

Designing in Conversation With Dance Practice

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ABSTRACT

We present a long-term collaboration between dancers and designers, centred around the transmission of the century-old repertoire of modern dance pioneer Isadora Duncan. We engaged in a co-design process with a Duncanian dancer consisting of conversations and participation in her transmission of Duncan's choreographies and technique. We then articulated experiential qualities central to Duncan's repertoire and used them to guide the design of the probes, the sounding scarfs. Our probes sonify dancers' movements using temporal sensors embedded in the fabric of the scarfs, with the goal of evoking Duncan's work and legacy. We shared the probes with our Duncan dance community and found that they deepen the dancers' engagement with the repertoire. Finally, we discuss how co-designing with slowness and humility were key to the dialogue created between the practitioners, allowing for seamless integration of design research and dance practice.

CCS CONCEPTS

• **Human-centered computing** → **Interaction design process and methods.**

KEYWORDS

Dance, co-design, first-person perspectives, soma design, longitudinal study, sonification

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1 INTRODUCTION

In recent years, effort has been made to demonstrate the value of performance-led research [11] and artistic practice as a method of inquiry for Human–Computer Interaction (HCI) research [3, 30, 43, 44]. These works contribute to acknowledging that there is much to learn from art practice and performance as an experimental ground to study how people interact with technology. With third-wave HCI turning to cultural, experiential and context-aware applications of

computing and interaction design, we are seeing a general interest in drawing on artistic and somatic practices—with methods, theory and systems built around bodily practice—and calls for designers' own bodily engagement in the design process [2, 37, 38, 47, 50]. At the intersection of somatic and artistic practices and HCI research, we find works linking dance and choreography with HCI [3, 27, 57]. Over the past two decades, dance research in HCI has been a place for experimentation with technologies and dance, whether it be during the choreographic or learning processes, or on stage [19, 54, 63, 66].

Dance is an embodied practice that is challenging to capture because of the complex somatic and cultural knowledge involved. Up to date, dance is mainly recorded through audiovisual media or motion capture, depending on access to technology. In training environments, dancers often resort to oral transmission in addition to video for learning and sharing their knowledge of their practices [54]. However, video recordings do not inform on the cultural context, the movement qualities nor the kinaesthetic sensations in dance.

In this paper, we present a study of research through practice and design in conversation with Isadora Duncan's dance knowledge. Our study builds on a close collaboration between artists and interaction designers. Over a period of eight months, the first author and the third author were both active members of a dance company as a student and dance teacher, respectively. The third author is a professional dancer and a dance educator specialised in the work of early-twentieth-century modern dance pioneer Isadora Duncan. She created the company to transmit her knowledge of Duncan's repertoire to a group of dancers in the same way she acquired it. Isadora Duncan's work is transmitted exclusively orally from one generation of dancers to the next in a process that relies on embodied dance practice as well as transmission of historical knowledge.

In our study, we leveraged on both the embodied and the historical knowledge transmitted as design material. Coming together from different disciplines, as artists and interaction designers, we co-designed probes [32] that manifest our embodied understanding of the dance repertoire and reflect our collaborative practice. 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. The design of the probes were 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 whispers, voice and keywords with a sense of continuity and perpetual transformations. We shared these probes with our dance community in an inquiry similar to that of Wallace

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et al. where design probes “are considered as tools for design and understanding” [64].

In this paper we present our process of co-designing the probes in conversation with our practice of Duncan’s dances, as well as the findings that emerged from sharing the probes with our dance community. Our design study shows the critical importance of the elements of slowness, softness and humility, and their key role in the dialogue created between disciplines and practices. These elements allowed for a seamless integration of design research in artistic practice. The results of our sharing show how the probes made the Duncan movement qualities of *movement propagation*, *rhythmic qualities* and *continuity* palpable to the dancers, and how it provided an opportunity for the dancers to deepen their relationship to Duncan’s movements, sound, and the correspondence between the two.

Through such longitudinal engagement with the Duncan practice, and through integration of the probes into real practice, we are able to provide insights into the dancers understanding of Duncan’s work, as well as a reflection on our collaborative, practice-based process. With this study, we contribute to the demonstration of the value of longitudinal, collaborative, and engaged artistic and practice-based research [16] in HCI, and in doing so we also add to a growing body of work of art practice as a space of inquiry in HCI research.

2 THE ROOTS OF THE PROJECT

2.1 Who Was Isadora Duncan

American-born dancer and choreographer Isadora Duncan (1877–1927) is considered a pioneer of modern dance. She lived and worked in Europe, the United States and Russia. As she stepped away from the rigid codes of classical ballet, she introduced a new idea of dance based on what she would call “natural movement”, “free movement”, and the harmony of body, mind and nature. Isadora Duncan defined her dance as “an expression of life”, and did not want her dances to be imitated, but rather understood as a general approach to movement, life and nature [23, 51].

Isadora Duncan’s approach to dance was that of a profound expression of the body: “Movements, just like harmonies in music, are not invented; they are discovered”. In her search to express “natural movement” she studied ancient Greek antiquities, and in her recreation of the themes and philosophies of ancient cultures, she took it upon herself to “give dance its place as the choir”, expressing her role as a dancer and choreographer with the intention to “express the soul of the music”, a role that the Greek attributed to choirs [24, 51].

The transmission of her work follows an oral tradition, and has been passed on from one generation to the next. She refused to be filmed, as she believed the low frame rate at the time did not do justice to the fluidity of her movements. Therefore, there is no video material of Isadora Duncan herself and little traces left to fall back on in case the oral transmission ceases to exist [51]. Mainly because of the oral transmission through generations of devoted dancers, her knowledge and approach to dance is still alive today. Video continues not to be used as a resource for transmitting Duncan’s work. As expressed by the authors behind an online Isadora Duncan Archive, “The Duncan community strongly recommends

that videos only be used as reference material only, and discourages the learning of dances from video exclusively” [8].

2.2 Who We Are and Our Intentions with the Project

The third author is a 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 Levien, whom herself was taught by Isadora Duncan’s own adoptive daughter, Anna Duncan [7], the third author herself is transmitting knowledge of Isadora Duncan and her dances to both professional dancers and amateurs in addition to interpreting the repertoire. The second author is an interaction design researcher and trained dance artist. Together with the third author, she has been aiming to use interactive technologies to document and transmit the Isadora Duncan repertoire through research projects since 2018 [63]. The first author is an interaction design researcher, musician and music technologist with a particular interest in movement-based interaction.

The collaboration between the three authors started from a common interest in the transmission of Isadora Duncan’s legacy. The third author formed a dance company in 2019 to transmit Isadora Duncan’s dance repertoire to a group of 12 dancers, and invited the first author to join the group in 2021. Joining the company was a way for the first author to get close to both the qualities of Duncan’s work and the third author’s way of transmitting it. The dance company was selected to participate in a program supported by the French National Dance Centre, which aims to “open up a space for sharing for those who wish to deepen their practice and knowledge of dance in relation to its history” [21].

The three authors each contributed to this work with their different backgrounds: the third author with her expertise in modern dance and Isadora Duncan in particular, the second author with her expertise in dance and interaction design and the first author with her expertise and sensibilities towards music, movement and technologies. The second author played an intermediary role, supporting the first author in the design work as her PhD supervisor.

From here on and throughout the paper we refer to the third author as the connoisseur [57].

3 RELATED WORK

At the intersection of dance and HCI research, we situate our work within body-centred approaches, engaging with dance practice in the wild, and work using movement sonification as a means to support practitioners in their performance of movement qualities.

3.1 Systems Supporting Dance Practice in the Wild

Despite the longstanding relationship between dance and HCI research, the dance studio and actual practice have been slow to adopt new technologies [14, 58]. Thus, there is a challenge for designers to develop systems that integrate into dancers’ real-life practice over time. One of the earliest deployments of technology in a real-life rehearsal context is the Choreographer’s notebook (ChoNo), a system that lets dance artists analyse and annotate rehearsal videos [58]. Carroll et al. assessed how introducing this technology in three full

dance productions affected the dance work. They reported on how the choreographer and the dancers collaborated in annotating the videos and argued that the integration of the tool supported the dancers learning and made the learning process more time-efficient [17].

Later on, Rivière et al. investigated the role of digital and physical artefacts in dance re-staging in an observational study that took place during a year-long period of rehearsals with a contemporary dance company [55]. They observed how the dancers, depending on their individual learning strategies, use a collection of heterogeneous artefacts, including their own physical artefacts and existing digital tools, namely, video and *MoveOn*, an interactive system that lets them decompose video segments. With such a wide variety of artefacts used in dance learning, the authors demonstrate the importance of supporting different modalities to allow for the learning strategies that are required in individual and collective dance practice. What their contribution also highlights is the importance of longitudinal integration of technologies into dance practice “in the wild”. According to Felice et al., deploying technologies for dance in the wild allows us to capture interactions between people and with technology over time, which “would not have been possible to observe in a laboratory experiment or in any other controlled environment with artificial tasks and roles” [28].

Beyond the “tradition” of creativity support tools in learning contexts, performance-led research [11] in the wild shows new avenues to understanding humans in real-life interaction with technology in performative contexts. With a focus on the creative process rather than the “problem-solving” approach of creativity support tools, Fdili Alaoui discusses the messiness and tensions arising in the process of integrating technologies in the wild during the making of the dance piece, *SKIN* [27]. In her reflection, Fdili Alaoui argues for welcoming such messiness and shows the value of artists bringing their own craft, methods and voices into designing and reflecting on technology, thereby proving art practice in the wild to be a promising experimental ground for HCI.

As much as the general literature in HCI shows the value of research in the wild [11, 56], most systems supporting dance practice and learning are designed and assessed beyond the walls of the studio. Apart from technologies applied to performance and the stage, very few studies on dance learning and transmission include technologies built with and through the learning process and the complex knowledge that it entails. We contribute, through this study, with research where designing technology takes place in conversation with dance learning, where one builds upon the other, enriching one another.

3.2 Systems Conveying Movement Qualities

In collaboration with the dance company, Emilio Greco|PC, Alaoui et al. designed some of the earliest interactive visualisations that were meant to convey dance movement qualities using physical models [1]. From testing the installation with dancers, they found the visualisations to improve the dancers’ understanding of movement qualities, and encouraged movement exploration and improvisation. Along with Alaoui et al.’s use of physical models as representations of dance movement quality, Hsueh et al. designed

interactive visualisations for dancers to improvise with, using particle models because of their ability to communicate movement quality [36]. The visualisation served as a mediation tool for communication between dancers as representations of movement and as an object to “think with”. The authors discuss that through making the dancers’ felt experience of their own movements interactive, one can unleash dancer’s kinaesthetic creativity and generative potential.

In a literature review by Raheb et al., they examine interactive dance training systems, propose a design framework and discuss the implementation and use of factors such as movement qualities in existing systems [53]. Their review shows that most systems use a mimicking approach to learning movement, where the learner imitates pre-recorded movement, and are typically designed to be used by one student at a time. They further argue for designers to focus on and develop their systems based on the aspects of the dance learning that are important in their specific context, e.g. precision, relation to rhythm or movement quality.

In a more recent study, Vialle et al. collaborated with an expert Duncanian dancer to design an abstract visualisation of Duncan movement qualities [63]. The visualisation, a star-shaped flexible ribbon, was then shared with professional dancers in two workshops, one with a projection of the ribbon on a screen, and the other with augmented reality headsets. From both workshops, the dancers found the ribbon to faithfully convey the Duncan qualities of fluidity, wave-like movements and movements initiated from the solar plexus. However, their study shows how the screen projection was difficult to use and follow in context, as the dancers moved around and lost sight of the screen. This was not a problem with the augmented reality headset. Nonetheless, the use of the headset itself was a challenge to the dancers, both with navigating the menu of the interface and dancing with a headset on, something they had never done before.

In contrast with this previous work, our study is based on a long-term engagement with the practice of Duncan’s work. This led us to introduce technology in a subtle way, without disrupting or dominating the current practice, nor by taking the dance out of its present context and environment.

3.3 Designing for and With the Moving Body

With movement-based interactions ever more present in the field of HCI, a variety of approaches to designing with and for the moving body are being used [37, 38, 47, 50, 65]. Following the embodied turn in our field [22, 45], we are seeing theory and systems built around bodily practice. Some with a particular emphasis on the designer’s own bodily engagement [38], or engaging somatic connoisseurs [57] and sometimes drawing from dance [2] or through collaborations with dancers [48]. Among others, estrangement methods are being used in interaction design as a way to deepen the designer’s bodily sensitivities through defamiliarising habitual movement patterns [47, 65], similar to how an artist refines their tool or material [41].

Soma design is one proposed approach to designing with and through the body [38]. It leverages on slow and active engagement of the body, the “soma”, and the use of estrangement methods to

sensitise the body throughout the design process. This sensitisation process makes room for uncovering aesthetic sensitivities and experiential design qualities, which may not be available otherwise (through e.g. observational methods). This in turn can generate new designs. Soma design relies on the designer’s first-person perspective when grounding and guiding design decisions through subjective bodily experiences. Throughout a soma design process, the designer engages their own moving body in a somatic practice in order to sketch not solely onto paper, but rather with their body and with movement [38, 60]. From the designer’s first-person somatic experiences, experiential qualities are carefully articulated and serve as design material when designing interactive systems [39, 60].

We build on this body of work and use the methods of soma design as generative design methods that allow us to reach a design that honours the specificities of the Isadora Duncan repertoire and the connoisseur’s transmission of it.

3.4 Dance Movement Sonification

Following Hermann et al.’s definition, sonification is “the technique of rendering sound in response to data and interactions” [35]. Previous studies have shown that interactive movement sonification can improve sensori-motor learning, performance and experience [12]. Françoise et al. developed an interactive installation called *still, moving* that supports dancers’ kinaesthetic awareness of micro-movements through sonification [15, 29]. This project led to building a long term practice between two dancers and a live coder, in which they explored relationships between dance and sonification [30]. To do so, Françoise et al. designed a live coding environment, CO/DA, to support their improvisation practice, where the movements of two dancers were mapped to sound through live coding, resulting in on-the-fly sonification of their movements. Their work contributed with a new design and practice where the dancers and live coder improvise with movement and sonifications as they go through a collective embodied and artistic exploration [30].

Building upon work by Piana et al. and their system using mass-spring models to analyse the movement quality of fluidity [52], Frid et al. ran experiments exploring sound properties for sonification of fluid dance movements [31]. The authors found sounds reminiscent of wind, water and acoustic musical instrument, or continuous, calm, slow, pitched sounds to appropriately convey the movement quality of fluidity.

In our work, we are interested in the potential of sonification applied to embodied dance practice. We build on these previous works and explore interactive sound as a design material that can evoke Duncan’s movement qualities and deepen the practitioners’ embodied understanding of the dance repertoire.

4 DESIGN METHOD

We present our longitudinal and collaborative research through practice and design study in conversation with our practice of Isadora Duncan’s repertoire. We, the authors of this paper, collaborated in an open-ended co-design process over a period eight months, where practicing dance, understanding Duncan’s philosophy and legacy and prototyping with technology were intertwined—informing and inspiring one another.

We used a soma design approach to *sensitise the body* to Isadora Duncan’s repertoire [38, 60]. Concretely, the first author went through the sensitisation process by practicing the dance and learning about Duncan’s philosophy and legacy from the connoisseur. In her practice, the first author 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.

After each rehearsal with the dance company, the first author recorded audio memos and took notes to journal her reflections and first-person experience of learning the dances [39]. The audio material was later transcribed. In parallel with the dance practice, the connoisseur and the first author led private *conversations* where the first author shared her first-person accounts of learning the dance. In these conversations, the connoisseur guided the first author in gaining a deeper understanding of what she was experiencing during the process of *sensitising her body* through continuous dance practice. Together and over time, the two articulated the first author’s first-person accounts into *experiential qualities* that inspired initial design ideas. We then iterated collectively on these ideas and the resulting prototypes by bringing them into our dance practice and continuing *sketching* with our moving bodies with the technology, reflecting on and documenting the first-person experience of the interaction and the *experiential qualities*. Our iterative process led us to develop probes for the real time sonification of dance movement [33, 64].

Finally, we shared the probes with our dance community to investigate how they impacted their dance practice, and to open up our design process and learn whether—or how—our *experiential qualities* translated to other people’s experiences. Sharing and inviting others to experience our design at this point provided us with a way to assess how it can be useful and generative (rather than generalisable) in creating experiences to other somas than our own [60]. We report on our sharing session, the method of data collection and analysis, and the findings that emerged in section 6.

4.1 Studio Rehearsals

The connoisseur led the dance classes with the dance company and transmitted three choreographies of heroic dances by Isadora Duncan from her Soviet period at the beginning of the twentieth century. Over the eight-month period of this project, rehearsals took place two to three times a month, in addition to performances. The rehearsals lasted between three and four hours. In addition to the transmission of the choreographies, the connoisseur spent time transmitting her knowledge and understanding of the movement qualities that make up the foundation of Duncan’s dance.

4.2 Conversations

In addition to the studio rehearsals, the connoisseur and the first author met up for conversations a total of five times. They discussed the research, the transmission process with the dance company and the first author’s first-person experience of learning the dances. Together, they articulated the experiences, sensations and sensitivities involved in the transmission and learning of the dance. All these

meetings and conversations were audio recorded and transcribed, and constituted our data in addition to the first author's journal notes describing the *sensitisation process*. This data informed our co-design process, and is described in section 5. One of the conversations included a session of vocal sketching [10, 26], where the first author asked the connoisseur to vocalise Duncanian movements that were rehearsed in the studio. This was done with the intention of building an understanding of the connoisseur's ideas of movement associated with sound in the repertoire. The vocal sketching was recorded both with audio and video separately.

4.3 Making the Artefacts

As the work with the dance company progressed and the first author started to deepen her embodied and historical knowledge of the repertoire through somatic practice and conversations with the connoisseur, she drafted initial designs and prototypes, guided by the *experiential qualities*, and following a soma design method of *sketching with the body* [38]. The first author then brought the prototypes to the connoisseur to test and iterate on. Through dance improvisation, the connoisseur articulated her experiences and sensitivities that were evoked in the interaction with the prototypes and probes later on. Following this, our iterations of the design were guided by somatic judgement, as we continued refining and exploring interactions that evoked our *experiential qualities* [60].

5 DESIGNING THE SOUNDING SCARFS

5.1 Articulating the Experiential Qualities for the Design of the Probe

In this section, I, the first author, describe my sensitisation process and the beginning of our co-design process, in which I use the data collected from conversations and accounts of my own first-person experience that I journaled throughout the collaboration.

5.1.1 How Dancers Were Introduced to Duncan's Work. During the rehearsals with the dance company, the focus was on the transmission of the three choreographies. To build a solid foundation for the interpretation of the choreographies, the connoisseur spent time articulating and demonstrating the movement qualities central to the Isadora Duncan repertoire throughout the rehearsals, as seen in figure 1. She taught the group about the philosophy behind the dance by teaching the repertoire with an approach to movement, dance and life which went beyond interpreting the choreography simply as imitations of movement. Through this holistic approach of transmitting the repertoire, she paid much attention to the intentions and inner experience of the movements involved. For example, she often asked the dancers to close their eyes during the rehearsals to feel the movement "from within".

From early on, the connoisseur introduced the dancers to Duncan's movement qualities: continuous and fluid movements, one movement or impulse spurring another, attention to time rather than space, and the use of oscillations and disequilibrium. She worked with dancers to familiarise themselves with staying "on the verge of equilibrium" while dancing. In her exercises, she also emphasised the importance of weight, the sense of gravity and support in the feet. Finally, she introduced the dancers to Duncan's "origin of movement", the solar plexus, showing how, for Duncan:



Figure 1: Isadora Duncan movement qualities were transmitted to the dance company in studio rehearsals with the connoisseur. © 2022 Annie Hartmann.

"Movement originates from breathing", and: "The forward drive, the motivation in the movement is coming from the solar plexus".

5.1.2 How I Built an Embodied Understanding of Duncan's Work. Throughout the rehearsals, the connoisseur revisited all of the Duncan movement qualities on multiple occasions and in various contexts. For example, she expressed the importance of the qualities of weight and gravity, in how they provide a certain naturalness to the movement. In one of the earlier rehearsals, we had not been working with the weight in the legs during the warm up, and the connoisseur commented that this became very visible during the practice and rehearsal of the choreographies. At first, this was not yet something that I could sense on my own. As the exercises were revisited and along with the guidance of the connoisseur, I started feeling how easy it was to become too light and lose a sense of anchoring and "naturalness".

Language played a big role in transmitting the repertoire. The connoisseur often used Laban movement analysis language to describe the movements with words. Laban movement analysis is one of the most wide spread methods and languages for description, analysis and documentation of movement and movement qualities [46]. Additionally, she often used metaphors, e.g. from nature, many of them drawing from Duncan's own writings on the connections between dance, life and nature. She also used musical metaphors, mentioning e.g. syncopation (a rhythmic variation disrupting a regular flow) and anacrusis (an accent preceding the beginning of a phrase) in the dance when working on rhythmic qualities and onset in movement, or by using phrases such as: "Within the duration [of the movement], I modulate". The musical metaphors were more easily relatable and understandable to me, being a trained musician myself.

Over time, through practice, getting to know each other within the group, and with the guidance from the connoisseur, I started gaining new awareness of the dance and feeling the Duncan movement qualities from within. One of the choreographies that the company worked on includes walking with the ball of the foot

touching the floor first, then the heel. This stride looks lightweight from the outside, almost floating. But from within and over time, I could feel that when I did it right, this movement went in a straight, almost horizontal line, with little movements up and down while the legs and feet remained animated. The feeling of being grounded was strong. As I gained awareness of my extremities through subtle guidance from the connoisseur, e.g. pointing out to me to keep my arms low and having the intention in the movement spurring from the solar plexus, walking and the sense of gravity took on new meaning for me and I felt that my experience of the dance was widening.

5.1.3 Engaging in Conversations Around Duncan's Work. As I gained deeper awareness of the dance, through for example my new feeling of gravity in the whole body and especially in the extremities, I brought my reflections to conversations with the connoisseur, where we built a dialogue around articulating these experiences in relation to the connoisseur's transmission of the dance repertoire. From these conversations, I started associating my inner experiences with the principles and philosophy of Duncan transmitted by the connoisseur. Thus, Duncan's work, through the connoisseur's transmission, took on new meaning over time as I started being able to connect theory and practice. I viscerally felt the *anchoring*, the movements spurring from the solar plexus and the *continuous* movements, among others, and I was now able to articulate these experiences in relation to what the connoisseur was teaching the group.

Early on in the project, I took note on how sound was one of the materials that the connoisseur used extensively in her transmission in class, both metaphorically through her use of language and as support through music. I shared this observation with the connoisseur and told her about how my musical expertise helped me understand the dance. Indeed, my experiences of feeling the music and letting the music lead the movement was often helpful. I also shared my observations of the connoisseur herself at times vocalising movements during rehearsal to e.g. emphasise an impulse in the movement. The connoisseur shared her knowledge of Isadora Duncan's own relationship to music and her own understanding of the repertoire through music. From there on, the relationship between sound, music and movement became a common language between the connoisseur and myself when conversing about the dance.

The conversations with the connoisseur gave more depth to my experience of learning the Duncan movement qualities and the legacy of Isadora Duncan's work. Along the way, through our conversations about my embodied experience, the connoisseur's transmission of the dance and the music that Isadora Duncan choreographed to, we started sharing design ideas and exploring new design spaces with the experiential qualities of *continuity* and *anchoring*.

5.2 The Iterations on the Sounding Scarfs

The importance of the relationship between music and movement in learning Duncan's dances led the connoisseur and the first author to sketch design ideas related to movement sonification.

5.2.1 Vocal Sketching of Duncan's Qualities. To get a clear idea of the connoisseur's imagination of what Duncanian movements could sound like, the first author proposed that she imitate the sounds she imagines while dancing, in a vocal sketching session. Together, the connoisseur and the first author were dancing following an exercise, with undulating movements in an infinity-like shape, that was used in the rehearsals with the dance company and that expresses the Duncanian movement qualities. During this exercise, the connoisseur used her voice to express the sounds accompanying the dynamic movements. This session was recorded, such that we then had audio (and video) material of the connoisseur's subjective take on the sound of Duncanian movements.

The vocalisation ranged from melodic, singing-like sounds to fluid sounds reminiscent of nature, such as water or wind, all while also reflecting what the connoisseur earlier said that, "within the duration [of the movement] I modulate". The connoisseur emphasised the importance of modulation, accents and impulses. As the dynamics in her movement modulated, in terms of tempo, rhythm and amplitude, so did her vocalisation. Movement and sound were tightly linked and modulations were immediately expressed in the vocalisations, similarly to the action-sound coupling in acoustic instruments. Within phrases of movements, she sometimes also clearly vocalised a rhythm. As she was following this tight coupling between action and sound, the rhythmic changes remained dynamic all along and included changes in beat patterns or musical metre. She vocalised melodically across changing time signatures. She also expressed the dynamic rhythmic patterns in her vocalisation through imagery of sound from vocals, piano and other percussive instruments. Regarding melodic sounds, she mentioned associations to the composer Gabriel Fauré being especially strong that day.

5.2.2 Initial Design of the Sounding Scarfs. Silk scarfs were introduced to the first author during her third rehearsal with the dance company, as an element in exercises and also in one of the three choreographies, as seen in figure 2 from rehearsal. In one exercise, the dancers, each with their own scarf, were passing them in between each other. We were asked to work with the scarfs such that our movements expressed the same fluid movements as the scarf. The connoisseur pointed out that the scarf was a prolongation of our movement, and that *it* too should express our intentions in the movement. The use of the scarf in rehearsals and several of Isadora Duncan's choreographies was the origin of the idea to sonify a scarf with interactive sounds evoking the qualities of the dances as thought by the connoisseur in her transmission of the heroic dances of Isadora Duncan.

We built a first iteration of the probes for movement sonification by prototyping a sounding scarf, using a temporal motion sensor, a wireless internal measurement unit (IMU) and Max/MSP¹. The scarf was made of woven cotton fabric, with pouches sewn in for the IMU (see figure 3). We chose this sensor to reflect the importance of temporality, as pointed out by the connoisseur. The initial sound designs and mappings of the movement sonification were built around the experiential qualities of *continuity* and *anchoring* as articulated by the connoisseur and the first author, from the

¹<https://cycling74.com/products/max/>



Figure 2: Scarfs used by the company during rehearsals.
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first author learning the dances and her conversations with the connoisseur.



Figure 3: The initial design of the sounding scarf included a pouch to embed the wireless IMU for movement sonification.

We developed three different sound designs using a concatenative synthesis that takes grains of a selected audio source, structures them and puts them back together depending on the energy level of the audio. Then, the intensity (in terms of changes to acceleration) and orientation in the sensor, are mapped to the grains in the concatenative synthesis. The synthesis was made up of three different audio sources separately, making up three different sound designs. The first one used ocean sounds (downloaded from the collaborative database Freesound^{2,3}), referencing Isadora Duncan's attachment to the ocean and water. The second design used the entire audio recording of the connoisseur's vocalisation of Duncanian movement. The third design used a recording of *2 Mélodies, Op. 46: No. 1, Les présents*, with piano and voice by Gabriel Fauré, reflecting the melodic imagery brought up by the connoisseur during the vocal sketching.

5.2.3 First Iteration on the Sounding Scarfs. During a meeting with the connoisseur, the first author gave the sounding scarf to the connoisseur to try and dance with the different sound designs. The

connoisseur explored the scarf by improvising with Duncanian like movement qualities. She improvised alone and at times invited the first author to join the improvisation. While dancing, she talked about her thoughts and associations around the sounding scarf and the sound designs. During this iteration, the connoisseur found that the scarf was lacking sensitivity. She was trying to move it just a tiny bit, about a centimetre, wishing to hear sounds from it, but the sounds were only there when she made bigger movements. She also wished for the melodic sounds, in the sound design with the Fauré piece, to be more dynamic and variable so that she could modulate them with her movement. Overall, she enjoyed the ocean sounds and found them well-suited to convey Duncanian imagery. Additionally, the cotton fabric lacked fluidity in its movements, as opposed to the silk scarfs that both the connoisseur and the first author were used to dancing with.

Following this first testing, the connoisseur deepened the first author's understanding of *continuity* and *anchoring*, as manifested in the sounding scarfs. She explained that it is related to a sense of connection to the ground in the Isadora Duncan repertoire. We re-framed and further articulated our *experiential quality* as *connection to the ground*, consisting of perpetual transformations of various Duncan dance movement qualities: anchoring, lightness, continuity and fluidity.

During this conversation of re-framing the experiential quality, the first author gave an example of what she imagined as a movement sonification of the opposite of anchoring. A bouncing, spring sound, giving a feeling of lightness and of letting go. The connoisseur pointed out that this bouncing movement contains both anchoring and detachment/lightness, that one does not exist without the other, and she explained how anchoring is a physical necessity with Duncan, to be able to find the lightness. She said, "you need to feel the 'opposite' to be able to gain awareness of the present". Regarding continuity and fluidity, the connoisseur emphasised the importance of expressing a relationship with time as well as with energy. Furthermore, she noted how fluidity is tied to a continuous energy that requires liberty and letting go. The connoisseur also expressed the need for perpetual modulation. She pointed out, "you need modulation to not lose awareness". In Isadora Duncan's dance, the connoisseur summarised that movement is "in perpetual transformation: of lightness–anchoring, acceleration–slowing down, space which opens up–space which is restricted".

When discussing the quality of *connection to the ground*, the first author used an example of a particular movement phrase, jumps with a forward drive, from rehearsals giving her a strong sense of anchoring. The connoisseur clearly identified these as jumps that keep the *connection to the ground*. She went on to say that, "there is anchoring, but also uprising. As if you are torn away from the earth". In this jump, there is clear modulation, providing an opening to feel the anchoring compared to the lightness in the uprising.

Testing the sound designs and re-framing the experiential quality together inspired new design ideas. The connoisseur shared a poetic imagination of whispers. She imagined them as sounds resurfacing from the past that would reactivate Isadora Duncan's century-old work into the present. She saw a metaphor of archives in the whispers, like a memory of a knowledge left behind that is resurfacing. The sounds of the resurfacing whispers, she imagined as voices, water, rustles, or words.

²<https://freesound.org/people/HarryPeeks/sounds/243665/>

³<https://freesound.org/people/tom.p/sounds/62555/>

5.2.4 Second Iteration on the Sounding Scarfs. We continued discussing the ideas of the resurfacing whispers and recorded the connoisseur reading snippets of text she had selected from Isadora Duncan's works, related to the connection to the ground, nature, waves and gravity. Interacting with the scarf, we wanted to hear fragments of phrases and keywords, at times distorted, at times discernible. Based on our reframing of the experiential quality of *connection to the ground* and on reiterating on our designs, we developed two final sound designs (find code here⁴) and two scarfs (see figure 4). The scarfs are made of silk fabric with sewn-in pouches for the IMU. The silk fabric provided the desired quality of fluidity compared to the cotton fabric in our first iteration. We additionally attempted using smaller lithium ion batteries with the IMU to reduce the weight of the scarf, but we found the difference in weight to be minimal, and that the experience of dancing with a scarf without an embedded sensor compared to one with a sensor was no different. We thus decided to keep the larger batteries for longer battery life. Below we describe the implementation of the sound designs.

Sound Design 1: 'The Ocean'. With the first sound design, we kept the ocean sounds. Following what the connoisseur pointed out during the first iteration, we made the mapping more sensitive to subtle movements. Drawing from the sense of anchoring in the *connection to the ground* in particular, we wanted the mapping to also hold a strong sense of gravity, with a slow drag to the ground. To do so, we designed a mapping combining a sonification of subtle movements spurring immediate sonic reaction, with a sonification responding to the movement with a lingering effect that can be perceived as resonance or a delay.

From the IMU (a Bitalino R-IoT⁵), sending data in real-time over wi-fi, we calculated the exponential of the angular velocity and the exponential of the accelerometer intensity (similar to jerk) and mapped these to CataRT⁶, a corpus-based concatenative synthesis, in Max/MSP. With CataRT, the incoming data from the IMU are mapped to a 2D space, spread across the two axes, based on the acoustic descriptors of loudness and frequency of the grains of our audio corpus. The corpus was made of the same recordings of ocean sounds as in the initial design. We manually adjusted the spread of the grains to obtain a corpus that mapped well to the IMU data stream. The mapping has a "sticky" effect, with a pull towards the lower left corner and with a lingering effect following movements with higher velocity, almost floating and sinking, as if moving through water⁷.

Sound Design 2: 'Murmurs From the Past'. The second sound design is a reiteration of the previous one based on the vocal sketching recording of the connoisseur with melodic and vocal features. We use the entire vocal sketching recording, combined with the recordings of texts from Isadora Duncan's written works, to create a sound design that represents the imagery of dialoguing with the past. The snippets of texts read by the connoisseur that we recorded, are taken from the following three books by Isadora Duncan: *Ma Vie*,

⁴<https://github.com/togrba/designing-in-conversation-with-dance-practice>

⁵<https://ismm.ircam.fr/riot/>

⁶<https://forum.ircam.fr/projects/detail/catat-mubu/>

⁷See supplemental material for an animation of the sensor moving with 'The Ocean' and the described effect of the mapping onto the 2D space in Max/MSP.



Figure 4: Guided by the experiential quality *connection to the ground*, we designed two silk scarfs embedded with temporal sensors and two different sound designs 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 voice and keywords with a sense of continuity and perpetual transformations.

Gallimard, first published in 1927 in English, *Isadora danse la révolution*, Éditions du Rocher, 2002 and *Écrits sur la danse*, Éditions du Grenier, 1927.

As in Sound Design 1, we mapped the incoming IMU data to CataRT onto a 2D space spread across axes based on the acoustic descriptors of periodicity and the spectral centroid of the grains of our audio corpus. We then spread the grains uniformly across the entire 2D space. With 2000ms grain chops, words are at times deformed and at times discernible. They are blended together with the whisper-like sounds from the audio recording of the vocal sketching. From the IMU, we mapped orientation data onto the 2D space, reflecting a sense of continuity and perpetual transformations of movement. This, together with accelerometer intensity mapped to a low-pass filter, created a rich variety of textures and melodic features of sound within the corpus allowing for a lot of modulation of sound through movement⁸.

6 SHARING THE SOUNDING SCARFS

6.1 Exploring With the Dancers: Method

We ran a sharing session where we introduced the sounding scarfs to the dancers of the company. The scarfs acted as objects that they could interact with while dancing, in a manner that they were already familiar with in their practice. The scarfs also provided us, the researchers, with a means to probe into both their practice of Duncan's dances and their interaction with the designed artefacts. Our sharing was a way for us to observe and reflect on how the dancers were thinking with the body and through the probe.

6.1.1 Procedure and Participants. 6 of the 12 dancers from the company participated in the sharing session, coded as P1 through P6. Prior to the sharing session, the three authors planned the procedure together, preparing the activities and roles for each of us during the session. With the mapping and the sound design 'Murmurs From the Past' evoking a sense of continuity and perpetual transformations, the connoisseur proposed that we include the choreography, Dubinushka, in the activity. Dubinushka was one of the three choreographies that the company had been learning and holds the qualities of continuity and perpetual transformations with movements of continuously changing orientation and pace. Then, with 'The Ocean' evoking a strong sense of gravity and a lingering effect, the connoisseur proposed that the participants dance the choreography Varshavianka, one of the two other choreographies, as this choreography holds qualities of anchoring, lightness, strength and resistance.

The connoisseur guided the dancers through the physical exercises. The second author was there as an observer and facilitator together with the first author. The session started with the first author introducing the research project and the program of the day. The connoisseur then led the group through a warm-up, similar to the warm-ups the group is used to in regular rehearsals. From there, we went into 2 different activities, that required the dancers to dance with the probes, with a focus on Duncan's specific movement qualities. Before and after each exercise with the probes, the participants filled in body maps [20] in which we asked them to reflect and note down how their body felt in the moment and if they noticed any changes. The body maps served as a moment of introspection and as a sensitisation tool creating bodily awareness

for the participants. For us, the researchers, the body maps served "to probe, trigger dialogue, document the experience, and provide a visual reference for self-reflection," as described by Cochrane et al. [20]. Finally, after each exercise, we sat down to discuss the experience of dancing with the probes, in a group discussion led by the second author.

Activity 1: 'Murmurs From the Past' - Dubinushka. The first activity started with an improvisation guided by the connoisseur, focusing on continuity and moving in an infinity-like shape. Then the whole group danced the choreography, Dubinushka, together. After dancing the choreography and filling in the body maps, the group continued improvising with movements from Dubinushka in two groups. Each group improvised with a sounding scarf and a sound source playing the real-time movement sonification, with the sound design 'Murmurs From the Past' that was built around the qualities of continuity and perpetual transformations of movement. After the improvisation with the probe, the participants filled in the body maps again and went into the group discussion.

Activity 2: 'The Ocean' - Varshavianka. The second activity started with the entire group dancing the choreography Varshavianka, where the sense of gravity is important. The group then filled in the body maps, before splitting up into two new groups, based on their previously assigned roles in the choreography. In these groups, each with their sounding scarf and sound source, the dancers were working on their parts of Varshavianka collaborating with each other, but this time with the sounding scarf and the sound design 'The Ocean', which was built around a sense of gravity. Then, as in the first activity, the dancers went on to fill in the body maps again and finished with the group discussion.

6.1.2 Data Collection and Analysis. The activities were video recorded, the group discussions were audio recorded and the body maps were collected, upon consent given by participants. The first author transcribed the audio recordings and took notes from the video recordings and the body maps. The first and second authors analysed all of the transcribed data and the notes inductively, following a reflective thematic analysis [13]. After an initial read through the full data set, we read through it again and individually coded it according to what we found noteworthy. We then sorted these codes into themes that captured recurring patterns of the participants' interaction with and experience with the probes and with each other.

6.2 Findings

6.2.1 Revisiting the Dance Practice Through Sonification. 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 the connoisseur's use of music and musical language during the rehearsals, but the movement sonification made Duncan's movement qualities palpable to the dancers, as it allowed them to clearly perceive continuity, rhythmic qualities and movement propagation.

The Interaction with Sound Evoked Duncan's qualities. The dancers drew parallels to Duncan's imagery in the sound designs as well as the movements incited by the sonification. In the discussion

⁸See supplemental material for an animation of the sensor moving with 'Murmurs From the Past' and the described effect of the mapping onto the 2D space in Max/MSP.

following the first activity, with the sound design ‘Murmurs From the Past’, P5 mentioned how the sounds were reminiscent of water, the movements of air and of the scarf passing through the air. She found it, “organic, soft and fluid”, and without any rhythmic demarcation, inviting one to move in, “soft movements of waves, that went well with the scarf and with Duncan’s movements”.

Additionally, P6 found the continuous movement in the Duncanian dance to go well with the sound of the waves in ‘The Ocean’ sound design. Such a sensation of continuity was also made explicit by participant P4 in her body map (see figure 5) where she illustrated how the scarfs allowed her to feel her arms extending beyond her fingers.

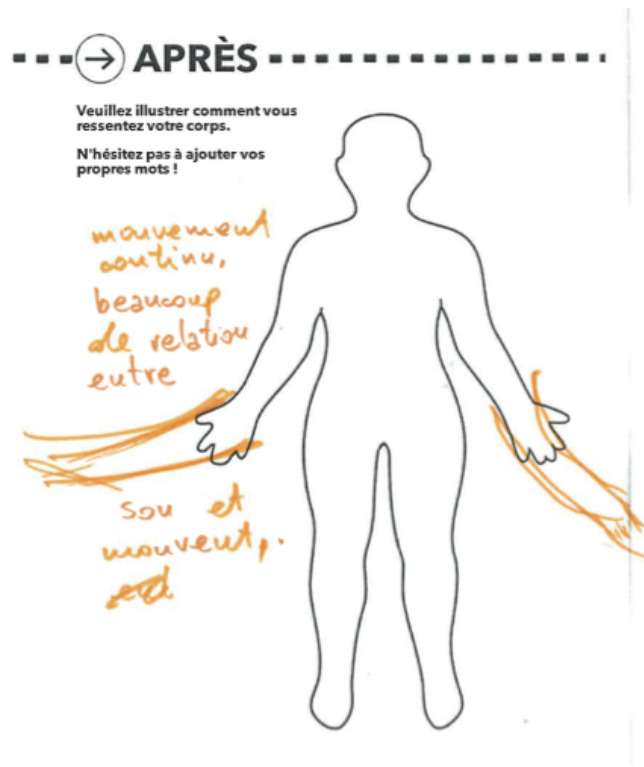


Figure 5: P4 illustrating continuity through elongated arms through the scarfs.

Another example of how the sound design made Duncan’s imagery more concrete to the dancer can be seen from a passage towards the end of choreography, Varshavianka, in the activity with ‘The Ocean’. In this choreography, P4 accompanies the other dancers in a powerful movement of resurrection with her arms moving upward as a sign of awakening the dead. When performing that passage with the sound generated from the scarfs, P4 said, “the connoisseur have been telling me to do it with more strength. Maybe I understood it now [with the scarfs]... I think I understood it now, with the sounds, what [she means by adding strength to the movement]”. Indeed, the mapping of ‘The Ocean’ sonifies an increase in movement intensity with an increase in sound that, together with the lingering effect helped P4 understand the impact of her movement when raising her hands slowly towards the sky.

Another aspect of Duncan’s movement qualities that was made palpable through interacting with the scarfs was the rhythm of movement. According to the connoisseur, in Duncan’s work, “the accent is the famous anacrusis”. An anacrusis puts an accent right before the beginning of a phrase, creating a rhythm that starts with an impulse. She further added, that with this impulse, the movement propagates in the body in a successive manner. She reported that she observed that the dancers, when interacting with the sounding scarf, felt the impulses in Duncan’s work. Also with the tight coupling between intensity in movement and intensity in the sound, the movement sonification incited the dancers to place the accent at the beginning of the phrase. Moreover, dancers used great intensity in their movements to properly hear the sonified accent and to propagate their movement from their solar plexus toward the arms, then to their hands, then to the scarfs, as a continuation of their body.

Hearing the Movement Propagating. The echo in the sound design ‘The Ocean’, that lingers after movement is performed, was perceived by some dancers as a “lag”. The connoisseur shared her observations of this lingering effect. She found it to be a way of letting the dancer recognise and embody what her Duncan teacher, Julia Levien, herself and other dance scholars call “the after-movement”. An after-movement refers to the movement that follows an impulse when the body has almost reached stillness. The connoisseur went on explaining how the choreography that the group interpreted during this activity, Varshavianka, was made of successive waves which required the dancers to initiate the movement and pay attention to the resulting after-movement. The sounding scarfs allowed the dancers to hear the after-movement. Indeed, several participants (P3, P5, P6), when interacting with the sounding scarfs, reported that they clearly perceived the effect of their movements like a wave propagating through the fabric of the scarfs. They performed movements of waves, with small and big waves, with the undertows and the eddies. The resulting sound resembled bigger waves, smaller waves, or waves hitting pebbles.

6.2.2 Entanglements of Movement and Sound. Our findings 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 body, or an outward-looking way that encouraged a poetic exploration of movement and sound.

Movement–Sound Interaction Loop. In the discussion following the activity with ‘The Ocean’, the participants started talking about “hearing the movement”, until realising that they were actually referring to hearing the sound of the movement through the movement sonification. They talked interchangeably about hearing the sound and hearing the movement. P2 pointed out that the sound was a consequence of their movement, e.g. that their movements were producing the sound. P3, P5 and P6 found that, on the contrary, their movements were a consequence of the sound, as the sound made them move more, “searching for the waves”, or move slowly, taking the time to let the movements propagate with the sound. This shows how movement and sound were perceived as entangled entities, as movement created sound that in turn impacted movement and vice versa.

Focusing Inwards or Outwards. Participants elaborated on their experience of the connection between movement and sound, where they were hearing sound as a consequence of their movement. This connection incited some to focus on the body (inward), and others to focus on the scarf (outward). P2 explained how her focus stayed with the scarf being the sound-producing entity: “It’s almost as if there is a lag in our movement, and then the lag is also in the scarf floating behind us, so it is [the scarf] producing [the sound] actually”. Similarly for P3 and P6, hearing the consequence of their movement made them focus on having the scarf in their hands and moving it, with the goal of making sounds. For P1 and P5, on the other hand, hearing the consequence of their movement took on a poetic dimension. They felt the sound supporting the movements in between dancers as the scarf was being passed from one dancer to the next. P4 went further in explaining her bodily experience of dancing with the sounding scarf, with the mapping ‘Murmurs From the Past’, as feeling like she was being covered by sound like a blanket. She illustrated this sensation in her body map (see figure 6). She explained how at first she was focused on her solar plexus and the continuous movements in an infinity-like shape, but she later started feeling an energy passing through her entire body: “It was sort of everywhere, like a blanket [...] A sonic blanket”. This shows the two different attitudes towards the scarfs, where some of the dancers incorporated them as an extension of their body in ways that supported their movements and provided an inward-looking quality to the interaction, while others treated them as foreign objects that they manipulated and explored.

The Sonification Encouraged Exploration. All of the dancers found that the sonification encouraged them to explore both movement and sound through a variety of intensities and possible sonic responses. They reported that it made them want to move more, make larger movements, or “the right” Duncanian movement. Talking about ‘The Ocean’, P5 shared, “it makes us slow down the movement and perhaps enjoy it more. It was also a pleasant sound to hear, a relaxing sound, and yes I also found it nice, I wanted to go slower.”

The different sounds in the sound designs led to different intensities in the dancers’ movements. P4 mentioned, after the second activity, how she saw the other dancers searching for larger, more generous movements to hear the increasing intensity in the sound of their movement and how she tried to do the same herself. And in a particular passage in the choreography from activity two, where P1 and P5 slowly passed the scarfs between each other, they talked about how they were able to hear their movements accompanied by small, subtle sounds of gentle lapping waves. P1 said, “we could feel the handover of the scarf from [P5] to me, I really liked it...”. The dancers were also exploring the soundscape looking for certain sounds. Sometimes they searched with their own movement, for sounds that they had heard from their peers dancing with the scarfs. Other times, they searched for sounds that they imagined being in the soundscape they interacted with, as P3 said, “I enjoyed searching for the undertow”.

Heightened Sensitivity to Sound and Movement. In the group discussions, the connoisseur pointed out how she observed how the scarfs enriched the dancers’ sensitivity to the relationship between sound and movement. She mentioned *the challenge of listening and*



Figure 6: P4 illustrating the feeling of the sonic blanket.

of being heard. P4 illustrated, in her body map, how the interaction highlighted “a strong relationship between sound and movement”. Indeed, the interaction with the scarfs seemed to have deepened their engagement with the sound and the movement, by both dancing to it and producing it. P5 said, “I focused on following the sound and moving with it really sensitively”.

Additionally, in the first activity with ‘Murmurs From the Past’, P4 pointed out how the continuity in the sound added organicity to the movement as they were dancing with the scarfs. In the activity with ‘The Ocean’, the lingering effect of the sonification allowed the dancers to embody the idea of continuity, where movement never stops abruptly but rather modulates between speeding up and slowing down. Indeed, when the body was on its way to stillness, they could still hear the sonification of the scarf that continued moving. Thus, sonifying the still moving scarf, contributed to the dancer’s movements ebbing out in an organic, “after-movement-like” way. In this activity, consisting of continuous sounds of impulse and fade out and bodies (like the scarfs) that moved like waves that come and go, the sonification was blurring the lines between what was part of the body and what was foreign to it. Indeed, the dancers reported that the scarfs became invisible to them during the activities. They extended the dancers limbs with lightness, and manifested how their movement evolved in wave-like patterns, sounding like whispers and water.

6.2.3 A Collective Experience Rooted in Its Precedents. In the sharing session, the already existing relationships between people in

the dance company played a part in how this new shared experience unfolded. During the first activity, the connoisseur guided the attention and perception of the dancers of one of the groups with P5 and P6). She suggested that they close their eyes, and be attentive to the sound and to each other. In this group, the connoisseur facilitated a collective effort of looking inward. In the discussion following this activity, P6 shared her rich experience of being guided by the connoisseur. She started out concentrating on doing a certain movement without making any particular connection with the sound. Then, after closing her eyes, she started moving with the sound. Then finally she said, “something got connected between the two [movement and sound], in a multi-sensory way, I would say. All the senses were awake [...] Something was being carried by the sound and the movement at the same time, it all connected simultaneously”. See figure 7 for P6’ body map where she illustrates how her body was full of energy and her senses were awake when the group danced together. The connoisseur said that the intention behind how she facilitated the interaction was to go beyond the self-evidence of moving fast and slow, and she wanted to explore the tight relationship between movement and music in dance, and: “How the dynamics of the sound induces a dynamic in us”.

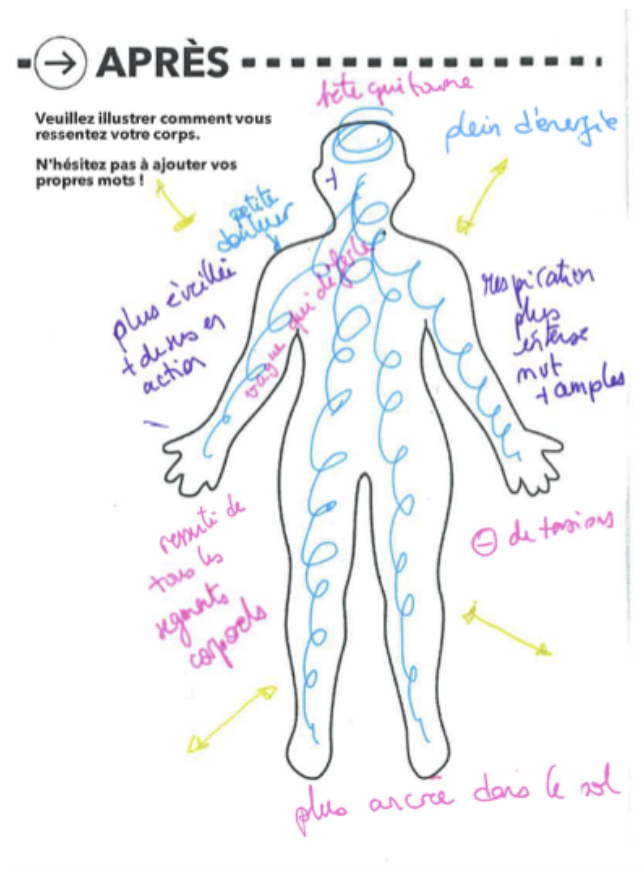


Figure 7: P6 illustrated in her body map how energy was circulating in her body with doodles inside the whole outline of the body and with text reading “senses awake”.

The other group, with P2, P3 and P4 shared a different experience, mainly feeling their body was detached from the sound. P3 expressed a feeling of frustration when struggling to modulate the sound. P2 mentioned feeling like she had misunderstood the task, after hearing about the other dancers’ collective experience. P2 and P3 expressed awe in how P4 “managed to do more with the scarf” then what they did, and that they were searching for the same variety of sounds as what P4 was interacting with but were struggling to find them. We observed that P2 and P3 were quick to pass the scarf to P4, taking the role of observers and letting P4 lead (see figure 8). P4 on the other hand had yet a different experience, and talked about her personal, profound connection with the movement and sound during the interaction with the scarf.



Figure 8: In one group (upper), some of the participants took an observer role and were quick to pass the scarf to other dancers. While in another group (lower), the connoisseur guided the dancers’ attention and perception and facilitated a collective experience of looking inward, staying attentive to sound and each other.

Seemingly, P5 and P6 had a profound experience of sound because their exploration was facilitated by the connoisseur, while P4 was able to feel that same depth of engagement because she is the dancer in the group with the most extensive training in Duncan’s work. This goes to show that background and past experience with

the dance knowledge influence the participation in a sharing session like this and the experience that can emerge from it. It also emphasises the importance of an experienced pedagogue, like the connoisseur who has the skill-set to facilitate deep engagement. The depth of the lived experience and the influence of past experience and expertise were also manifested in some dancers having the language to give detailed descriptions of what they were experiencing, while others less so.

7 DISCUSSION

We have presented a long-term collaboration between dancers and designers, centred around the transmission of Isadora Duncan's dance repertoire. We discuss hereafter our methodology, as well as what we learned from both the process of co-designing the sounding scarfs and from the findings of our sharing session.

7.1 Designing in Proximity

The connoisseur brought in improvisation as a creative and collaborative method to learn Duncan's work, both with the first author alone and with the dance company through rehearsals and in the sharing session with the scarfs. Particularly during the sharing session (see section 6.2.3), the connoisseur facilitated the interaction with the scarfs using improvisation. This improvisational practice provided structure to the dancers as they were getting to know the probes. It also helped guide their perception and deepen their attentiveness to each other and to the scarfs. This was later described by the dancers as allowing for a "rich movement experience through improvisation". We observed how improvisation made space for a shared learning experience where dancers' knowledge of the dance repertoire evolved in collaboration with each other and with the artefact. During the design process, improvisation became a shared site for the sensitisation of the body and for the emergence of design ideas, echoing Kang et al., who sees in improvisation a mode of inquiry for HCI [44].

Our design process was built on our collaborative art practice, and took place through engaging somatically with a body of work that the connoisseur has devoted her life to study and transmit. The goal was to uncover and get close to the sensitivities and specificities of Duncan's work, and proximity was made possible through collaboration and embodied, somatic engagement with the dance repertoire. With dance practice as our anchoring, we built a deep understanding of the embodied experiences of Duncan's dances upon which—and in conversation with whom—we designed our probes.

The same proximity was shared with the dance company as a whole, as we together were part of the same practice, getting to know Isadora Duncan, the connoisseur and each other. Most importantly, the proximity with the connoisseur, the third author, brought us all together and enabled this design process to unfold.

The proximity with the dance community and the expert provided us with space and time to learn about so much more than solely the movement qualities of Isadora Duncan. We learned about the history of who Isadora was as a person beyond her movements. We also learned about the Duncan community that the connoisseur has been part of for decades and how the community is evolving differently on different continents, with different sensitivities to

the work according to their different historical and sociopolitical contexts. We also learned about the history surrounding the heroic dances, two of which the connoisseur describes as *agitprop*, and we learned this at a time where many countries' relationship to today's Russia was changing due to an ongoing war. The creative process and decisions made behind the connoisseur's *mise-en-scène* and musical choices with these choreographies were affected by our present day political context, namely the war in Ukraine. Thus, proximity with the dance material, the dance community and the connoisseur allowed us to take in the past and present contexts, history, people and collaboration between them into account as entangled entities highly affecting and shaping the co-creative and co-design process.

Our own individual creative practices too, beyond our shared dance practice, played a crucial role in shaping our co-design work. Through finding common ground and shared understanding of the work through our experience of music and movement, we built a space where our individual practices could converse and converge and where we could share our creativity and theoretical musings on parallels between design practice and embodied learning. This process took place with mutual commitment through long-term investment, humility, slowness and attentive listening to each other and each of our artistic practices. We found the value of open-ended collaborations lying in the discovery of that which is unavailable to a practitioner operating on their own, as argued by Kang et al. [43, 44].

7.2 Why Is Sound a Great Modality

With sound and music already being central components to the transmission of the dances, designing the interaction with the auditory modality made for a seamless integration of design practice into ongoing dance practice. The dancers were already familiar with the connoisseur's use of music and musical metaphors, together with the scarfs that were also a part of the dances transmitted. Thus, we were able to easily introduce the sounding scarfs to our dance community during the sharing session, as interacting with them only required the dancers to dance with them as they usually do. The technology itself was less apparent as it did not dominate the interaction and made for a subtle integration into the dancers' regular rehearsal environment, as opposed to bringing in screens or headsets with interactive animations, or visualisations, which has often been done in work at the intersection of dance and HCI research [6, 18, 49, 62, 63].

In the co-design process, the connoisseur and the first author iteratively explored the experiences evoked by interacting with the scarf. The sense of correspondence between movement and sound, or tightness in the mapping between intensity in movement and intensity in sound for "The Ocean", demanded rounds of negotiation before finding the "right" mapping. With our final mapping we found qualities that evoked a sense of anchoring and continuity by combining a tightly coupled yet lingering response. Thus, we were able to create a complex correspondence between movement and sound as entangled entities [4, 34, 42, 61]. For some of the dancers this correspondence made for a rich experience. For others, it made the artefacts challenging to interact with. For the

connoisseur it allowed the dancers to hear the effect of their “after-movement”, an important notion in Duncanian dances that relates to the propagation of the impulse of the movement.

We find this sound design to be particularly interesting in how it opened up an experience of intimate correspondence for some of the dancers, while it remained unavailable to others. Intimate correspondence is described by Höök et al. as, “feedback and interactions that follow the rhythm of the body” [40] drawing from work by Ingold [41]. Höök et al. emphasise the role of immediacy and synchronisation, when designing for intimate correspondence. We extend on this notion of designing “interactions that follow the rhythm of the body” in our work, by acknowledging the complexity and irregularity of our bodily rhythms. We recognise how our work differs from intimate correspondence in Höök et al.’s somaesthetic appreciation design, as our complex correspondence create an active dialogue between the dancers’ movements and the sound, through the combination of immediacy, synchronisation *and* lack thereof. Most importantly, the different experiences that the probes evoked in the dancers also showed us how the shared experience of dancing together with the scarf as well as the following group discussion, brought real insights into a collective reflection on what the technology actually brought to each dancer’s practice and to the group as a whole.

7.3 Enlivening Duncan’s Repertoire

We have been working with a dance practice and knowledge that is more than a hundred years old. The transmission of Isadora Duncan’s work and technique is continuing to live on thanks to the profound and often life-long investment of a few people spread around Europe and North America. The tradition of oral transmission of the repertoire is fragile, as the process of passing embodied knowledge on through generations of devoted dancers is a slow process and depends on a small number of people. Moreover, the Duncan community is committed to their (oral) mode of transmission, as they consider it to be the only way to adequately transmit the complex knowledge that encompasses the dance. This makes the educational dance transmission context the main mode of safeguarding and preserving this intangible cultural heritage. Through our collaboration with the main Duncanian dancer and educator in our country, we aimed at accompanying this ongoing transmission of Duncan’s knowledge and legacy, rather than finding ways for technology to ensure or “save” it from decay. We resist the temptation to create tools that mirror or imitate the pedagogue’s role in knowledge transmission. We consider the human embodied knowledge and transmission much more valuable and desirable for our community (and society as a whole) than the knowledge solely provided by an (intelligent) system. Thus, we propose to design interactions *in conversation* with the transmission of Duncan’s knowledge. It is an approach where designing, learning and embodying the dance are intertwined, enriching and accompanying one other.

The HCI community and sub-communities of interaction design practice are seeing ever more attention given to innovation, with new technologies making us rethink how we organise, develop, design and value our work, creative practices and transmission of embodied knowledge [5, 63]. While design speculation and futuring

might serve us with tools and theory on how to better deal with rapid technological advances [25], we take on an approach that stays with the present moment. With this work, we suggest an approach to design practice that celebrates the knowledge that is already there and that is already being transmitted. Our approach integrates technology into practice while staying faithful to the methods and ways with which transmission is being done at present. With that, we engage attentively and with care with the practices that contribute to human knowledge and cultural and artistic legacy.

7.4 Beyond Supporting, How Interaction Is Dialoguing With Dance

The process that we have described in this paper led to a transformation of the first author’s sensitivities to dance. With one foot in design research and another in art practice, being a part of a dance company for the first time in her life brought new understanding and value to her practice. Community-level engagement was a way for the first author to gain a deeper understanding of what is at stake when we, as designers and technologists, enter a creative stage, whether we facilitate ongoing practice, or intervene in potentially harmful ways that do not value existing knowledge. A stage that functioned very well without us, before we got there.

Instead of taking on interventionist strategies designing systems that “support” transmission, where perhaps no-one even asked for support, we aim to develop on how design can become one of the means (the body being another one) to dialogue with other practices, to share knowledge and ask questions, developing reciprocal creative and learning encounters as described by Kang et al. [44]. The interactive system in our study was brought in by designers to dialogue with the dance. Each one of us involved brought a piece of our own craft to the encounter, fostering a dialogue that was generative of ideas, learning and transmission. On our way through this process, the dancer learned about design, and the designer learned about dance. We believe that 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 [9]. We found that the foundations of such a long-term engagement with practitioners is humility, slowness and careful listening. These qualities allowed us to make space and time for everyone’s knowledge, ideas, interests and goals, without instrumentalising dance for the sake of technological advancement or using technology to enable artistic innovation.

We want to emphasise the importance and value that a pedagogue brings to embodied practices. We argue that a pedagogue’s somatic connoisseurship [57] (or others’ working with transmission of embodied knowledge) is more than simply a resource to exploit in our design processes to design better systems that support body-centred interaction. Whether such connoisseurship is our own or our collaborators’, it is a knowledge, wisdom and craft, unique to their person, that they have spent years building. In engaging with it, it is important to show appreciation and respect for it with humility careful listening.

We recognise, however, the challenges of longitudinal research and artistic practice foregrounding slowness and careful listening, as they rely on a resource that is central to building the deep

relationships on which they thrive—time. Time constraints are typically bound to financial constraints. For many practitioners in both research and the arts, pointing to the values of going slow in a reflective process of *slow science* [59] is simply not an option, not for everyone nor for all contexts.

8 CONCLUSION

This paper presents a collaborative art practice between dancers and designers, constituting the space of a design inquiry into the repertoire of modern dance pioneer Isadora Duncan. We presented our process of co-designing probes through our long-term engagement with a dance community and conversations with an expert transmitting Isadora Duncan's dances to us. The probes, the sounding scarfs, sonify dancers' movements using temporal sensors embedded in the fabric of the scarfs, with the goal of evoking qualities of Duncan's work and legacy. We created two sound designs driven by our experiential quality *connection to the ground*, one using ocean sounds and a mapping of movement to sound creating a strong sense of gravity and a lingering effect, and the other sound design consisting of whispers with a mapping creating a sense of continuity and perpetual transformations. We shared the probes with our Isadora Duncan dance community and found that the probes made the Duncan dance movement qualities of *continuity*, *movement propagation* and *rhythmic qualities* palpable to the dancers, as dancing with the probes provoked poetic imagery and incited interactions and organic movements that the dancer's found reminiscent of Duncan's work. Through their interactions with the probes, the dancers deepened their relationship to Duncan's movements, sound and the correspondence between the two. In our discussion we share our reflections on the process of co-designing the probes and how our collaborative art practice made space for slowness and humility, serving as key elements in the dialogue created between the practitioners, allowing for seamless integration of design research and dance practice.

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REFERENCES

- [1] Sarah Fdili Alaoui, Frederic Bevilacqua, and Christian Jacquemin. 2015. Interactive Visuals as Metaphors for Dance Movement Qualities. *ACM Transactions on Interactive Intelligent Systems* 5, 3 (Oct. 2015), 1–24. <https://doi.org/10.1145/2738219>
- [2] Sarah Fdili Alaoui, Baptiste Caramiaux, Marcos Serrano, and Frédéric Bevilacqua. 2012. Movement qualities as interaction modality. In *Proceedings of the Designing Interactive Systems Conference on - DIS '12*. ACM Press, Newcastle Upon Tyne, United Kingdom, 761. <https://doi.org/10.1145/2317956.2318071>
- [3] Sarah Fdili Alaoui and Jean-Marc Matos. 2021. RCO : Investigating Social and Technological Constraints through Interactive Dance. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–13. <https://doi.org/10.1145/3411764.3445513>
- [4] Miquel Alfaras, Vasiliki Tsaknaki, Pedro Sanches, Charles Windlin, Muhammad Umair, Corina Sas, and Kristina Höök. 2020. From Biodata to Somadata. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–14. <https://doi.org/10.1145/3313831.3376684>
- [5] Catarina Allen d'Ávila Silveira, Ozgun Kilic Afsar, and Sarah Fdili Alaoui. 2022. Wearable Choreographer: Designing Soft-Robotics for Dance Practice. In *Designing Interactive Systems Conference*. ACM, Virtual Event Australia, 1581–1596. <https://doi.org/10.1145/3532106.3533499>
- [6] Fraser Anderson, Tovi Grossman, Justin Matejka, and George Fitzmaurice. 2013. YouMove: enhancing movement training with an augmented reality mirror. In *Proceedings of the 26th annual ACM symposium on User interface software and technology (UIST '13)*. Association for Computing Machinery, New York, NY, USA, 311–320. <https://doi.org/10.1145/2501988.2502045>
- [7] The Isadora Duncan Archive. 2022. Dancers. Julia Leven (1911–2006). <https://isadoraduncanarchive.org/dancer/17/>
- [8] The Isadora Duncan Archive. 2022. Repertory Information. <https://www.isadoraduncanarchive.org/dances/>
- [9] Karen Michelle Barad. 2007. *Meeting the universe halfway: quantum physics and the entanglement of matter and meaning*. Duke University Press, Durham. OCLC: ocm71189745.
- [10] Ross Bencina, Danielle Wilde, and Somaya Langley. 2008. Gesture=Sound Experiments : Process And Mappings. In *Proceedings of the International Conference on New Interfaces for Musical Expression*. Genoa, Italy, 197–202. <https://doi.org/10.5281/ZENODO.1179491> Publisher: Zenodo.
- [11] Steve Benford, Chris Greenhalgh, Andy Crabtree, Martin Flintham, Brendan Walker, Joe Marshall, Boriana Koleva, Stefan Rennick Egglestone, Gabriella Gian-nachi, Matt Adams, Nick Tandavanitj, and Ju Row Farr. 2013. Performance-Led Research in the Wild. *ACM Transactions on Computer-Human Interaction* 20, 3 (July 2013), 1–22. <https://doi.org/10.1145/2491500.2491502>
- [12] Frédéric Bevilacqua, Eric O. Boyer, Jules Françoise, Olivier Houix, Patrick Susini, Agnès Roby-Brami, and Sylvain Hanneton. 2016. Sensori-Motor Learning with Movement Sonification: Perspectives from Recent Interdisciplinary Studies. *Frontiers in Neuroscience* 10 (Aug. 2016). <https://doi.org/10.3389/fnins.2016.00385>
- [13] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (Jan. 2006), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- [14] T. Calvert, W. Wilke, R. Ryman, and I. Fox. 2005. Applications of computers to dance. *IEEE Computer Graphics and Applications* 25, 2 (March 2005), 6–12. <https://doi.org/10.1109/MCG.2005.33>
- [15] Yves Candau, Jules Françoise, Sarah Fdili Alaoui, and Thecla Schiphorst. 2017. Cultivating kinaesthetic awareness through interaction: Perspectives from somatic practices and embodied cognition. In *Proceedings of the 4th International Conference on Movement Computing*. ACM, London United Kingdom, 1–8. <https://doi.org/10.1145/3077981.3078042>
- [16] Linda Candy and Ernest Edmonds. 2018. Practice-Based Research in the Creative Arts: Foundations and Futures from the Front Line. *Leonardo* 51, 1 (Feb. 2018), 63–69. https://doi.org/10.1162/LEON_a_01471
- [17] Erin A. Carroll, Danielle Lottridge, Celine Latulipe, Vikash Singh, and Melissa Word. 2012. Bodies in critique: a technological intervention in the dance production process. In *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work - CSCW '12*. ACM Press, Seattle, Washington, USA, 705. <https://doi.org/10.1145/2145204.2145311>
- [18] Jacky C.P. Chan, Howard Leung, Jeff K.T. Tang, and Taku Komura. 2011. A Virtual Reality Dance Training System Using Motion Capture Technology. *IEEE Transactions on Learning Technologies* 4, 2 (April 2011), 187–195. <https://doi.org/10.1109/TLT.2010.27> Conference Name: IEEE Transactions on Learning Technologies.
- [19] Mariana Ciolfi Felice, Sarah Fdili Alaoui, and Wendy E. Mackay. 2018. Knotation: Exploring and Documenting Choreographic Processes. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, Montreal QC Canada, 1–12. <https://doi.org/10.1145/3173574.3174022>
- [20] Karen Anne Cochrane, Kristina Mah, Anna Ståhl, Claudia Núñez-Pacheco, Made-line Balaam, Naseem Ahmadpour, and Lian Loke. 2022. Body Maps: A Generative Tool for Soma-based Design. In *Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction*. ACM, Daejeon Republic of Korea, 1–14. <https://doi.org/10.1145/3490149.3502262>
- [21] Centre National de la Danse. 2022. Danse en amateur et répertoire Programme d'aide. <https://www.cnd.fr/fr/page/323-danse-en-amateur-et-repertoire-programme-d-aide>
- [22] Paul Dourish. 2004. *Where the action is: the foundations of embodied interaction* (1. mit press paperback ed ed.). MIT Press, Cambridge, Mass. London.
- [23] Irma Duncan. 1937. *The Technique of Isadora Duncan*. Kamin, New York.
- [24] Isadora Duncan, Élie Faure, and Isadora Duncan. 2003. *La danse de l'avenir*. Ed. Complexe, Bruxelles.
- [25] Anthony Dunne and Fiona Raby. 2013. *Speculative Everything: Design, Fiction, and Social Dreaming*. The MIT Press.
- [26] Inger Ekman and Michal Rinott. 2010. Using vocal sketching for designing sonic interactions. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems - DIS '10*. ACM Press, Aarhus, Denmark, 123. <https://doi.org/10.1145/1858171.1858195>

- [27] Sarah Fdili Alaoui. 2019. Making an Interactive Dance Piece: Tensions in Integrating Technology in Art. In *Proceedings of the 2019 on Designing Interactive Systems Conference*. ACM, San Diego CA USA, 1195–1208. <https://doi.org/10.1145/3322276.3322289>
- [28] Mariana Ciolfi Felice, Sarah Fdili Alaoui, and Wendy E. Mackay. 2021. Studying Choreographic Collaboration in the Wild. In *Designing Interactive Systems Conference 2021*. ACM, Virtual Event USA, 2039–2051. <https://doi.org/10.1145/3461778.3462063>
- [29] Jules Françoise, Yves Candau, Sarah Fdili Alaoui, and Thecla Schiphorst. 2017. Designing for Kinesthetic Awareness: Revealing User Experiences through Second-Person Inquiry. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, Denver Colorado USA, 5171–5183. <https://doi.org/10.1145/3025453.3025714>
- [30] Jules Françoise, Sarah Fdili Alaoui, and Yves Candau. 2022. CO/DA: Live-Coding Movement-Sound Interactions for Dance Improvisation. In *CHI Conference on Human Factors in Computing Systems*. ACM, New Orleans LA USA, 1–13. <https://doi.org/10.1145/3491102.3501916>
- [31] Emma Frid, Ludvig Elblaus, and Roberto Bresin. 2019. Interactive sonification of a fluid dance movement: an exploratory study. *Journal on Multimodal User Interfaces* 13, 3 (Sept. 2019), 181–189. <https://doi.org/10.1007/s12193-018-0278-y>
- [32] Bill Gaver, Tony Dunne, and Elena Pacenti. 1999. Design: Cultural probes. *Interactions* 6, 1 (Jan. 1999), 21–29. <https://doi.org/10.1145/291224.291235>
- [33] William W. Gaver, Andrew Boucher, Sarah Pennington, and Brendan Walker. 2004. Cultural probes and the value of uncertainty. *Interactions* 11, 5 (Sept. 2004), 53–56. <https://doi.org/10.1145/1015530.1015555>
- [34] Rolf Inge Godøy and Marc Leman (Eds.). 2010. *Musical gestures: sound, movement, and meaning*. Routledge, New York. OCLC: ocn298781501.
- [35] Thomas Hermann, Andy Hunt, and John G. Neuhoff (Eds.). 2011. *The sonification handbook*. Logos Verlag, Berlin. OCLC: ocn771999159.
- [36] Stacy Hsueh, Sarah Fdili Alaoui, and Wendy E. Mackay. 2019. Understanding Kinaesthetic Creativity in Dance. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, Glasgow Scotland UK, 1–12. <https://doi.org/10.1145/3290605.3300741>
- [37] Caroline Hummels, Kees C. J. Overbeeke, and Sietske Klooster. 2007. Move to get moved: a search for methods, tools and knowledge to design for expressive and rich movement-based interaction. *Personal and Ubiquitous Computing* 11, 8 (Oct. 2007), 677–690. <https://doi.org/10.1007/s00779-006-0135-y>
- [38] Kristina Höök. 2018. *Designing with the Body: Somaesthetic Interaction Design*. MIT Press. Google-Books-ID: 9oZ0dWAAQBAJ.
- [39] Kristina Höök, Baptiste Caramiaux, Cumhur Erku, Jodi Forlizzi, Nassrin Hajinejad, Michael Haller, Caroline Hummels, Katherine Isbister, Martin Jonsson, George Khut, Lian Loke, Danielle Lottridge, Patrizia Marti, Edward Melcer, Florian Müller, Marianne Petersen, Thecla Schiphorst, Elena Segura, Anna Ståhl, Dag Svanæs, Jakob Tholander, and Helena Tobiasson. 2018. Embracing First-Person Perspectives in Soma-Based Design. *Informatics* 5, 1 (Feb. 2018), 8. <https://doi.org/10.3390/informatics5010008>
- [40] Kristina Höök, Martin P. Jonsson, Anna Ståhl, and Johanna Mercurio. 2016. Somaesthetic Appreciation Design. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, San Jose California USA, 3131–3142. <https://doi.org/10.1145/2858036.2858583>
- [41] Tim Ingold. 2011. *Being alive: essays on movement, knowledge and description*. Routledge, London. OCLC: 719519068.
- [42] Alexander Refsum Jensenius. 2007. *Action-sound : developing methods and tools to study music-related body movement*. Ph.D. Dissertation. University of Oslo. <https://www.duo.uio.no/handle/10852/27149>
- [43] Laewoo Kang, Steven Jackson, and Trevor Pinch. 2022. The Electronicists: Techno-aesthetic Encounters for Nonlinear and Art-based Inquiry in HCI. In *CHI Conference on Human Factors in Computing Systems*. ACM, New Orleans LA USA, 1–17. <https://doi.org/10.1145/3491102.3517506>
- [44] Laewoo (Leo) Kang, Steven J. Jackson, and Phoebe Sengers. 2018. Intermodulation: Improvisation and Collaborative Art Practice for HCI. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, Montreal QC Canada, 1–13. <https://doi.org/10.1145/3173574.3173734>
- [45] David Kirsh. 2013. Embodied cognition and the magical future of interaction design. *ACM Transactions on Computer-Human Interaction* 20, 1 (March 2013), 1–30. <https://doi.org/10.1145/2442106.2442109>
- [46] Rudolf von Laban. 1975. *Modern educational dance* (3rd ed.). Macdonald and Evans, London.
- [47] Lian Loke and Toni Robertson. 2013. Moving and making strange: An embodied approach to movement-based interaction design. *ACM Transactions on Computer-Human Interaction* 20, 1 (March 2013), 1–25. <https://doi.org/10.1145/2442106.2442113>
- [48] Jin Moen. 2007. From hand-held to body-worn: embodied experiences of the design and use of a wearable movement-based interaction concept. In *Proceedings of the 1st international conference on Tangible and embedded interaction - TEI '07*. ACM Press, Baton Rouge, Louisiana, 251. <https://doi.org/10.1145/1226969.1227021>
- [49] Paisarn Muneesawang, Naimul Mefraz Khan, Matthew Kyan, R. Bruce Elder, Nan Dong, Guoyu Sun, Haiyan Li, Ling Zhong, and Ling Guan. 2015. A Machine Intelligence Approach to Virtual Ballet Training. *IEEE MultiMedia* 22, 4 (Oct. 2015), 80–92. <https://doi.org/10.1109/MMUL.2015.73>
- [50] Elena Márquez Segura, Laia Turmo Vidal, Asreen Rostami, and Annika Waern. 2016. Embodied Sketching. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, San Jose California USA, 6014–6027. <https://doi.org/10.1145/2858036.2858486>
- [51] Isabelle Namèche. 2019. *Le savoir-danser d'Isadora Duncan: origine et transmission d'une œuvre esthétique*. Ph.D. Dissertation. Normandie Université. <https://tel.archives-ouvertes.fr/tel-02879189>
- [52] Stefano Piana, Paolo Alborn, Radoslaw Niewiadomski, Maurizio Mancini, Gualtiero Volpe, and Antonio Camurri. 2016. Movement Fluidity Analysis Based on Performance and Perception. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*. Association for Computing Machinery, New York, NY, USA, 1629–1636. <https://doi.org/10.1145/2851581.2892478>
- [53] Katerina El Raheb, Marina Stergiou, Akviri Katifori, and Yannis Ioannidis. 2020. Dance Interactive Learning Systems: A Study on Interaction Workflow and Teaching Approaches. *Comput. Surveys* 52, 3 (May 2020), 1–37. <https://doi.org/10.1145/3323335>
- [54] Jean-Philippe Rivière, Sarah Fdili Alaoui, Baptiste Caramiaux, and Wendy E. Mackay. 2019. Capturing Movement Decomposition to Support Learning and Teaching in Contemporary Dance. *Proceedings of the ACM on Human-Computer Interaction* 3, CSCW (Nov. 2019), 1–22. <https://doi.org/10.1145/3359188>
- [55] Jean-Philippe Rivière, Sarah Fdili Alaoui, Baptiste Caramiaux, and Wendy E. Mackay. 2021. Exploring the Role of Artifacts in Collective Dance Re-staging. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW1 (April 2021), 1–22. <https://doi.org/10.1145/3449182>
- [56] Yvonne Rogers. 2011. Interaction design gone wild: striving for wild theory. *Interactions* 18, 4 (July 2011), 58–62. <https://doi.org/10.1145/1978822.1978834>
- [57] Thecla Schiphorst. 2011. Self-evidence: applying somatic connoisseurship to experience design. In *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11*. ACM Press, Vancouver, BC, Canada, 145. <https://doi.org/10.1145/1979742.1979640>
- [58] Vikash Singh, Celine Latulipe, Erin Carroll, and Danielle Lottridge. 2011. The choreographer's notebook: a video annotation system for dancers and choreographers. In *Proceedings of the 8th ACM conference on Creativity and cognition - C&C '11*. ACM Press, Atlanta, Georgia, USA, 197. <https://doi.org/10.1145/2069618.2069653>
- [59] Isabelle Stengers. 2018. *Another science is possible: a manifesto for slow science* (english edition ed.). Polity Press, Cambridge, UK. OCLC: 1019900743.
- [60] Anna Ståhl, Vasiliki Tsaknaki, and Madeline Balaam. 2021. Validity and Rigour in Soma Design-Sketching with the Soma. *ACM Transactions on Computer-Human Interaction* 28, 6 (Dec. 2021), 1–36. <https://doi.org/10.1145/3470132>
- [61] Atsu Tanaka. 2019. Embodied Musical Interaction. In *New Directions in Music and Human-Computer Interaction*. Simon Holland, Tom Mudd, Katie Wilkie-McKenna, Andrew McPherson, and Marcelo M. Wanderley (Eds.). Springer International Publishing, Cham, 135–154. https://doi.org/10.1007/978-3-319-92069-6_9
- [62] Georgios Tsampounaris, Katerina El Raheb, Vivi Katifori, and Yannis Ioannidis. 2016. Exploring Visualizations in Real-time Motion Capture for Dance Education. In *Proceedings of the 20th Pan-Hellenic Conference on Informatics (PCI '16)*. Association for Computing Machinery, New York, NY, USA, 1–6. <https://doi.org/10.1145/3003733.3003811>
- [63] Manon Vialle, Sarah Fdili Alaoui, Mélina Skouras, Vennila Vilvanathan, Elisabeth Schwartz, and Remi Ronfard. 2022. Visualizing Isadora Duncan's movements qualities. In *Creativity and Cognition*. ACM, Venice Italy, 196–207. <https://doi.org/10.1145/3527927.3532805>
- [64] Jayne Wallace, John McCarthy, Peter C. Wright, and Patrick Olivier. 2013. Making design probes work. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, Paris France, 3441–3450. <https://doi.org/10.1145/2470654.2466473>
- [65] Danielle Wilde, Anna Vallgård, and Oscar Tomico. 2017. Embodied Design Ideation Methods: Analysing the Power of Estrangement. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, Denver Colorado USA, 5158–5170. <https://doi.org/10.1145/3025453.3025873>
- [66] Qiushi Zhou, Cheng Cheng Chua, Jarrod Knibbe, Jorge Goncalves, and Eduardo Velloso. 2021. Dance and Choreography in HCI: A Two-Decade Retrospective. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–14. <https://doi.org/10.1145/3411764.3445804>