Temporal Trajectories: Characterizing Somatic Experiences that Unfold Over Time

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Figure 1: Participants in the study engaging in their daily activities (dancing, unloading the dishwasher, walking, movement explorations) while wearing SoniBand (highlighted as a black belt), a movement sonification wearable.

Abstract

The body technologies we design profoundly influence our somatic experiences, yet they are often evaluated through short-term or one-off studies. To design for sustained, longer-term engagements, we need to understand how somatic experiences evolve when people repeatedly interact with the same technology over time. With this goal, we report on two in-the-wild studies of body sonification, one with physically inactive individuals and another with professional dancers. For one month, participants used SoniBand, a movement sonification wearable, in their daily lives and shared their experiences with us through questionnaires and in-depth interviews. Drawing from the concept of trajectories, we identified four temporal patterns that characterized the participants' evolving experience with SoniBand: singular, sustained, deepening, and meandering. We unpack these temporal trajectories and reflect on the characteristics that may contribute to their emergence. Our findings offer insights for studying and designing future technologies that embrace the dynamic, evolving nature of people's somatic experiences.

CCS Concepts

• **Human-centered computing** → **Interaction design theory, concepts and paradigms**; **Empirical studies in interaction design**.

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Movement sonification, wearable, temporality, sensory feedback, somatic experiences, soma, embodied interaction, dance

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1 Introduction

With the appearance of body sensing and actuating technologies, Human Computer Interaction (HCI) and Interaction Design have experienced a *somatic turn* [47, 61], characterized by the appearance of different approaches to designing with the body (e.g.[46, 47, 59, 60, 70, 111]) and an increased focus on the experience of people interacting with technologies (e.g. [47]). This somatic turn has also prompted the emergence of body technologies (technologies that sense and actuate on the body) across a multitude of application domains, such as sports (e.g. [19]), rehabilitation (e.g.[72]), reproductive health (e.g. [104]), performative arts (e.g.[18]), music (e.g.[86]), and somaesthetic experiences (e.g. [47]).

Previous research has consistently demonstrated that the body technologies we design profoundly impact our somatic experiences[1] (e.g. [47, 59, 108, 111, 121, 128, 129]), transforming how we perceive our identity [11], our body and movements [54, 56, 116, 128, 129],

[1]We adopt a non-dualistic view on the body [48], considering that somatic experiences encompass both bodily and cognitive aspects, e.g. felt body sensations, feelings, emotions, thoughts about the experience, appreciations, and so forth.

our practices [92, 108, 130] and our emotional and social functioning [1, 12, 28, 83, 98].

In interaction design, body technologies are often explored through short-term or one-off studies, leaving longer-term investigations into people's engagements with these technologies relatively scarce (e.g., [15, 63, 108]). This gap in longer-term research may seem at odds with the fluid nature of our body, which is inherently dynamic, fluctuating and continuously evolving [36, 42].

We contend that designing for meaningful, longer-term engagement with body technologies requires first understanding how people's somatic experiences with these technologies unfold and transform over time.

In this paper, we contribute to exploring this gap by examining people's somatic experiences of a particular type of body technology -a movement sonification device- over the course of one month, while they repeatedly interacted with the device in their daily lives. We organized two in-the-wild studies in which participants engaged with SoniBand. SoniBand is a wearable device for real-time movement sonification previously studied in short-term evaluations [54–56, 102, 113, 128], that offers four different metaphorical sonifications of the wearer's movement (wind, mechanical, tone and water). The first study involved professional dancers, while the second focused on physically inactive individuals - a choice that enabled us to explore how longer-term experiences of SoniBand would be for two different groups that had previously engaged with it [56, 128]. During the month, all participants used SoniBand in their daily lives as they saw fit, and reported on their experiences through an online questionnaire and weekly in-depth interviews.

Using thematic analysis [9], we explored how participants' somatic experiences with SoniBand changed throughout the study. We focused on identifying commonalities and differences among the sonifications that participants chose, the activities they used it for, and their reported somatic experiences (e.g., body sensations, emotions, or reflections). We then organized these findings by drawing on the concept of trajectories [40, 45, 121] to highlight temporal patterns. In this paper, we understand *trajectory* as a flexible, situated category that conceptually frames the evolution of a participant's experience with a technology. Rather than representing fixed types, our trajectories serve as interpretive lenses to help others make sense of dynamic, contextual somatic engagements.

We identified four **temporal trajectories**: patterns that characterize how the participants' experience of using one of the sonifications, during a specific activity, repeated and changed over time. During the study, the trajectories sometimes overlapped. These trajectories, which we will illustrate with detailed examples from our study, are:

- **Singular** experiences, with which participants engaged only once.
- **Sustained** trajectories, in which participants' somatic experience remained consistent over time, with little variation.
- **Deepening** trajectories, in which participants' somatic experience became more profound with each engagement, leading to progressively richer and more nuanced insights into their body, themselves, or the sonification.
- **Meandering** trajectories, in which participants' somatic experience varied significantly and unpredictably over time.

These temporal trajectories provide a *conceptual tool* for understanding longer-term somatic experiences with body technologies. By unpacking these temporal trajectories, we highlight the factors that contribute to their emergence, such as differences between the two participant groups, or the choice of activities and sonification.

Our work contributes to addressing the gap in longer-term studies of body technologies. We contribute the four temporal trajectories as conceptual tool to examine, understand and characterize how an individual's experience with a body technology unfolds and evolves over time.

We also contribute insights from the two studies that show the fluid and dynamic somatic experience that people have of a technology over time, when they engage with it repeatedly. Finally, we also offer insights into designing future technologies that embrace the dynamic and evolving nature of somatic experiences. These contributions can hold significance for body-centric research communities within HCI and interaction design (including areas such as soma design and other critical approaches to designing with and for the body [44, 47–49, 122], embodied interaction and movement-based design [46, 70, 111], and human-computer integration [69, 137]), to help study and design technologies that account for the fluid nature of somatic experiences, and that meaningfully weave into the fabric of people's lives, over time.

2 Background

2.1 Body Sonification

To explore longer-term engagements with body technologies, in this paper we turn to a specific type of body technology, body sonification devices, which map signals sensed from a body (e.g. movement [5, 56], muscle engagement [18, 87], or force [37]) to a sound signal, so that a person can 'hear' their body through a body-sound feedback loop.

Body sonifications challenge rigid dichotomies between humans and technology, as well as questions of agency [8]. From an experiential perspective, they present fuzzy boundaries between the technology and the body, often rendering *cyborgs* [134]. Multiple works have shown that experiencing a sound as emanating from the body deeply influences how people perceive themselves, and how they move and act [5, 11, 18, 37, 56, 72, 102, 103, 105, 128]. For example, people feel bigger, heavier, more masculine and move more slowly when they hear their own footsteps altered through a low-pass filter [11, 13, 52, 112, 116]. Sound feedback loops can change people's perception of their limbs' lengths (e.g., arms [71, 88, 114, 117–120], the body's perceived materiality (e.g., feeling that one's hand is made of marble [99]), or how people move during exercising [5, 56, 57, 102, 103, 106, 107].

The effects of body sonification on people's body perception and behaviours can be attributed to the plasticity of people's body experience [7, 14, 62, 100, 117]. How we experience our bodies is shaped by the spatiotemporal correlation of multisensory and sensorimotor signals, as well as individual and sociocultural influences (involving memories, prior experiences and sociocultural norms) [115, 128]. Body sonification can thus be conceptualized as an entangled experience [87] between bodies, signals, culture and activities that collectively influence somatic experiences.

There is a rich body of work in HCI on body sonification. Prior works emphasize contexts of sensorimotor activity and learning [5, 6], such as sports (e.g. [39, 73, 93, 94, 106, 107, 132]), dance (e.g. [18, 37, 50, 128]); exercising (e.g. [54, 56, 102]); rehabilitation [34, 93, 96, 97, 133], functional activities (e.g. [57, 101]); aerial acrobatics [58], or walking (e.g. [13, 116]). Other contexts are interactive art installations [21, 22] [26] and performances [18, 79, 80], chronic pain [72, 103], somaesthetic appreciation [4], music [86, 87], and sonification of abstract concepts, e.g. Laban Effort factors in [27].

However, as with other body technologies, body sonifications are often examined in short evaluative studies or one-off research activities. Here, we are interested in examining the somatic experience of body sonification over longer time periods.

2.2 Bodies Engaging with Technologies, Over Time

Time is central in HCI and interaction design research and practice [74, 84], as the very concept of interaction emphasizes the dynamic gestalt of engaging with technologies [49, 64].

Interaction design as a field is increasingly focusing on issues of temporality (the state of existing within time) [75, 84], exploring slow design to foster sustainable human-technology relationships [74, 75]; accounting for the interwoven temporalities in RtD [77]; or proposing designs that encourage slowing down [10, 53, 74]. There have also been multiple in-the-wild studies of technology engagement over long periods of time. For example, people living several weeks with an electronic coffee table that displays slowly moving images [33]; philosophers living for three months with an automatically tilting bowl to analyze human-technology relations [135]; a five-month study of a creativity-support tool for choreographers [20]; a year-long longitudinal observational study on dance re-staging through an ecology of physical and digital artifacts [89]; a mother and son using a simple communication device for two years to support a feeling of connection in their long distance relationship [31]; and up to a four years' study of a system to gather and review personal hiking data [76].

However, this increasing focus on temporality has not yet been matched in body-centric research in HCI. Longer-term examinations of people's somatic engagement with technologies that sense and actuate on the body are still few, as prior works suggest [19, 42, 108, 121, 131]. This gap in longer-term perspectives may seem at odds with the fluid and *volatile* [36] experience that people have of their bodies over time. Bodies are in a constant state of flux [42], and how somatic experiences unfold over time shapes how people perceive and engage with themselves, others and the world. This is made evident in recent feminist autoethnographic works in HCI that examine longer-term somatic experiences. For example, Homewood's 18-month autoethnography whilst experiencing long COVID [43], or Gamboa's exploration of her pregnancy [29].

These works provide valuable insights into the depth and complexity of studying somatic experiences over an extended period of time. However, they fall short in explaining how people's felt experiences with a particular technology evolve over time - when they repeatedly interact with it, in their daily lives.

Few examples of works that examine longer-term somatic engagements with technologies are found in soma design [47], an approach that engages the lived body to examine the aesthetic experience between materials, bodies, technologies, and contexts. For example, Ståhl et al. [108] deployed two prototypes, the Soma Mat (which uses thermal stimuli to guide attention to the body) and the Breathing Light (which synchronizes the light' brightness to the a person's breathing), in four households for three months. They found that that the prototypes helped some individuals navigate challenging life situations, and inspired others to make lifestyle changes. Luft et al. [63] engaged in an autobiographical design process to create an interactive wooden dummy for martial arts training. This process, which took several months, led the first author, a martial arts expert, to develop new training habits and change his practice. Sanches et al.[92] conducted a one-month in-the-wild home study on the Affective Health bracelet, a self-tracking wearable device offering ambiguous representations of skin conductance data. Participants incorporated the device into their somatic practices, using it as a reflective tool.

We argue that not only we need more design examples like these, showcasing longer-term somatic engagement with technologies, but also knowledge to help us understand such experiences. Towards that, the concept of trajectories and how it has been used in prior soma design works provides an interesting departure point.

2.2.1 Trajectories. Trajectories as a concept have a long tradition in HCI [121], originating from observing people's interaction with an experience [40, 45, 121]. Since then, they have been widely adapted in HCI, often with a focus on examining practicalities of interaction (e.g. what people did, or said) [3, 24, 35, 78]).

More relevant to our work is the use of trajectories to explore participants' somatic experiences. Tennent et al. (e.g., [121]) introduced *soma trajectories* as a graphical tool to capture and represent temporal changes in how a person *feels* interacting with a design. Soma trajectories focus on specific dimensions of an experience (e.g., familiar<->strange), using graphs to visualize how these fluctuate. They have been applied to analyze experiences of balance (e.g., [121]), playful water interactions (e.g., [67]), and digital musical instruments (e.g., [23]). Our understanding of *trajectories* in this paper draws from these works. We consider trajectories not as rigid or pre-defined categories, but rather flexible and dependant on the context, allowing for variation and change. Further, we use trajectories as an analytical construct to interpret and make sense of how a participant's experience develops - rather than to trace direct data observations (as in e.g. [3]).

Soma trajectories excel at analyzing short-term changes in felt experiences, offering a "micro" lens to detail how feelings shift during a brief interaction. However, they do not conceptualize how somatic experiences evolve over time, through repeated engagement with technology. We introduce *temporal trajectories* as a broader conceptual tool, characterizing patterns of evolving somatic experiences over extended periods, grounded in our study of SoniBand, a wearable device for movement sonification.

3 SoniBand: a Movement Sonification Wearable

To examine how people engaged with a body technology when they returned to it repeatedly in their daily lives, in this work we used an existing body sonification device: SoniBand, which has been introduced in prior works [54–56, 102, 113, 128]. SoniBand (Figure

Figure 2: On the left, SoniBand's technical implementation. On the right, a person illustrating a potential start/end positions for calibration. Images reproduced with permission of the original authors.

2) is a wearable that sonifies in real real-time movement angles using various sounds. It integrates a BITalino R-IoT module [5] with a 9-axis Inertial Motion Unit (IMU) placed within a wearable fabric patch, that can be worn at various body locations with a band. The R-IoT wirelessly transmits movement angle data to a Raspberry Pi Zero, which can be controlled via a web browser. SoniBand is calibrated by recording the minimum and maximum angle of a movement, and uses the captured data to generate real-time movement-sound feedback loops.

SoniBand incorporates four distinct *metaphorical* sonifications [56]: wind, mechanical, tone and water (see Figure 3 for a description of each, and the supplementary materials for audio clips). These sonifications utilize naturalistic-environmental sounds to induce metaphorical associations between the body and the material characteristics that the sound represents. For example, prior works have found that the mechanical sonification, similar to rusty gears turning, induces people to perceive their body as more stiff, broken, heavier or robot-like [56, 128].

We chose SoniBand for our studies because it had already been extensively studied through short-term, or one-off, evaluations in previous research [54–56, 102, 113, 128]. Thus, its effects on people's body perception and behaviour during shorter-term engagements were already well understood, and we could build on those to explore longer-term perspectives. For instance, Ley-Flores et al. [56] explored how sonifications affected body perception and physical activity during strength and flexibility exercises in both physically active and inactive participants. Physically inactive people often have negative or distorted body perceptions (e.g., feeling incapable or weak to perform physical activity) [88]. The authors wanted to explore if metaphorical movement sonifications could help physically inactive participants change those perceptions during physical activity, and compare the effects to the active population. They found that the wind sonification improved participants' perception of body control, fluidity, weight, and joy of movement, serving as a motivating guide. The mechanical sonification made participants feel heavier and rustier, but aided in movement coordination. The tone sonification enhanced flexibility and lightness; while the water sonification promoted relaxation and comfort during movement. In particular, physically inactive participants felt motivated and encouraged to exercise more. Ley-Flores et al. also found similar effects in two experimental studies [54, 55], confirming that the metaphorical sonifications influenced adult participants' body perceptions and physical activity.

Building on these insights, Singh et al. [102] studied the tone sonification through three quantitative experiments in which they explored the sonification's effects on squats. They found that participants felt "pushed" by the sound, helping them in performing the exercise. Finally, Turmo Vidal et al. [128] conducted an exploratory somatic workshop with professional dancers, who as *somatic connoisseurs* [95] have a deep and rich connection to their somatic experience. However, dancers often suffer from distorted body perceptions that emerge from the pressure of achieving peak physical performance and conforming to an ideal body image [82]. The authors found that the water and mechanical sonifications of SoniBand deeply *transformed* the dancers' body perception. Dancers felt important changes in their body image, perceived physical capabilities and body awareness.

This existing body of work has thoroughly examined how SoniBand performed in one-time or short-term evaluations and in experimental studies, yielding a robust understanding of the sonifications' short-term effects. In this paper, we extend on these other prior works by studying the diverse ways in which people experienced the sonifications when they returned to them repeatedly, in their daily lives, without a pre-defined set of activities they needed to do.

4 Methodology and Methods

This work is part of a larger project, BODYinTRANSIT, that seeks to understand the impact of sensory feedback loops on body perception. Our group is interested in sound and haptic stimuli, and different people in our team has experience working with these sensory modalities across different technologies.

We adopted an in-the-wild research approach [90] that emphasizes studying new technologies *in-situ*, within real-world contexts. Novel technologies in in-the-wild studies are often deployed to augment people, places or environments, and not necessarily to meet specific user needs. Thus, this approach favors exploratory examinations of how people react to novel technologies that are integrated in their daily life, and how this might affect existing perceptions and behaviours [90]. For us, this approach was particularly apt to examine how people engaged with SoniBand's sonifications in their daily life, as well as how they experienced the technology over an extended period of time.

4.1 Data Collection through Two Case Studies

Our data collection was conducted through two separate case studies with two different groups who took SoniBand at home for a month: physically inactive adults and professional dancers. Research has shown that these groups often have negative, but different, body perceptions. For dancers, their body is their main tool in their creative work and expression and their practice is often geared towards mastering skills [82]. Yet, they often experience pressure to embody an optimal physical performance and to adhere to aesthetic ideals exceeding the physical requirements of dance

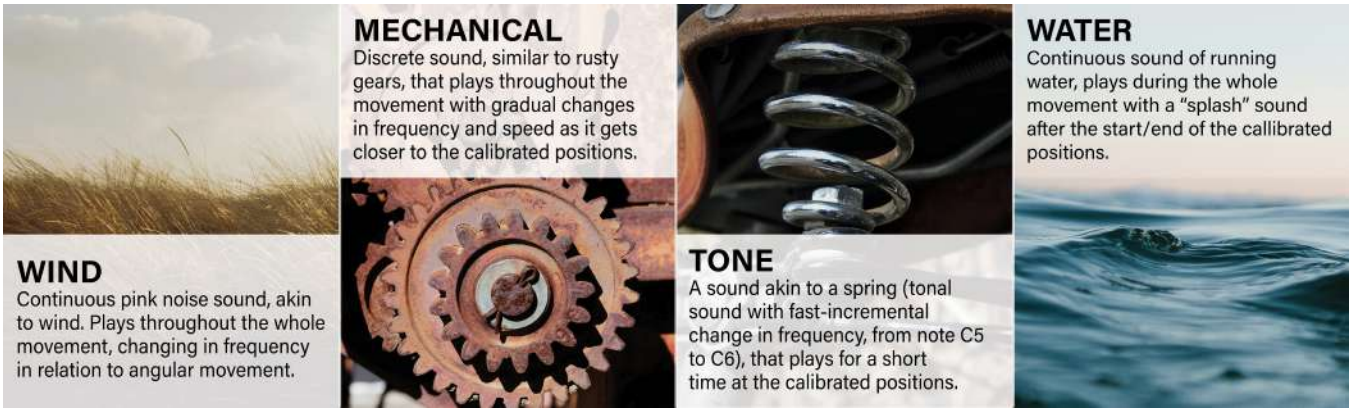

Figure 3: Overview of the four sonifications present in SoniBand, and their sound characteristics. Audio clips can be found in the supplementary material. Created with images from Pexels' free stock photos.

which leads to body dissatisfaction [82]. Physically inactive people experience negative perceptions of their body, often as cause and result of their physical inactivity and other social and contextual factors that limit their activity [57, 88]. Our choice of target groups was inspired by their differences in body experiences, and by previous works' that evaluated SoniBand with them [56, 128], which provide a solid foundation on the sonification effects on them in shorter-term studies (Sec. 3). However, in contrast to prior works [56], our goal was not to conduct a qualitative comparative study and analysis [66] between the two groups, because we did not aim at uncovering relationships between causal conditions and outcomes [66]. Instead, analyzing data-sets from two case studies with different groups allowed us to 1) uncover a broader range of ways in which SoniBand is used in real-life contexts, 2) enrich our understanding of how different participants' somatic experiences evolve over time, which is strongly shaped by their subjective corporealities; and 3) to identify similarities and differences between the short term engagements with SoniBand in prior works and the longer-term engagement in our study.

The case studies were approved by Universidad Carlos III de Madrid's Ethics Committee. In the first study, we invited professional dancers. Potential participants were recruited through our dancer contacts, who are actively involved in the professional and pedagogical dance community in Madrid, Spain. Four participants (2 women and 2 men, aged 19-36), expressed interest in the study. One had 7 years of professional experience in contemporary dance, while two others had over 10 years of experience. All three held graduate degrees in dance, and the fourth was currently pursuing a graduate degree in classical dance. All participants provided informed consent and received 160€ as compensation.

The second study, involving physically inactive people, was conducted during the same time-frame as an experimental study (which is outside of the scope of this paper) examining differences in strength and flexibility when training with and without SoniBand during two exercise: squats and back stretch bends. The experimental study followed a systematic, quantitative approach, tracking the movements and impressions of participants over a month of home training with alternating two-week periods of training with and without sound. This experimental study involved 30 physically inactive adults (18 women, 11 men, 1 non-binary person, aged 19–59), pre-screened using the International Physical Activity Questionnaire [38] and weekly sports activity [91]. We invited these participants to also join our qualitative, exploratory study of SoniBand in their daily life. Participants were encouraged to freely explore SoniBand, outside the structured training context of the experiment. Of the 30 participants, 27 joined the exploratory study. All provided informed consent and received 200€ for participating in both studies.

The two qualitative studies that we present here shared the same study design. They involved participants borrowing a SoniBand and using it in their daily life as they saw fit, for a month. Before starting, we met with each participant individually to introduce the study's goals, provide a SoniBand, and supply a booklet with instructions on technology setup and troubleshooting. We also gave broader guidance, such as prompting participants to use the SoniBand a few times and to contact us if they encountered any problems. We emphasized that there were no prerequisites or expectations for how they should use SoniBand, encouraging open explorations.

All participants were asked to complete a brief online questionnaire each time they used SoniBand, covering how and when they had used it, its impact on their experience (e.g., perception, movements, emotions), and general impressions. Participants could share photos or videos of their SoniBand's use, if they wished, through the questionnaire. We also conducted a weekly $\tilde{3}$0 minutes interview with each participant. In these, we used the questionnaire responses as a basis to discuss the participant's somatic experiences in depth. After the studies, we met participants in person to collect the SoniBands and thank them for their participation.

4.2 Data Analysis and Reporting

Analyzing somatic experiences presents a deeply complex space [47, 121, 125]. Any somatic experience is shaped by a myriad of factors. These can include both conscious elements that people can report on, such as the activity a person is engaged in, the movements and emotions they are aware of, or the technology use. But they can also include unconscious ones, like past experiences, subtle

Figure 4: Temporal trajectories of somatic sonification experiences in our data. Conceptual illustrations to help illustrate each trajectory.

movements or sociocultural influences. Given the vast complexity of these aspects, it is almost impossible to fully unveil or report on every contributing factor that shapes an experience.

Here, we draw from prior recent soma design works that have used either dimensions [121], or lenses [30, 128] as a way to focus the analysis on selected facets of the somatic experience. We found most fruitful to focus on three facets shaping our participants' somatic experience: the technology mediating the experience (i.e. a particular sonification), the activity they chose to use it in, and their reported feelings about the experience (e.g. felt body sensations, emotions, or appreciations). By focusing on these three interconnected lenses, we were able to highlight the unique ways in which they came together to shape each participant's somatic experience. They also allowed us to explore patterns, meanings, and insights that might have otherwise not been uncovered if we had tried to account for every potential influence.

We based our analysis on the questionnaire's responses and the in-depth interviews, which we transcribed using a software compliant with applicable data privacy regulations. We analyzed our data with an approach inspired by reflexive Thematic Analysis [9], combining deductive and inductive analysis to find conceptually related codes and themes. We coded in a spreadsheet each answer of the questionnaire, focusing on our three lenses (activity, sonification, and reported aspects of the somatic experience, such as sensations, emotions, appreciations, etc.). We complemented those responses with transcriptions from the interviews, which helped enrich and contextualize them, and provided illustrative quotes.

Once we had all the responses coded in the spreadsheet, we filtered for each participant and sonification, and examined the temporal unfolding of their experiences, e.g.: did they engage with the same sonification and activity once, or more than once, over the month? And if so, what changed or stayed the same in their somatic experience? We authors coded these changes in new columns in the spreadsheet. Once we started to identify temporal patterns across our analytical lenses, we organized those sequences of experiences into overarching themes that spoke of their temporal unfolding, using the concept of trajectories as inspiration [121]. This resulted in the temporal trajectories that we present in the next section.

To report on our results, we take a qualitative reporting approach [9] based on thick descriptions of participants' subjective experiences, which provide detailed and illustrative accounts of our insights. Original images from the participants that we use have been digitally edited, to enhance their clarity. We have also assigned pseudonyms to participants. We report participants' quotes in *italics*, to distinguish their direct voices.

5 Temporal Trajectories of Body Sonification Experiences

Participants in both studies interacted with SoniBand multiple times over the month, though the frequency of their engagement varied. Dancers, on the other hand, interacted more times with SoniBand: between 10 and 13 times. Physically inactive participants typically tried SoniBand 4 to 5 times each, with some using it as few as 2 times and others up to 7 times. Thus, their use was more sporadic than that of the dancers over the month. Through our analysis, we found distinct temporal patterns that characterized, with an overarching perspective, how participants' somatic experience of a particular sonification during a particular activity changed (or not) over time, when they returned to SoniBand repeatedly in their daily lives. We present these patterns as *temporal trajectories*. We found four temporal trajectories in our data: singular, sustained, deepening or meandering (Figure 4). These different types impacted the depth, variability, and continuity of the participants' felt sensations, emotions, perceptions, and engagement with activities. Next, we unpack each trajectory's characteristics. Each participant experienced multiple, sometimes overlapping trajectories, over the month, upon which we will also reflect at the end of this section.

5.1 Singular

We refer to *singular experiences* as those with which participants engaged only once: a one-time interaction with a particular sonification during a specific activity, in which participants reported a distinct somatic experience. This combination of 'sonification-activity-somatic experience' was not repeated in subsequent engagements with SoniBand. Since these experiences occurred only once and were not revisited, we considered them singular.

In our study, singular experiences were the most common, occurring with every type of sonification. They were particularly prevalent among physically inactive participants, accounting for the majority of their reported experiences. In fact, several of them *only* had singular experiences.

Physically inactive participants engaged in a wide range of activities while using SoniBand. Many used SoniBand while doing

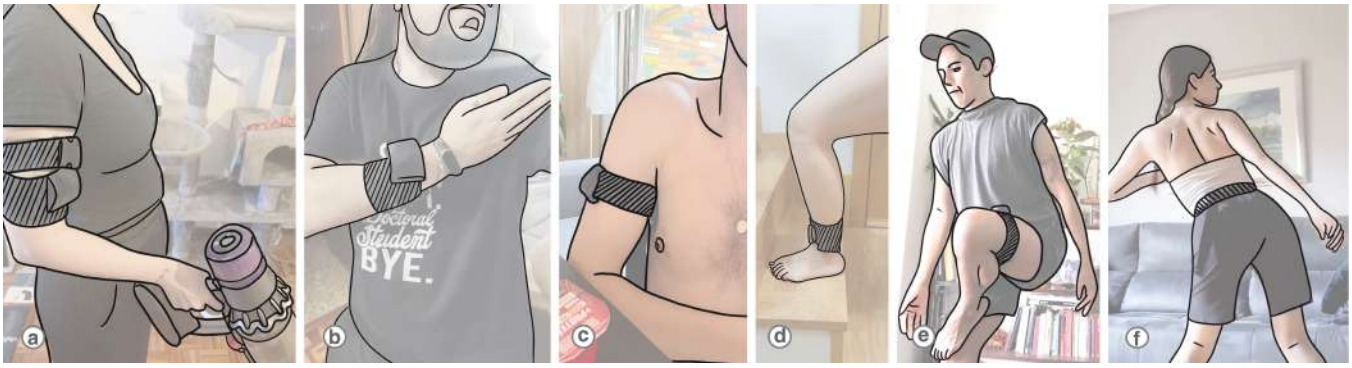

Figure 5: Stills from various participants using SoniBand in various activities: a) Cristina while using the vacuum cleaner; b) Damian while exercising his arm; c) Joel about to eat a yogurt; d) Andrea going up the stairs to her terrace; e) Ruben exploring alternative ways of doing leg stretches; f) Clara exploring movements in her waist.

household chores. For example, Figure 5.a shows Cristina [1], a 21-year-old student, used the wind sonification while vacuuming. She reported that the sonification prompted her to *explore novel movements that I could do with the vacuum cleaner*, but she also reported that *the wind seemed to me like a broken radio [...]* and that she *preferred the water sound without a doubt.*

Many participants also used the SoniBand during home exercising. Among them, the majority started exercising at home motivated by their involvement in the experimental study - in which they were taking part of in parallel. That was the case of Damian (Fig. 5.b) a 32-year-old man who used the wind sonification while exercising his arm. He was motivated to continue exercising after finishing the squats and back bends from the experimental study. He noted that the sound helped him to *not give up and to continue, although I was feeling I could not do it any more.*

Other participants used SoniBand while eating or cooking. For example, Fig. 5.c shows Joel, a 28-year-old office worker, who used the tone sonification while eating yogurt. Every time he scooped yogurt, SoniBand would sound. He found this helpful to *not eat so impulsively [...] I ate more slowly because it made me very conscious of my eating pace.*

Finally, some physically inactive participants used SoniBand during transportation, e.g. during walks, or car rides. For example, Fig. 5.d shows Andrea, a 32 year office worker using the wind sonification to go up the stairs that lead to her terrace, where she hangs her wet clothes. The wind sonification made her *experience new things and coordinate my movements with the sound [...] listening to the wind gave me different and fun sensations, and made the activity less tedious.*

Dancers also had singular experiences. While they also did chores and strength exercises with SoniBand, their singular experiences primarily involved using a sonification during their one-off movement explorations. For example, Fig. 5.e shows Ruben, a 36-year-old contemporary dancer with over 13 years of experience, using the wind sonification while exploring different ways to do leg stretches in the morning. He noted that this experience *boosted my movement creativity [...] it was interesting to try the combination of flexing and extending the leg with the sound.* Similarly, Clara, a 19-year-old classical dance graduate student, used the SoniBand during waist-focused movement explorations (Fig. 5.f). The mechanical sonification she used created *an imaginary of the body through the sound it emits* and that it *fed into an [imaginary] and movement of a body-machine*, which made her movements *more robotic.*

These examples show only a fraction of the kind of singular experiences that both dancers and physically inactive participants had. Our corpus includes singular experiences in a broader range of activities. For example, other chores (unloading the dishwasher, making one's bed, or dusting), playing with pets, working, studying, during moments of relaxation, craft activities (such as sewing, or painting) and even during very intimate moments (such as having sex with a partner).

Finally, it is worth noting that some singular experiences prompted other related, but still singular, experiences. This mostly occurred when participants enjoyed or abhorred a particular sonification for a particular activity. In some of these cases, after some days, participants explored a different sonification in that said activity, and examined how the change shaped their somatic experience.

5.2 Sustained

Sustained trajectories were those where participants' experiences with the same sonification for the same activity stayed consistent over time. In contrast to singular experiences, in these trajectories participants engaged more than once with the same sonification during the same activity, and their reported experience (such as their emotions, perceptions, or bodily sensations) remained relatively stable. That is, these experiences presented little to no variation: they were steady experiences that did not change over time.

In our corpus, there were several sustained trajectories with the wind, mechanical, and tone sonifications. These were experienced by both dancers and physically inactive participants during a range of activities, including dance improvisations, movement explorations, resting, strength exercises at home, and household chores like cleaning.

To illustrate this type of temporal trajectory, we provide an account of Carmen's experience. Carmen is a 33-year-old woman studying to become a state administrator. Due to her studies, she

[1]All participants' names in the paper are pseudonyms.

spends many hours sitting and rarely engages in physical activity. During her month-long use of the SoniBand, she had a specific experience with the water sonification while doing leg raises, an exercise she described as particularly challenging: *this exercise is the toughest one for me [...] it kills me, I often need to stop.* She initially tried the wind sonification but did not find it helpful. When she switched to the water sonification, the exercise *seemed a bit easier, because I connect it to being in a pool.* Associating the sound with water also helped her feel slightly cooler during the hot summer, which she found motivating. A few days later, Carmen did the leg raises again with the water sonification and had a similar experience. Using the water sonification from the start, she again connected it to being in a pool, noting, *it is not like I am suddenly in the North Pole, but it helps me push through the exercise better.* She once again felt the exercise was easier with this sonification.

Sustained trajectories in our study also included those that participants did not find particularly enjoyable, or helpful. For example, Mia, a 21-year-old university student with little time for physical activity, wore the SoniBand on her leg while tidying her room, using the wind sonification. Although she had previously liked the wind sonification in other activities, she felt that during this activity, *it did not help me much [...] the sound did not have much impact on what I was doing, and I felt indifferent towards it.* Yet, she said that when the sound played as she bent over, it made her more mindful of bending her back properly. A few days later, Mia tried the wind sonification again. Her experience was similar: the wind *did not add anything to my experience [...] it did not help me*, but again *made me pay attention to how I bend when I grab things off the floor.*

These two examples illustrate that sustained trajectories were fairly stable throughout the different engagements: the sonification, activity and participant's somatic experience barely varied. Some participants enjoyed the familiarity and consistency that sustained experiences brought forward. For example, Ruben, the 36 years old dancer, had sustained experiences with the water sonification during his dance explorations. He actively sought these experiences because *I knew what I can expect [...] I needed to relax emotionally, loosen my body [...] and I chose to dance with [the water sonification] because I knew it, and I knew it would help me in my explorations.*

5.3 Deepening

Similar to sustained trajectories, *deepening trajectories* involved participants using one sonification in a particular activity. However, unlike sustained trajectories, the repeated engagement led to a progressively deeper understanding and awareness of the interplay between the technology, the activity, and the participants' body. Over time, as participants returned to these experiences, they progressively gained new insights into particular aspects of a bodily sensation, emotion or movement, and the nuances of their relation to the sonification. This recurring engagement allowed for a more profound and evolving temporal trajectory, revealing layers of understanding that became richer with each repetition.

In our corpus, there were only a few deepening trajectories, and they all happened with the wind or the water sonification. Further, all of them were experienced by the dancers during activities related to their dance practice (e.g. dancing choreographies, dance improvisations, movement explorations). To illustrate this type of temporal trajectory, we offer a detailed account of Clara's experience, the 19-year-old classical dance graduate student. Over her month-long engagement with SoniBand, she experienced a deepening trajectory with the *water* sonification, as she incorporated it into her classical dance movement improvisations.

Figure 6: Still from Clara's second exploration with the water sonification, wearing SoniBand on her forearm.

Clara found her first improvisation with the water sonification very enjoyable, noting that it allowed her to *explore the sonification in movements that were common for me.* Wearing SoniBand on her torso, she appreciated that her movements produced the sound, saying that dancers are *used to it being the other way around [...] but here you listen to the consequences of your movements and it creates a kind of a bubble of sound-movement, into which you step in.* In this "bubble," she felt as time stretched and her focus sharpened, enhancing her improvisations. The water sonification helped her escape the norms of classical dance, which she described as having *a rigid vocabulary and rigid body schemes.* She found that it allowed her to *feel body sensations that I usually do not feel when dancing normally.* The fluidity and organic nature of her movements were, in her view, a result of the water's *qualities [...] moving with it created an atmosphere that was conducive to these sensations.*

Few days later, Clara did classical dance improvisations with the water sonification for second time, now wearing SoniBand on her arm (see Figure 6). She reported that she was now familiar with

the water sonification and knew *how the sound worked and that I like it*. She reported that her familiarity with the sound allowed her to *delve deeper into how the sound integrated with my movements*, which in turn allowed her to refine her understanding of moving with the sonification.

Clara used the water sonification for a third improvisation a week later, wearing SoniBand on her torso again. This time, she delved even deeper on her emotional relationship with the sound and her movements, noting that *as a dancer, the way you express through dancing can be a way to energize yourself emotionally, and also release pent up emotions*. Clara found the water sonification ideal for releasing emotional tension, as it *really complements my movement expression [in a way that] allows me to regain energy, relax and to disconnect*. Clara found that this increased focus on the emotional aspects of the experience strongly related to her perceived identity as a dancer, saying *it was comfortable for me, as in finding myself truly feeling "these are my movements, my energy, it's me... this is my sound. [...] I identify with the water"*. Clara felt that *the water sound aligns with my movement style*, which made her movements more effortless and expressive. This improvisation also created for Clara a *safe space where my own movements were fostered and emphasized, [...] because I didn't need to overthink your movements, I only needed to let myself go*. Clara felt that this comfort and ease facilitated a pleasant, and deep emotional release.

Finally, few days later Clara returned for her final improvisation with the water sonification, wearing SoniBand on her torso again. She set to explore how the water sonification could help her *include the torso's movement in improvisation [...] an area that I often leave aside when I dance, as usually I focus more on the extremities*. Initially, she concentrated on consciously mobilizing her torso, producing sound with SoniBand. However, through the improvisation she came to realize that her torso's movement was already naturally integrated into her dance, as SoniBand *would sound regardless of whether I consciously think about moving the torso or not*. Clara noted even that slight movements of the limbs would sometimes make SoniBand sound in her torso, sometimes unexpectedly for her. This experience increased substantially her awareness of her body's fluidity and interconnectedness between different parts of her body. She concluded that *listening to water many times these days has been enjoyable and fluid [...] making my improvisations organic and easy, both movement-wise and mentally.*

Clara's example over four instances of improvising classical dance with the water sonification reveals how through this deepening trajectory, she gained richer, deeper insights of her somatic relationship with the sonification. These insights related to her identity as a dancer. She also developed a greater awareness of how different parts of her body connected to each other in movement. This growing awareness enriched her understanding of how her improvisations, emotions, sensations, and the water sonification came together with each repetition, leading to an increased, deeper and richer somatic experience.

5.4 Meandering

Meandering trajectories involved participants returning to the same sonification and activity over time. However, unlike in sustained and meandering trajectories, in meandering trajectories participants' somatic experience varied significantly over each engagement, leading to less predictable experiences over time. Through the trajectory, participants would encounter differing bodily sensations, emotions, perceptions in almost each engagement with SoniBand. Additionally, often participants' subjective appraisal of the experience would also vary significantly over time. These changes made meandering trajectories richer in variation and change than the previous trajectories.

In our corpus, there were several meandering trajectories happening with the wind, the mechanical, and the tone sonifications. They were all experienced by the dancers, and during activities related to their dance practice (e.g. dancing choreographies, dance improvisations, movement explorations). To illustrate this type of temporal trajectory, we offer a detailed account of Laura's experience, a 30 year old contemporary dancer with a graduate degree and more than 10 years of professional experience. Laura had a meandering trajectory during the study with the mechanical sonification, as she incorporated it into her open-ended dance explorations.

When Laura first tried the mechanical sonification, she had already experimented with the wind and water sonifications, both of which she deeply appreciated. Wearing SoniBand on her thigh, she found the mechanical sonification *extremely unpleasant* and *rigid and piercing*, which significantly limited and influenced her movements. Initially, the sonification stressed her as she struggled to integrate it into her dancing, noting that *this is not how I move! [...] It transmits some movement characteristics that I do not have in my own movements [...] my dancing style is fluid*. This perception brought her to adopt movements that felt *unnatural or inorganic [...] more cut, more mechanical, more sudden and abrupt"*. In the first interview, Laura frequently compared the mechanical sonification to the fluidity and ease of the water and wind sonifications, which she preferred.

Despite her initial discomfort, Laura revisited the mechanical sonification a week later in her movement explorations. This time, she placed SoniBand on her hand *"to maximize the range of motion"*, consciously focusing on integrating the sound into her movements without viewing it as a burden. She described her mindset shift: *the mechanical was like a thorn in my side. I said to myself, "I cannot move 'wrong' with a sound" [...] so as I was experiencing these abrupt, shearing movements and sensations, I tried to approach them not as a burden, but as something to explore and emphasize*. Embracing this challenge, she experimented with moving *rigidly, like a robot*, which led her to feel that *different areas of my body were disconnected [...] the shoulder here, the elbow there.* This time, the mechanical sonification felt disjointed, but Laura found it "interesting".

The third time that Laura did movement explorations with the mechanical sonification, she said she experienced a significant change with it. She acknowledged that *[the sound] is very different from everything I am used to, so it took me some time to "get it", but now that I "get it", it has a distinct impact on me that the others sounds do not have*. Laura noted that the sound altered her body perception, defamiliarizing her habitual movements: *The sound fostered in me a strange, different understanding of my body [...] like when you repeat a word until it sounds strange. That's how I felt moving with [the mechanical] this time.* Although the sound made her feel "strange," she saw it as positive: *the sound pushed me out of my comfort zone,*

making me do different movements [...] sometimes, when you are dancing in your style, you enter into a loop from which you cannot escape, you do the same movements time and again. It is an overwhelming, distressing experience. [...] The mechanical sound helps a lot in that sense, to find new sensations or dynamics to incorporate into your own movement repertoire. [...] I guess you can explore and learn a lot of new things, even if they are not "your" things. This estrangement was ultimately liberating for her: *this [strange] way of moving allowed me to release emotional tension [...] in the end, I don't know if physically or mentally, but I felt liberated.*

A few days later, in her fourth and final session with the mechanical sonification, wearing it on her calf, Laura felt that her most recent previous experience consolidated: the mechanical sonification helped her release tension and explore unfamiliar movement patterns, and she reported that it enhanced her creative abilities. Reflecting on her overall experience, she concluded: *in the end, the mechanical sound is all about rigidity, control [...] and initially, I didn't like it at all. But later, when I learned how to engage with it, it taught me a lot, both emotionally and creatively.*

Laura's example shows that throughout the four instances in which she explored dance movements with the mechanical sonification, her somatic experience varied significantly, and was not easy for her to predict. Her temporal trajectory was rich in variation and change, and she encountered diverse bodily sensations, emotions and perceptions through each engagement. Further, her appraisal of the sonification changed vastly from the first to the last time she engaged with it.

However, it is important to note that not all meandering trajectories in our corpus presented an increasingly positive trajectory (appraisal-wise), as Laura's did - which could be attributed to becoming familiar with the sonification, or that participants learned how to use and enjoy it. For example, Ruben, the 36-year-old contemporary dancer with over 13 years of experience, initially enjoyed doing movement explorations with the wind sonification, feeling fluid, light and free (Figure 7). Throughout his explorations, however, his experiences varied significantly. In subsequent engagements, he found that the sonification prompted him to reflect on the weight of his movements, which he felt was accentuated with the wind. He reported that this deep exploration of his body weight prompted a more introspective and serious mood, in contrast to the light and playful mood of his first engagement. In his last engagement, wearing SoniBand on his leg, he found the sound monotonous and overwhelming. He reported that the type of movement explorations he was doing with the legs did not match well with changes in the sonification, making the wind sound all the time, and very loud. This led him to move in a limiting and uncomfortable manner, in order to quiet the sonification.

Throughout each of his engagements, Ruben had very different experiences with the wind sonification. While he partly partly attributed these changes to different placements and calibrations of the SoniBand, ultimately his temporal experience with the wind sonification was meandering.

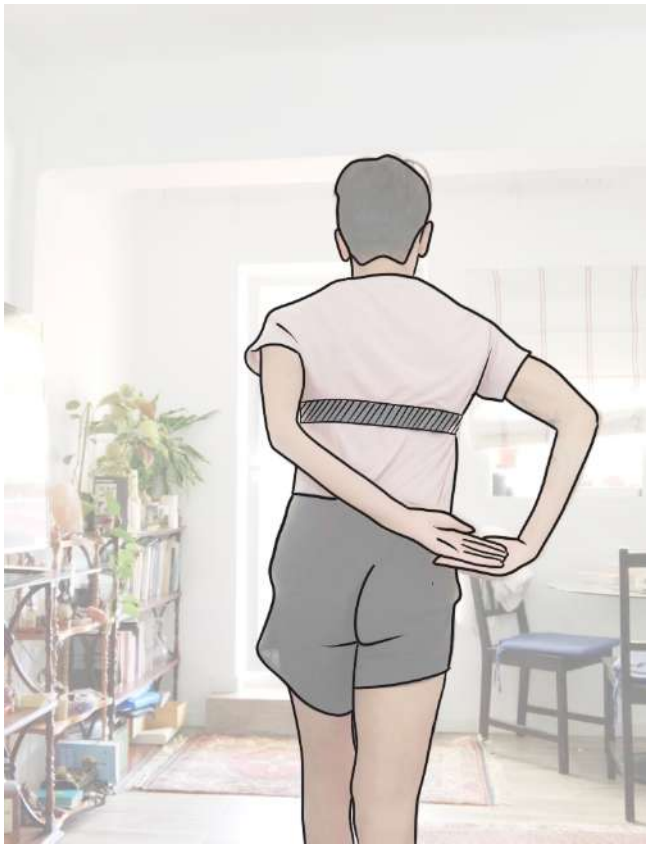

Figure 7: Still from Ruben's first movement exploration with the wind sonification.

5.5 Overlaps Between Trajectories

Over the one-month study, each participant experienced multiple, often overlapping trajectories. Figure 8 illustrates this based on the data of four participants. For example, Ruben experienced the meandering trajectory with the wind sound described in Section 5.4, through four engagements throughout the month. During those weeks, he *also* experienced a deepening trajectory with the mechanical sound and two sustained ones: using the water sound to relax after intense dance sessions and the tone sound during movement explorations. Although participants engaged with one sound-activity combination at a time, the overall trajectory for a particular sonification-activity-felt experience could overlap with others over time. Fig. 8 also shows overlaps for Clara, who had multiple singular experiences. She also experienced a deepening trajectory with the water sound during improvisations (described in Section 5.3); and a meandering trajectory with the wind. In contrast, two physically inactive participants, primarily experienced singular trajectories, e.g. Andrea's walking up the stairs with the wind sonification (described in 5.1); or Ruth's experience of unloading the dishwasher with the water sound (depicted in Fig. 1). Fig. 8 illustrates how overlaps might look different among participants.

6 Discussion

We reflect on how the sonifications were experienced differently across trajectories. We also reflect and on the characteristics of each

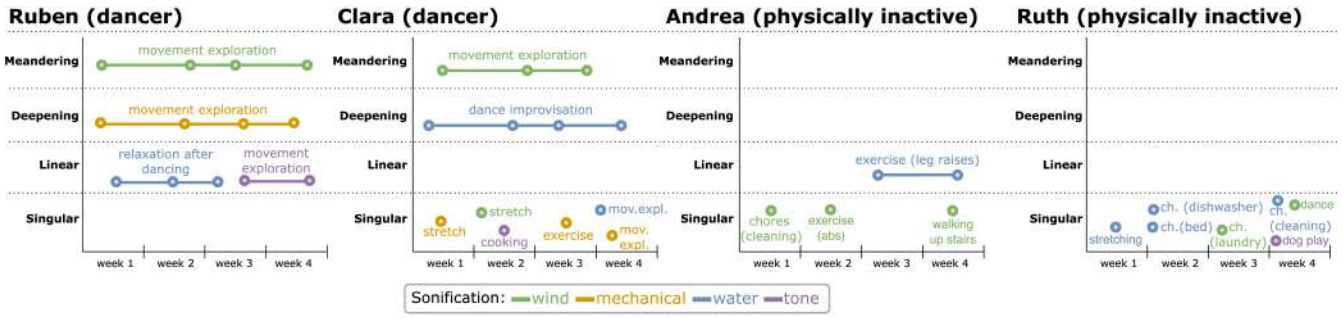

Figure 8: Illustrative examples of the different trajectories experienced over a month by four different participants, chosen for their capacity to illustrate differences in experience and overlaps. The image is color-coded by sonification, including a text describing the type of activity in that trajectory. In the image, each colored dot represents one engagement with SoniBand. Lines graphically connect the engagements (dots) that end up constituting a trajectory. Abbreviations: ch.=chores; mov.expl.=movement exploration. Full resolution figure also in the supplementary material.

trajectory beyond the context of the sonifications. We discuss our limitations and contributions.

6.1 Experiencing the Body through Metaphorical Sonifications

Participants in our study experienced the metaphorical qualities of the sound as part of their *body materiality* [81], as shown in the examples of the mechanical or the water sonification. Similarly, they felt their movements impacted by this "new materiality" of their body, e.g. feeling their movements as lighter with the wind sonification, more fluid with the water sonification, or more stiff with the mechanical one. Dancers often related body sonifications to their core identity: either reinforcing and enriching their habitual ways of moving and perceiving themselves (e.g. the water sonification, for Clara) or disrupting them (e.g. the mechanical sonification, for Laura). These disruptions can be seen as a form of *estrangement* [47, 136], and were often conducive of creative explorations.

Designing for particular temporal trajectories goes beyond designing a mere technology. It requires an *orchestration* [47] of different design materials: bodies, signals, technologies, activities, etc. Prior work on body sonification has articulated this coming together as a *complex entanglement* [87] blurring the boundaries between body and technology [8, 134]. Future work should explore how this orchestration can yield particular temporal trajectories.

6.1.1 Particular Sonifications Across Different Trajectories. How the different sonifications were perceived in each trajectory reveals similarities and changes across trajectories and prior work.

The **wind** sonification in singular and sustained trajectories enhanced proprioception, making most participants feel more coordinated. Physically inactive individuals found it a useful distraction from chores, motivating them to explore new movement patterns. Most participants felt lighter, which is consistent with prior works [55, 56, 128]. For some dancers in deepening trajectories, the wind sonification pushed them out of their comfort zones, fostering creativity and emotional engagement. However, in meandering trajectories, a few participants eventually found the sound annoying, suggesting that for some it may become overwhelming.

The **mechanical** sonification in singular experiences was found by a few dancers and physically inactive participants to improve their coordination and stability. However, to many it negatively impacted their body perception, making them feel rigid, heavy or broken. These experiences align with prior short-term studies [55, 56, 128]. Yet, in contrast to these, many dancers found that over time the mechanical sonification expanded their creative boundaries and introduced new movement possibilities, as seen in some meandering trajectories. Indeed, some even named it their favorite sonification by the study's end.

The **tone** sonification improved body awareness and creativity in singular experiences for both dancers and physically inactive participants, aligning with previous findings [54, 56]. Further, in sustained trajectories, few dancers found that it led to monotonous movements related to weight and gravity, complementing earlier evaluations in which participants feeling pushed by it [54, 56, 102].

Lastly, the **water** sonification in singular experiences was perceived as relaxing, making activities more playful and movements fluid, and evoked in both dancers and physically inactive participants memories and feelings of being in real water. These findings are consistent with previous studies [56, 103, 128]. Physically inactive participants also found the water sonification motivating for completing tasks at home. Additionally, some dancers had deepening experiences with water, leading to a more nuanced understanding of their moving bodies over time. Both of these insights stand in contrast to previous studies, where some dancers and physically inactive people had difficulties making sense of the sonification [56, 128]. In sustained trajectories, dancers reported improved emotional well-being (e.g. feeling calm, relaxed, and liberated) which encouraged new movement improvisations.

These results show that while there were similarities, there were also important differences in how dancers and physically inactive participants experienced specific sonifications during short-term or one-time evaluations (as seen in [56, 128]) compared to the longer period of time in our studies. This highlights the importance of conducting longer-term examinations of body technologies, as people's experiences with them may vary from those observed in shorter engagements.

6.2 Characteristics of the Temporal Trajectories

We identified four types of temporal trajectories: singular, sustained, deepening and meandering. Here we reflect, at a more abstract level, on key characteristics of each trajectory, and offer preliminary insights for designing for each one of them in the future. We connect these reflections to prior research where similar trajectories have been reported - to highlight the trajectories' potential for understanding temporal somatic experiences in other technologies and contexts beyond our study's. We reflect on the trajectories' overlaps and future evolution, considering differences among groups.

Singular experiences were those with which participants engaged only once: a one-time interaction with a sonification during a specific activity, in which participants reported a particular somatic experience. These experiences were the most common in our study, especially among physically inactive participants. They occurred in a variety of sonifications and activities such as chores, exercise, transportation, sex, relaxation, play, and dance explorations. This diversity highlights the exploratory nature of singular experiences, allowing participants to creatively experiment with different movements and interactions. However, it is important to notice that, compared to other trajectories, these experiences offered a shallower depth of somatic appreciation. This is reflected in our reported data, in which the participants' descriptions of their singular experiences were often shorter, flatter.

Despite their one-time occurrence, many singular experiences were still meaningful and rich for the participants. This is well documented in body-centric design, where single interactions with technology can create profound experiences. For instance, Kilic Afsar et al.'s pneumatically actuated corset [51] enabled participants to experience intersubjective haptic voice, altered perceptions of time and space, and dissolved body boundaries — all from a single interaction. Similarly, Françoise et al. 's sonification of micro-movements yielded very personal and meaningful singular experiences [26]. These examples further underscore the potential of brief yet impactful engagements with body-centric technologies.

However, in contrast to these works, our participants had the opportunity to return to and reengage in the experience. And yet, they did not. This raises an important question: Why did singular experiences, even when impactful, not lead to repeated engagement over time? One possibility is that SoniBand's versatility encouraged exploration and novelty, making one-time, self-contained engagements more appealing than ongoing ones, for some participants.

This type of engagement with singular experiences can be found in prior longer-term works developing wearables for populations who experience physical challenges. For example, Márquez Segura et al. [65, 126] developed biofeedback wearables using sound, visuals and haptics for playful circus training with children having sensory processing disorders. During a 6-week course, the wearables were integrated into various activities and games, each time generating distinct singular experiences. Similarly, Singh et al. [101, 103] designed Go-with-the-flow, a sonification device for chronic back pain patients. During a two-week study, participants integrated it into daily movements, such as reaching for shelves, producing distinct one-time interactions.

These prior works and our own reveal that singular experiences with the same technology are common among populations experiencing physical challenges or inactivity. This insight suggests two potential directions for future research: one, to design interactive technologies that encourage more diverse temporal experiences for these groups, and two, to explore how singular experiences might be intentionally leveraged to address specific needs or contexts. After all, participants continued to return to SoniBand throughout the study, although many chose to explore new combinations of activities and sonifications each time. Novelty can positively influence people to engage with a technology [17]. SoniBand's design made that novelty was not something that wore off after few uses, but rather a characteristic of interaction that could be continually reproduced if engaging in different activities or sonifications.

In **sustained** trajectories, participants engaged in a particular sonification in the same activity repeatedly, with little variation in their somatic experience. Sustained trajectories were fairly common, both participant groups experienced them. Sustained trajectories led to stable, often predictable experiences. For some participants, the familiar and largely unchanging nature of the experience was appealing, offering a sense of consistency and reliability. For example, some participants reported that they returned to a particular experience because they could anticipate its effects on their emotions, movements or feelings. Others who had sustained trajectories wanted to revisit experiences to confirm whether previously perceived positive or negative somatic experiences would repeat - before eventually moving on to explore new options. This tendency was especially common among physically inactive participants. A possible explanation is that they favored expanding on their repertoire of experiences rather than sticking to exploring at length those that "worked well" for them.

Prior works also show engagements with technologies over time that can be conceptualized as sustained trajectories. For example, in the aforementioned Go-with-the-flow's study [101] participants reported repeating and consistent experiences with the device for specific tasks, like loading the washing machine. Similarly, Turmo Vidal et al.'s study of BodyLights [127, 130], an optomechanical wearable for visualizing movement qualities in weightlifting, revealed sustained trajectories among some of the participants over three different training sessions: BodyLights enabled users to repeatedly identify performance errors or serve as a co-supervisor alongside a trainer, reflecting a sustained, sustained, and goal-driven engagement across sessions.

Whether or not sustained experiences are the ones we should design for is worth considering. While they offer consistency that fosters ongoing engagement, designers must weigh this against the potential for stagnation over time, for example, few participants in the BodyLights's study reported that the device no longer added value to their training in the third session. In designing for sustained experiences, it may be beneficial to offer opportunities for people to either deepen their engagement or pivot if the experience stops being meaningful.

Finally, deepening and meandering trajectories both required of a focused and sustained engagement, and involved participants returning to the same sonification and activity over time. They both only occurred with the dancers, and in activities that related to their dancing practice. These trajectories differed in that a **deepening**

trajectory allowed participants to progressively deepen their somatic experience and develop a rich understanding of the relations between design materials, body and movement.

This trajectory allowed for more profound somatic experiences, bringing participants with each repetition new insights into their body sensations, emotions, or the nuances of the sonification. Similar deepening trajectories can be found in soma design works. For example, Luft et al. [63] found that repeated engagement with an interactive wooden dummy for martial arts training over several months deepened the main author's understanding of his body and movements, transforming his somatic practice and offering new insights into his training habits and athletic performance. Similar effects were found in the aforementioned study of BodyLights [127, 130], even after only three training sessions. An example with a different technology is Sanches et al.'s [92] study of the Affective Health bracelet, a self-tracking wearable device focused on providing ambiguous representations of skin conductance data. Over a month, some participants developed an increasingly nuanced understanding of how data values related to, e.g., their stress management or sports performance, enriching their understanding of the connections between skin conductance data, somatic activities, and felt bodily states.

In contrast, a **meandering** trajectory introduced variability. In meandering trajectories, each encounter often brought participants new or different sensations, emotions, or appraisals, unlike the progressively deepening understanding found in deepening trajectories. This trajectory resulted in a dynamic, less predictable experience over time, and required participants to examine continuously their somatic experience, and attune to unexpected effects.

Accounts of technology interactions over time that can be conceptualized as a meandering trajectories can be found in previous works, e.g. Hobye's Mediated Body [41], an artistic experience where two interactuants hear complex sounds when they touch each other's bare skin. Hobye's account of using the device for over a week at the Burning Man festival reveals a meandering experience: his experience evolved from initial self-consciousness as performer, to a state of experimentation with other participants, sometimes resulting in unexpected interactions. Over the week, although most participants interacted only once, Hobye himself can be considered to have experienced a meandering trajectory with the Mediated Body, shaped by his participants' varied, dynamic responses, which including excitement, hesitation, exhaustion and creative experimentation. This variability enriched his overall experience, which he found deeply rewarding, creating a multifaceted and evolving engagement with the technology. A different example is Forlano's intimate account of living with an insulin sensor and pump [25], which highlights the volatile and unpredictable nature of her relationship with the device over four years. Her experience spans deep appreciation for the AI system's life-saving role and benefits (e.g. stabilizing glucose levels), to challenges like sleep deprivation from calibrating the device, or existential concerns about its hardware.

In our study, dancers' somatic connoisseurship [95] enabled them to deeply engage with and reflect on their somatic experiences, attuning to changes over time. This highlights the need to explore whether deepening and meandering trajectories can emerge in populations with less somatic expertise or in contexts lacking rich somatic practices. A soma design approach [47] offers promising avenues, as prior studies have shown its potential to foster rich somatic experiences, both in established practices [63] and everyday settings [108].

These different trajectories show that meaningful and sustained engagement with body technologies can take various forms. SoniBand promoted repeated use and exploration to all participants; and for some it also facilitated playfulness and meaningful emotional responses - all of which have been extensively studied as sources of engagement [17]. We believe that a key factor driving this engagement was the *ambiguity* [32, 123] in SoniBand's design, which allowed participants to interpret, appropriate and use the technology in multiple ways.

6.2.1 Reflections on the Overlap and Evolution of the Temporal Trajectories. We have shown (see Sec. 5.5) that temporal trajectories were not experienced isolated, but often overlapped, intersecting uniquely for each participant (see Fig. 8). While we did not explore causal links between trajectories, investigating how one trajectory might influence another is an avenue for future work.

Our trajectories are distinctly shaped by the data collected during the one-month studies, and our participants' engagements. For example, the more sporadic engagements of the physically inactive participants could have prompted an overabundance of singular experiences, instead of more longer-term trajectories. However, temporal trajectories are dynamic, and extending the observation period could shift these classifications. For example, an initially singular experience might, over time, evolve into a sustained, deepening, or meandering trajectories if participants revisit it. Or a sustained might become e.g. meandering with more data points. Thus, conceptualizing temporal trajectories is always contingent on the timeframe and dataset; and additional data points may influence their development and categorization. We do not intend these trajectories to be taken as conclusive, or isolated categories - rather, we would expect and welcome that future work expands and challenges them.

Further, the evolution of trajectories may depend on the target group and their engagement type. Physically inactive participants primarily experienced singular and sustained trajectories, indicating less deep somatic engagement, yet they creatively integrated SoniBand into many diverse activities. In contrast, dancers, with their somatic expertise and established practices, experienced all trajectories, including deepening and meandering ones. These differences may have been influenced by both engagement frequency and style: physically inactive participants used SoniBand 4–5 times, favoring one-time experiences; while dancers engaged 10–13 times with more sustained, reflective somatic practices. A possibility is that if inactive participants had engaged with SoniBand more frequently (adding data points), their trajectories might have evolved into meandering or deepening ones.

Alternatively, as noted earlier, such trajectories may inherently rely on contexts with rich, sustained somatic practices or emerge through specific design contexts. Including two distinct participant groups allowed us to identify differences in frequency of use, engagement, and felt experiences. Although we initially selected these groups due to shared struggles with negative body perceptions, their inclusion revealed how experiences with the same technology can

follow different temporal patterns depending on the group. This highlights the need for future research on temporal trajectories and long-term body experiences to account for the subjective, situated, and embodied realities of participants.

In overall, exploring trajectory overlaps and evolution offers pathways for future research, e.g. longer observation periods, longitudinal and comparative studies with balanced engagement across groups. Our findings here lay the groundwork for future work investigating the dynamic nature of temporal experiences.

6.3 Limitations and Future Work

Our study has limitations. We deployed SoniBand over one month, a period of time similar to other in-the-wild studies of wearables at home (e.g. Sanches et al.'s Affective Health bracelet [92]), but shorter than other soma design processes (e.g. Luft et al.'s autobiographical design in martial arts [63]) and in-the-wild deployments (e.g. Ståhl et al.'s three month deployment of the Soma Mat and Breathing Light in [108]). For future work, we would like to draw particular inspiration from Ståhl et al.'s deployment of their work in real-world settings with participants. We see value in even longer-term engagements than ours, exploring how somatic trajectories evolve, consolidate, or merge over time. Our work marks an initial step toward investigating how our relationship with body technologies develops and transforms over time.

Methodologically, physically inactive participants participated in a quantitative, experimental study involving doing squats and back bends with SoniBand. While this may have influenced their decision to try other exercises at home, the training activities they chose (e.g., abs, leg raises, stretches) were distinct from those in the experimental study (squats and back stretches). Additionally, their use of SoniBand across a wider range of activities beyond home training demonstrates their freedom to engage with the technology in everyday life, independent of experimental conditions.

The number of dancers was low compared to physically inactive participants, and recruiting more dancers might have led to different experiences. The physically inactive participants used SoniBand less frequently, and this sporadic use makes it unclear whether certain one-off experiences might have developed into longer-term trajectories with more time or repeated use. This represents a limitation of our study, which was designed to let participants decide how and when to use the device. As such, the trajectories we present should not be seen as definitive or fixed categories—they are shaped by the study design, the participants, and the timeframes involved. Future research with even longer-term engagements could explore how trajectories might evolve or merge over time (e.g., a sustained trajectory eventually becoming a deepening one), or uncover new types of temporal trajectories beyond the four we have articulated.

Despite these limitations, having two distinct groups ultimately enriched our analysis by revealing different temporal trajectories and patterns of engagement with body technologies.

These methodological and theoretical choices, although generative for us, shaped our findings. Future research on temporal trajectories may enrich, expand or even change aspects of the ones we have articulated. Thus, the knowledge we bring forward in this paper should be taken as *provisional design knowledge* [85] to help advance our understanding of how somatic experiences of a technology unfold over longer periods of time. For example, while we have grounded the concept of trajectories in interaction design knowledge [121], future research could benefit from incorporating insights from somatic practices (such as Feldenkrais or the Alexander Technique) which can offer valuable observations on how somatic experience unfolds over time, helping to evolve our current understanding of temporal trajectories.

7 Conclusion

We contributed to addressing the gap in longer-term studies of body technologies. We examined how somatic experiences evolve with repeated use of a movement sonification device, SoniBand, over the course of a month. Through two in-the-wild studies involving dancers and physically inactive individuals, we identified four distinct temporal trajectories (singular, sustained, deepening, and meandering) that characterize how participants' experiences of the body technology changed over time.

The four temporal trajectories are the primary contributions of our work. They provide a *conceptual tool* for understanding the evolution of somatic experiences over time. Their characteristics can guide others in analyzing and categorizing their own data. We have demonstrated how these trajectories and their features can be applied to examine and conceptualize other designs and contexts (Sec. 6.2), connecting them to prior works that exhibit similar temporal patterns of experience.

We believe temporal trajectories can inspire both generative and analytical work, though further work is needed. The design insights discussed in Sec. 6.2 can provide inspiration and starting points for generative work focused on designing for specific trajectories. Additionally, pairing temporal trajectories with visualizations, like the one in Fig. 8, can help analyze how different trajectories overlap, revealing trends across individuals, groups, and activities; or to examine potential relationships between trajectories across multiple data points (by e.g. visualizing temporal patterns of emergence and relations). Future work could also explore how to combine temporal trajectories with soma trajectories [121], to analyze the evolution of specific dimensions of experience over time.

Our work also presents additional contributions. First, we extend previous studies on SoniBand [54–56, 102, 113, 128], and in particular those focusing on physically inactive participants [56] and dancers [128] with two in-the-wild studies, expanding prior lab-based or experimental insights that demonstrate how the effects of sonifications can evolve with repeated, longer-term use, sometimes aligning but also diverging from insights in prior shorter-term evaluations of SoniBand (discussed in Sec. 6.1.1). Second, our insights contribute to showing the fluid, dynamic somatic experiences people have when engaging with technology over time. These extend previous body sonification research, which has typically focused on one-off or short-term evaluations [4, 11, 13, 18, 21, 34, 52, 58, 72, 79, 86, 94, 103, 112, 116, 132, 133] and add to autoethnographic research in body-centric HCI showing somatic fluctuations [16, 29, 43]. Finally, we contribute to previous work on trajectories [3, 24, 40, 45], particularly soma trajectories [23, 67, 121]), offering a complementary conceptual tool that, instead of focusing on the detailed, moment-to-moment analysis of a specific experience, can

help in conceptualizing patterns of how somatic experiences evolve over time.

Our contributions can be relevant to body-centric communities in HCI and interaction design interested in designing and studying longer-term somatic experiences of technology in the future, e.g. the soma design community [2, 15, 47, 48, 63, 108–110, 124]; embodied interaction and movement-based designers [46, 60, 68, 70, 111], or human technology integration researchers [137].

We conclude with a call for longer-term research that engages with the temporal experience of body technologies. To design technologies that truly weave into the fabric of people's lives meaningfully, we must account for the fluid, ever-changing nature of somatic experiences. Understanding how these interactions evolve over time is essential to shaping more sustainable engagements. It is our hope that the temporal trajectories and empirical insights we offer will inspire future research and design in body-centric HCI.

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References

[1] Rachel Andrew, Marika Tiggemann, and Levina Clark. 2016. Positive body image and young women's health: Implications for sun protection, cancer screening, weight loss and alcohol consumption behaviours. *Journal of Health Psychology* 21, 1 (Jan. 2016), 28–39. https://doi.org/10.1177/1359105314520814

[2] Karen Anne Cochrane, Kristina Mah, Anna Ståhl, Claudia Núñez-Pacheco, Madeline 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 (TEI '22)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3490149.3502262

[3] Jon Back, Laia Turmo Vidal, Annika Waern, Susan Paget, and Eva-Lotta Sallnäs Pysander. 2018. Playing Close to Home: Interaction and Emerging Play in Outdoor Play Installations. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, 156:1–156:11. https://doi.org/10.1145/3173574.3173730

[4] Ilias Bergström and Martin Jonsson. 2016. Sarka: Sonification and Somaesthetic Appreciation Design. In *Proceedings of the 3rd International Symposium on Movement and Computing (MOCO '16)*. ACM, New York, NY, USA, 1:1–1:8. https://doi.org/10.1145/2948910.2948922 event-place: Thessaloniki, GA, Greece.

[5] 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 (2016). https://www.frontiersin.org/articles/10.3389/fnins.2016.00385

[6] Frederic Bevilacqua, Norbert Schnell, and Sarah Fdili Alaoui. 2011. *Gesture Capture: Paradigms in Interactive Music/ Dance Systems.* transcript Verlag, Bielefeld, 183–194. https://doi.org/doi:10.1515/transcript.9783839415962.183

[7] M. Botvinick and J. Cohen. 1998. Rubber hands 'feel' touch that eyes see [8]. *Nature* 391, 6669 (1998), 756. https://doi.org/10.1038/35784

[8] Rosi Braidotti. 2022. *Posthuman Feminism* (1st edition ed.). Polity, Cambridge.

[9] 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

[10] Justin Cheng, Akshay Bapat, Gregory Thomas, Kevin Tse, Nikhil Nawathe, Jeremy Crockett, and Gilly Leshed. 2011. GoSlow: designing for slowness, reflection and solitude. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11)*. Association for Computing Machinery, New York, NY, USA, 429–438. https://doi.org/10.1145/1979742.1979622

[11] Sunje Clausen, Ana Tajadura-Jimenez, Christian P. Janssen, and Nadia Bianchi-Berthouze. 2021. Action sounds informing own body perception influence gender identity and social cognition. *Frontiers in Human Neuroscience* (2021). https://doi.org/10.3389/fnhum.2021.688170

[12] Katri K Cornelissen, Helena Widdrington, Kristofor McCarty, Thomas V Pollet, Martin J Tovée, and Piers L Cornelissen. 2019. Are attitudinal and perceptual body image the same or different? Evidence from high-level adaptation. *Body Image* 31 (2019), 35–47. https://doi.org/10.1016/j.bodyim.2019.08.001

[13] Amar D'Adamo, Marte Roel Lesur, Laia Turmo Vidal, Mohammad Mahdi Dehshibi, Daniel De La Prida, Joaquín R. Diaz-Durán, Luis Antonio Azpicueta-Ruiz, Aleksander Väljamäe, and Ana Tajadura-Jiménez. 2024. SoniWeight Shoes: Investigating Effects and Personalization of a Wearable Sound Device for Altering Body Perception and Behavior. In *Proceedings of the CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '24)*. Association for Computing Machinery, New York, NY, USA, Article 93, 20 pages. https://doi.org/10.1145/3613904.3642651

[14] Frédérique De Vignemont, Henrik H. Ehrsson, and Patrick Haggard. 2005. Bodily illusions modulate tactile perception. *Current Biology* 15, 14 (2005), 1286–1290. https://doi.org/10.1016/j.cub.2005.06.067

[15] Arife Dila Demir, Kristi Kuusk, and Nithikul Nimkulrat. 2022. Squeaky/Pain: Articulating the Felt Experience of Pain for Somaesthetic Interactions. *Temes de Disseny* 38 (July 2022), 162–178. https://doi.org/10.46467/TdD38.2022.162-178 Number: 38.

[16] Arife Dila Demir and Claudia Núñez-Pacheco. 2024. Autosomatographical Narratives: Towards the Articulation of Felt Accounts of Pain for Somaesthetic Design. In *Designing Interactive Systems Conference*. ACM, IT University of Copenhagen Denmark, 3287–3301. https://doi.org/10.1145/3643834.3660756

[17] Kevin Doherty and Gavin Doherty. 2018. Engagement in HCI: Conception, Theory and Measurement. *ACM Comput. Surv.* 51, 5 (Nov. 2018), 99:1–99:39. https://doi.org/10.1145/3234149

[18] Joaquín Roberto Díaz Durán, Laia Turmo Vidal, and Ana Tajadura Jimenez. 2023. Joakinator: An Interface for Transforming Body Movement and Perception through Machine Learning and Sonification of Muscle-Tone and Force. *Proceedings of the International Conference on New Interfaces for Musical Expression* (May 2023), 1–4. https://e-archivo.uc3m.es/handle/10016/38906 Accepted: 2023-11-20T10:24:02Z Publisher: NIME.

[19] Don Samitha Elvitigala, Armağan Karahanoğlu, Andrii Matviienko, Laia Turmo Vidal, Dees Postma, Michael D Jones, Maria F. Montoya, Daniel Harrison, Lars Elbæk, Florian Daiber, Lisa Anneke Burr, Rakesh Patibanda, Paolo Buono, Perttu Hämäläinen, Robby Van Delden, Regina Bernhaupt, Xipei Ren, Vincent Van Rheden, Fabio Zambetta, Elise Van Den Hoven, Carine Lallemand, Dennis Reidsma, and Florian 'Floyd' Mueller. 2024. Grand Challenges in SportsHCI. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)*. Association for Computing Machinery, New York, NY, USA, 1–20. https://doi.org/10.1145/3613904.3642050

[20] Marianela Ciolfi Felice, Sarah Fdili Alaoui, and Wendy E. Mackay. 2021. Studying Choreographic Collaboration in the Wild. In *Proceedings of the 2021 ACM Designing Interactive Systems Conference* (Virtual Event, USA) *(DIS '21)*. Association for Computing Machinery, New York, NY, USA, 2039–2051. https://doi.org/10.1145/3461778.3462063

[21] Frank Feltham and Lian Loke. 2017. Felt Sense Through Auditory Display: A Design Case Study into Sound for Somatic Awareness While Walking. In *Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition (C&C '17)*. ACM, New York, NY, USA, 287–298. https://doi.org/10.1145/3059454.3059461

[22] Frank Feltham, Lian Loke, Elise van den Hoven, Jeffrey Hannam, and Bert Bongers. 2013. The Slow Floor: Increasing Creative Agency While Walking on an Interactive Surface. In *Proceedings of the 8th International Conference on Tangible, Embedded and Embodied Interaction (TEI '14)*. ACM, New York, NY, USA, 105–112. https://doi.org/10.1145/2540930.2540974

[23] Yuan-Ling Feng, Zhaoguo Wang, Yuan Yao, Hanxuan Li, Yuting Diao, Yu Peng, and Haipeng Mi. 2024. Co-designing the Collaborative Digital Musical Instruments for Group Music Therapy. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–18. https://doi.org/10.1145/3613904.3642649

[24] Martin Flintham, Stuart Reeves, Patrick Brundell, Tony Glover, Steve Benford, Duncan Rowland, Boriana Koleva, Chris Greenhalgh, Matt Adams, Nick Tandavanitj, and Ju Row Farr. 2011. Flypad: Designing Trajectories in a Large-Scale Permanent Augmented Reality Installation. In *ECSCW 2011: Proceedings of the 12th European Conference on Computer Supported Cooperative Work, 24-28 September 2011, Aarhus Denmark*, Susanne Bødker, Niels Olof Bouvin, Volker Wulf, Luigina Ciolfi, and Wayne Lutters (Eds.). Springer, London, 233–252. https://doi.org/10.1007/978-0-85729-913-0_13

[25] Laura Forlano. 2023. Living Intimately with Machines: Can AI Be Disabled? *interactions* 30, 1 (Jan. 2023), 24–29. https://doi.org/10.1145/3572808

[26] 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* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 5171–5183. https://doi.org/10.

1145/3025453.3025714
[27] Jules Françoise, Sarah Fdili Alaoui, Thecla Schiphorst, and Frederic Bevilacqua. 2014. Vocalizing dance movement for interactive sonification of laban effort factors. In *Proceedings of the 2014 Conference on Designing Interactive Systems* (Vancouver, BC, Canada) *(DIS '14)*. Association for Computing Machinery, New York, NY, USA, 1079–1082. https://doi.org/10.1145/2598510.2598582
[28] Shaun Gallagher. 2005. *How the Body Shapes the Mind.* Oxford University Press, Oxford. 294 pages. https://doi.org/10.1093/0199271941.001.0001
[29] Mafalda Gamboa. 2023. My Body, My Baby, and Everything Else: An Autoethnographic Illustrated Portfolio of Intra-Actions in Pregnancy and Childbirth. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '23)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3569009.3572797
[30] Rachael Garrett, Kristina Popova, Claudia Núñez-Pacheco, Thorhildur Asgeirsdottir, Airi Lampinen, and Kristina Höök. 2023. Felt Ethics: Cultivating Ethical Sensibility in Design Practice. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3544548.3580875
[31] William Gaver and Frances Gaver. 2023. Living with Light Touch: An Autoethnography of a Simple Communication Device in Long-Term Use. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3544548.3580807
[32] William W. Gaver, Jacob Beaver, and Steve Benford. 2003. Ambiguity as a resource for design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, Ft. Lauderdale Florida USA, 233–240. https://doi.org/10.1145/642611.642653
[33] William W. Gaver, John Bowers, Andrew Boucher, Hans Gellerson, Sarah Pennington, Albrecht Schmidt, Anthony Steed, Nicholas Villars, and Brendan Walker. 2004. The drift table: designing for ludic engagement. In *CHI '04 Extended Abstracts on Human Factors in Computing Systems (CHI EA '04)*. Association for Computing Machinery, New York, NY, USA, 885–900. https://doi.org/10.1145/985921.985947
[34] Simone Ghisio, Ksenia Kolykhalova, Gualtiero Volpe, Beatrice Amadeo, Paolo Coletta, Nicola Ferrari, Chiara Tacchino, Sofia Fiscon, Ludovica Primavera, Paolo Moretti, and Antonio Camurri. 2018. Designing a Platform for Child Rehabilitation Exergames Based on Interactive Sonification of Motor Behavior. In *Proceedings of the 4th EAI International Conference on Smart Objects and Technologies for Social Good (Goodtechs '18)*. ACM, New York, NY, USA, 208–213. https://doi.org/10.1145/3284869.3284919
[35] Chris Greenhalgh, Adrian Hazzard, Steve Benford, Laurence Cliffe, and Elizabeth Kelly. 2022. Crafting Trajectories of Smart Phone Use at the Opera. *ACM Transactions on Computer-Human Interaction* 29, 6 (Dec. 2022), 1–37. https://doi.org/10.1145/3531007
[36] Elizabeth Grosz. 1994. *Volatile Bodies: Toward a Corporeal Feminism.* Indiana University Press, Bloomington.
[37] Tobias Großhauser, Bettina Bläsing, Corinna Spieth, and Thomas Hermann. 2012. Wearable Sensor-Based Real-Time Sonification of Motion and Foot Pressure in Dance Teaching and Training. *Journal of the Audio Engineering Society* 60, 7/8 (2012). https://pub.uni-bielefeld.de/record/2528002
[38] Maria Hagströmer, Pekka Oja, and Michael Sjöström. 2006. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nutrition* 9, 6 (Sept. 2006), 755–762. https://doi.org/10.1079/PHN2005898 Publisher: Cambridge University Press.
[39] Shoichi Hasegawa, Seiichiro Ishijima, Fumihiro Kato, Hironori Mitake, and Makoto Sato. 2012. Realtime Sonification of the Center of Gravity for Skiing. In *Proceedings of the 3rd Augmented Human International Conference (AH '12)*. ACM, New York, NY, USA, 11:1–11:4. https://doi.org/10.1145/2160125.2160136
[40] Christian Heath and Dirk Vom Lehn. 2002. *Misconstruing Interaction.*
[41] Mads Hobye and Jonas Löwgren. 2011. Touching a stranger : Designing for engaging experience in embodied interaction. *International Journal of Design* 5, 3 (2011), 31–48. https://urn.kb.se/resolve?urn=urn:nbn:se:mau:diva-1621 Publisher: Chinese Institute of Design.
[42] Sarah Homewood. 2018. Designing for the Changing Body: A Feminist Exploration of Self-Tracking Technologies. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (CHI EA '18)*. Association for Computing Machinery, New York, NY, USA, 1–4. https://doi.org/10.1145/3170427.3173031
[43] Sarah Homewood. 2023. Self-Tracking to Do Less: An Autoethnography of Long COVID That Informs the Design of Pacing Technologies. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3544548.3581505
[44] Sarah Homewood, Marika Hedemyr, Maja Fagerberg Ranten, and Susan Kozel. 2021. Tracing Conceptions of the Body in HCI: From User to More-Than-Human. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3411764.3445656
[45] Eva Hornecker and Jacob Buur. 2006. Getting a Grip on Tangible Interaction: A Framework on Physical Space and Social Interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '06)*. ACM, New York, NY, USA, 437–446. https://doi.org/10.1145/1124772.1124838
[46] Caroline Hummels, Kees C. 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 (Dec. 2007), 677–690. https://doi.org/10.1007/s00779-006-0135-y
[47] Kristina Höök. 2018. *Designing with the Body: Somaesthetic Interaction Design.* The MIT Press, Cambridge, Massachusetts.
[48] Kristina Höök, Steve Benford, Paul Tennent, Vasiliki Tsaknaki, Miquel Alfaras, Juan Martinez Avila, Christine Li, Joseph Marshall, Claudia Daudén Roquet, Pedro Sanches, Anna Ståhl, Muhammad Umair, Charles Windlin, and Feng Zhou. 2021. Unpacking Non-Dualistic Design: The Soma Design Case. *ACM Transactions on Computer-Human Interaction* 28, 6 (Nov. 2021), 40:1–40:36. https://doi.org/10.1145/3462448
[49] 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 (CHI '16)*. Association for Computing Machinery, New York, NY, USA, 3131–3142. https://doi.org/10.1145/2858036.2858583
[50] Simon Katan. 2016. Using Interactive Machine Learning to Sonify Visually Impaired Dancers' Movement. In *Proceedings of the 3rd International Symposium on Movement and Computing (MOCO '16)*. Association for Computing Machinery, New York, NY, USA, 1–4. https://doi.org/10.1145/2948910.2948960
[51] Ozgun Kilic Afsar, Yoav Luft, Kelsey Cotton, Ekaterina R. Stepanova, Claudia Núñez-Pacheco, Rebecca Kleinberger, Fehmi Ben Abdesslem, Hiroshi Ishii, and Kristina Höök. 2023. Corsetto: A Kinesthetic Garment for Designing, Composing for, and Experiencing an Intersubjective Haptic Voice. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, 1–23. https://doi.org/10.1145/3544548.3581294
[52] Norimichi Kitagawa and Charles Spence. 2006. Audiotactile multisensory interactions in information processing. *Japanese Psychological Research* 48 (09 2006), 158 – 173. https://doi.org/10.1111/j.1468-5884.2006.00317.x
[53] Gilly Leshed. 2012. Slowing down with personal productivity tools. *interactions* 19, 1 (Jan. 2012), 58–63. https://doi.org/10.1145/2065327.2065339
[54] Judith Ley-Flores, Eslam Alshami, Aneesha Singh, Frédéric Bevilacqua, Nadia Bianchi-Berthouze, Ophelia Deroy, and Ana Tajadura-Jimenez. 2022. Effects of pitch and musical sounds on body-representations when moving with sound. *Scientific Reports* 12, 1 (2022), 2676. https://doi.org/10.1038/s41598-022-06210-x
[55] Judith Ley-Flores, Frédéric Bevilacqua, Nadia Bianchi-Berthouze, and Ana Tajadura-Jimenez. 2019. Altering body perception and emotion in physically inactive people through movement sonification. In *Proceedings of the 2019 International Conference on Affective Computing and Intelligent Interaction (ACII), 3rd-6th September, 2019, Cambridge, UK.*
[56] Judith Ley-Flores, Laia Turmo Vidal, Nadia Berthouze, Aneesha Singh, Frédéric Bevilacqua, and Ana Tajadura-Jimenez. 2021. SoniBand: Understanding the Effects of Metaphorical Movement Sonifications on Body Perception and Physical Activity. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, New York, NY, USA, 1–16. https://doi.org/10.1145/3411764.3445558
[57] Judith Ley-Flores, Laia Turmo Vidal, Elena Márquez Segura, Aneesha Singh, Frederic Bevilacqua, Francisco Cuadrado, Joaquín Roberto Díaz Durán, Omar Valdiviezo-Hernández, Milagrosa Sánchez-Martin, and Ana Tajadura-Jimenez. 2024. Co-Designing Sensory Feedback for Wearables to Support Physical Activity through Body Sensations. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 8, 1 (March 2024), 40:1–40:31. https://doi.org/10.1145/3643499
[58] Wanyu Liu, Artem Dementyev, Diemo Schwarz, Emmanuel Flety, Wendy E Mackay, Michel Beaudouin-Lafon, and Frederic Bevilacqua. [n. d.]. SonicHoop: Using Interactive Sonification to Support Aerial Hoop Practices. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery. https://doi.org/10.1145/3411764.3445539
[59] Lian Loke and Toni Robertson. 2011. The Lived Body in Design: Mapping the Terrain. In *Proceedings of the 23rd Australian Computer-Human Interaction Conference (OzCHI '11)*. ACM, New York, NY, USA, 181–184. https://doi.org/10.1145/2071536.2071565
[60] Lian Loke and Toni Robertson. 2013. Moving and Making Strange: An Embodied Approach to Movement-based Interaction Design. *ACM Trans. Comput.-Hum. Interact.* 20, 1 (2013), 7:1–7:25. https://doi.org/10.1145/2442106.2442113
[61] Lian Loke and Thecla Schiphorst. 2018. The Somatic Turn in Human-computer Interaction. *Interactions* 25, 5 (Aug. 2018), 54–5863. https://doi.org/10.1145/3236675
[62] Matthew R. Longo and Patrick Haggard. 2012. What Is It Like to Have a Body? *Current Directions in Psychological Science* 21, 2 (2012), 140–145. https://doi.org/10.1177/0963721411434982

[63] Yoav Luft, Pavel Karpashevich, and Kristina Höök. 2023. Boards Hit Back: Reflecting on Martial Arts Practices Through Soma Design. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, 1–18. https://doi.org/10.1145/3544548.3580722

[64] Jonas Löwgren. 2009. Toward an Articulation of Interaction Esthetics. *New Rev. Hypermedia Multimedia* 15, 2 (2009), 129–146. https://doi.org/10.1080/13614560903117822

[65] Elena Márquez Segura, Laia Turmo Vidal, Luis Parrilla Bel, and Annika Waern. 2019. Circus, Play and Technology Probes: Training Body Awareness and Control with Children. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (San Diego, CA, USA) *(DIS '19)*. Association for Computing Machinery, New York, NY, USA, 1223–1236. https://doi.org/10.1145/3322276.3322377

[66] Patrick A. Mello. 2021. *Qualitative Comparative Analysis: An Introduction to Research Design and Application*. Georgetown University Press. Google-Books-ID: XbRHEAAAQBAJ.

[67] Maria F. Montoya, Rakesh Patibanda, Christal Clashing, Sarah Jane Pell, and Florian 'Floyd' Mueller. 2022. Towards an Initial Understanding of the Design of Playful Water Experiences Through Flotation. In *Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play*. ACM, Bremen Germany, 120–126. https://doi.org/10.1145/3505270.3558324

[68] Florian Floyd Mueller, Zhuying Li, Richard Byrne, Yash Dhanpal Mehta, Peter Arnold, and Tuomas Kari. 2019. A 2nd Person Social Perspective on Bodily Play. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3290605.3300868

[69] Florian Floyd Mueller, Pedro Lopes, Paul Strohmeier, Wendy Ju, Caitlyn Seim, Martin Weigel, Suranga Nanayakkara, Marianna Obrist, Zhuying Li, Joseph Delfa, Jun Nishida, Elizabeth M. Gerber, Dag Svanaes, Jonathan Grudin, Stefan Greuter, Kai Kunze, Thomas Erickson, Steven Greenspan, Masahiko Inami, Joe Marshall, Harald Reiterer, Katrin Wolf, Jochen Meyer, Thecla Schiphorst, Dakuo Wang, and Pattie Maes. 2020. Next Steps for Human-Computer Integration. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3313831.3376242

[70] 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 (CHI '16)*. ACM, New York, NY, USA, 6014–6027. https://doi.org/10.1145/2858036.2858486

[71] Elena Nava and Ana Tajadura-Jiménez. 2020. Auditory-induced body distortions in children and adults. *Scientific Reports* 10, 1 (2020), 3024. https://doi.org/10.1038/s41598-020-59979-0

[72] Joseph W. Newbold, Nadia Bianchi-Berthouze, Nicolas E. Gold, Ana Tajadura-Jimenez, and Amanda CdC Williams. 2016. Musically Informed Sonification for Chronic Pain Rehabilitation: Facilitating Progress & Avoiding Over-Doing. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. Association for Computing Machinery, New York, NY, USA, 5698–5703. https://doi.org/10.1145/2858036.2858302

[73] Stina Nylander, Alex Kent, and Jakob Tholander. 2014. Swing Sound: Experiencing the Golf Swing Through Sound. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14)*. ACM, New York, NY, USA, 443–446. https://doi.org/10.1145/2559206.2574789

[74] William Odom, Siân Lindley, Larissa Pschetz, Vasiliki Tsaknaki, Anna Vallgårda, Mikael Wiberg, and Daisy Yoo. 2018. Time, Temporality, and Slowness: Future Directions for Design Research. In *Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems (DIS '18 Companion)*. Association for Computing Machinery, New York, NY, USA, 383–386. https://doi.org/10.1145/3197391.3197392

[75] William Odom, Ron Wakkary, Ishac Bertran, Matthew Harkness, Garnet Hertz, Jeroen Hol, Henry Lin, Bram Naus, Perry Tan, and Pepijn Verburg. 2018. Attending to Slowness and Temporality with Olly and Slow Game: A Design Inquiry Into Supporting Longer-Term Relations with Everyday Computational Objects. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3173574.3173651

[76] William Odom, Jordan White, Samuel Barnett, Nico Brand, Henry Lin, Minyoung Yoo, and Tal Amram. 2024. Capra: Making Use of Multiple Perspectives for Capturing, Noticing and Revisiting Hiking Experiences Over Time. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)*. Association for Computing Machinery, New York, NY, USA, 1–27. https://doi.org/10.1145/3613904.3642284

[77] Doenja Oogjes and Audrey Desjardins. 2024. A temporal vocabulary of Design Events for Research through Design. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3613904.3642560

[78] Léa Paymal and Sarah Homewood. 2024. Good Days, Bad Days: Understanding the Trajectories of Technology Use During Chronic Fatigue Syndrome. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–10. https://doi.org/10.1145/3613904.3642553

[79] Youhong Friendred Peng and Atau Tanaka. 2019. Body and Embodiment in Dance Performance. In *Proceedings of the 6th International Conference on Movement and Computing (MOCO '19)*. Association for Computing Machinery, New York, NY, USA, 1–6. https://doi.org/10.1145/3347122.3359596

[80] Youhong (Friendred) Peng, Atau Tanaka, and Jamie A. Ward. 2020. The light: exploring socially improvised movements using wearable sensors in a performative installation. In *Adjunct Proceedings of the 2020 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2020 ACM International Symposium on Wearable Computers (UbiComp/ISWC '20 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 102–105. https://doi.org/10.1145/3410530.3414378

[81] Bruna Beatriz Petreca, Ana Tajadura-Jiménez, Laia Turmo Vidal, Ricardo O Nascimento, Hasti Seifi, Judith Ley-Flores, Aneesha Singh, Nadia Berthouze, Marianna Obrist, and Sharon Baurley. 2023. Body x Materials: A Workshop Exploring the Role of Material-Enabled Body-Based Multisensory Experiences. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI EA '23)*. Association for Computing Machinery, New York, NY, USA, Article 334, 7 pages. https://doi.org/10.1145/3544549.3573807

[82] Edgar F Pierce and Myra L Daleng. 1998. Distortion of Body Image among Elite Female Dancers. *Perceptual and Motor Skills* 87, 3 (Dec. 1998), 769–770. https://doi.org/10.2466/pms.1998.87.3.769 Publisher: SAGE Publications Inc.

[83] Olga Pollatos, Anne-Lene Kurz, Jessica Albrecht, Tatjana Schreder, Anna Maria Kleemann, Veronika Schöpf, Rainer Kopietz, Martin Wiesmann, and Rainer Schandry. 2008. Reduced perception of bodily signals in anorexia nervosa. *Eating Behaviors* 9, 4 (Dec. 2008), 381–388. https://doi.org/10.1016/j.eatbeh.2008.02.001

[84] Amon Rapp, William Odom, Larissa Pschetz, and Daniela Petrelli. 2022. Introduction to the special issue on time and HCI. *Human–Computer Interaction* 37, 1 (Jan. 2022), 1–14. https://doi.org/10.1080/07370024.2021.1955681 Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/07370024.2021.1955681.

[85] Johan Redström. 2017. *Making Design Theory*. The MIT Press, Cambridge, Massachusetts.

[86] Courtney N. Reed and Andrew P. McPherson. 2023. The Body as Sound: Unpacking Vocal Embodiment through Auditory Biofeedback. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction* (Warsaw, Poland) *(TEI '23)*. Association for Computing Machinery, New York, NY, USA, Article 7, 15 pages. https://doi.org/10.1145/3569009.3572738

[87] Courtney N. Reed, Landon Morrison, Andrew P. McPherson, David Fierro, and Atau Tanaka. 2024. Sonic Entanglements with Electromyography: Between Bodies, Signals, and Representations. In *Proceedings of the 2024 ACM Designing Interactive Systems Conference* (Copenhagen, Denmark) *(DIS '24)*. Association for Computing Machinery, New York, NY, USA, 2691–2707. https://doi.org/10.1145/3643834.3661572

[88] Patricia Rick, Milagrosa Sánchez-Martín, Aneesha Singh, Sergio Navas-León, Mercedes Borda-Mas, Nadia Bianchi-Berthouze, and Ana Tajadura-Jiménez. 2022. Investigating psychological variables for technologies promoting physical activity. *DIGITAL HEALTH* 8 (Jan. 2022), 20552076221116559. https://doi.org/10.1177/20552076221116559 Publisher: SAGE Publications Ltd.

[89] Jean-Philippe Rivière, Sarah Fdili Alaoui, Baptiste Caramiaux, and Wendy E. Mackay. 2021. Exploring the Role of Artifacts in Collective Dance Re-staging. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW1, Article 108 (April 2021), 22 pages. https://doi.org/10.1145/3449182

[90] Yvonne Rogers and Paul Marshall. 2017. *Research in the Wild*. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-031-02220-3

[91] Giulio Rosati, Antonio Rodà, Federico Avanzini, and Stefano Masiero. 2013. On the Role of Auditory Feedback in Robot-Assisted Movement Training after Stroke: Review of the Literature. *Intell. Neuroscience* 2013, Article 11 (jan 2013), 1 pages. https://doi.org/10.1155/2013/586138

[92] Pedro Sanches, Kristina Höök, Corina Sas, and Anna Ståhl. 2019. Ambiguity as a Resource to Inform Proto-Practices: The Case of Skin Conductance. *ACM Trans. Comput.-Hum. Interact.* 26, 4, Article 21 (jul 2019), 32 pages. https://doi.org/10.1145/3318143

[93] Nina Schaffert, Thenille Braun Janzen, Klaus Mattes, and Michael H. Thaut. 2019. A Review on the Relationship Between Sound and Movement in Sports and Rehabilitation. *Frontiers in Psychology* 10 (2019). https://www.frontiersin.org/articles/10.3389/fpsyg.2019.00244

[94] Nina Schaffert and Klaus Mattes. 2015. Interactive Sonification in Rowing: Acoustic Feedback for On-Water Training. *IEEE MultiMedia* 22, 1 (Jan. 2015), 58–67. https://doi.org/10.1109/MMUL.2015.9 Conference Name: IEEE MultiMedia.

[95] Thecla Schiphorst. 2011. Self-evidence: applying somatic connoisseurship to experience design. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11)*. Association for Computing Machinery, New York, NY, USA, 145–160. https://doi.org/10.1145/1979742.1979640

[96] Gerd Schmitz, Jeannine Bergmann, Alfred O. Effenberg, Carmen Krewer, Tong-Hun Hwang, and Friedemann Müller. 2018. Movement Sonification in Stroke Rehabilitation. *Frontiers in Neurology* 9 (June 2018). https://doi.org/10.3389/fneur.2018.00389

[97] Daniel S. Scholz, Sönke Rhode, Michael Großbach, Jens Rollnik, and Eckart Altenmüller. 2015. Moving with music for stroke rehabilitation: a sonification feasibility study. *Annals of the New York Academy of Sciences* 1337 (March 2015), 69–76. https://doi.org/10.1111/nyas.12691

[98] Ralf Schwarzer. 1992. Self-Efficacy, Physical Symptoms, and Rehabilitation of Chronic Disease. In *Self-Efficacy*, Ralf Schwarzer (Ed.). Taylor & Francis. Num Pages: 110.

[99] Irene Senna, Angelo Maravita, Nadia Bolognini, and Cesare V. Parise. 2014. The marble-hand illusion. *PLoS ONE* 9, 3 (2014), 1–6. https://doi.org/10.1371/journal.pone.0091688

[100] Andrea Serino and Patrick Haggard. 2010. Touch and the body. *Neuroscience & Biobehavioral Reviews* 34, 2 (feb 2010), 224–236. https://doi.org/10.1016/j.neubiorev.2009.04.004

[101] Aneesha Singh, Nadia Bianchi-Berthouze, and Amanda CdeC Williams. 2017. Supporting Everyday Function in Chronic Pain Using Wearable Technology. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 3903–3915. https://doi.org/10.1145/3025453.3025947

[102] Aneesha Singh, Marusa Hrobat, Suxin Gui, Nadia Bianchi-Berthouze, Judith Ley-Flores, Frederic Bevilacqua, Joaquin R. Diaz Duran, Elena Márquez Segura, and Ana Tajadura-Jimenez. 2024. Pushed by Sound: Effects of Sound and Movement Direction on Body Perception, Experience Quality, and Exercise Support. *ACM Transactions on Computer-Human Interaction* (March 2024), 3648616. https://doi.org/10.1145/3648616

[103] Aneesha Singh, Stefano Piana, Davide Pollarolo, Gualtiero Volpe, Giovanna Varni, Ana Tajadura-Jimenez, Amanda CdeC Williams, Antonio Camurri, and Nadia Bianchi-Berthouze. 2016. Go-with-the-Flow: Tracking, Analysis and Sonification of Movement and Breathing to Build Confidence in Activity Despite Chronic Pain. *Human–Computer Interaction* 31, 3-4 (July 2016), 335–383. https://doi.org/10.1080/07370024.2015.1085310 Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/07370024.2015.1085310.

[104] Marie Louise Juul Søndergaard, Marianela Ciolfi Felice, and Madeline Balaam. 2021. Designing Menstrual Technologies with Adolescents. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 260, 14 pages. https://doi.org/10.1145/3411764.3445471

[105] Tasha R. Stanton, G. Lorimer Moseley, Arnold Y. L. Wong, and Gregory N. Kawchuk. 2017. Feeling stiffness in the back: a protective perceptual inference in chronic back pain. *Scientific Reports* 7, 1 (Aug. 2017), 9681. https://doi.org/10.1038/s41598-017-09429-1 Number: 1 Publisher: Nature Publishing Group.

[106] Jelle Stienstra, Kees Overbeeke, and Stephan Wensveen. 2011. Embodying Complexity through Movement Sonification: Case Study on Empowering the Speed-Skater. In *Proceedings of the 9th ACM SIGCHI Italian Chapter International Conference on Computer-Human Interaction: Facing Complexity* (Alghero, Italy) *(CHItaly)*. Association for Computing Machinery, New York, NY, USA, 39–44. https://doi.org/10.1145/2037296.2037310

[107] Jelle Stienstra, Kees Overbeeke, and Stephan Wensveen. 2011. Embodying Complexity Through Movement Sonification: Case Study on Empowering the Speed-skater. In *Proceedings of the 9th ACM SIGCHI Italian Chapter International Conference on Computer-Human Interaction: Facing Complexity (CHItaly)*. ACM, New York, NY, USA, 39–44. https://doi.org/10.1145/2037296.2037310 event-place: Alghero, Italy.

[108] Anna Ståhl, Madeline Balaam, Rob Comber, Pedro Sanches, and Kristina Höök. 2022. Making New Worlds – Transformative Becomings with Soma Design. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI '22)*. Association for Computing Machinery, New York, NY, USA, 1–17. https://doi.org/10.1145/3491102.3502018

[109] Anna Ståhl, Martin Jonsson, Johanna Mercurio, Anna Karlsson, Kristina Höök, and Eva-Carin Banka Johnson. 2016. The Soma Mat and Breathing Light. 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, 305–308. https://doi.org/10.1145/2851581.2889464

[110] 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

[111] Dag Svanæs. 2013. Interaction Design for and with the Lived Body: Some Implications of Merleau-ponty's Phenomenology. *ACM Trans. Comput.-Hum. Interact.* 20, 1 (April 2013), 8:1–8:30. https://doi.org/10.1145/2442106.2442114

[112] Ana Tajadura-Jimenez, Maria Basia, Ophelia Deroy, Merle Fairhurst, Nicolai Marquardt, and Nadia Bianchi-Berthouze. 2015. As Light as your Footsteps: Altering Walking Sounds to Change Perceived Body Weight, Emotional State and Gait. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 2943–2952. https://doi.org/10.1145/2702123.2702374

[113] Ana Tajadura-Jimenez, Francisco Cuadrado, Patricia Rick, Nadia Bianchi-Berthouze, Aneesha Singh, Aleksander Väljamäe, and Frédéric Bevilacqua. 2018. Designing a Gesture-sound Wearable System to Motivate Physical Activity by Altering Body Perception. In *Proceedings of the 5th International Conference on Movement and Computing (MOCO '18)*. ACM, New York, NY, USA, 46:1–46:6. https://doi.org/10.1145/3212721.3212877

[114] Ana Tajadura-Jimenez, Ophelia Deroy, Torsten Marquardt, Nadia Bianchi-Berthouze, Tomohisa Asai, Toshitaka Kimura, and Norimichi Kitagawa. 2018. Audio-tactile cues from an object's fall change estimates of one's body height. *PLOS ONE* 13, 6 (June 2018), e0199354. https://doi.org/10.1371/journal.pone.0199354 Publisher: Public Library of Science.

[115] Ana Tajadura-Jimenez, Merle T. Fairhurst, and Ophelia Deroy. 2022. Sensing the body through sound. *The Routledge Handbook of Bodily Awareness* (11 2022), 230–246. https://doi.org/10.4324/9780429321542-21

[116] Ana Tajadura-Jimenez, Joseph Newbold, Linge Zhang, Patricia Rick, and Nadia Bianchi-Berthouze. 2019. As Light as You Aspire to Be. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, New York, NY, USA, 1–14. https://doi.org/10.1145/3290605.3300888

[117] Ana Tajadura-Jimenez, Aleksander Väljamäe, Iwaki Toshima, Toshitaka Kimura, Manos Tsakiris, and Norimichi Kitagawa. 2012. Action sounds recalibrate perceived tactile distance. *Current Biology* 22, 13 (2012), R516–R517. https://doi.org/10.1016/j.cub.2012.04.028 ISBN: 1879-0445 (Electronic)\r0960-9822 (Linking) Publisher: Elsevier.

[118] Ana Tajadura-Jiménez, Helen Cohen, and Nadia Bianchi-Berthouze. 2017. Bodily Sensory Inputs and Anomalous Bodily Experiences in Complex Regional Pain Syndrome: Evaluation of the Potential Effects of Sound Feedback. *Frontiers in Human Neuroscience* 11 (July 2017). https://doi.org/10.3389/fnhum.2017.00379

[119] Ana Tajadura-Jiménez, Manos Tsakiris, Torsten Marquardt, and Nadia Bianchi-Berthouze. 2015. Action sounds update the mental representation of arm dimension: contributions of kinaesthesia and agency. *Frontiers in Psychology* 6 (2015). https://doi.org/10.3389/fpsyg.2015.00689

[120] Ana Tajadura-Jiménez, Aleksander Väljamäe, Frédéric Bevilacqua, and Nadia Bianchi-Berthouze. 2018. Principles for Designing Body-Centered Auditory Feedback. In *The Wiley Handbook of Human Computer Interaction*. John Wiley and Sons, Ltd, 371–403. https://doi.org/10.1002/9781118976005.ch18

[121] Paul Tennent, Kristina Höök, Steve Benford, Vasiliki Tsaknaki, Anna Ståhl, Claudia Dauden Roquet, Charles Windlin, Pedro Sanches, Joe Marshall, Christine Li, Juan Pablo Martinez Avila, Miquel Alfaras, Muhammad Umair, and Feng Zhou. 2021. Articulating Soma Experiences using Trajectories. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21)*. Association for Computing Machinery, New York, NY, USA, 1–16. https://doi.org/10.1145/3411764.3445482

[122] Vasiliki Tsaknaki, Madeline Balaam, Anna Ståhl, Pedro Sanches, Charles Windlin, Pavel Karpashevich, and Kristina Höök. 2019. Teaching Soma Design. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19)*. ACM, New York, NY, USA, 1237–1249. https://doi.org/10.1145/3322276.3322327 event-place: San Diego, CA, USA.

[123] Laia Turmo Vidal and Jared Duval. 2024. Ambiguity as a Resource to Design for a Plurality of Bodies. ACM, Santa Cruz, CA, USA. https://doi.org/10.1145/3686169.3686176

[124] Laia Turmo Vidal, Yinchu Li, Martin Stojanov, Karin B Johansson, Beatrice Tylstedt, and Lina Eklund. 2023. Towards Advancing Body Maps as Research Tool in Interaction Design. (2023), 470–475.

[125] Laia Turmo Vidal and Elena Márquez Segura. 2018. Documenting the Elusive and Ephemeral in Embodied Design Ideation Activities. *Multimodal Technologies and Interaction* 2, 3 (June 2018), 35. https://doi.org/10.3390/mti2030035

[126] Laia Turmo Vidal, Elena Márquez Segura, Luis Parrilla Bel, and Annika Waern. 2020. Training Technology Probes Across Fitness Practices: Yoga, Circus and Weightlifting. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI'20)*. ACM, New York, NY, USA. https://doi.org/10.1145/3334480.3382862

[127] Laia Turmo Vidal, Elena Márquez Segura, and Annika Waern. 2023. Intercorporeal Biofeedback for Movement Learning. *ACM Transactions on Computer-Human Interaction* 30, 3 (June 2023), 43:1–43:40. https://doi.org/10.1145/3582428

[128] Laia Turmo Vidal, Ana Tajadura-Jimenez, Jose Manuel Vega-Cebrian, Judith Ley-Flores, Joaquin R. Díaz-Durán, and Elena Márquez Segura. 2024. Body Transformation: An Experiential Quality of Sensory Feedback Wearables for Altering Body Perception. In *Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '24)*. Association for Computing Machinery, New York, NY, USA, 1–19. https://doi.org/10.1145/3623509.3633373

[129] Laia Turmo Vidal, José Manuel Vega-Cebrián, María Concepción Valdez Gastelum, Elena Márquez Segura, Judith Ley-Flores, Joaquin R. Diaz Duran, and Ana Tajadura-Jiménez. 2024. Body Sensations as Design Material: An Approach to Design Sensory Technology for Altering Body Perception. In *Proceedings of the 2024 ACM Designing Interactive Systems Conference* (Copenhagen, Denmark) *(DIS '24)*. Association for Computing Machinery, New York, NY, USA, 2545–2561. https://doi.org/10.1145/3643834.3660701

[130] Laia Turmo Vidal, Hui Zhu, and Abraham Riego-Delgado. 2020. BodyLights: Open-Ended Augmented Feedback to Support Training Towards a Correct Exercise Execution. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20)*. Association for Computing Machinery, Honolulu, HI, USA, 1–14. https://doi.org/10.1145/3313831.3376268

[131] Laia Turmo Vidal, Hui Zhu, Annika Waern, and Elena Márquez Segura. 2021. The Design Space of Wearables for Sports and Fitness Practices. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–14. https://doi.org/10.1145/3411764.3445700

[132] Vincent van Rheden, Thomas Grah, and Alexander Meschtscherjakov. 2020. Sonification approaches in sports in the past decade: a literature review. In *Proceedings of the 15th International Conference on Audio Mostly (AM '20)*. Association for Computing Machinery, New York, NY, USA, 199–205. https://doi.org/10.1145/3411109.3411126

[133] Katharina Vogt, David Pirrò, Ingo Kobenz, Robert Höldrich, and Gerhard Eckel. 2010. PhysioSonic - Evaluated Movement Sonification as Auditory Feedback in Physiotherapy. In *Auditory Display (Lecture Notes in Computer Science)*, Sølvi Ystad, Mitsuko Aramaki, Richard Kronland-Martinet, and Kristoffer Jensen (Eds.). Springer Berlin Heidelberg, 103–120.

[134] Lucie Vágnerová. 2014. *Sirens/Cyborgs: Sound Technologies and the Musical Body*. Ph. D. Dissertation. Columbia Academic Commons. https://lucievagnerova.com/research/dissertation/

[135] Ron Wakkary, Doenja Oogjes, Henry W. J. Lin, and Sabrina Hauser. 2018. Philosophers Living with the Tilting Bowl. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, 94:1–94:12. https://doi.org/10.1145/3173574.3173668

[136] Danielle Wilde, Anna Vallgårda, 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* (Denver, Colorado, USA) *(CHI '17)*. Association for Computing Machinery, New York, NY, USA, 5158–5170. https://doi.org/10.1145/3025453.3025873

[137] Florian 'Floyd' Mueller, Nathan Semertzidis, Josh Andres, Martin Weigel, Suranga Nanayakkara, Rakesh Patibanda, Zhuying Li, Paul Strohmeier, Jarrod Knibbe, Stefan Greuter, Marianna Obrist, Pattie Maes, Dakuo Wang, Katrin Wolf, Liz Gerber, Joe Marshall, Kai Kunze, Jonathan Grudin, Harald Reiterer, and Richard Byrne. 2022. Human–Computer Integration: Towards Integrating the Human Body with the Computational Machine. *Foundations and Trends® in Human-Computer Interaction* 16, 1 (2022), 1–64. https://doi.org/10.1561/1100000086