engaged in a dialogue on the differences between following an imposed decomposition versus creating their own. Jean-Philippe captured all the data through video and sound recording, and we analyzed it together using thematic analysis.

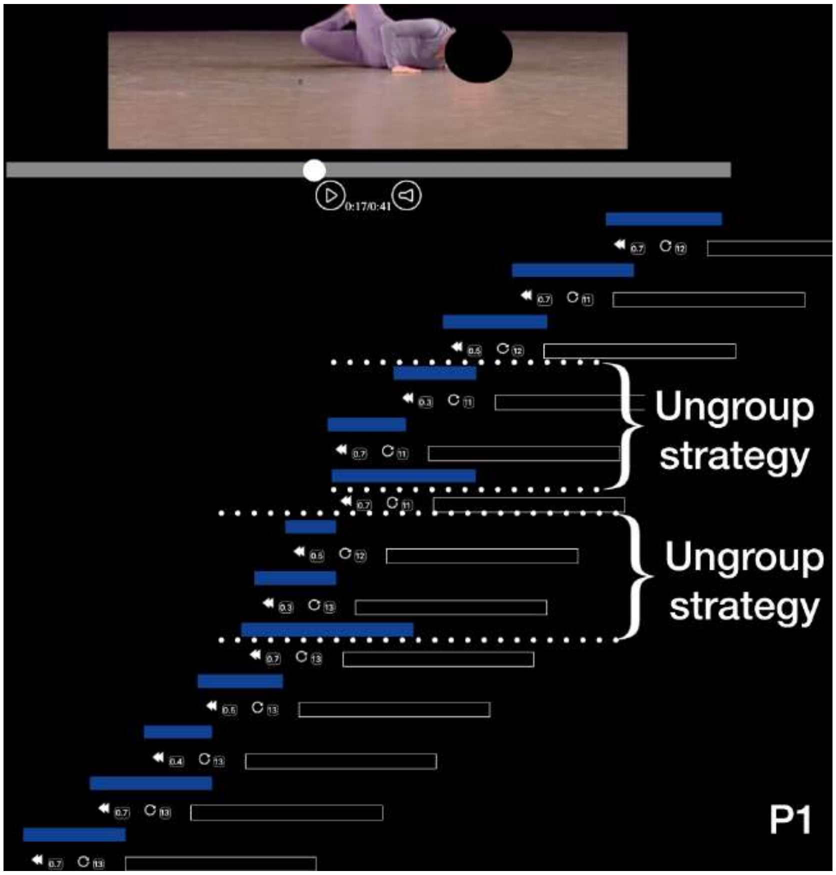

Figure 4.23. The dance teacher decomposed the first video into more than 25 segments overlapping segments. We detected the same strategies of regrouping and ungrouping segments in her decomposition.

The results of the third workshop corroborated those of the second workshop and showed how dancers followed both regrouping and ungrouping strategies to segment the videos. Moreover, the results confirmed the foci used by the dancers to decompose the videos that were identified in the previous workshop such as space and orientation, qualities, etc.. In comparing the experience of using personal versus imposed decomposition, we showed that most of the participants preferred their own decomposition compared to the teacher's decomposition. However, the most novice dancers stated that the teacher's decomposition suited them better because it was more detailed. This is consistent with how the teacher assessed the dancers' performance with their personal versus imposed decomposition.

While our 3 studies allowed us to understand the value of Move-on in supporting personal learning strategies by reifying common learning techniques into interactive instruments, our findings still lacked insights into how users would use the tool in their own contexts. Workshop 3 took place in a real dance class. During this workshop, we started to get a sense of what actually happens outside of the lab. Indeed we observed unexpected reactions triggered by the task. Mainly, a dancer abandoned the workshop before the end of the task. She explained that the task of learning on her own reminded her of traumas encountered in childhood dance classes, where she had trouble learning dance phrases. This highlights the social nature of dance learning (in a studio) and the isolated nature of designing technology in the lab. Our study showed us, that while we valued the individual ways in which dancers can learn we overlooked the group's social dynamics, context, and histories. In the following study, we aimed at bridging this gap by studying how Move-On could be integrated into a real context of learning among other artifacts and a group of practitioners.

4.3.2.5 Studying how dancers use Move-on in the wild

We used Move-on in a longitudinal study. The idea was to investigate how dancers learn a dance piece in a group and what artifacts mediate such a process and how Move-On contributes to that.

Jean-Philippe had the opportunity to collaborate during a full year with a dance company called De l'air dans l'art consisting of 12 dancers, a teacher, and a company director on the re-staging of Frame(d) originally choreographed for the Eastman company4 (see image 4.24 for a photo of the dancers performing Frame(d)). In collaboration with the company director, Jean-Philippe introduced Move-On to the members of the company to use during the year of learning and rehearsing as a tool to support their collective and personal process [Rivière et al., 2021].

During each rehearsal, he also brought between three to six tablets and connected them to MoveOn through an internet browser. He invited the dancers and the rehearsal director to use MoveOn instead of their usual media player cautious not to impose it on them. Throughout the rehearsal process, he observed how the dancers and the rehearsal director used digital and physical artifacts as well as MoveOn to support the transmission, learning, and rehearsal of the dance. Moreover, he gathered the physical and digital artifacts created by the company and observed their use and evolution throughout the re-staging. During each rehearsal, Jean-Philippe organized group discussions and performed individual interviews and observations.

Figure 4.24. A photo of the dancers performing the piece Frame(d)

To analyze the group discussions and interviews, Jean-Philippe transcribed audio and video data and anonymized all interviews. We then performed a thematic analysis together to extract themes related to the creation and use of digital and physical artifacts.

Figure 4.25. Dancers collaborating on Move-on to re-stage the dance

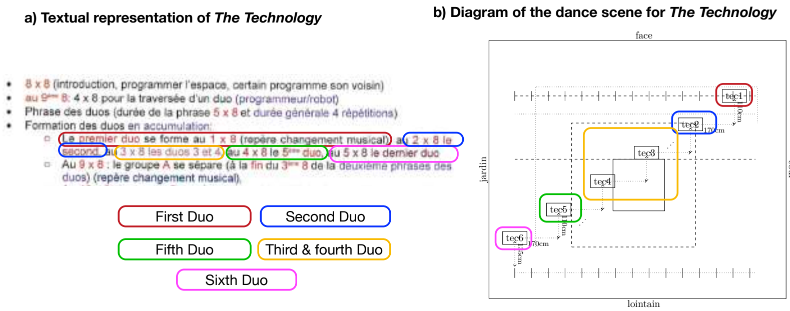

Figure 4.26. Two different representations of the same dance sequence using text and spacial diagrams

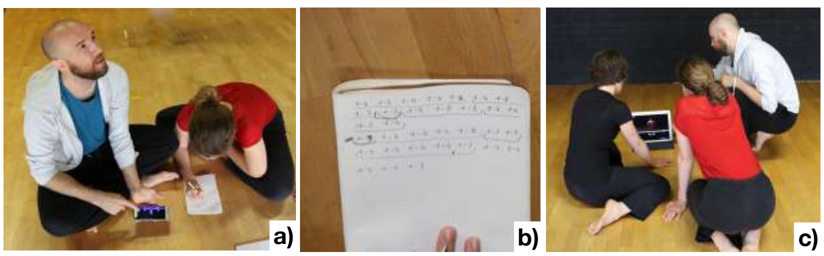

Figure 4.27. Dancers using different artifacts such as documents, videos, and notation to re-stage the dance

Our longitudinal study showed that learning the dance relied not only on one tool but on an ensemble of heterogeneous and complementary artifacts that the dancers created, appropriated, and shared. Indeed, the dancers and rehearsal director created several physical and digital artifacts related to different parts of the piece. Each artifact took a different form such as videos, texts, diagrams, scores, or notations, among others. We observed how digital artifacts help to decompose and analyze the movement. For example, video help analyze dance, and Move-On segment it and focus on its parts. We observed that the physical artifacts were used to focus on specific aspects of the choreography. For example, the diagrams created helped depict the position of the dancers in space and the (Benesh) notation created by the Benesh notators helped represent the overall structure of the piece. While the form and language used to represent information varied from one artifact to another, the group considered them equally important to focus on specific aspects of the piece with complementary views.

Additionally, from our study, we observed the challenges around the readability and accessibility of these artifacts that are due to the fact that they highly embody their creators' perspectives, expertise, and personal vocabularies. The personal approaches used to represent the information sometimes collided with other learners' ideas of the choreography. However, the participants overcame these challenges by compiling the artifacts to create a common document that facilitates access to dance knowledge for all. They also appropriated these artifacts for their own personal use and shifted their function and initial purposes to better adapt them to their needs. Finally, throughout the time of the collaboration, we saw how dancers distributed roles and responsibilities among each other in order to complement each other in the collective learning process.

Our study showed that in the ecology of artifacts created by the group, the ones that served to analyze in-depth elements of the choreography became external representations that build "scaffolding for thought", as Kirsh termed [Kirsh et al., 2009]. This emphasizes that learning dance is not only driven by physical training but also by the ability to analyze the underlying choreographic ideas (space, dancers' positions, rhythm, etc.). Our study also illustrated how the same choreographic ideas were represented with different artifacts and expressed with different forms and languages depending on the perspectives and expertise of their creators emphasizing the importance of allowing flexibility in representing information to include the diversity of learning styles. Additionally, We found that in the process of learning Frame(d), some dancers shifted roles and responsibilities echoing the conclusions drawn from the study with Stacy Hsueh [Hsueh et al., 2019a] where we argued for the need to support the fluidity, diversity, and shifts of dancers' roles and build on the different expertise that dancers can have to foster distributed knowledge among the group [Hollan et al., 2000].

4.3.3 Choreoprobe: Designing a system to support kinaesthetic creativity

The study that I conducted with my previous Ph.D. student Stacy Hsueh in collaboration with the co-supervisor Wendy Mackay, investigating the creative process in dance in interaction with collaborators and artifacts allowed us to highlight how creating dance relies on complex interactions between the creator and the various objects that they manipulate and the people that they work with. Prior to this study, we aimed at delineating a design space to build a technology that supports the very first emergence of a creative idea for choreographers and dancers [Hsueh et al., 2019b]. For that, we turned to the concept of Kinaesthetic creativity which refers to"the active use of the body through abstract movements to explore possible futures" [Svanæs, 2013]. We linked the concern of "enacting alternate futures" to the goal of breaking movement habits in movement ideation as articulated by [Loke and Robertson, 2013b]. We designed interactive visual artifacts with the goal of probing the mechanisms of kinesthetic creativity and the strategies dancers use to generate creative movement materials.

4.3.3.1 Designing Choreoprobe

Stacy and I designed a Kinect-based visualization system called Choreoprobe that tracks movement contours and dynamics. We deployed it in workshops as a technology probe [Hutchinson et al., 2003]. To explore different options for the visualizations, Stacy compiled movement visualization artworks by professional artists including Golan Levin [3], OpenEnded Group[4], Universal Everything[5], and onformative[6]. The probe consisted of different visualization systems that focused on movement structure, movement dynamics, or body form as shown in figures 4.32. We chose to display particles, trails, blobby fluid, and springy forms as the basis for the visualizations given their capacity to express various movement qualities [Fdili Alaoui et al., 2015a]. These are common techniques in computer graphics that can simulate different effects and behaviors.

[3] http://www.flong.com/

[4] http://openendedgroup.com/

[5] http://universaleverything.com/

[6] https://www.onformative.com/

4.3.3.2 Probing dancers' kinesthetic creativity

We held three separate observation sessions with two choreographers and 15 dancers. The aim is to articulate through these experimentations how practitioners interact with and through the visual artifacts to generate movement [Hsueh et al., 2019c]. At the end of every workshop, Stacy held semi-structured interviews with the participants. She used a variation of Flanagan's Critical Incident Technique to capture open-ended but detailed stories. We then analyzed the data using thematic analysis.

Our observations and interviews unveiled a diverse set of interaction patterns that dancers developed with the visuals. We developed a taxonomy for this set of interaction patterns. We placed the different patterns along two dimensions. The first of the dimensions, "relationship to visuals", refers to the different ways dancers relate to visuals, as an instrument, a partner, or a medium. When employed as an instrument, the visuals are objects containing properties that can be mobilized during movement, helping dancers form a first-person relationship. For example, a dancer can use her visualized body as a brush, leaving traces on the virtual canvas via movements. The vi-

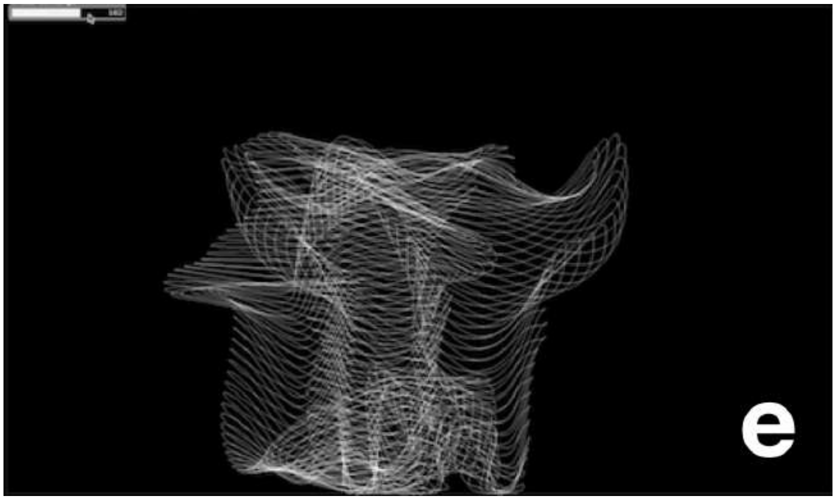

Figure 4.28. The interactive visualization artworks displaying Trails

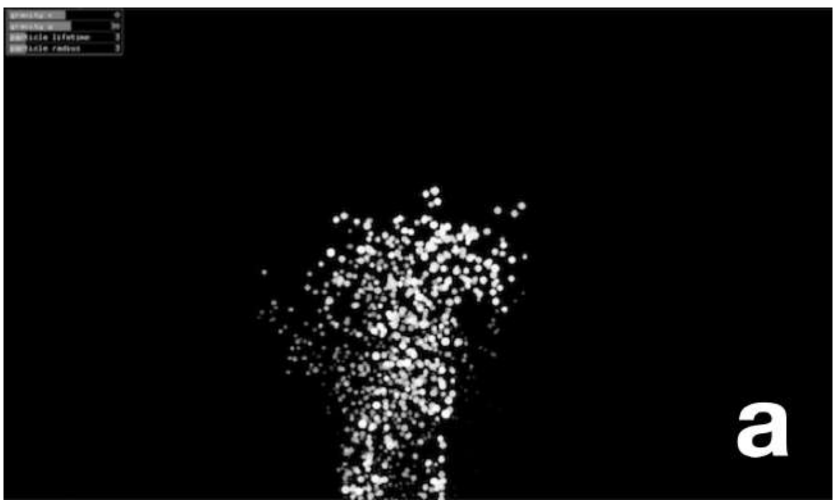

Figure 4.29. The interactive visualization artworks displaying Particles

suals can also serve as a dance partner with behaviors of their own, facilitating dancers' second-person relationship with them. Finally, the visuals can be used as a medium, mediating communication between people, thereby fostering a third-person relationship. The second dimension, "movement types", refers to two kinds of movement behaviors that emerge as a result of the visuals configuring the dancers spatially and kinesthetically: reactive and self-reflexive. In reactive movements, dancers move in response to constraints set by particular contexts, for example, the conic space delineated by the Kinect's range of capture. In self-reflexive movements, dancers turn their attention from the external environment back to the movement itself: instead of conforming to situation-relative constraints, dancers place the primacy back on movement: making movements for movement's sake.

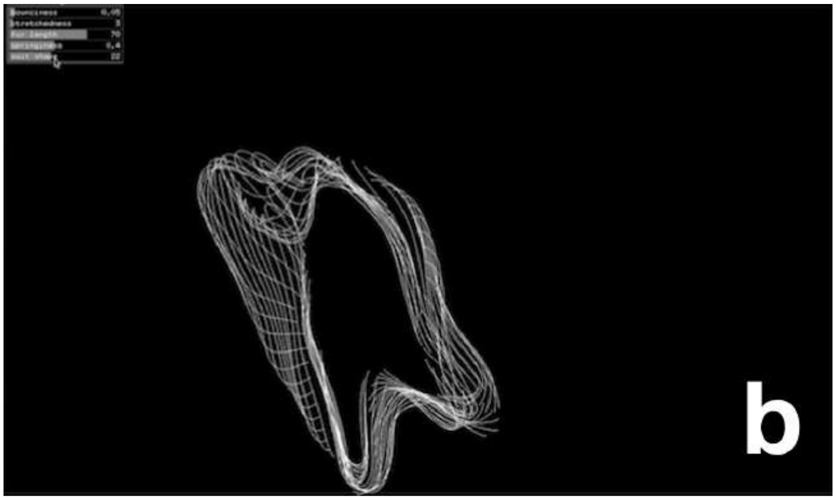

Figure 4.30. The interactive visualization artworks displaying Springs

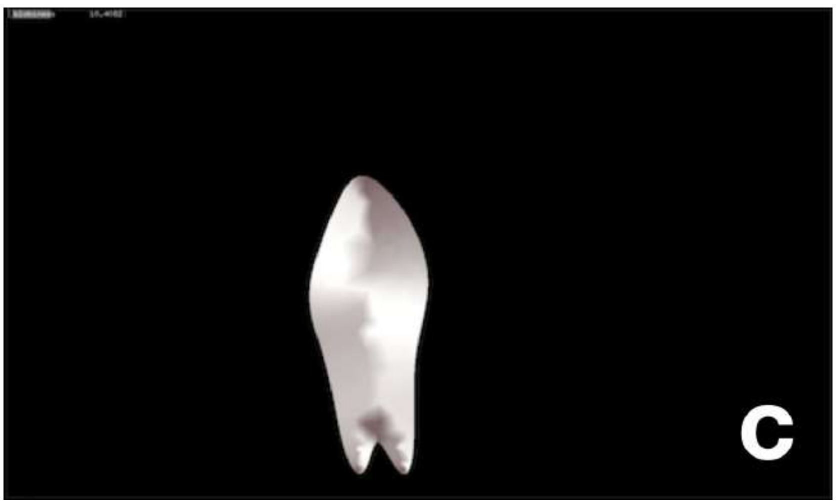

Figure 4.31. The interactive visualization artworks displaying a Blobby form

We identified 6 different modes of interaction that result from crossing these two dimensions and provide illustrative examples from our interviews and observations of each mode of interaction in the paper [Hsueh et al., 2019c].

- Instrument/reactive: control-based interaction. A dancer can use the visualization system as an instrument with restrictive properties, resulting in movements that are aimed at understanding the visual mechanisms.

- Instrument/self-reflexive: expressive interaction. When a dancer uses the visuals as an instrument to afford future movement possibilities, her focus turns from controlling the external visual be-

Figure 4.32. The interactive visualization artworks displaying a Fluid body

haviors back onto her body, resulting in expressive interaction with the visuals where the dancer embodies the visual behaviors, choreographing not the visuals themselves (as seen in "control-based" interaction) but rather her relationship to the visuals.

- Partner/reactive: “following" interaction. Here the dancer produces movements that are courteous or polite toward the virtual partner.

- Partner/self-reflexive: “negotiating" interaction. The dancer can also take a more active role, in relation to their virtual partner, in creating movements that are self-initiated rather than imitative.

- Medium/reactive: directed interaction. The visuals here are used by the choreographer as an interface to communicate with the dancer to direct their movement.

- Medium/self-reflexive: co-creative interaction. Here the choreographer and the dancer are entangled in a duet via the visualization.

We were able to observe how dancers shift from one interaction mode to another with different visualizations. The first strategy that they use to do these shifts is the construction of complex relationships. The visuals are objects filled with significance and potential for action. That potential is released via meaning-making, i.e. creating complex relationships that go beyond the original cause-and-effect relationship. This strategy enables the dancer to switch from "control-based" and "following" interactions to “expressive and “negotiating". Additionally, another strategy was progressive learning of system behaviors.

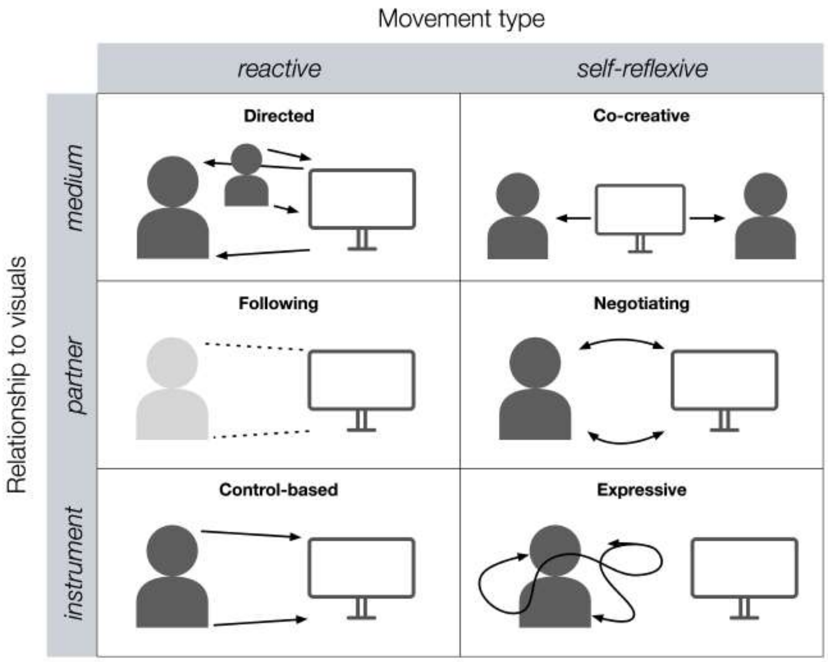

Figure 4.33. The taxonomy of interaction patterns and the resulting interaction modes

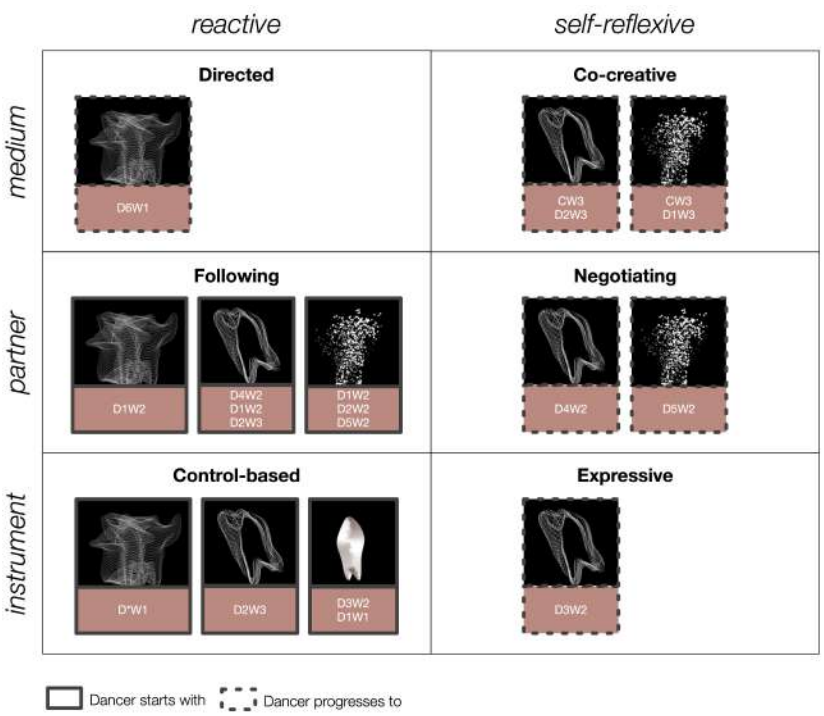

Figure 4.34. The visualizations that fall into each interaction mode.

This allowed dancers to shift from "control-based" mode to "expressive" or from "following" "negotiating". We observed that they progressively absorbed or embodied the instrument and hence adapted their own body schema in the process of movement acquisition to shift between modes of interactions and move to more expressive modes [Kirsh, 2013].

What our study with the Choreoprobe revealed was the dancers' ability to transition between different modes of interaction with the visuals driven by the various strategies that they employed in their kinesthetic creativity through learning or meaning-making. We saw indeterminacy, discoverability, and appropriability, as design qualities that invite kinaesthetic creativity to unfold. We argued for leveraging indeterminacy to facilitate constructing complex relationships, employing discoverability to guide progressive learning, and considering appropriability to enrich movement exploration.

4.4 Involving the self in design

In the latest experimentations that I am doing with my current Ph.D. students Tove Grimstad and Manon Vialle, we are going beyond user-centered methods, exploring auto-ethnographic and first-person methods. To do so, we collaborate closely with a dance connoisseur. Moreover, we engage with our own bodies in the practice of dance over a long period of time. This allows us to design technologies with and for the self. These experimentations took place within a larger project aiming at designing technologies for the documentation, transmission, and archiving of Isadora Duncan's repertoire that I will detail hereafter.

4.4.1 Collaboration with a connoisseur in Isadora Duncan

Since 2019, I have built a close collaboration with Elisabeth Schwartz, a Duncan dancer based in Paris. Isadora Duncan (1877-1927) is considered as the early-twentieth-century pioneer of modern dance. She stepped away from the rigid codes of classical ballet and introduced a new idea of dance based on what she would call "natural movement", "free movement", and the harmony of body, mind, and nature. Elisabeth Schwartz is a professional dancer, pedagogue, dance historian, and a "third generation" Duncan dancer, who for many years has been devoted to dancing the modern dance repertoire of Isadora Duncan. Taught by renowned Duncan expert and teacher, Julia Levin, who herself was taught by Isadora Duncan's own adoptive daughter, Anna Duncan, Elisabeth transmits knowledge of Isadora Duncan and her dances to both professional dancers and amateurs in addition to interpreting the repertoire, for example, in the latest piece of Jerome Bel called "Isadora Duncan" as seen in the image figure 4.42.

Figure 4.35. Elisabeth Schwartz performing Isadora Duncan's repertoire in Jerome Bel's piece

4.4.2 Designing a ribbon that represents Isadora Duncan's qualities

The first project that Elisabeth and I initiated involved my Ph.D. student Manon Vialle and her co-supervisor Melina Skouras. Along with Elisabeth as a connoisseur, we co-designed a graphical model of a ribbon that performs Isadora Duncan's pieces based on motion capture data. We recorded Elisabeth as she danced several pieces using motion capture at a high frame rate. Through multiple discussions and iterations with her, we co-designed a digital model with the goal to represent Duncan's movement qualities of 1) fluidity, 2) initiation from the solar plexus, and 3) propagation like a wave [Vialle et al., 2022]. After multiple iterations where we engaged with Elisabeth and tested the various versions of the prototype, we designed the final model as a star-shaped digital representation made of 5 flexible ribbons that can bend and twist and smoothly deform to follow the pre-recorded motion capture markers' positions as shown in figure 4.36. The ribbon can be played and experienced by dancers in augmented reality headsets with the aim to learn about the Isadora Duncan repertoire. An overview of the system from motion capture recording to displaying the ribbon in an augmented reality headset can be seen in figure 4.37.

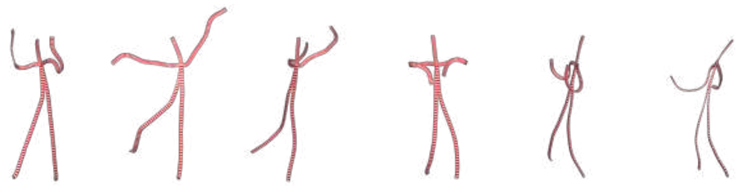

Figure 4.36. Moment Musical performed by the ribbon

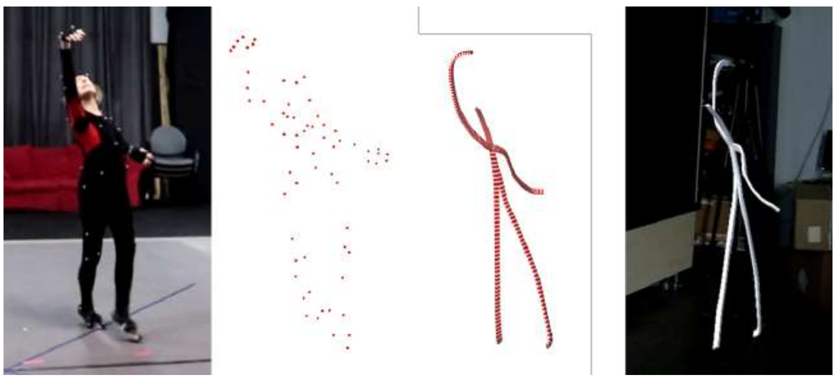

Figure 4.37. System overview. From left to right: mocap recording, mocap data extraction, ribbons generation, ribbon in augmented reality

Figure 4.38. Dancers discussing their experience

4.4.2.1 Sharing the ribbon with dancers

Through 2 workshops with professional contemporary dancers from Elisabeth's personal network, we experimented with the digital ribbons that we displayed first on a screen and second in an augmented reality environment. After trying the prototype with their bodies dancers were invited to take part in a group discussion and to reflect on their embodied experience of the ribbon. Manon recorded the discussions and transcribed the data and we used a thematic analysis to analyze it.

These workshops allowed us to articulate how our abstract visualization provided the dancers with an immersive, embodied, and expressive experience of Duncan's movement qualities of fluidity and naturalness. The star-shaped body represented a Duncanian body that let the dancers perceive the fluidity and ripple in the movement. The abstract form of the ribbon was viewed as suitable to represent the qualities of Duncan and in particular the initiation from the solar plexus. All participants thought that the ribbon viewed in augmented reality was visually appealing and allowed them to appreciate and "contemplate" the choreography (see figure 4.39). However, the use of the augmented reality headsets was found challenging as the dancers could not move freely with the device, and in most cases observed the dance or solely marked the movements.

Figure 4.39. One dancer dancing with the Hololens headset

4.4.3 Designing in conversation with Isadora Duncan dance practice

Following this first project, along with my Ph.D. student Tove Grimstad and Elisabeth Schwartz we embarked on a second project. Elisabeth created a company to transmit her knowledge of Duncan's repertoire to a group of dancers in the same way she acquired it through orality, embodiment, and transmission of historical knowledge. Tove took part in the dance company and over a period of eight months trained in Duncan's repertoire and performed it at different venues. By doing so she embarked on an auto-ethnographic longitudinal research through practice and design study in conversation with Isadora Duncan's repertoire [Grimstad Bang et al., 2023]. The process consisted in an open-ended process where practicing dance, understanding Duncan's philosophy, and legacy, and prototyping with technology were intertwined—informing and inspiring one another. Tove used a soma design approach to sensitize her body to Isadora Duncan's repertoire [Höök, 2018, Ståhl et al., 2021]. Concretely, she practiced the dance and learned about Duncan's philosophy and legacy from Elisabeth. She trained her body over a long period of time searching for Duncan's "natural movement". She paid attention to the nuances of the movements and experiences that allow this quality (naturalness) to be felt and expressed. By doing so, she slowly experienced it from within and progressively gained a deeper more embodied understanding of the dance.

4.4.3.1 Auto-ethnographic design of sonic scarfs

After each rehearsal with the dance company, Tove recorded audio memos and took notes to journal her reflections and first-person experience of learning the dances [Höök et al., 2018b]. The audio material was later transcribed. In parallel with the dance practice, Tove and Elisabeth led private conversations where Tove shared her first-person accounts of learning the dance and where Elisabeth guided her in gaining a deeper understanding of what she was experiencing. Together and over time, they articulated Tove's accounts into experiential qualities that inspired initial design ideas. Tove and I then iterated on these ideas and the resulting prototypes. Tove then brought these prototypes into her dance practice and continued sketching with her body and with the technology, reflecting on and documenting her experience of the interaction and the experiential qualities [Ståhl et al., 2022]. This iterative process led us to develop probes for the real-time sonification of dance movement [Gaver et al., 1999, 2004, Wallace et al., 2013]. These probes manifest Tove's embodied understanding of the dance repertoire and reflect the collaborative practice built between her and Elisabeth.

Figure 4.40. Guided by the experiential quality connection to the ground, we designed two silk scarfs for movement sonification. One with ocean sounds reflecting the experiential quality through a strong sense of gravity and a lingering effect, and the other sound design consisting of whispering voices with a sense of continuity and perpetual transform

Inspired by the close relationship between sound and movement in Isadora Duncan's work, we designed the sounding scarfs. These are two silk scarfs embedded with temporal sensors and two sound designs mapping movement to sound as shown in figure 4.40 and 4.41. The design of the probes was guided by the experiential quality "connection to the ground", with one sound design using ocean sounds and a mapping with a strong sense of gravity and a lingering effect, and the other sound design consisting of whispering voices with a sense of continuity and perpetual transformations.

Figure 4.41. The two silk scarfs embedded with temporal IMU sensors

4.4.3.2 Sharing the sonic scarfs with dancers

We shared these probes with the dancers of the company in an inquiry similar to that of Wallace et al. where design probes "are considered as tools for design and understanding" [Wallace et al., 2013]. The goal was to understand how the scarfs impacted dancers' practice, to open up our design process, and to learn whether —or how— our experiential qualities translated to other people's experiences [Ståhl et al., 2021].

Figure 4.42. Dancers exploring the sonic scarfs in a group of 3.

From the sharing, we observed how the sounding scarfs brought a new dimension to sound and movement in the dance practice. Sound was already a part of the practice, through Elisabeth's use of music and musical language during the rehearsals, but the movement sonification made Duncan's movement qualities of continuity organicity, and fluidity palpable to the dancers, as it allowed them to clearly perceive rhythmic qualities and movement propagation with bigger waves, smaller waves, or waves hitting pebbles. Figure 4.43 represents a body map where a dancer drew her feeling of movement continuity through the elongated arms that are augmented by the scarf. Our findings also illustrate how the dancers entangled sound and movement as they interacted with the sounding scarfs, in either an inward-looking way that heightened their sensitivity to their own body or an outward-looking way that encouraged a poetic exploration of movement and sound.

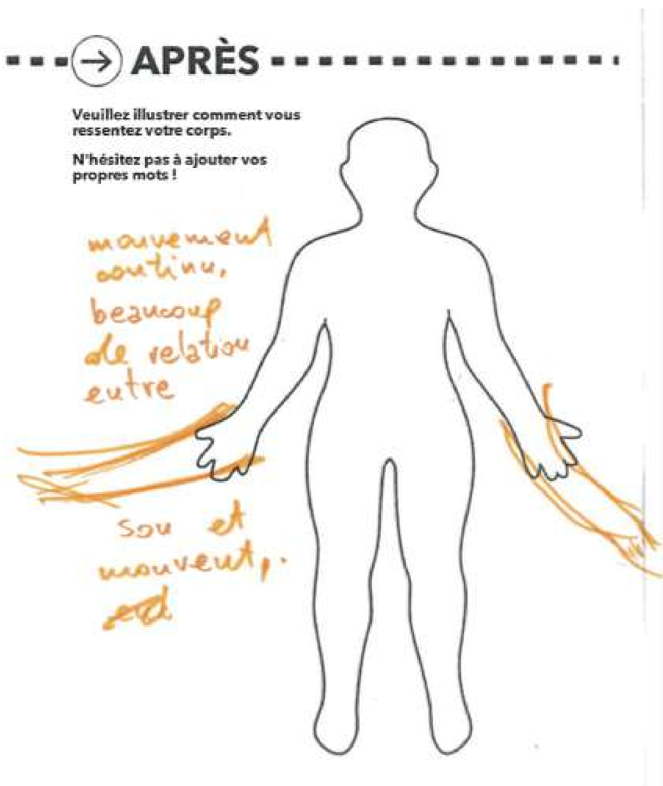

Figure 4.43. **Dancer illustrating continuity through elongated arms through the scarfs**

4.5 Discussion

As the reader can probably sense, there is a progression in the methodologies used in the studies that I presented in this chapter, from user-centered design to research in the wild to auto-ethnographic approaches.

Indeed, most of the first studies that I conducted with Marianela, Stacy, and Jean-Philippe, my first 3 Ph.D. students, were based on a user-centered design approach, which consisted in interviewing and observing practitioners to better understand their practices of respectively documenting, learning, and generating dance in order to define and delineate the design space in which we could ideate technologies that would possibly support such practices. These endeavors are not ethnographic per se as they don't engage us in fieldwork beyond interview or workshop sessions. They don't require digging deeply into these practices ourselves. An interview consists of barely an hour spent with people and a workshop will not enact a real-life situation. However, what this approach allowed was to probe multiple practitioners around the same question and to gather an understanding of the common patterns that a group of practitioners share in terms of how they document, learn, or generate movement. By doing so, we were able to design systems that could leverage these commonalities while accommodating a variety of dance contexts and approaches.

In the studies that followed the development of the various versions of Knotation, Move-On, or Choreoprobe, we were able to see how these designs could be appropriated by the practitioners in order to adapt the interactions to their personal approaches, needs, and vocabularies. Dancers imbued the knots, the visualizations, and the segments from all 3 systems with their own personal definitions and philosophy of dance. In that sense, these systems functioned as proofs of concept. All of these systems were designed based on the principle of reifying people's actions that we discovered in the interviews and observations ahead of the prototype design, such as applying operations on choreographic objects or segmenting and repeating chunks of video to learn movement [Beaudouin-Lafon and Mackay, 2000, Beaudouin-Lafon, 2000]. The process of reification is defined as "the process by which concepts are turned into first-class interactive objects". These interactive objects give the dancers the possibility of manipulating concrete visible tools that embody their practice. The studies proved that if a designer acquires knowledge of people's actions through interviews and/or observations, and extracts principles out of these actions, then it is possible to reify these principles into first-class interactive objects or instruments that would help people perform these actions [Beaudouin-Lafon et al., 2021].

In the last phases of Marianela and Jean-Philippe's PhDs, it became clear to us that the studies that we performed in short workshops with professionals were lacking the kind of insights that come from deploying Knotation and Move-On as fully-fledged technologies in the wild. To bridge this gap, Marianela and Jean-Philippe embarked on longitudinal studies where they deployed their systems within wider ecosystems made of other tools that dancers use, be they analog or digital. They probed the use of their systems in real-world contexts, such as a class in which there are hierarchies between the professor and the students, or a dance company where there are ad-hoc distributions of roles according to the dancer's skills and collective organization. These studies of technology in the wild were courageous. They demanded a higher personal engagement with the field. Both Marianela and Jean-Philippe spent a long time in the studio with the dancers, ranging from five months to a year. They got to know these dancers personally. They got to understand the challenges and tensions that arose from the practice and participated in them. In both of their studies, they had to diverge from an idealized narrative of how technology supports people's practice by reifying their actions into interactive objects. Such a scenario was too simplistic for the real-life perceptions and relationships that were much more "messy" [Brown et al., 2011]. Their narrative became more complex and also more critical. Marianela showed that technology abided by the rules and hierarchies of the real world and did not mediate or democratize documentation when practitioners resisted it, nor did it generate common annotation practices when they were not already there. Jean-Philippe showed that technology was integrated simply as an artifact among others, supporting some aspects of learning but not all. What both of these studies allowed us to do is to be more honest with what we designed, avoiding ready-made arguments about technology and its enabling and unifying capacities in creative practices. It allowed us to dare to have a critical reflection on technologies and the methods to assess them. The argument that prevailed in these studies was that real-life situations are worth looking at when designing CSTs in HCI for dance-making because they provide much more situated, contextualized, and complex insights into people's interactions with each other and with technology [Rogers, 2011].

With my current Ph.D. students Tove and Manon, we have further deepened our engagement with the field through first-person autoethnographic methods and longitudinal collaborations with a connoisseur. Both Tove and Manon work closely with Elisabeth Schwartz on Isadora Duncan's dance vocabulary and have respectively spent up until now one and two years interacting with her and taking dance classes with her to train in the Duncan repertoire. Their approach consisted of digging into a specific vocabulary in a deep and committed way, avoiding an all-encompassing design. They did not seek to provide generalizable models of dance movement. They contributed with specifically tailored designs for the work that they spent a long time learning. This process has been not only informative for the design of the artifacts that they explored in the studio, but it has also been transformative for them. They have had "aha moments" while embodying Duncan's qualities that changed their perception of their body and their performance of the dance. This has been a profound process that led to very distinct designs and ways of collaborating and conversing with dance practice. Closely working with a connoisseur such as Elisabeth with high levels of expertise and dedication to a dance style was more than simple input as can be the case in user-centered design [Schiphorst, 2011]. Elisabeth was one of the initiators of the project and co-authored the papers that we published about the experiments [Vialle et al., 2022, Grimstad Bang et al., 2023]. She was a co-owner of the work. She was curious about how technology could carry information about dance and how it has the capability to represent the qualities of Isadora Duncan's repertoire. Her knowledge of the dance, both theoretical and embodied, was built over 40 years of learning this repertoire and transmitting it to other dance artists. She used her knowledge to accompany both projects as well as Manon and Tove's learning journeys. Such collaboration, which put the somatic embodied expertise of a connoisseur at the center, was fundamental in the design of the technologies that we proposed. The proximity with Elisabeth as the connoisseur brought us all together and enabled the design process to unfold. With the dance practice as an anchor, Manon and Tove built a deep understanding of the embodied experiences of Duncan's dances upon which and in conversation with which they designed technologies.

Instead of adopting interventionist strategies and designing systems that "support"' transmission, Tove in particular, sought to view how design can become one of the means (along with the body) to dialogue with another practice, share knowledge, and ask questions, developing reciprocal creative and learning encounters, as described by Kang et al. [Kang et al., 2018]. The interactive system in our study was brought in by Tove to dialogue with the dance. Each one of us involved brought a piece of our own craft to the encounter, fostering a dialogue that generated ideas, learning, and transmission. In this process, the dancers learned about design, and the designers learned about dance.

I believe that such long-term engagement and building close relationships with a group of practitioners allows for a more balanced configuration of power in collaboration, and a better understanding of the design space, which ultimately makes for seamless design work [Barad, 2003, 2007]. We found that the foundations of such a long-term engagement with practitioners are humility, slowness, and careful listening. These qualities allowed us to make space and time for everyone's knowledge, ideas, interests, and goals, without instrumentalizing dance for the sake of technological advancement or using technology to enable artistic innovation.

My experiments with Elisabeth are some of the latest works that I describe in this manuscript. This collaboration has the goal of generating knowledge of a dance style that is, in a way, in danger of extinction. Indeed, the experiments were situations where embodied knowledge about Isadora Duncan's work was built and circulated. I cared that everyone engaged physically with the material, including the researchers, the designers, and the dancers. Everyone performed the pieces to better articulate what the Duncanian style meant for us, with Elisabeth's guidance. The design process allowed everyone who participated in our workshops (including the researchers and the practitioners) to enrich their palette of embodied experiences with a dance style that we had had no previous opportunities to learn nor perform. Thus, I consider these experiments to be attempts to make Isadora Duncan's heritage alive again in the studio. The transmission sessions, mediated by technology and guided by Elisabeth, gave the dancers an embodied experience of an "archive" that so far is only stored in the embodied memory of the few expert Duncanian dancers that remain. Therefore, designing and experimenting with the technology through embodied auto-ethnographic and soma design processes is an excuse for me to revive a repertoire that, for most dancers, is almost dead but that remains very fundamental to what has become today's modern and contemporary dance forms.

5

Researching through creation and creating through research

May, 4th, 2022

Dear Alejandro,

I am sorry to answer your email 2 months later.

First of all, thank you very much for sharing your thoughts and your process with me in the form of an email where you discuss your doubts and your insights on research-creation and the steps you were at when you sent the email. Thank you also for choosing the form of correspondence in order to write and elaborate on your academic ideas. What a blast to be able to write freely, without the formalities of academic thinking, and how cathartic it is to feel that an email is a production of knowledge just like a CHI paper might be.

In this Habilitation that I am writing, or perhaps procrastinating to write, there will be a chapter where I situate my work in research-creation, to talk about it as a method, as a site for creating art and generating knowledge. How odd is it to mix these two things together? why and how? So, I thought perhaps I could write you an answer via email and include it in my Habilitation instead of a formal methodology chapter. This will be my way to explain my process, my goals, and my means to my readers.

I was aiming to write this Habilitation as a book that looks like a non-fiction book. I wanted to write it in a different way than a formal academic manuscript, to play with the form as much as I like to play with the academic norms. I then lacked some of the inspiration to do so, or perhaps these past two years, I didn't find the fuel to inspire me, I didn't dance enough, a pandemic *and a child contributed to isolating me, as well as an office that is 1h30 of commute away from home. So I stayed home a lot, trying to write, but writing takes so much from one's inner self. You need to nurture it every day and seek for a reason to write. This email motivates me to direct my thoughts to you and encourages me to feel authentic and genuine about them. But is this email an academic essay? When practicing research-creation one plays with epistemologies and methods, and one can invent what can be held as academic writing just like what can be held as a site for research.*

As you know, I have very gradually moved away from quantitative scientific investigation, to frame my work in research through practice, and this practice is sometimes design, but mainly performance and art. I have started my Ph.D. doing quantitative modeling of dance movement, mainly movement qualities. At that time, I didn't think one could blur the boundaries of what art making and science were, so I had to choose sides, and I chose the side of science. So I scienticised much of what I learned from the practices of the choreographers I worked with. Slowly, as I did my post-doctoral work in Vancouver, I discovered that the academics in my school claimed that they were artists and the artists that they were academics. Everyone was everything. And I gained the courage to claim that I also had a dance practice that fed my thinking and my embodied self. That my research was an academic practice and an artistic one as well. I started reading about people who sought to talk about their work with long descriptive narratives. I remember, back in 2012, in the doctoral consortium of the conference Designing Interactive System, where I was a Ph.D. student along with Will Odom and Daniela Rosner, I had genuinely asked Will (who is a designer) after his presentation: "But why is your work computer science", he blushed and said "It's design research" I came out of that room, still flustered by all what I saw. There was a different way than the ones developed in HCI departments in France which are mainly computing and system engineering departments. It was a moment that changed the path of my career. What you call a transformative moment in education, where the result does not matter as much as the transformation that you go through personally.

Little by little, I started making the choreographic work that I talked about in my papers. I allowed myself to experience the pleasure of creating an artwork that is certainly personal and sometimes intimate. To experience the joy of performing a piece in front of a crowd of audience members. To experience the thrill of seeing how a dance performance can be perceived, how it can move people or make them think. How what I designed can speak to others, to people I don't know, to people that are anyone and everyone. To experience the pride of sharing my process with students to give them directions that can feed their own thinking or creative process. To experience the wonders of bringing groups of dancers to think of new ways of making dance. Just *like I love to discover other choreographers' processes, the steps they create for themselves, and the constraints they build to generate their ideas, I allowed myself to experience the delights of sharing my process and inventing new ones with others.*

And then every time, I discovered something from the process of making or the process of sharing the making. A story I can tell. And because my making has some computing or some design in it, because the story is usually told to an HCI crowd, I say it from the perspective of what I learned about how people relate to these machines. Sometimes, I wish to make these works without machines and to tell the story about the people not the interaction with the machines. And then I realize that much of what people do is mediated by these machines. These machines can be a camera to film someone or a recorder to capture their voices. Our lives are so entangled with these technologies that mediate them every day in the very mundane actions that we do. So my stories always involve these machines, as platforms for how people's actions and thoughts unfold. Therefore, it makes sense that my academic work consists of communicating discoveries about humans and computers.

Do you remember, I told you once, that if I were only an artist, I would miss the thinking that goes with framing these stories and making theories about them. If I were only a researcher, I would miss the contexts in which my thinking deploys the best: when I am with people inventing things, scores, movements, and stories.

So I wrote about Skin, and RCO, CO/DA. I need to write about Vintage and "Some Assembly Required Reproduced". I would like to write about what we did in Chamarande, with the young disabled adults. I would like to write about the game I invented for people to dance while capturing environmental data called "data dance". So much to write about. So many things and I do not have the energy to write a CHI paper for each one of them. Should I get an academic blog to write more freely and report on the work I do? Should I simply send you an email and put it somewhere?

I have read that postface of Yves Citton [Manning and Massumi, 2018], what was significant for me in his text, beyond his amazing capacity to say complex ideas in simple words, which always impresses me, is that he considers research-creation as somehow something that would democratize research and creation. He shows how fundamental this de-compartmentalization is to rethink the world we live in. This is still a place of controversy, at least in France, as it redefines what the walls of the "temples" are. Can we do science by inventing a device that is critical, satirical, or poetic? What are we observing and analyzing? Is it telling us anything about the world, humans or other species? And thus, if we accept that people doing this kind of work are *doing science, what about people doing the hard stuff, the "real science"? Are we delegitimizing them? Should we always define something as excluding something else? Many people would say that never ever would a research-creation fellow get a chair at College de France, simply because whatever they do is beyond the scope or perhaps incomparable to whatever a physician or a sociologist is doing. By defining what art is and what science is, should we always exclude many other contributions that might aspire to be both? I believe that this type of disciplinary slips and epistemological battles is inherent to the history of what humans have ever produced or invented. Computer scientists had to go through many justifications to legitimate that their field is science although not a natural or social science because they study data, systems, and information. Psychologists had to go through that by formalizing their methods with rigorous criteria that were perhaps too rigid for the sake of being welcomed to the club.*

When I think of the guardians of the "temples", be it art or science, I think of how I felt their power that other day when I went to the College de France to listen to Wendy Mackay's inaugural talk. I think of institutional committees and I also think of curators and museum or festival directors. Those that have the power to say what is art and what is not, what is science and what is not. Science at least, compared to art, has the benefit of defining those criteria in explicit terms so that not much, or at least in theory, not much is decided only through the whims of those who have the money to make an artist trendy and desirable. In science, it looks like a good argument, good data, and rigorous methods get you a seat at the table. Of course, we both know, it is not as simple as that, and there are implicit biases of who gets that door open, who gets the support needed, and the platform and space to allow them to dedicate time and energy to do scientific research. When I think of the guardians of the temple, I think, of course, of the discourse of "equal opportunities" in France. Hypothetically speaking, everyone can study what they want and get wherever they want as long as they put in the work needed. Feminists then argue that there are simply not enough women, queer people, or people of color in research fields such as HCI, computing, or even in the arts. The guardians of the temple then argue that the only criteria are rigor and excellence. In fact, what these criteria do is define what gets inside and what is left out. They define art and science by excluding. They create walls that only a few can pierce. And schools are obviously the tunnel that channels the inclusion of a few and the exclusion of many. By bringing in feminist epistemologies, by saying we can make science differently, feminists attempt to push these walls, redefine their borders and make them porous [Alcoff and Potter, 1993, Haraway, 2016, Bardzell, 2010]

This to me is what research creation does the best, and the delight I find in practicing it. It is a feminist epistemology and a way for me to practice subtle *activism from within. Every time I think I understood the layout, the form, the border, and the method, I discover new limits of my thinking that inspire me to push these borders. I re-draw the map. Your email and process of writing a thesis as a blog, a series of correspondences, and sonic ABCDairs inspired me to re-draw the map. I thought: yes! that is knowledge too; that is research too!*

Your work is on music and disability. There is an obvious social component to your work. Instead of emphasizing that, you are questioning the stance from which you embarked on this work. In other words, you reflect on your own transformation through the process of working with disabled people using a research-creation method. Until my recent project Living Archive which aims at working on documentation of minorities' practices of dance, much of my work was personal and intimate or based on collaborations with other artists whose works are personal and intimate. All I was talking about was my own process or that of my collaborators. And after 2 years of a pandemic, the question became: Who cares? The emphasis on reflexive processes as a main way of producing knowledge in research through practice can feel a bit navel-gazing. Sometimes, I am tempted by a direction in which the ego was tamed.

I think that a self-reflecting process written from a first-person method becomes useful, insightful, and generous to whoever reads it when it is meant to resonate with others trying to develop their work that way too. I noticed how such processes and methods allowed me for example to adopt horizontal pedagogies and care about the kind of novel forms that my students can invent. Instead of constraining them in rigid rules, I was able in my classes and workshops to co-create a sort of flexible container for their work and share it with the world or at least the tiny pockets of communities where we have an available platform to show it.

Do you remember when I told you how I thought that the main pitfall of research-creation is nombrilism and you sent me this quote by Laura Forlano[1]*:*

> *As ethnographers, it is not enough to describe social reality, to end a project when the last transcripts and field notes have been analyzed and written up. We must find new ways to engage and collaborate with our subjects (both human and nonhuman). We need better ways of turning our descriptive, analytical accounts into those that are prescriptive, and which have greater import in society and policy. We may do this by inhabiting narratives, generating artifacts to think with, and engaging more explicitly with the people formerly known as our "informants" as well as with the public at large.*

I then responded to that quote with a sentence that summarizes my intention behind using research-creation :

[1] http://ethnographymatters.net/blog/2013/09/26/ethno from-the-future-what-can-ethnographers-learn-from-science-fiction-and-speculative-design/

> *"I think that I am more into making artifacts (and performances) as part of how I make sense of the world rather than a way to express who I am and what I have to say"*

This is precisely why I do research-creation. Through creating things and situations, I invent contexts that allow me to think better about the world, people, technology, and politics.

I googled "research-creation" and of course, Hexagram popped out with a definition that comes from the Human Sciences Research Council of Canada (SSHRC). (They are so ahead of us here in France.) [2]

[2] https://www.sshrc-crsh.gc.ca/funding-financement/programs-programmes/

> *Research-creation is an emerging trend in the academic research community that links the practice of the arts and the sciences of the arts to the interpretative sciences and the pure sciences, in order to generate new knowledge through social, material, and performatives. A research approach that combines academic creative and research practices and fosters knowledge production and innovation through artistic expression, scientific analysis, and experimentation. The creative process, which is an integral part of the research activity, makes it possible to produce well-rounded works in various art forms. Research-creation cannot be limited to the interpretation or analysis of the work of a creator, traditional works of technological development or works that relate to the design of a curriculum. The research-creation process and the resulting artworks are judged according to the merit evaluation criteria established by SSHRC. Fields that can be linked to research-creation include the following: architecture, design, literary creation, visual arts (painting, drawing, sculpture, ceramics, textiles, etc.), performing arts (dance, music, theatre, etc.), cinema, video, interdisciplinary arts, media, and electronic arts as well as new artistic practices.*

Overall I think this definition is quite good. Two points that I might critique. First, linking research-creation to innovation. The word innovation irritates me. Given the state of our world and the type of destruction that we have contributed to creating in the name of innovation, we might need to start dis-innovating. There are very attractive values that we can look at, those of un-design [Pierce, 2012], or repair [Jackson and Kang, 2014] or designing sustainable [Blevis, 2007], fair, just technologies [Pargman et al., 2018] and artifacts that benefit humans, other species [Smith et al., 2017] and the planet rather than innovate for the sake of novelty. This innovation race is very much fed by the silicon valley narrative that is also responsible for creating monsters, and billionaires, harming minorities and workers, and enlarging the social gap between people. So let us innovate to go beyond the goal and narrative of innovation, especially when developing technologies. Second, the merit evaluation criteria of SSHRC frightens me as again I think these definitions are certainly made to define by excluding. We need to think of other possibilities for contributing beyond the definition of excellence. We need to be porous enough to allow for flexibility non linearity and re-shaping *as we invent new ways of thinking and framing our ideas out in the world.*

Thank you again for sparking this conversation,

See you in a bit,

Love you,

Sarah

5.1 Overview of research through practice within and beyond HCI

5.1.1 Performance-led research in HCI

From [Zhou et al., 2021]'s extensive review summarizing important themes in the literature at the intersection of HCI and dance, there are a few examples of HCI research that venture into the world of dance productions, or what goes under Benford et al.'s umbrella term of "performance-led research in the wild "[Benford et al., 2013]. Benford et al. argue that performance can act as an experimental frame through which to study how people interact with technologies in the wild, meaning in real performance settings outside of the lab [Rogers, 2011]. Such projects triangulate artistic practice with studies to understand people's experiences with the generation of concepts and frameworks theorizing the results of the studies.

Hereafter, I describe some of the contributions that emerged in HCI from studying dance performance in the wild. Neural Narratives, developed by Bisig and Palacio, is a piece that displays an interactive visualization that responds to the dancer's movement in order to encourage novel movements during improvisation [Bisig and Palacio, 2016]. Bluff and Johnston presented their long-term collaboration with a physical performance company that culminated in the creation of five major performance works. The authors describe the "trajectories" that shaped the relationship between the stakeholders and the interactive systems and how they evolved over the duration of the production. They put that in perspective with the evolution of the technology itself, in terms of aesthetic capability, performance robustness, operational cost, and complexity [Bluff and Johnston, 2019]. Eriksson et al.

described a performance of the classic opera "Medea" in which they incorporated drones to act as Medea's children. Through this performance, the authors discuss the inter-corporeality between humans and drones [Eriksson et al., 2019].

Despite these few examples, performance-led research in the wild remains scarce in HCI. This might be due to the fact that art practice is usually personal and driven by individual goals and intentions and thus generates insights that are hard to generalize or sometimes articulate in academic forms and languages.

5.1.2 Research through design in HCI

The intersection of HCI and practice is particularly clear in the rising voice given to designers [Kang and Jackson, 2018, Goodman and Wakkary, 2011] as well as the formalization of research through practice as an investigation undertaken in order to gain new knowledge through practice [Zimmerman et al., 2007]. In the context of HCI, practice refers mainly to design practice. An overview that summarizes the extensive literature arguing for HCI research to embrace design practices can be found in [Goodman and Wakkary, 2011].

In his essay, Gaver argues that research through design is likely to produce theories that are "provisional, contingent, and aspirational". Rather than aiming to develop comprehensive theories of design, he suggests that practice-based researchers should focus on producing annotations of realized design exemplars. He emphasizes that the diversity of approaches in research through design is not a problem per se. According to him, the research community should refrain from aiming towards convergence and standardization, and instead "take pride in its aptitude for exploring and speculating, particularizing and diversifying [...] and manifest the results in the form of new, conceptually rich artifacts" [Gaver, 2012].

Dunne and Raby introduced critical and speculative design "more as an attitude than anything else, a position rather than a method" [Dunne and Raby, 2013]. In their work, they produce speculative accounts that challenge preconceptions about the role products play in people's everyday life. Auger characterized speculative design as an approach that serves two purposes: 1) to enable designers to think about the future and 2) to critique current practice [Auger, 2013]. Critical and speculative design has been largely used in HCI through the development of slow interaction [Odom, 2015] or adversarial design [DiSalvo, 2012] among others, and through applications across a large number of contexts.

In their essay on design practice, Pierce et al. argue for openness to authorship. They show that authorial voices are clearly acknowledged in design, particularly in critical and speculative design, and provide alternatives to user-centered design (UCD) and solutionist views in HCI [Pierce et al., 2015]. Such an argument is supported by a variety of research through practice works within the HCI community that diverge from UCD and critique its methods such as design thinking and its goal of creating average design according to acceptable user needs [Zimmerman, 2011, wakkary, 2021].

According to Mark Blythe in his essay *Anti-solutionism through Design Fiction*, the roots of solutionism in UCD go back to the main scenario that HCI traditionally addresses, which is solving workplace problems [Blythe, 2017]. In a more unionized context, such a scenario aimed to support labor and historically implied a participatory approach to design as exemplified in Scandinavian interaction design traditions [Bødker and Kyng, 2018]. Since the last two decades, interaction designers are exploring alternative scenarios other than the workplace problem, where the"monster" to fight against is rather the "lack of informed debate" and the need for more "reflective and critical practice and discourse in design" [Blythe, 2017]. These scenarios embody a critical stance on UCD and a political stance on HCI's productivist agenda and the field's ties to industry and Silicon Valley [Bardzell and Bardzell, 2013].

As examples of such alternative practice-based approaches in HCI, we can cite feminist HCI [Bardzell, 2010], which reveals patriarchal values within HCI's dominant paradigms. There are approaches highlighting the underlying hegemonic structures of production in HCI [Tanenbaum et al., 2013] and those resisting corporate Silicon Valley agendas [Hanna et al., 2017, Pargman et al., 2018]. I can also cite works engaged with activist communities [Fox et al., 2018, Asad, 2018] that take political stances on technological innovation.

In his recent book, wakkary argues that design should move away from the exploitation of nonhuman species and materials. Inspired by post-humanist philosophies, he calls for a commitment to design with more than human participation wakkary. In the same vein, Smith et al. proposed a critique of the Anthropocene that allows for designing for cohabitation with other species [Smith et al., 2017]. Biggs and Desjardins involved more-than-human perspectives in designing embodied environmental speculations [Biggs and Desjardins, 2020]. Oogjes and Wakkary recently argued for the need to further engage with posthuman theories conceptually, materially, and methodologically Oogjes and Wakkary.

I believe that these approaches led by design practice and embedding reflection and criticality laid the groundwork to open HCI to art practice as a fertile ground for experimentation and reflection.

5.1.3 Research-creation beyond HCI

Research-creation has flourished in the past twenty years, with a particular impulse from academics and artists at universities in Quebec. According to Manning, one of the main theoreticians of research-creation, linking the art practices to the interpretative and pure sciences generates new forms of experience and knowledge, "many of which are not intelligible within current understandings of what knowledge might look like" [Manning, 2016]. Manning and Brian Massumi's work is deeply grounded in Félix Guattari's philosophy. In Chaosmosis , Guattari enthuses about the possibilities of an "ethico-aesthetic paradigm" [Guattari, 1995]. In an interview for Transversales magazine in 1992, he said: "In this sense, we will move from a paradigm that was intended to be scientific in the different eras and structures of socialism, to a more ethical-aesthetic paradigm, that is to say, more focused on the creation of oneself, of one's relationship to the body, to the world, to the other... This relationship to the other is the foundation of an ethic that I have called ecosophy" [Banaré, 2014].

In "How to Make Art at the End of the World: A Manifesto for Research-Creation", Loveless contributes with a full overview of this burgeoning area of research. The book does not provide methods to do research-creation per se but rather takes on the task of grappling with the ethics and politics of research-creation, offering a feminist, queer, and intersectional perspective [Loveless, 2019]. Similarly, Lowry looked at research-creation as a "queering of the academy" through the production of artistic acts that blur the boundaries of art and science [Lowry, 2015].

Manning frames 10 propositions in the form of a manifesto for thinking-in-action that summarizes the values and the potential of research-creation effectively [Manning, 2016]:

1. Create new forms of knowledge (embrace the non-linguistic)
2. Practice thinking (don't be afraid of philosophy)
3. Make beyond the object (work the work)
4. Dwell in the transversal (keep moving)
5. Be speculatively pragmatic (enjoy the process)
6. Invent beyond technique (activate the more-than)
7. Meta-model (make it an event)
8. Render formative forces (create a platform for relation)
9. Create alter-economies of value (value emergence)
10. Activate new forms of life (invent the interstices)

As mentioned previously, my work is rooted in a research-creation process where both the creation and the academic research are intertwined. I consider my dance practice and my experimentation with my own body, as well as with my collaborators in the studio, as a fertile ground for both my creative and academic endeavors. In my dance pieces, I include technologies that I design with sensitivity given to the aesthetics of interaction and an emphasis on bodily experiences. Moreover, in making my pieces, I practice movement observation from first-person to second-person perspectives [Fdili Alaoui et al., 2015b, Höök et al., 2018a] and use micro-phenomenology [Prpa et al., 2020]. I also use somatic practices inspired by LMA to articulate movement. These are the tools that I manipulate that allow me to articulate the embodied experiences that I design for.

In my research-creation approach, I create dance pieces designed as situations in which I learn about people in relation to technology, be they the dancers, the audience members, or my own self. I study how people perceive the pieces that I create or how they behave in them or interact with the technology that is involved. Integrated in an intertwined way with dance making, technology is thus a means to support, partner with, reflect upon and subvert my dance practice [Salter, 2010]. It is in this intertwining that I aim to produce knowledge that can be useful and generative (rather than generalizable) for HCI and interaction design, science, and art [Ståhl et al., 2021].

Figure 5.1. Performing an improvised form

5.2 First-person methods

First-person methods have a long history in the humanities and social sciences and were introduced later on in HCI, and interaction design [Neustaedter and Sengers, 2012, Höök et al., 2018b]. In HCI, first-person methods include design methods such as auto-ethnography, autobiographical design, and research-through-design [Desjardins and Ball, 2018, Lucero et al., 2019] as well as interviewing methods such as experience elicitation technique or micro-phenomenology [Prpa et al., 2020].

5.2.1 First-person design methods in HCI

Auto-ethnography is a research method that uses personal experience to describe and interpret cultural experiences, beliefs, and practices [Ellis et al., 2011]. In HCI and design, it enables researchers to articulate experiences of a design, a prototype, or a concept from within, using themselves as the subject of the study. For example, Lucero presented an auto-ethnography of their own experience of living without a mobile phone over a period of nine years, showing the social, professional, and personal impact of mobile technology removal [Lucero, 2018]. Later, Homewood et al. applied an auto-ethnographic method to show how the removal of technology in their menstrual cycle tracking facilitates emotional, embodied, and cultural knowledge of their lived experience of self-tracking [Homewood et al., 2020]. Jain et al. presented an auto-ethnographic study of their travel as a hard-of-hearing individual [Jain et al., 2019] which led them to design personalized technology to aid their travel and more broadly the travel of deaf and hard-of-hearing users. Beyond generalizability, these auto-ethnographic methods are generative because their insights resonate critically with the readers' personal experiences and understanding of the interaction with technology [Ellis et al., 2011, Ståhl et al., 2021].

Autobiographical design and research through design focus on using personal experiences within the design process. With "the video window", Gaver described their own design, aesthetic choices, and personal experiences of living with a video screen hanging on their bedroom wall, which displays the image of the skyline from outside [Gaver, 2005]. Later on, Neustaedter and Sengers introduced autobiographical design more formally and argued for the value of developing a systematic way of designing with and for the self [Neustaedter and Sengers, 2012]. Desjardins and Wakkary described their project of converting a Mercedes Sprinter into a camper van [Desjardins and Wakkary, 2016]. Through their autobiographical design, they offered a rich reflection on the making of their personal space. Heshmat et al. used an autobiographical method to design "Moments", an always-on video recording system used by one of the researchers and their family over a two-year period. Their design shed light on the family's experience of being captured, their commitment to keeping the system running, and privacy issues [Heshmat et al., 2017].

First-person methods in HCI have raised questions regarding their validity and generalizability. According to Zhang and Wakkary, it is undeniable that designers apply and benefit from their personal experiences in their design practice [Zhang and Wakkary, 2014]. They argue for recognizing the legitimacy of designers' experiences in interaction design, whether it concerns their observation of real-life events or their interaction with design artifacts and systems [Zhang and Wakkary, 2014].

Experiments and designs that take the stance of first-person methods show the relevance of researchers' and designers' personal experiences for designing and gaining in-depth and long-term knowledge about the interaction with systems within the field. My work, partic-

Figure 5.2. co-creating with dancers

ularly when using research-creation to build dance pieces and reflect on them as experimental situations, aligns with such methods, their values, and their benefits. Indeed, the knowledge emerges from my personal practice of making dance and designing technologies. The insights thus come from my own embodied experiences of making the artwork. They also come from the audience members' experience of it. Therefore I reflect on my own experience as a maker and a user of the technologies that I design and the situations in which they are embedded. Rather than generalizable findings or guidelines to replicate my work, the idea is to see if my design work "speaks to other" people [Ståhl et al., 2021] or if the insights that are provided can be useful for interaction designers working in art and embodied interaction. My hope is that my personal reflexive understanding of my artistic endeavor and design process will resonate with readers' experiences and their critical thinking of technologies in art.

5.2.2 Micro-phenomenology as a first-person interviewing method

One of the ways in which I was able to unpack the complexity of my first-person experience or that of my collaborators, which unfolded in the making of my pieces, is to use experience elicitation technique or micro-phenomenology. Micro-phenomenology is a qualitative interview technique used to investigate the first and second-person accounts of lived experiences. The origins of micro-phenomenology draw from Pierre Vermersch's experience elicitation interview for eliciting finely grained descriptions of experience and activity [Vermersch, 2008]. Pierre Vermersch trained a large body of researchers (e.g., Béatrice Cahour, Ann Light, and Claire Petitmengin) to develop the method. Claire Petitmengin extended his work by contributing with a method for analyzing the interviews under the new, overarching name "micro-phenomenology" [Petitmengin, 2006]. While experience elicitation relies on various qualitative data analysis methods (thematic analysis, grounded theory, etc.), micro-phenomenology data analysis follows its own set of predetermined actions and procedures. Finally, both methods share the same objective which is to bring experiential content to our attention including parts of the experience that we might not have been aware of during the experience.

I followed a weeklong training in experience elicitation interviewing techniques in 2016 that allowed me to initiate my practice of this method and to apply it to the various research-creation projects in which I investigate both my experience and that of my collaborators and the audience members when making or participating in the performances that I create.

There is a previous body of work in experience elicitation and micro-phenomenology within HCI, going back to the early 2000s. In collaboration with Mirjana Prpa, who is also trained in micro-phenomenology, we aimed to investigate the perspective of HCI researchers who have used micro-phenomenology, understand how they applied the method, and hear their opinion on the value that this method provides to the fields of HCI and design [Prpa et al., 2020]. Mirjana conducted interviews with 5 HCI and design experts who used micro-phenomenology extensively in their research and analyzed the data from the interviews. She and I wrote a paper that contributed with an in-depth understanding of micro-phenomenology and its potential within HCI research and design as a method for eliciting fine-grained descriptions and unfolding structures of experience.

In the paper, we describe the eight crucial steps in the experience elicitation interview process as follows [Petitmengin, 2006]:

- Establishing the communication contract and verbal agreement
- Stabilizing attention
- Inducing the evocative state
- Shifting the attention from what to how
- Re-directing towards a singular experience

- Unfolding the dimensions of the experience
- Deepening the description to the required level of precision
- Bringing the interviewee back to the present moment

From these interviews with the five interaction designers using micro-phenomenology, we showed how, for all of them, a crucial point was the importance of training and developing the practice of interviewing. The interaction designers emphasized the complexities of the interviews, regarding 1) the need to distribute the interviewer's attention among the questions asked, 2) the interviewee's bodily cues that signal whether they are in the evocative state, and 3) the quality and level of precision of the descriptions. Our findings also emphasized the important role that the context and setting play in accessing the evocative state and delivering detailed accounts of the experience. Finally, we uncovered a range of opportunities that micro-phenomenology can bring to HCI and design research – mainly the capacity to unfold the tacit, embodied dimension of experience in design processes, and to articulate it and find a vocabulary for this newly found knowledge.

In the next sections, I will describe the development of four artistic pieces that I choreographed and that integrate interactive technologies. I will articulate the trajectories that I followed in designing the technologies and creating the pieces as well as the questions that emerged from that process and that I addressed through micro-phenomenological interviews of my collaborators and of audience members. The results of these interviews allowed me to reflect not only on the making process but also on the value of artistic performances as situations in which I can question the use of technology in art-making and art reception.

5.3 SKIN: Examining the tensions emerging from the integration of technology into an interactive dance piece

Between 2016 and 2018, I created a 50 minutes dance performance called SKIN, along with another choreographer and videographer called Tamara Erdé [Fdili Alaoui, 2019]. The performance appears as a film that unfolds with 3 different scenes and the transitions between them. It involved three dancers, one musician, and one developer and integrated interactive technologies mapping the dancers' inner movement captured through physiological sensing to sound and video on stage. The motivation to use technologies was to make what is inside of the body accessible to the outside viewer by mapping sensations "under the skin" to sound and videos. In SKIN, the interaction and the media are designed to be aesthetic, sensorial, cinematic, and felt kinesthetically by the audience members. While it is a technologically augmented performance, I was looking for an aesthetic that challenges the cold and neutral one that we typically see in digital art festivals such as Ars Electronica or Mutek. The piece instead conveyed a sense of fragility, intimacy, and nostalgia.

Figure 5.3. The aesthetics of fragility and intimacy in SKIN

We received a 1-year art grant and had one irrevocable date for the premiere plus 3 additional gigs. It was tight, in terms of time and budget (as usual in artworks and not in most academic grants). The whole project was a co-creation between the choreographers, the dancers, and the musician. The roles were defined but the boundaries were loose: we the two choreographers took artistic decisions based on the propositions of the dancers and the musician. However, when it comes to the HCI outcome, my creative collaborators who are independent artists had no interest in engaging with academic questions nor they were paid for it. After making and touring the piece, I wrote about the piece in a paper [Fdili Alaoui, 2019] where I related our journey from my own perspective.

5.3.1 Trajectories in making the dance piece

The academic contribution of this work resided in describing my research-creation process of making the interactive dance performance as well as the reflections that came along with it. I used the notion of practitioners' trajectories developed by Edmonds and Candy to reflect and describe my process [Edmonds and Candy, 2010]. Our creative process unfolded in a number of rehearsals with all the team members, where we iteratively created the choreography and integrated the technological prototypes until the piece took shape. In this process, we let artistic, design, and research ideas, opportunities, and questions emerge.

Figure 5.4. The developer testing the conductivity of the cooper paper on the shoulder blade of the dancer

In SKIN, I hired a developer to develop the mapping between physiological sensors and media. They designed an initial platform in a non-ecological setting (i.e. the lab). We surveyed the state of the art of existing physiological sensors. I worked with them to test the possible sensors and discard most of these for various reasons, including cumbersomeness or inertia. Following this process, we selected the following physiological sensors: Myo for muscle activity, accelerometers, heart pulse, and proximity sensors via a conductive copper paper. The developer integrated these sensors into an Arduino board and set up wireless communication between this module and a MaxMSP patch. We tested these sensors during a preliminary full day of rehearsal with one of the dancers, as shown in figure 5.4. From these tests, we identified several limitations. For example, with the sweating, the copper paper was not sticky anymore. In addition, we had to simplify the electronic elements and make them more robust.

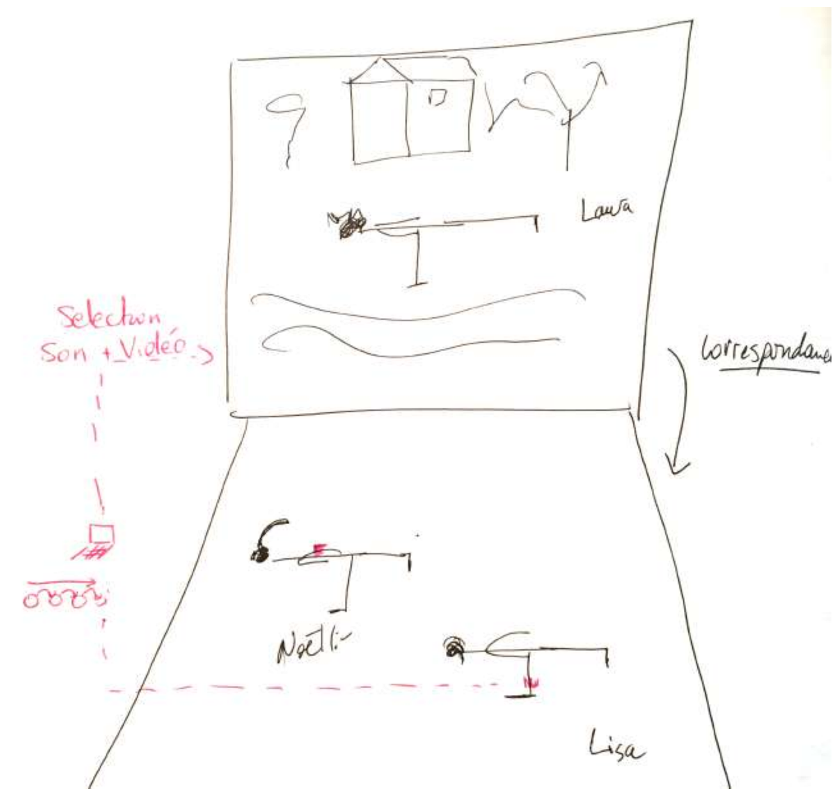

Figure 5.5. The sketches of the first interaction using the Myos feeding the machine learning algorithm to trigger videos and sound

Subsequently to this first step of testing, we made the sensors more robust and incorporated the contact zone for the proximity sensor into the fabric through a printed conductive silicone patch. We then prototyped three interactions on MaxMSP for the three scenes and tested them during the following rehearsals. These developments were parallel to the creation of the choreography and visual composition of the three scenes. In each scene, the dancers interact in real-time with projected digital video and sound. The videos display the choreography staged in a remote house in the south of France. It is a place of family

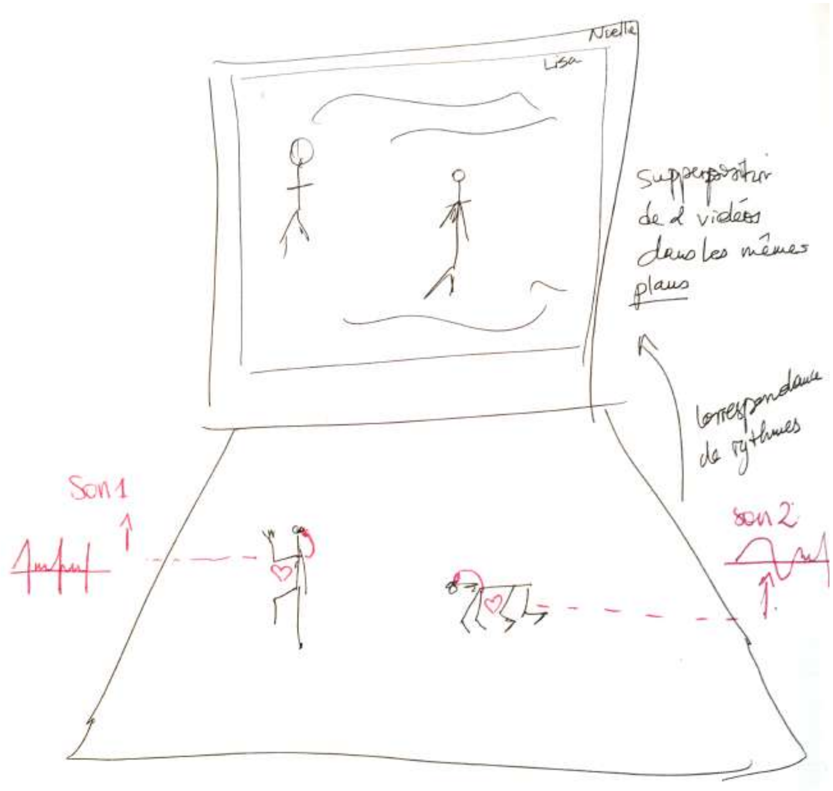

Figure 5.6. The sketches of the second interaction using the heat rate mapped to the frequency of the videos and sound

stories and lived experiences where the dancers perform with a poetic detachment, just on the edge of strangeness. The house is a metaphor for the dancers' skin, a shield and an interface, the home where they live, sleep, dream, and play.

In the first scene of the final prototype, the dancers are equipped with MYO sensors, and their movement is captured and analyzed through a machine learning algorithm for movement recognition (based on Hidden Markov Models) to trigger videos that correspond to the sequence performed, filmed in the remote house. Figure 5.5 shows a sketch of the interaction scenario of the first scene of the piece. In the second scene, the dancers are equipped with heartbeat sensors and their heart rate controls the frequency of the videos filmed in the remote house. Figure 5.6 shows a sketch of the interaction of the second scene. In the third scene, the dancers are wearing the touch sensor that we built and when they touch each other they slow down and eventually freeze the video of them performing the dance in the remote house. Figure 5.7 shows a sketch of the third scene of the piece.

Throughout our multiple residencies and rehearsals, I soon realized

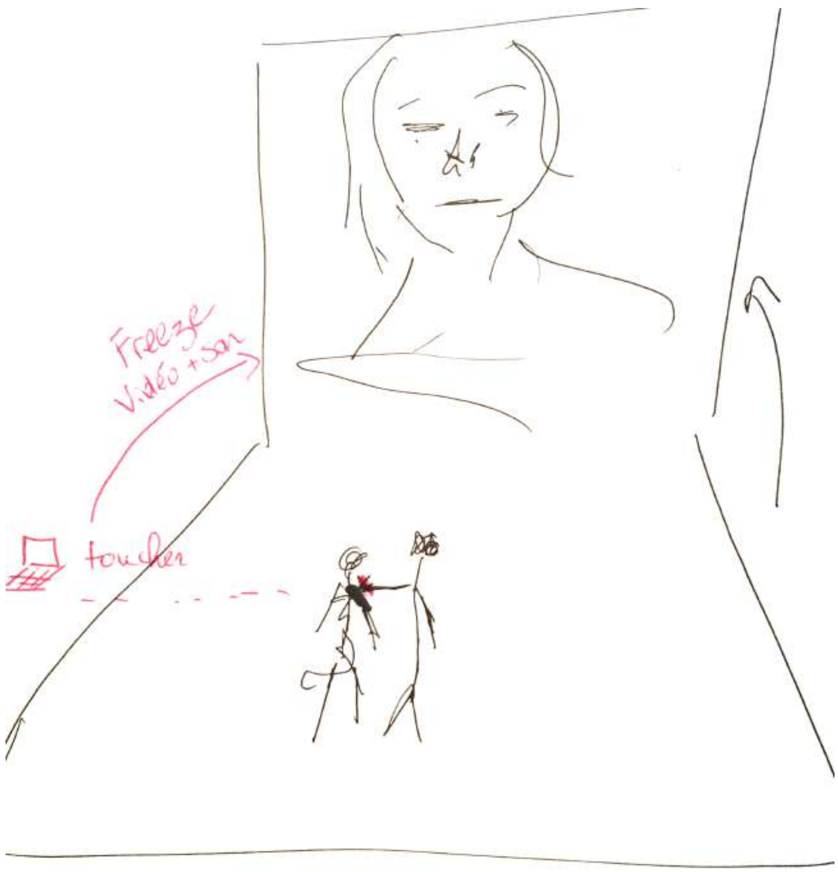

Figure 5.7. The sketches of the third interaction using the touch mapped to slow down the videos

that the reality of the practice would force me to let go of some of the technologies developed and use a wizard of Oz instead. The lack of robustness of the heartbeat and touch sensors and the instability of the movement recognition algorithms when the motion became complex and lengthy contributed to prioritizing the artistic outcome instead of the technological imperatives. And so, I simplified the apparatus to use a wizard of Oz technique to trigger the videos and change their frequency. The only interaction that I kept is the one using the touch sensor on the shoulder of the dancer, and that consists of slowing down and freezing a video when the two dancers touch each other. However, I abandoned the device that was initially developed on Arduino with a contact zone for the proximity and touch sensor integrated into the costume fabric through a printed conductive silicone patch. I realized that the robustness of such a device does not meet the requirement of a staged piece. For example, during one of the weeks of rehearsals, there was a heat wave in Paris, not only did the patch and wire break constantly, but the rates of conductivity varied with the temperature in unreliable ways. Therefore, I had to make the difficult choice of letting go of what was developed and using a mobile phone for touch sensing. In doing so, I felt the fear of having not much to say about technology in the publication that I was foreseeing. Despite that, I continued developing a piece that looked much simpler in apparatus but more robust to tour on stage.

5.3.2 Probing the audience and artists' perception of the piece

From the process of making and letting go of the technologies developed, a set of research questions emerged : (1) How much does the technology serve or subjugate the dance? (2) Augment or limit the body? (3) How does hiding or revealing the interaction affect the art?

To address these research questions, I run interviews of both audience and creative team members using experience elicitation technique [Vermersch, 1996, 2008], after the premiere of the piece. I analyzed the interview data using thematic analysis [Braun and Clarke, 2006].

In terms of clarity versus ambiguity, the interviews showed that the first scene involving triggering videos according to the dance sequences performed was perceived as obvious. The second scene involving the heartbeat was qualified as ambiguous and intriguing. The obvious touch gesture that triggers the freeze in the third scene was perceived as "taking a lot of space". In terms of serving versus subjugating the dance, there were specific gestures that triggered the digital events that made it look like the dancers were solely trying to "demo the technology". Part of what was perceived as the technology subjugating the art was due to practitioners' fear of the system breaking during the rehearsals. This prevented us from taking the risk of using our original prototypes during the premiere for example and caused multiple hesitations and struggles. However, despite the struggles that we faced the dancers felt that the constraints of the technology were an opportunity to rethink things and that its failures were an opportunity to reflect. Dancers considered that these struggles allowed them to "explore diversity" and to work on reproducing movement faithfully. Finally, in terms of augmenting or limiting the body, the audience and the team members gave different roles to the technology ranging from an instrument to control, a dance partner to improvise with, an additional scenographic layer independent of the dance, or a tool to enhance their bodily awareness.

Figure 5.8. The dancers wearing the Myos in SKIN for triggering gesture recognition and controlling videos on stage

Figure 5.9. The dancers wearing the touch sensors with mobile phones on their shoulder blades to control the freezing effect on the video

5.3.3 Reflecting on the tensions that emerged from integrating technologies in dance

In describing the process of making the piece and the findings that came from interviewing the team and audience members, I started seeing a theme emerge. This theme describes the tensions that we perceived and experienced when negotiating the technological ruptures that occurred as a result of stage-level robustness and artistic intents. I cared about the technology, so I was frustrated. It took me a long time to accept using a Wizard of Oz, and I did it with a taste of disappointment. From the interviews' findings, the audience members did not discern what was done through a wizard of Oz, and their perception of the piece did not correlate to how frustrated I felt about abandoning the technology nor to how much of it was simulated.

Throughout the making process, a persistent pressure was that of the implicit HCI academic values that I had interiorized. I was still seeking academic validation of my work, while my most urgent endeavor was to create an art piece. Sometimes I felt the need to use the technology because otherwise there was limited academic value in my insights. Slowly, I let go of this pressure and resisted altering the art for the sake of using the technology.

In terms of robustness, I realized that there is a difference between lab robustness and stage robustness with a device that should work for months of rehearsals, 8 hours a day with paid professional dancers sweating, rolling on the floor, and fully engaged physically. A prototype is simply not an option.

These tensions that emerged in reconciling the technological ruptures showed me the non-suitability of linear problem-solving approaches in HCI, such as user-centered design for making interactive performances [Zimmerman, 2011, Blythe, 2017, wakkary, 2021]. Simply engineering solutions to problems did not suffice. I had to embrace the messiness of the process of art-making and accept compromises. In their collaboration with a local theatre house where they designed interactive costumes,Honauer reveal the challenges of staging such interactive systems into existing structures of traditional theatre houses. Their paper shows how real-life art and science collaborations need to transcend established boundaries between fields by challenging established work processes, and structures [Honauer, 2017]. I would like to push this argument further. I believe that delving into art requires the academic community to tolerate art's perceived messiness and open its methods to a plurality of discourses beyond problem-solving and recipes for success [Howell et al., 2021]. For this reason, I do not propose any implications for design as a recipe to be followed to make better interactive art or better technology for art, or a better intersection between technology and art. I propose a shift from the predominant understanding of art in HCI to a plurality of voices retracing singular intentions, pathways, challenges, questions, and inspirations that artists have to offer. Following post-structuralist philosopher Jacques Derrida who avoids a unique discursive theory on art. He deconstructs institutions, traditions, beliefs, and practices by showing that they do not have definable meanings and missions that limit them [Derrida, 1967]. Deconstructing what is considered the scope of art practice (in HCI) stretches it beyond methodological and theoretical boundaries and transgresses these confines. In summary, we should embrace how artists are experimenting with technology, facing its resistance, and pushing its limits. Perhaps we should not attempt to artificially problem-solve in order to contribute to knowledge. In a practice-based scenario, there should be space for alternative discourses, with different natures of insights and where knowledge comes authentically from the practice [Zimmerman et al., 2022].

5.4 RCO: Creating a dance piece as a situation to understand people's relationship with technology and dance

Between 2018 and 2020 I co-created a piece called Radical Choreographic Object (RCO) along with the choreographer Jean-Marc Matos. RCO is a participatory performance where the audience members respond to instructions and interactions sent to their mobile phones as well as invitations to dance from the performers [Fdili Alaoui and Matos, 2021]. Again, RCO followed a performance-led research [Benford et al., 2013] approach where it served as an experimental ground in which I observed how humans relate to each other and to mobile technologies.

Our intention was to generate an in situ composition that invites the audience to participate voluntarily, according to their desire. They can engage in the interactions or simply contemplate at leisure the course of the performance. To do so, we asked the participants to connect to a server online through their mobile phones and sent them a set of text instructions. We defined and scripted text instructions as follows: (1) Illuminate the dancers. (2) Stroll in space. (3) Get close to one of the dancers. (4) Get close to an unknown person or a person of your choice. (5) Stay in the rhythm. (6) Enter the dance. (7) Follow the dancers. (8) Find a dance partner. (9) Cooperate with the dancers. (10) Carry one of the dancers. (11) Lay on the floor. (12) Run away. (13) Kiss a person of your choice.

We also prompted them to perform a set of gestural interactions: (1) The shaker (based on the accelerometer in the phone): they are asked

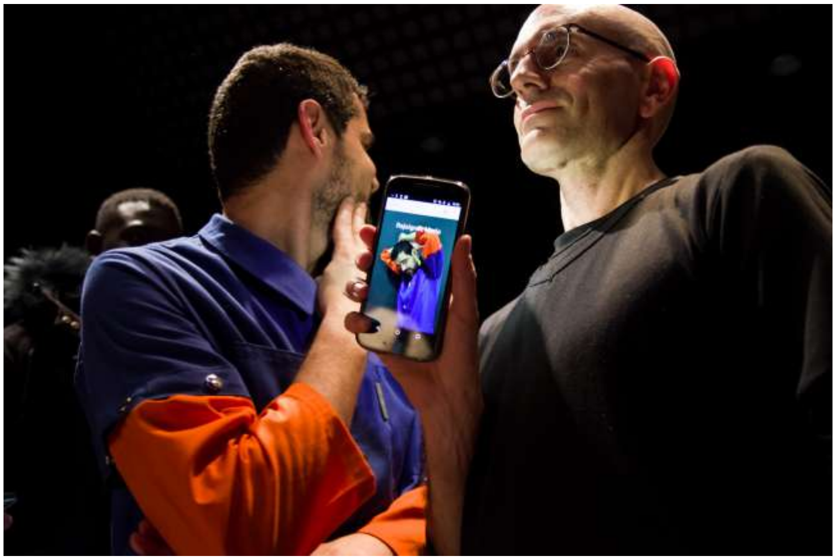

Figure 5.10. An instruction sent on the Mobile phone of an audience member, calling them to follow a dancer

to shake the phone as much as possible to stop an annoying noise. (2) The sketcher (based on the gyroscope in the phone): they are asked to use the mobile phone to move in the space and the gesture varies the pitch of a sinusoidal sound. (3) The compass (based on the compass in the phone): they are asked to rotate the phone to find a specific orientation that will turn a noise into a nice Bossa Nova sound. (4) The kick (based on the accelerometer in the phone): they are asked to follow the rhythm of the general music by performing kicks with their mobile phone.

Additionally, the participants are invited by the performers to interact with them. For example, the performers can mimic the participants, make them dance, carry them or touch them. In terms of the quality of the dance, we trained the performers to disrupt their usual dance patterns. Such a quest for non-habitual movements is meant to destabilize the participants and disconnect them from a socially acceptable gestuality. It creates a dance where all behaviors are possible, and eccentricity is welcomed. We designed these instructions and gesture-based interactions to give the participants actions to do and to invite them into the role of active creators of the piece. To do so, we followed an iterative step-by-step process that I describe in detail in the paper [Fdili Alaoui and Matos, 2021] using the notion of practitioners' trajectories [Edmonds and Candy, 2010]. Our process consisted of several rehearsals with all the team members, during which we iteratively created the choreography and developed mobile phone prototypes. We also evaluated the prototypes through open studios and follow-up conversations with participants.

Figure 5.11. A performer and an audience member touching each other

5.4.1 Probing participants' relationship to the piece and the mobile phones

In designing and choreographing RCO I started questioning how participants participate in the dance and their perception of their own way of moving in public space. I also questioned their relationship to their mobile phones which are interactive technology of everyday life, personal, ubiquitous, and addictive yet objects of collective responses and possible insidious repressions. To address these questions, I conducted a series of observations and led conversations with the participants and the performers during and after three showings of RCO.

A large variety of audience members participated in the observations and conversations during the three showings of RCO. The observations and conversations took place in the studios and theaters where we performed. The observations took place during the performance. The conversations took 30 to 60 min each time. They were carried out in groups after the performances. I took notes during the observations and follow-up conversations with the participants. I transcribed and analyzed these notes using a thematic analysis approach [Braun and Clarke, 2006].

The Ethics were tricky here because RCO exists as a dance performance independent of the academic study and the standards in both these communities are different. RCO has been performed in more than 15 different art venues and has been successful in attracting an audience eager to experience it. The institutions that showed RCO, knowing fully the content of the performance, advertised it as a participatory piece in which the audience members are invited to move and interact with people and mobile phones. From an artistic point of view, we could not reveal additional details to the audience members about the actions that would occur. Otherwise, we would break the surprising and spontaneous quality of the artwork. Moreover, the standard practice in artistic institutions is to consider that if people were informed of the participatory nature of the work and if they agreed to come, then they consented to take part in it. From an academic ethical point of you, we informed the audience members at the beginning that they have the choice to participate or not. The dancers are aware of the possible interactions that are involved in RCO (they developed them with us) and are also informed that they are free to step out of them at any given time. Moreover, we collected participants' and performers' consent for the data that was collected during the open studios, which served to iterate on RCO, and during the showings, which served as a basis for the empirical study.

Figure 5.12. The instruction sent to the audience members at the end of the piece, calling them to go to the floor.

The results of my observations and conversations showed that participants felt that they were being held hostage and socially constrained in the RCO situation and in the use of mobile phones. They felt subjected to physical and embodied constraints that are imposed on them by implicit social roles such as inactivity and invisibility. A participant said "We are formatted not to act" and another one legitimized his ac-

Figure 5.13. The audience members taking part in the performance by carrying a dancer

tions through others: "I watch how others act to act". Some were able to ignore the phone. They then passively observed the dance and took the posture of "voyeurs" that seemed to take pleasure in observing something private and forbidden.

Most participants reported that they always accommodated the instructions and they reflected on their obedience to it with mixed feelings: "I felt between fusion and resistance with technology" said one participant. However, we observed that participants at times broke free and reinterpreted (sometimes creatively) the instructions and appropriated specific roles in the piece, such as one of the mediators or the dance partner.

Finally, Participation was either viewed as worrisome or as creative. Indeed, a participant reflected on the moments during which they were invited by the dancers to do an action as "anxiety-inducing", another participant said: "I realize that with this same phone, I give my data to Google for free services, how can it not bother me?". However, participants also thought they were "beautiful moments of sharing" where the participants let go of their anxieties and entered a state of freedom and euphoria.

5.4.2 Reflections on the RCO situation

Our results allowed us to reflect on people's felt technological social constraints. RCO reinforced a situation of uncanny social interactions. For example, when participants were asked to kiss each other or to carry a dancer. These behaviors challenge the everyday social interactions that the sociologist Erving Goffman calls "interaction rituals" [Goffman, 1974]. In parallel, participants reflected on the frames that restrained them within these predetermined rituals, and that prevented them from imagining other possibilities of being. This echoes Michel Foucault's description of the social limits that define the areas of exclusion and inclusion [Foucault, 1975]. For Foucault, the political problem consists of the resulting micro-powers that invest in the body and that, in the case of RCO, prevented our participants from behaving outside of the frame of social norms and values, although this was encouraged in the piece. This also echoes Martin-Juchat reflection on how the body conforms to the bodies of others as well as to the context in which it exists with its social, cultural and symbolic norms [Martin-Juchat, 2020a].

On the other hand, the feeling of being subjected to technology in RCO echoes how smartphones have been seen as devices that frame and alienate individuals echoing Georgio Agamben [Agamben, 2014]. This also reminds us of Nicolas nova's metaphor of the leash [Nova] to describe mobile phone predominant presence as illustrated in the image 5.14.

However, there is a happy ending to this story. RCO's progression offered alternatives in the last text messages sent, such as "dance as much as you can!" or "kiss whoever you want!" We could see that the participants took control of the piece and the interaction with their phones and entered a state of collective enjoyment. In summary, RCO generates a situation mediated by dance and technology that allows both the participants and the artists to reflect on forms of social and technological norms. It also allows to resist, sketching alternatives where people break free from norms, embrace eccentricity and dare to dance with humor and irreverence.

Figure 5.14. An image found on the internet illustrating how the mobile phone can be placed as a leash, a metaphorical representation of how they alienate individuals

5.5 *Still, moving*: Designing an installation encouraging kinesthetic awareness

In an earlier work that I did along Jules Françoise and Yves Candau, we aimed at enhancing kinesthetic awareness of the micro-movements that are produced while being still [Françoise et al., 2017]. We took inspiration from the work of Steve Paxton, "material for the spine" where he trains dancers to utilize acute awareness of the micro-movement in the simple activity of standing in stillness [Paxton, 2008] which reveals a stream of minute falls and recoveries as stillness is fragile [Paxton, 1997].

We focused in this work on designing for kinesthetic awareness to bring attention to these ongoing processes and associated sensations. We started looking at ways to design a sonification system in an installation that allows participants to listen to their micro-movement. Additionally, we looked at how experience elicitation interviews can help us access and articulate participants' subjective kinesthetic experiences.

5.5.1 Designing *Still, moving*

We designed *Still, moving* following a research-through-design process [Zimmerman et al., 2007] that relied widely on autobiographical design [Neustaedter and Sengers, 2012], with constant exchanges between designing interaction, curating movement and sound. The design process was grounded in the studio as a shared space of experimentation, allowing the expression of our own 'somatic connoisseurship' [Schiphorst, 2011] as Yves and I have years of contemporary dance and somatic practices (Yves is an Alexander technique practitioner) and Jules and Yves are experienced in sound art and design. Given our focus on kinaesthesia, we chose electromyography (EMG) to access subtle muscular activity in the lower legs using Myo devices [3]. This was also inspired by the long history of using physiological sensors in the field of New Interfaces for Musical Expression (NIME), such as Tanaka's BioMuse [Tanaka and Knapp, 2002] or Donnarumma's XTH [Donnarumma, 2013].

[3] http://myo.com/

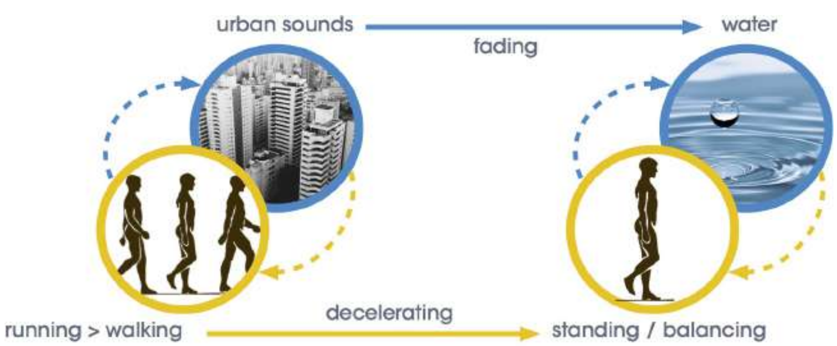

Figure 5.15. Schematic representation of the interaction scenario of *Still, moving*.

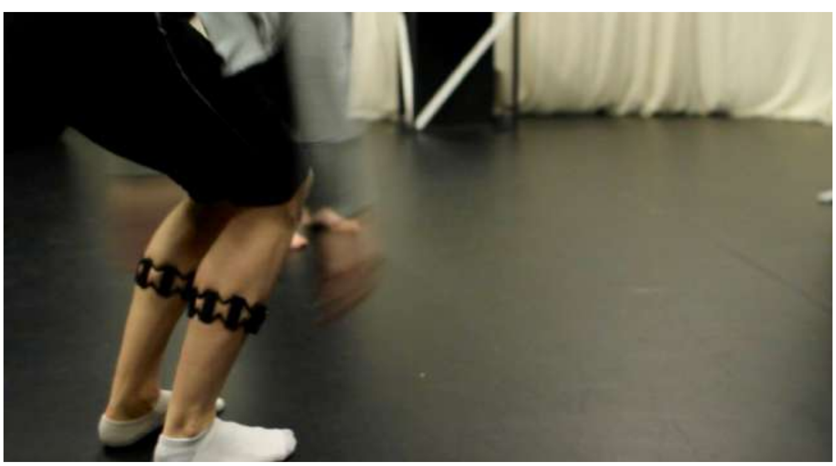

Figure 5.16. A participant interacting with the *Still, moving* installation. The Myo devices are capturing muscular activity and motion to generate the sound environment

Using field recordings as rich source materials, the installation generates a continuously evolving sound environment in response to participants' micro-movements and muscular activity. The interaction design leverages an adaptive mapping strategy, refining sensitivity depending on the activity level. This dynamic adjustment provides users with a sonic 'zoom' into their kinesthetic experience. The design process converged towards a multi-layered sonic interaction scenario, where several modes can be accessed through different types of movements (See Figure 5.15). When participants start walking, the frequency and energy of the walking pattern are computed to generate a texture from overlapping fragments of urban sound recordings. As the frequency of the walk increases, the urban environment gains presence and noisiness. When participants slow down, the urban atmosphere fades into a quieter environment, based on recordings of water, rustling leaves, and other organic materials. The force of each step, as captured by muscular activations in the lower legs, continuously controls sound synthesis. When they settle into stillness, sound variations become more nuanced, zooming in to reveal minute postural changes. Throughout the whole scenario, the sound grains move in space following weight shifts from one foot to another.

5.5.2 Probing participants' experience of *Still, moving*

We exhibited *Still, moving* as a public art installation and interviewed participants on their experience of the sound in relationship with their movement using experience elicitation interviews [Vermersch, 1996] to gain nuanced insights into the participants' subjective kinesthetic experiences.

From our interviews, we found that participants first engaged in an exploration of the system's behavior, by trial and error, in an attempt to "decipher" or understand the relationship between particular movements and the auditory feedback. Throughout their exploration, they deepened their relationship with sound. Participants reported rich imagery evoked by the sounds of water present in the auditory feedback. Although this immediate recourse to imagery for sense-making is not surprising, it came in various modalities and individual relationships to past experiences. These specific reactions were also translated into specific approaches to make sense of the feedback loop through movement.

We were able to show how the interaction between the participant and the sound progressed in time through their ongoing engagement and learning. There were specific pathways of experience and exploration

Figure 5.17. A participant interacting with the *Still, moving* installation and exploring the sound feedback of her walk.

along the movement session. Such progression involved an initial disconnect and its resolution, the appreciation of subtlety through facilitation, and the expansion toward more complex kinesthetic experiences.

5.5.3 Reflections on *Still, moving*

In the process of making *Still, moving*, we practiced a design 'inside' the feedback loop to explore the variations in movement and sound in the implementation of the mapping. We could see that we often lacked a single criterion to find the 'optimal' design — e.g., an ideal sound design or mapping function. Instead, we embraced the uncertainties of exploration through movement [Gaver et al., 2004]. We deployed deep attention toward movement and sound until singular experiences revealed themselves in the design space through incidents and discoveries. Making space for exploration during the design process, using nuanced qualities of attention was essential to capture and unpack these 'Aha moments' that revealed singular experiences within the exploration of design concepts [Höök, 2018].

After showing the installation, we continued exploring *Still, moving* with our own bodies. We started performing with the interactions that we created, Yves and I as dancers wearing the Myos and Jules as the designer constantly adjusting the mapping to what we discovered in the studio. And just like that, a new practice where all 3 of us would improvise with sonification based on mappings that Jules would craft on MaxMSP emerged. During MOCO 2017 which took place at Goldsmiths in London, Yves Jules and myself performed a version of our improvisational piece that we called *Still, moving*[4]. As we rehearsed to create the piece, we realized that crafting MaxMSP patched on the fly was no longer a sustainable option. We decided to create a live coding environment and formalize an improvisation practice. That is how CO/DA was born!

[4] http://moco17.movementcomputing.org/index.php/eve performance/

5.6 CO/DA: Developing an improvisational practice combining dance and live-coding

Following these first experimentations, Jules Françoise, Yves Candau, and I embarked on a performance-led inquiry that involved Yves and me as two dance improvisers and Jules as a live coder. We developed a joint improvisation practice where the movements of Yves and myself, alone or together equipped with sensors, are streamed, allowing Jules to program "on the fly" the interactions between our movements and the sound feedback [Françoise et al., 2022]. To support our improvisation practice, we designed a new live coding environment called CO/DA that facilitates the real-time manipulation of continuous streams of dancers' motion data for interactive sound synthesis.

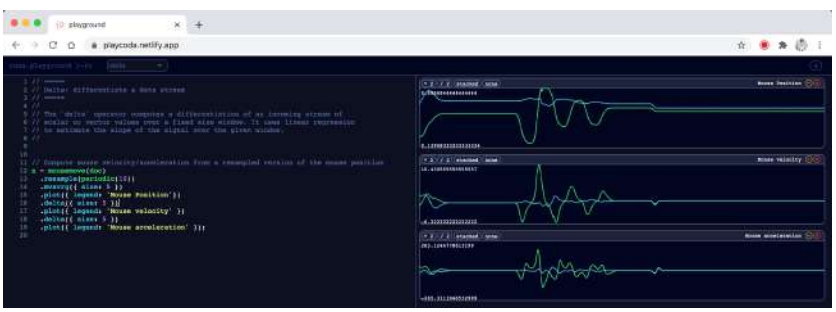

Figure 5.18. The CO/DA system where dancers' movement data are used in the live coding platform to sonify movement on stage.

Our design is autobiographical in that it is built for ourselves based on our own interests and for our own practice [Lucero et al., 2019]. We were inspired by Live coding as an improvisation practice that engages with the audience through the projection of the code during performances, as stated in the TOPLAP manifesto:"Obscurantism is dangerous. Show us your screens."[5]. The Temporal Organization for the Parsimony of Live Art Programming (TOPLAP) was founded to promote live coding. Its manifesto affirms that "algorithms are thoughts".

[5] https://toplap.org/

It highlights the fundamental desire of practitioners to engage with algorithms and code, during improvisations [Collins, 2011, Magnusson, 2011].

Figure 5.19. A rehearsal with both dancers (Yves Candau and myself) and the live coder (Jules Francoise). The interaction on CO/DA is projected on the screen.

5.6.1 Designing the joint improvisation with CO/DA

For two years we collaborated together and engaged in improvisation sessions aimed to facilitate the experimentation of new embodied ideas and strategies for movement-sound interaction. These sessions involved Jules improvising with either Yves or myself or both of us simultaneously. Improvisation sessions served as material for a reflection on both technological constraints (the characteristics of the live coding environment) and aesthetic constraints (the mapping strategies employed). By integrating the outcomes of each session rapidly into the live coding environment, reflection is fed back into practice. In order to allow the emergence of new interactions, we progressively developed a set of structures, rules, and exercises to foster exploration on the fly :

- Verbal communication between the dancers and the live coder is not allowed during improvisations in order to encourage embodied risk-taking and to allow the resolution of problems encountered through the improvisation itself.

- Failure is not a reason for interruption. Solutions should be found on the fly through movement or edits to the code.

- Improvisation exercises can stimulate the discovery of new relationships between movement and sound. The exercises can for example, stimulate the generation of counter-intuitive movements or focus on the body's response to particular sounds.

To design CO/DA, we opted for textual programming and to base CO/DA on an existing programming language; JavaScript to run on the WEB. Moreover, CO/DA provides built-in utilities for sensor data acquisition and sound synthesis, event stream management, and signal processing as well as visual feedback on various streams of motion data for monitoring. The core libraries provided are :

- Input components to acquire data from different sensors
- Motion analysis modules implemented as functional operators acting on data streams
- Real-time data visualizations of the motion parameters
- Machine learning modules for dimension reduction
- Sound synthesis engines and audio effects whose parameters can be continuously driven by reactive streams.

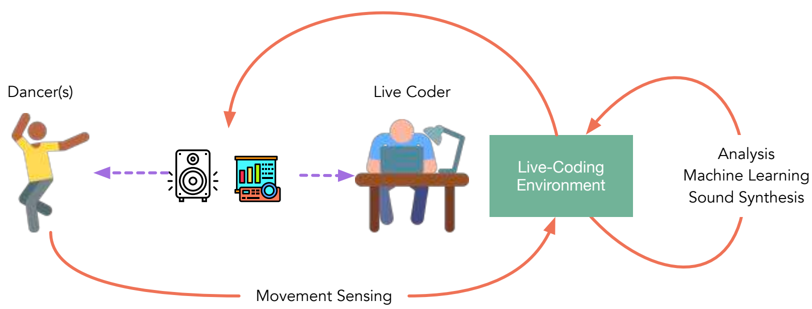

Figure 5.20. The interaction scenario in CODA involves a joint improvisation between one or two dancers and a programmer where the data of the performers is sent to CO/DA and used to sonify movement in real-time.

5.6.2 Analyzing our joint improvisation with CO/DA

We followed a first-person auto-ethnographic method making use of a story-based approach to gather data on our own personal embodied experiences of the improvisation with CO/DA [Höök et al., 2018b, Höök, 2018]. We analyzed through thematic analysis about 23 improvisation sessions performed over 13 days, between June 2018 and April 2019 [Braun and Clarke, 2006].

Our findings highlight that the degree of clarity in the relationship between the performers and thus between the movement and the produced sound varied on a scale that went from total ambiguity to total control. Exceeding ambiguity arose when the sonic space was too layered and complex or when the movement was too fast or changed too much. That led the performers to perceive the mapping as non-readable. On the other hand, performers experienced improvisations as overly controlled when the mapping was too simple, direct, and predictable.

All three performers expressed their experience of being in the flow of the collective exploration and in connection with each other in a memorable session that lasted one hour of uninterrupted improvisation, without speaking nor stopping. They reflected on the quality of the mapping during that session by calling it "a sweet spot" when "it's readable but surprising and ambiguous at the same time. That creates material that I can play with for a long time" (I said). According to the live coder, "the performance becomes much more organic [...] when I look at you two, you seem together, connected. You are not looking at the screen".

Moreover, in most of our sessions, we observed that the performers played with repetition and sustained exploration of particular patterns. These phases of persistence were modulated by moments of rupture that would allow to break the flow of the improvisation, introduce surprise and thus avoid boring the body into an endless redoing of the same movement. Navigating between persistence and rupture creates a dynamic practice of relationships, where surprises are taken as opportunities to explore movement variations in order to progressively and tacitly integrate the new action-perception loop until it is fully appropriated.

Our findings also show that in most of our improvisations, richness came from the way the dancers and the live coder influenced each other. In our practice, we always start with blank code and silent bodies. Movement barely starts, then the coder starts populating the CO/DA platform. Little by little, we build on layers of relationships. Through this process, there is an inherent complexity to an interaction scenario involving collective improvisation where none of the performers feels in total control of the interaction. And with complexity comes ephemerality. Indeed, the combination of the live coder's choices with their interpretation by dancers creates moments that are not reproducible. Each mapping and interaction scenario is only experienced once and then vanishes with our movement.

Figure 5.21. A improvisation session with me as the performer and Jules Francoise as the live coder on CO/DA

5.6.3 Reflecting on our joint improvisation with CO/DA

From our long-term experimentation and auto-ethnographic study, we were able to articulate the values of designing with openness to the emergence of unexpectedness, complexity, ephemerality, and shifts (between repetition and rupture or control and ambiguity) as conditions to experiment with technologies in art [Gaver et al., 2003]. Our improvisation practice offered opportunities to engage with design in a way that promotes constant discovery, adaptation, and learning. This was challenging. What if nothing happens? And certainly, there have been many improvisation sessions where the magic did not happen. We discovered that there was no other way for such serendipitous interactions to occur than by taking the (long) time to be in the embodied and listening state that was necessary for these possibilities to form. Moreover, embracing the shifts [Hsueh et al., 2019a], nonlinearity [Kang et al., 2022], and complexity was part of our messy practice [Fdili Alaoui, 2019]. Finally, openness to ephemerality was another value that emerged as fundamental to our work. This value goes against how current technological innovation saves and stores our most mundane experiences. Practicing with ephemerality allowed us to critically question the notion of persistence of experiences. Do we need to store and quantify all human experiences?

Our experimentations showed the benefit of exploring entangled feedback loops, engaging early with technology, and experimenting through shared in-situ experiences. Live coding transformed the process of designing embodied interactions into a performative practice, considerably affecting our experience in favor of risk-taking and on-the-fly problem-solving. Additionally, exploring non-verbal communication as a substrate for embodied design enabled us to enter a deep listening state and attunement to ourselves and others. This constraint fostered rich experiences with early prototypes and facilitated problem-solving through interaction rather than judgment and evaluation. Another important value was favoring long-term experimentation with interactive systems in the wild [Rogers, 2011]. This has helped us build various skills starting from the capacity to attune to and deepen our kinesthetic empathy towards one another [Françoise et al., 2017] and to fine-tune our listening skills with regards to the possibilities of the sonification [Candau et al., 2017]. Thus our improvisation practice with live coding was not about programming faster, innovating, or generating design scenarios quickly. The process of learning and appropriating the technology and building the sensitivities that are required to improvise together was a long journey. It is through a slow and long breath that we deeply explored the possibilities of sound and movement and enriched our creative experiences and design outcomes.

5.7 Discussion

5.7.1 The studio as laboratory

In this chapter, I presented a narrative journey of my creative practice, reflecting upon what this practice means to me and how it fits into my research in HCI and interaction design. The main aspects of my research consisted of reflecting and sharing those reflections and showing their value to my readers [Dalsgaard, 2016].

In making the pieces that I described (SKIN, RCO, *Still, moving*, and CO/DA), I reflected on my own practice by documenting my process through scores, texts, journals, and interviews, among other artifacts that I collected. Just as designers reflect on design as part of doing research through design [Schön, 1983, Dalsgaard and Halskov, 2012], this documentation and the resulting reflection allow me to formalize my practice and share what I learned from it with the rest of my academic community. For example, SKIN allowed me to share my reflections on the tensions that emerge from integrating technologies on stage, which are usually overlooked in HCI for the sake of present-ing an ideal narrative of technologies augmenting performances. In sharing these reflections, I invite others to take a look at my craft with the body and with technology, which can be a personal and messy endeavor. Besides revealing an aspect of my personal practice, I write about my process as a way to share how I make sense of the world and how I probe or intervene in specific situations, which can generate interesting questions about that world – a world that is heavily mediated by machines. RCO is a good illustration of this. It is a piece that I created to ask questions about a world in which mobile phones mediate many of our relationships. It allowed me to reflect on the tensions that come from involving the audience members in the dance through these same controversial mobile phones. My hope is that these kinds of questions will speak to others just as much as they speak to me or to my collaborators.

However, reflection does not only serve the purpose of sharing my work with my academic community. I find meaning in articulating and formalizing my artistic endeavors. The more I do so, the more I learn about myself, others, technology, and its role in mediating relationships and perceptions. Echoing Edmonds et al., I view the "studio as laboratory ... the natural working environment where [I] dream, explore, experiment and create ..." [Edmonds et al., 2005]. This is something that the process of creating and developing CO/DA showed very clearly. Our improvisation sessions were a laboratory for us to reflect on our practice of dancing and producing sound, and on the design of the technology that was meant to support us in such joint improvisation. Thus the research unfolded almost entirely in the studio through embodied and collective research and the creation of both a tool and a practice.

In the same way, I view the pages of this manuscript as a laboratory and an experimental space that allows me to dig even deeper into what I previously did. I hope that, by the end of this writing process, I will have "a view from above" of what I did and open new avenues and inspirations for myself and others. This chapter, in particular, has been a liberating space for me to tinker with concepts and artistic ideas that I developed. As I was writing it, I realized that each one of my research-creation projects had its own starting point, methods, and outcomes. None of them had links to one another or to a pre-determined research agenda. They were independent experiments that all led to singular pieces and knowledge. Yet, for me, they represent a body of work in which I use artistic and scientific research to investigate my relationship with technology in creation. They all show the interplay between the practice and the research, between the body and the computer, stitching together two worlds that might seem separate but that, in my perspective, are not so distinct [Martin-Juchat, 2020b]. These works illustrate how making art is not simply an application for the technology I design, nor is it a hobby of mine. They give my dance practice full "credence and credit where it is due" [Sturdee et al., 2021].

Thus this chapter, among all others, is the one that frames my work the best at the seams of what science, design, technology, and art are, with all aspects cohabiting and nurturing each other.

5.7.2 On being an artist and a researcher

Finley and Knowles describe themselves as both artists and researchers [Finley and Knowles, 1995]. They show how they experienced the duality of research and art and how that influenced the formation of their worldviews. Just like them, I embrace both roles. It was not easy at the beginning to define myself as both. This difficulty depended on where I found myself within academia, as I moved between computer science, art, science, and design departments since the beginning of my career. In every one of these contexts, self-definition had a different meaning. In IRCAM, artists are strictly composers who spent years learning about composition in conservatories. Moreover, they tend to be exclusively represented by white men, a social category from which I am excluded by default, being a woman from Arab and North African backgrounds. Researchers, on the other hand, constitute a separate group and live in different parts of the building. Although most of them/us have musical or artistic practices, we are rarely given the "artist" label, just as composers are rarely called "researchers". In SIAT, everyone had all labels – it was easy to co-exist according to one's self-claimed status. In LISN, most people are computer scientists. They are, however, welcoming to people's specificities. Although I do not feel a need to justify myself as one or the other, I often feel like the odd one in the lab, the one whose research is seen as "exotic" and "special", or even particularly entertaining – but is it scientific enough? As I landed in LISN, because my work had somehow matured and because other people like Christian Jacquemin or Wendy Mackay had already introduced art and science collaborations in the lab, I felt comfortable claiming both roles of "researcher" and "artist".

I would like to emphasize that one of the reasons why I chose HCI as an academic community to start with is because, of all fields of computer science (HCI is in computer science departments in France), it is the one that welcomes interdisciplinarity the most. HCI and interaction design constantly prove their ability to question themselves and their own methods, welcoming contributions that can push their boundaries. Certainly, artists' contributions do!

I would like to finish this discussion by asking questions taken from a collective pictorial that I co-authored with colleagues from around the world, called "A Plurality of Practices: Artistic Narratives in HCI Research" [Sturdee et al., 2021]. These questions aimed to open up a dialogue on research-creation in HCI and interaction design. To that end, we collectively asked our readers to consider the following:

- In what ways does the disciplinary setting you work in impact your creative and research practice?
- How do your colleagues respond to alternative publication formats?
- What type of knowledge comes from the intersection of art practice and HCI?
- How does your artistic practice inform your research in HCI? And how does your research inform your artistic practice?
- How comfortable are you with labels such as 'HCI researcher' or 'artist'? And why do you think that is?
- Where do you place yourself and your own work in relation to art, craft, HCI, or design?

6

A view from above to dream of what's next

Yesterday I was at a birthday party where I invited a group of friends who did their PhDs at the same lab as me to come to my HDR defense on March 22nd. And there in that fancy living room, where everyone had a glass of sparkling natural white wine in their hand, I got the dreadful question: "So what is your HDR about?". How can I summarize 10 years of work? But also how can I not summarize 10 years of work?

There should be an argument that I weave through the whole manuscript that can be synthesized into a presentation short enough to be delivered at a birthday party. Would "it's complicated" suffice? Certainly not. I responded that the HDR describes a sort of progression in the approaches that I have used throughout the years for designing and integrating technologies in dance.

Of course, this response did not convince my interrogators. It gave birth to another dreadful question: "How is that useful for others?"

I responded that people can read my HDR and understand the values and limitations of each of these approaches. I added that I provide not only a reflection on the design and the applications of these technologies but also an epistemological and critical reflection on these interdisciplinary endeavors. Of course, I said it in a way that sounded less sharp and articulated. Luckily, my answer at this stage seemed to be enough to satisfy my audience. The conversation went on to other topics, such as how far away the campus is, how muddy it is with all the construction work going on, and how difficult it is for them, Parisians, to attend the defense outside of the city.

I was left thinking about this inconsequential conversation. What have I truly learned from my research and creation practices over these years? And what is next for me?

6.1 Beyond solutionism and techno-chauvinism

While I acknowledge the value of designing interactive systems with and for the users, I also see limitations to how we commonly implement that in HCI. Most methods that are currently used in HCI, such as user-centered design or participatory design, seek to achieve a level of generalizability, with the goal of developing a solution to a problem identified as common to a group of users [Pierce et al., 2015]. Moreover, in HCI research, we seek to theorize our design processes by generating common methods, metrics, and abstractions that can be generalized to other contexts of inquiry and applied to other groups of people, hence the traditional request for "guidelines for design". In dance, there is no such thing as a generic problem, solution, or metric. If all of the experiments that I described in this manuscript have anything in common, it is to show that generalizability is not achievable in dance. We found in our interviews and in the workshops where we probed dancers on paper that they share common tools to learn, craft, or document their work. But the nature of this work challenges all attempts to define movement, style, and processes. I can even say that generalizability, beyond not being achievable, is actually not desirable. None of the practitioners that we worked with have ever expressed their interest in letting researchers define what they manipulate for them or design according to whatever these definitions mean. If there is a clear message throughout this manuscript, it would be that diversity and non-determinism of the practice are to be honored and celebrated, rather than problematized for scientific purposes and agendas [Andersen et al., 2018, Fdili Alaoui, 2019].

User-centered design (UCD) was a great way for me to explore alternatives to codification and modeling of movement through LMA, which is what I had mainly done during my post-doctoral work. It's a method that I truly learned to use when I started my assistant professor position at Paris Saclay University in Wendy Mackay's lab. She had been using it for years and trained students to master it. UCD was rigorous and methodic. There were steps to follow and if followed well, these steps would bear good results in HCI. It was the closest that design could be to science. Practicing it was a good transition for me. I had the feeling that I was learning a designerly method of inquiry while not giving up the systematic nature of scientific knowledge production.

Throughout the years of designing interactive systems along with my students, I realized that there is always an underlying agenda driven by our interest in gaining knowledge from developing the best, most novel solution for the users' needs. I was uncomfortable with such a hidden agenda that was the heritage of our field's techno-chauvinism, solutionism, and obsession with innovation. In HCI, technological innovation is desired. What the field considers a contribution to knowledge is in most cases work that builds novel technologies. Thus, the design of novel technologies is the starting goal, irrespective of whether these technologies are useful or truly needed by anyone. The field considers as a contribution to knowledge, work where such novel technology solves an identified problem. This same solutionist narrative structures most of what HCI produces [Blythe et al., 2016]. But there are surely problems that technology cannot address. There are surely problems where it's better to refrain from inventing technologies at all [Homewood et al., 2020]. There are surely situations that are difficult to frame as a problem to solve [Hale, 2018]. Indeed, a lot of what the HCI researchers identify as a problem can sometimes look like a pretext to develop technologies. The solutions sometimes look imposed upon people. Additionally, the assessment of these technologies usually takes place in experimental lab setups, where participants are guided to use the designed systems according to specific tasks during short time periods. Although this might be sufficient to assess the system academically, it does not prove its value in real-life contexts.

The critiques that I am expressing here are related to a larger issue in academia. As researchers, we are incentivized to publish a lot. This means producing maximum knowledge in minimum time. We simply can not afford to spend months observing real people as there is a high cost to conducting long-term studies. Thus, running small lab experiments with few participants –in many cases in HCI, these participants are students in these same labs– is considered enough to publish a paper. While this allows us to pollinate our CVs with long lists of publications, the knowledge that comes from it remains shallow and incomplete.

In this manuscript, I talk about the gap that my students and I identified between reality and what we designed for. To address this gap, we have engaged in longitudinal collaborations in the wild to see how the technologies that we developed such as Knotation or Move-On can benefit people in complex and real-world situations with multiple protagonists, challenges, and desires. Although we went as far as doing that, our involvement in these contexts was partial.

I would like to go further and engage in a deeper way in fieldwork, similarly to how anthropologists do. In her essay "The anthropologist as hero", Sontag describes Lévi-Strauss as a hero who struggles with the difficulties and dangers of fieldwork [Sontag, 1994] in his book "Tristes Tropiques" [Lévi-Strauss, 1955]. For Sontag, Lévi-Strass is a hero for grappling with the unknown. He is also a hero for doing that through an interpretative lens, producing what combines the qualities of poetic prose, a travel book, an ethnography, and a philosophical and political essay critiquing colonialism [Kubica, 2014].

I am not sure I can pretend to be following in Lévi Strauss' footsteps. Moreover, anthropology is moving beyond Lévi Strass's era, during which anthropologists' western visions of the world are claimed to represent something universal. Nowadays, anthropologists study groups that are located near them without having to take on a heroic journey into an exotic unknown land. In these de-exoticized contexts, researchers are held accountable to their informants. They situate themselves in the contexts of their studies, demonstrating humility with regard to the knowledge that they produce [Hartman, 1970].

I also recognize the value of research-creation as a way to mix the boundaries between research and artistic endeavors. It is a way to include the voice of the researcher and the artist in the inquiry, avoiding a neutral stance with a solely third-person perspective and instead embracing an active, involved stance through one's first-person perspective. Research-creation allows for the invention of new ways of doing both research and art. However, I also see limitations to how that can carry the voice of the protagonist only. Research-creation can easily slip into a narcissistic quest of one personal intimate thought process that does not speak to others, and does not scale to others. After living through a pandemic and giving birth to a child, I have somehow lost sight of my interest in research-creation. It's probably a temporary pause from the studio. I simply don't want to spend too much time rolling on the floor and feeling my body, as much as I want to spend time working with people from a variety of cultural contexts where perhaps everything I have done up to now can be challenged and contradicted.

6.2 Beyond contemporary dance

For the past 10 years (and more if we include my Ph.D.), I have worked almost exclusively on contemporary western dance. Contemporary dance developed during the mid-twentieth century and is currently one of the main genres in which dancers are formally trained in western countries. Historically, contemporary dance followed post-modernism, a current that was represented by choreographers such as Merce Cunningam or the Judson Church choreographers. Postmodernism is in its own right a continuation in dance history of the heritage of modern dance choreographers like Isadora Duncan, who rejected the rigidity of ballet, or Martha Graham, who filled choreography with intense emotions and an emphasis on gravity in contrast to ballet's light quality. Postmodern dance considers that dance could be anything, questioning the process behind making dance and challenging the expectations of the audience. Contemporary dance recognizes its genealogy with postmodern, modern but also classical dance, while constantly trying to reinvent its codes and forms. Its specificity is to question the limits of live performance while recognizing a common way of addressing the body and movement. Experiments such as those developed in the improvisation work of Steve Paxton or Simone Forti are among the foundational methods that many contemporary dancers use to explore the capacities of the body and to enrich their personal kinesthetic creativity.

When we look at what defines contemporary dance, we can see that it is above all constituted by a generation of dance artists. As an art form, it does not have a specific aesthetic per se. There are surely filiations that emerge between artists but there are also ruptures that can be recognized. However, I think that what perhaps characterizes it best is its capacity to always borrow techniques from modern and classical forms and appropriate and disrupt them to the level of denying them (with non-dance movement, for example). Somehow, my work integrating technology at different stages of the dance process confirmed that the common principle between all the practitioners and contexts in which we intervened is their resistance to encapsulating their work in one single definition and process. This might translate for some of my readers to my work failing to deliver what is expected of it, which would be a way to articulate and model this art form. I would respond that, throughout the years, I have become comfortable with the continual quest of grasping the elusive. I guess my answer to the question of "What is your HDR about?" is that it describes working with a

Figure 6.1. Judson Church dancer Yvonne Rainer performing Trio A

practice that is plural and slippery and that requires me to constantly re-imagine new lenses through which to look at it [Hsueh et al., 2019a].

Figure 6.2. One of the Guedra dancers who I interviewed in her home

Lately, I have developed an interest in designing technology to archive dances of communities whose practices are not seen as formal dance forms. Communities whose practices have never been documented, nor archived. I have initiated a project in which I am spending time in the south of Morocco, my home country, in the villages of a region called "Oued a Noun", near the city of Guelmim, where people practice a dance form called "Guedra". In Guedra everyone dances on their knees. Men are in a circle, clapping their hands to the rhythm of the percussion and singing Arab poetry altogether in rhythm. One man is in the center of the circle. He plays a percussion instrument itself called "Guedra", a recipient made of terracotta that is used to cook a local recipe and that is covered with skin in order to turn it into an instrument. One or two women are inside the circle, dancing with their upper bodies, particularly the arms and hands, and stomping on their knees to move around the circle to honor the loudest man. I stayed for a week in a village called "Tighmert" in the spring of 2022. It's an oasis where people dance Guedra at every wedding. I spent that week visiting people in their homes and talking to them about what made this dance important to them, and how they transmitted it from one generation to another. Our discussions were originally about the dance, but they quickly became about the life in the village that is withering because the water sources are drying. The dance also became rare because women don't want to be filmed and "thrown on Facebook" to be seen by everyone and anyone. Dancing was not a profession that people had. It was not the result of work in the studio to invent a new language. It was part of a larger story, that by which people express their identity and their belonging to a land, a village, and a local culture. After that week I did not feel like I could start designing any technology to archive Guedra. I thought that I needed to go back to Tighmert and spend more time there. I thought that I should describe my account of that experience in more detail, and describe how that changed my understanding of dance and my willingness to consider technology as a medium or a possible intervention.

From that experience in Tighmert, I became more and more attracted to co-creation projects rather than research-creation ones. For that, I would like to use action research. I see action research as a methodology that tightens the gap between academic research and the field. It can be applied to HCI and can broaden the scope of UCD [Hayes, 2012]. Indeed AR's end goal is not to develop the "best solution to a problem" but rather to gain an understanding of the practice through a deep and long-term engagement in fieldwork [Rogers, 2011]. Specifically, I can cite five characteristics that distinguish action research from other user-centered methods. First, action research relies on collaborative action to develop knowledge. Second, action research requires the academic partner to recognize their role, bias, and influence on the inquiry. Third, it focuses on developing local solutions for lo-

Figure 6.3. Dancers of Guedra

cal contexts and does not privilege the generalization of its results. Fourth, it focuses on developing scientific knowledge and supporting partners' needs using design artifacts as a means rather than an end in themselves. Finally, action research involves academics and partners as co-investigators, co-participants, and co-subjects and relies on co-designing interventions that provoke change with partners, not for them [McNiff, 2006, Hayes, 2011].

My dream for the years to come is to develop sustainable collaborations in fieldwork where I would produce literary ethnographic accounts of my experiences. I would also develop co-creations with an action research approach where I might or might not design interactive systems that intervene in artistic communities, depending on the benefit that it could have on them. If I do develop technologies, I would make sure that they are accessible to practitioners and that they integrate into their practice seamlessly. Through a long-term commitment to fieldwork, I would seek to simultaneously contribute to knowledge and benefit communities of dancers and performers. This would emphasize the social impact ensured through my authentic and long-term commitment to people. This kind of work would result in the co-creation of transformative and sustainable positive change, with or without technological interventions, but that cares about directly and positively affecting the practitioners (me included). In summary, I would develop co-creative artistic pieces and ethnographic accounts of my understanding of dance practice that would contribute to HCI with critical frameworks through which to question these (un)uses of technology in these contexts. To do so, I would stay committed to asking simple questions like: for whom and why?

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