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Hearing the Invisible: Affective Bodily Awareness through EMG Sonification and Situated Sound with Joakinator

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***Abstract*— This paper presents a practice-based exploration of affective bodily awareness through the sonification of muscle tonicity. We utilize Joakinator, a wearable interface combining electromyogram (EMG) and force-sensing resistor (FSR). Originally developed for performative applications, the system employs machine learning to flexibly map internal physiological activity to auditory parameters. Between 2023 and 2024, the interface was deployed across diverse artistic and academic workshops in the BODYinTRANSIT project framework. Engaging dancers, visual artists, musicians, and HCI/NIME researchers, the study utilized an exploratory methodology combining somatic practices, situated sound stimuli, and qualitative evaluation tools like BodyMaps. Findings indicate a shift in participants' experience: rather than primarily producing new movement vocabularies or enhancing performative expressivity, the closed-loop sonification heightened interoceptive awareness regarding muscle tension, relaxation, and affective states. These results show that EMG-based sonification operates as a perceptual interface for sensory transformation. By highlighting how situated auditory feedback shapes somatic attention and affective awareness, this research opens new design spaces for affective computing within creative practices, somatic exploration, dance education, and physical rehabilitation.**

***Index Terms*—Affective Sonification, Embodied Interaction, Electromyography (EMG), Interoceptive Awareness, Bodily Awareness, Practice-Based Research, Interactive Machine Learning.**

I. Introduction

Seeing the invisible seems paradoxical, yet it is possible. Just as incense smoke reveals hidden air currents, electromyography (EMG) [1]- [2] makes concealed muscular and physiological processes perceptible. This work explores the proprioceptive and affective effects of EMG-based sonification. Moving beyond traditional musical interfaces, we frame sonification as a perceptual layer bridging physiological signals and experiential awareness, allowing users to consciously perceive otherwise hidden affective and somatic states.

This article presents a series of workshops, demos, and performing arts improvisations utilizing the Joakinator ecosystem across artistic and academic contexts. Involving diverse participants—including HCI researchers, musicians, dancers, and visual artists—the interactive experience iteratively evolved. Although initially aimed at exploring EMG-assisted performative expression, the observation of enhanced bodily awareness redirected this work. Focus thus shifted from performative expressivity to bodily awareness, encompassing both proprioceptive (felt sense of bodily position and movement) and interoceptive (perception of internal states like effort, tension, and relaxation) dimensions [3].

Joakinator is a wearable movement sonification interface combining up to three EMG and four force-sensing resistor (FSR) inputs. EMG measures skeletal muscle electrical activity, utilized in affective computing to capture responses like physiological arousal [4]. FSRs detect pressure and body weight shifts. Joakinator employs machine learning to map these signals to sound parameters, adapting to specific artistic or athletic goals without significant technical overhead. Originally developed for the performing arts (2018–2024), Joakinator offered users novel understandings of bodily states beyond mere audiovisual control [4], [5]. Subsequently, the BODYinTRANSIT project adopted it in 2022 to explore Body Transformation Experiences (BTE) via movement sonification [6]- [7]. Neuroscience shows interactive multisensory feedback modifies sensory-motor signals, transforming bodily self-perception [8]- [9]. For affective computing, this presents an opportunity to leverage closed-loop auditory feedback for emotional and interoceptive regulation.

We proposed an exploratory, non-prescriptive approach combining somatic practices with movement sonification. Operating less like a conventional instrument and more like a **perceptual interface**, we utilized qualitative tools such as BodyMaps to discover how this closed-loop sonification impacts muscle proprioception and internal awareness. Furthermore, we observed how situated sounds (SiS)—recognizable audio recorded within the local environment, carrying specific socio-affective significance for participants—exert a powerful impact on body image and emotional sensations.

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Ultimately, this study opens a design space for technologies functioning as perceptual extensions, expanding possibilities for creative, educational, rehabilitative, and affective research practices.

II. Background and Related Work

The urge to physically connect the body with devices has been a recurring theme in the human imagination, as can be seen, for example, in the movie Ghost in the Shell [10]. In research contexts, this fascination has materialized in the development of new musical interfaces (NIMEs), in studies on sensory transformation, and in applications in rehabilitation and medical contexts.

Our bodily perception is more malleable than we usually think. Research in psychology, cognitive neuroscience, and somaesthetics has shown that body appearance [11], [8] body configuration [12], perceived location [13], and even motor skills [14] and bodily sensations [15], [16] can be modified through interactive and multisensory feedback, including visual [9], auditory [17], or haptic stimuli [18], [19]. These experiences, called Body Transformation Experiences (BTE), describe situations in which the perception of one's own body is temporarily altered through interactive technologies, generating perceptual changes with an impact on cognitive [20], emotional [21], and motor [22]. These effects have been explored in fields such as art [5], dance [23], motor learning, and physical (in)activity [24]- [25] among others.

Within this framework, various technologies generate sensory feedback; this study primarily utilizes electromyography (EMG) to control sound stimuli. EMG and mechanomyogram (MMG) signals are extensively researched for gesture-based sound control [26], [27], enabling novice users to quickly establish meaningful gesture-sound relationships that promote interoceptive awareness [28] Likewise, machine learning facilitates flexible sensor-to-sound mappings adaptable to diverse contexts [29].

The use of sonification interactive devices has also been explored in rehabilitation contexts, where the sonification of movement helps reduce fatigue associated with repetitive activities [30]. In particular, EMG-based interfaces have been used for these purposes, giving rise to what Corredera and Tanaka [31] call continuity in movement.

Finally, Courtney [1] distinguishes EMG within embodied interaction: while motion-capture, depth cameras, and inertial sensors externalize movement, EMG acts as a "signal from the inside," registering muscle activation before, during, or alongside visible motion. Rather than providing transparent interior access, EMG occupies an ambiguous middle ground between intention and action, voluntary and involuntary activity, and bodily signal and technological representation. This ambiguity is central to Joakinator, which treats the body not as an externally tracked object, but as a sensing, moving, sounding body.

A. The Joakinator Device

Within this context lies Joakinator (Fig.1), a sonification interface integrating EMG sensors and interactive machine learning via Wekinator [32], to enable dynamic, context-adaptable mapping [29]. Conceived through art-based research as a performative companion [33], [5] its architecture comprises a WiFi-enabled microcontroller transmitting OSC data from up to three EMG and four FSR (flexion/pressure) sensors. To reduce noise among the EMG sensors, we developed a custom PCB and implemented a rolling window of ten samples, balancing signal smoothing with low latency. For mapping and further signal stabilization, we utilized Wekinator and Wekinator Input Helper, applying a neural network regression algorithm with a maximum of 3,276 samples per output across all training sessions.

Fig. 1. Joakinator device and a performance apparition. (1) Arduino MKR1010 Myoware and special PCB for reducing noise, (2) EMG, (3) FSR, (4) Electrodes. Photo by Ari Agliati, 2023.

The interaction and software design of the workshops presented here were informed by thirteen performances across five artistic projects [33]. To minimize cognitive and technical complexity during these sessions, the setup was streamlined to two EMG sensors, omitting the FSRs.

The device is also integrated into BODYinTRANSIT's Body Transformation Experience (BTE) studies. Building on prior research showing altered bodily perception in dancers [34], this work further explores the system's impact on affective bodily awareness, expressiveness, and situated sounds, while outlining methodologies emerging from these workshops.

III. Workshops and Methodology

This article reports on five situated engagements (workshops from here onwards W1-W5) with Joakinator across artistic, academic, and cultural contexts conducted between 2023 and 2024: W1 was a public demo in the NIME conference 2023; W2 was an artistic improvisation with Butoh dancer teachers in Mexico City (Mexico); W3 was a workshop in the Tsonami Sound Art association in Valparaiso (Chile); W4 was an Artist Residency in MolinoLab (Spain). The sessions involved participants with diverse profiles, including dancers, performing artists, visual artists, musicians, and HCI researchers. Across these engagements, participants explored Joakinator in relation to movement, sound, bodily awareness and interaction. In some iterations, Joakinator was used alongside other prototypes (SoniBand in W2; Felt Sound in W3 and W5), as part of a broader inquiry into wearable and embodied sound interfaces. However, to maintain a coherent analytical scope, this article focuses exclusively on Joakinator.

Across all activities, a shared methodological thread was to explore how the sonification of muscle tonicity via EMG shaped expressive movement, affective proprioception, and bodily imagination. We understand bodily imagination as the capacity to extend sensitivity outward, allowing practitioners to sense and engage with the external world through felt, somatic experience. While rooted in the body's lived experience [35], [36], bodily imagination involves more than mental representation: it enables practitioners to physically explore and experience transformations of their bodies into other materials or elemental qualities, such as water or fire, and to move, perceive, and feel according to those somatic shifts [37].

This study builds on prior performative practices with Joakinator, which investigated body-technology relationship by using muscle signals to control of samplers and synthesizers. Over time, this practice evolved toward a broader inquiry into how the system might support novel artistic and creative expression.

Across encounters W1–W5 (Table 1), we iteratively reduced technical complexity (mappings, sensors, setup) to shift focus from troubleshooting to the experiential dynamics between movement, sonification, and bodily awareness. We sought an optimal configuration balancing technical legibility with Joakinator's embodied and affective qualities. Observations confirmed that reducing technical and cognitive complexity helped participants focus on bodily sensations and enhanced immediate interface legibility.

Across all sessions, we prioritized an exploratory, non-prescriptive approach: bypassing initial technical explanations, participants engaged with Joakinator through movement, sound, and bodily experimentation. Understanding emerged gradually from somatic and sonic experiences, foregrounding the movement-sonification-embodiment relationship. We hypothesized this closed-loop interaction would foster creative movement, new bodily languages, and deeper affective awareness and bodily perception.

TABLE I. OVERVIEW OF WORKSHOPS AND EVOLUTION OF METHODOLOGICAL AND SONIC APPROACHES IN THE JOAKINATOR STUDIES. *ONLY ONE OF THE DANCE TEACHERS PROVIDED A REPORT; **14 PARTICIPANTS USED JOAKINATOR / 10 PARTICIPANTS USED FELT SOUND.

	Demo at NIME 2023 (W1)	**Butoh Dance Improvisation (W2)**	**Tsonami Workshop (Valparaiso W3)**	**Biophony, Dancing Nature Workshop (W4)**	**Earth *Synthposium* Workshop (Cuenca W5)**
Focus of the experience	Expressivity and movement; proprioception and bodily awareness; movement–sound relationship; creative practices and device iteration.	Internal attention to movement; muscular awareness and proprioception; bodily tension and sound; performative expressivity.	Movement and emotions; bodily sensations; imagination and space; somatic techniques; situated sound.	Adaptation to artistic practices; personal sound; bodily imagination; proprioception; creative modalities.	Contextual sound; movement and emotions; bodily sensations; imagination; methodological refinement.
Participants	~12 participants	2 Butoh teachers*	4 dancers	4 performers	24 fine arts students**
Instrument	Open-ended questions (OEQ) with sticky notes (SN)	Open-ended questions (OEQ)	Body maps+open ended questions (BM+OEQ), semi-structured group interviews (SGI)	Semi-structured group/individual (SGI/SII) interviews and open-ended questions (OEQ) with sticky notes (SN)	Body maps+open ended questions (BM+OEQ), semi-structured group interviews (SGI)
Prototypes used	Joakinator	Joakinator + SoniBand [25]	Joakinator + Felt Sound	Joakinator	Joakinator + Felt Sound
Sounds used[a]	Electricity, lava, fire, paper, notes generator	Sounds from W1: electricity, water. Narrated voices; wind (SoniBand)	Sound from W2: water. Situated sounds (SiS): Departing ships, rain, beach , electric cable under rain	Sounds from W1: lava, notes generator; Sounds from W2: Water, Artist's sounds: birds, artist's own voice.	Sounds from W1: lava; Sounds from W3: Departing ships, beach. SiS: waterfall, Sinthy100

[a.] Sound design builds on W1 baseline sounds from a prior sensory study [35], expanded for the artistic context of subsequent workshops. General consistency was maintained through timbral and categorical alignment (e.g., water, fire, electricity), at times evolving within the same category, e.g.: Water (W2) -> Beach (W3) -> Water (W4) -> Waterfall & Beach (W5). W3 primarily explored "situated sounds" (SiS) of earlier categories such as water (e.g., rain, beach) and electricity (e.g., electric cable under rain), mapped to environmental sounds locally sourced and recorded in the host portuary city of Valparaiso. Later workshops (W4, W5) included locally produced sounds: the artist's generated sounds (W4), an attendee concert at the Synthposium using the Sinthy100 synthesizer, and local sounds like the waterfall in W5.

A. Data Collection and Analysis

Data were collected through qualitative methods focused on embodied experience, with the aim of investigating how Joakinator shaped participants' transformations in bodily perception, muscle awareness, and understandings of the device's possible applications in creative, educational, and research practices. The observation framework was designed to attend to changes in bodily expressiveness and bodily awareness in relation to movement and sound, while also identifying possible directions for adapting the device to other artistic, creative, and somatic practices.

To capture participants' first-person experiences, we combined body maps with open-ended questions (BM+OEQ) [38], semi-structured group/individual interviews (SGI/SII),

and open-ended questions (OEQ), tailored to each workshop's format, duration, and context (Table I). Across all sessions, qualitative OEQ responses elicited reflections on expressiveness, bodily awareness, affective experience, and device adaptations for creative or research practices. Specifically, W1 and W4 utilized sticky notes (OEQ+SN) for brief post-interaction responses. In W3 and W5, participants manually completed body maps immediately post-interaction to support visual and embodied reflection on how the device influenced movement, emotions, bodily sensations, imagination, and spatial relationships. SGI was conducted in W3, W4, and W5, with SII additionally used in W4. Finally, the NIME 2023 demo (W1), the Butoh dance improvisation (W2), and the Biophony workshop (W4) deployed an OEQ focusing on expressiveness, bodily awareness, and artistic practice adaptations.

Additionally, facilitators recorded post-workshop debriefs documenting observations and reflections. This complementary data source captured immediate, situated impressions of interaction dynamics, technical adjustments, participant responses, and methodological decisions.

All written data was digitized in spreadsheets to facilitate cross-reading across participants, workshops, and instruments. This heterogeneous material reflects the study's practice-based, research-through-design orientation, adapting methods to each workshop's situated conditions. Instead of imposing a uniform protocol, we tailored instruments to each activity's format, duration, and relational dynamics, spanning W1's public demo to extended workshop and residency formats.

Most sessions, along with the initial analysis, were conducted by the first author, a performance artist specializing in NIMEs and interactive sonification device design. Workshops W3 and W5 were co-led by an external collaborator and the fourth author, respectively.

This situated expertise shaped both the facilitation of the workshops, and the interpretation of the material. To address the potential subjective bias introduced by this position, the research protocols were iteratively co-designed with the co-authors, and the qualitative coding was cross-validated with senior HCI researchers (second, third and sixth authors) with expertise in qualitative methods and somatic experience.

Rather than applying predefined analytical categories, we adopted a bottom-up inductive strategy based on repeated review of the material and the progressive identification of common themes. These themes were refined through an iterative process of continuous comparison between participants, workshops, and contexts, allowing us to identify convergences, divergences, and recurring patterns in the data.

Special attention was paid to descriptions related to bodily expressiveness, muscle awareness, tension and relaxation, the sense of agency, and the role of sound in shaping bodily experience. This approach falls within the constant comparative method of grounded theory from Glaser & Strauss [39] and the inductive thematic analysis proposed by Braun and Clarke [40]. The following is a description of the experiences that constitute the study.

B. Demo at NIME 2023 (W1)

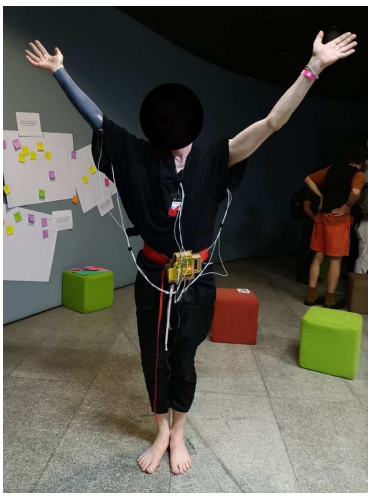

Fig. 2. Participant worn Joakinator and open questions wall at NIME 2023, W1. Photo by Emmanuel Torales, 2023.

1) Context and procedure

The first public experiment included in this study was a demo conducted during the NIME 2023 conference, in which approximately 20 attendees with diverse profiles linked to HCI research and artistic practice in new musical interfaces participated.

The demo was designed as a brief, exploratory interaction lasting approximately 15 minutes per participant. Participants were invited to select three muscles for the placement of EMG sensors, which controlled different sound parameters. During the experiment, the function of each sensor and its mapping (Fig.3) were not explicitly explained, prioritizing that participants establish their own associations between muscle activation, real-time graphic visualization, and sound.

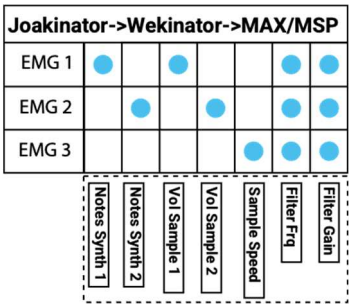

Fig. 3. Mapping from EMG to interactive sound system.

The interaction was organized progressively, moving from the exploration of a single sound material to the simultaneous control of multiple sounds, with an emphasis on the relationship between movement, muscular effort, and sound output. Two configurations were used: sampler control and stochastic MIDI notes generator.

At the end, participants and observers answered open-ended questions using sticky notes (OEQ+SN), addressing changes in bodily awareness, discovery of movements, and possible iterations of the device for their own practices (Fig.2).

2) Observations

During the demo, there was a continuous flow of participants for approximately three hours. After the first few minutes of interaction, most moved from an initial phase of frustration to a more immersive exploration. The observations

gathered from this experience, together with the subsequent improvisation with the Butoh dance teachers (W2), guided the following methodological iterations by revealing a recurring emphasis on bodily awareness rather than on the generation of new movements.

C. Butoh Dance Improvisation (W2)

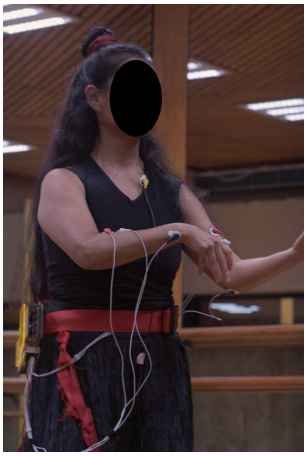

Fig. 4. Butoh dance teacher at improvisation. Photo by Emmanuel Torales, 2023

1) Context and procedure

In 2023, a 45-minute free improvisation was conducted with two Butoh dance experts whose practice centers on the nervous system as the primary motor of movement [41]. Conceived as an unguided, performative case study, each dancer wore a Joakinator interface (Fig.4), while one author used SoniBand [42], an accelerometer-based sonification system. Mirroring the logic of W1, an initial free-exploration phase transitioned from the visual recognition of muscle activation to mapping movement to controlled sound. Subsequently, minimal guidelines were introduced to encourage interaction. The dancers established a nonverbal dialogue using affective sound stimuli—including voices narrating dreams, water, electricity, and wind—modulated continuously by their movements.

2) Observations

A key methodological element was the use of external volume control managed by a sound technician. While this mediated setup—inherited from prior stage performances—enabled a distributed interaction model negotiated between performer, device, and technician, the dancers expressed a desire for fully embodied volume control to maintain their affective agency over the sonic environment.

Using the same open-ended questions as W1, one dancer provided feedback that explicitly articulated a fundamental shift from performative expressiveness to interoceptive awareness. She noted (OEQ): “I don't know if it's a new type of movement, but it is a greater awareness of possible bodily tensions and relaxations.” This observation guided the methodological shift toward bodily awareness in all subsequent workshops.

D. Biophony, Dancing Nature (W4)

1) Context and procedure

In 2024, the *Biophony, Dancing Nature* international residency gathered nine multidisciplinary artists to explore the intersection of Butoh dance, interactive technologies, and plant biosignals. Within this context, Joakinator was deployed to mediate the perception of internal physiological activity through the sonification of muscle tonicity, complementing other plant biorhythm systems. The methodological objective was for participants to explore the interface as an affective extension of their creative practices.

Four artists worked directly with the device, adopting distinct approaches. Two conducted free movement explorations using the W1 and W2 sound configurations. A third performer used breathing techniques to induce an altered state of consciousness, employing fragments of their own recorded voice as an affective sound stimulus activated and modulated by muscular arousal. A fourth artist, a guitarist, placed sensors on their forearm and dorsal muscles to control the dynamics of bird sounds during an instrumental improvisation. The residency director, a Butoh expert, also participated in this latter experience, generating a shared socio-affective dialogue between instrumental practice, movement, and the interactive system [43].

2) Observations

Fig. 5. Guitarist wearing the Joakinator for a performance Improvisation.

The residential setting’s extended timeframe enabled artists to adapt the interface directly to their specific creative languages. These exploratory discoveries were documented through field notes, as one author iteratively adjusted the system in real-time dialogue with the participants.

Technically, this iterative process supported reusing machine learning models and pre-processing EMG signals for specific instrumental practices (e.g., applying a second-order difference to forearm EMG via Wekinator for rapid hand activation). Experientially, modulating their own voice enhanced performers' perceived agency over their internal voice. This solidified the "situated sound" concept—first identified in W3—as auditory feedback carrying a direct symbolic or emotional charge. The following section expands on this affective-bodily intersection.

E. Tsonami (W3) and Earth (W5)

Fig. 6. Participant filling in a body map in W3. Photo by, Juan Hoppe, 2024.

1) Context and procedure

During the summer and fall of 2024, two methodologically similar workshops were conducted: W3 at the Tsonami sound art association (two days, consistent cohort), and W5 at Earth Synthposium centered on the restoration of a historic analog synthesizer (one day, two different groups). Both utilized the Joakinator and Felt Sound interfaces. The methodology synthesized HCI somatic techniques with Butoh dance awareness practices to sensitize the body prior to technological interaction. Sessions began with sensory warm-ups, including Mala Kline's "El Nido" visualization to induce a baseline of interoceptive awareness. This was followed by Atsushi Takenouchi's [44] Butoh exercises: "Mother Sea" (W3) where the facilitator guides participants to feel submerged in water and move with its cadence, later transitioning to embodying other natural elements [45], and "Zero Walking" (W5) where participants first walk rapidly to activate the body, followed by a gradual deceleration into an extremely slow, nearly static movement [46].

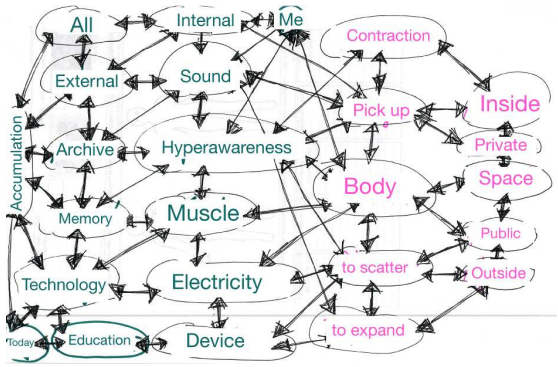

Fig. 7. Participants' semantic map trasnlated from spanish, W3.

Following a guided introduction, participants explored the prototypes in 25-minute rounds. A key innovation in these sessions was the explicit integration of situated sounds—emotionally and psycho-geographically meaningful stimuli, such as Valparaiso's port recordings (W3) or Synthi 100 synthesizer samples from a concert during the Synthpsosium (W5). These new selections replaced previous materials while trying to maintain timbral equivalence and categorical consistency (Table I). To capture this affective and somatic experience, participants completed body maps [34], [47] after each round, recording bodily perception, emotions, movement, imagination, and spatial relationships. Finally, sessions concluded by co-creating a collective semantic map, inspired by choreographer Guy Cools [48], to identify emerging themes and guide shared group reflection (Fig.7).

2) Observations

Across both workshops, notable insights emerged regarding shared socio-affective interaction and situated sound. When two participants shared a single interface to modulate a common auditory stimulus, distinct interaction dynamics surfaced. This shared control appeared to facilitate a strong sense of bodily transfer and connectivity, explicitly described by participants as (BM+OEQ): "The possibility of inhabiting another body that is not my own with respect" (W3), and "Adapting to the same space, to my movements and to my partner" (W5). Furthermore, the integration of situated sound was associated with a heightened focus on bodily sensations and affective somatic immersion—a phenomenon further expanded upon in the Discussion.

IV. Discussion

A. From Expressive Language to Bodily Awareness

Initially, we expected Joakinator to foster new forms of bodily expression. Giving muscles the ability to generate sound seemed conducive to developing a novel movement language, as we believed had occurred during prior artistic performances [33]. However, across all workshops, we observed that this focus predominantly shifted toward a different type of transformation.

Instead of discovering new movements, participants frequently reported a heightened focus on bodily awareness, particularly regarding muscle tension and relaxation. As the Butoh teacher noted (OEQ): "I don't know if it's a new type of movement, but it is greater awareness of possible bodily tensions and relaxations" (W2). This sentiment was echoed across different contexts, such as during the Biophony residency (OEQ-SN): "I don't feel like I found new movement but new awareness in movement" (W4). While this bodily awareness was observed across the diverse populations we engaged, the fundamental difference lay in expressive capacity: participants with somatic training (e.g., the Butoh teacher) possessed the tools to verbalize their lived experiences in greater detail.

This bodily awareness appears to develop incrementally. While baseline EMG sonification may initially support this increased focus, different sound materials seem to shape specific bodily sensations. Somatic techniques further facilitated interaction with the system, while "Situated Sound" appeared to add a layered effect, unfolding an affective dimension from the underlying sonification.

These results suggest that, with Joakinator, bodily awareness and affective transformation may precede expressive transformation. Sonifying muscle tonicity did not immediately produce new movement vocabularies; rather, it appeared to reorient attention inward [1]. Aligning with recent perspectives in embodied interaction, this shifts the role of Joakinator from an expressive control interface, toward a **perceptual interface** mediating between physiological signals, sound feedback, and experiential awareness. Ultimately, any novel expressivity seems to emerge from this deepened internal perspective of the body.

B. Role of Sound

Increased interoceptive awareness appeared to be facilitated by the affective feedback loop between body and sound. The need to consciously modulate muscle activation to produce a sound response encouraged an inward shift of attention. As the Butoh teacher noted (OEQ): "Attention is focused on making the Joakinator sound, on tensing or relaxing the muscles to produce a sound, which undoubtedly leads to attention to one's own body, one's own flesh and muscles" (W2). Sound seemed to function not merely as external feedback, but as a mediator making physiological states perceptible. A W4 participant described this as creating a second self (OEQ-SN): "It creates an 'other' that duplicates your identity and helps you to be your own (self) observer". This sonic reflection was associated with feelings of enhanced presence and strength, facilitating a more conscious integration of muscular perception.

Specific sound materials directly shape affective experience. Using situated, emotionally meaningful stimuli—such as recordings of ships departing the Valparaiso port—

intensified evocation and somatic immersion. During a two-person exercise, one participant reported (BM+OEQ): “The projection of the sound of the ship beyond the sea... I inhabited my partner's story, the projection of sound from the narrative” (W3), noting an improved overall bodily state (SGI). Linking physiological signals to recognizable, emotionally charged contexts amplifies affective agency and bodily involvement. This phenomenon, observed across W3, W4, and W5, opens avenues for future research into situated auditory feedback.

C. Implications Beyond Performance

Beyond the performative sphere, participants identified significant applications for Joakinator in educational and rehabilitation contexts (W1, W4). Specifically, they noted its potential for individuals with reduced mobility by translating internal muscular activation into audible feedback. Furthermore, a W3 participant reported a noticeable improvement in her somatic and affective state during a shared experience, highlighting the system's therapeutic potential (SGI).

From a dance education perspective, the Butoh teacher emphasized the interface's capacity to reveal movement as an expressive language (OEQ): “...it could serve to make us aware that movement is a language and to understand the body as a carrier of language... to understand the pause, create meaningful phrases, and accentuate certain phrases” (W2). This reflection frames the body as a carrier of affective meaning, where attention to tension, pause, and intensity becomes central.

Based on these observations, four emerging research trajectories appear: affective proprioception applied to physical rehabilitation; the sonification of internal physiological states for people with reduced mobility; the therapeutic and relational effects of closed-loop EMG sonification; and its integration as an auxiliary somatic tool in dance education.

D. Technical and Methodological Insights

Alongside experiential findings, methodological lessons seem to surface from the situated use of the device. Integrating somatic techniques from the performing arts as physical warm-ups were useful. These exercises established a baseline for bodily awareness, facilitating a progressive approach to the interface, reducing initial technological resistance, and promoting a more open disposition toward affective and sonic exploration.

Furthermore, shared control of the interface (W3, W5) manifested significant social-affective dynamics. Shared sonic interaction showed mutual coordination and attention mediated by sound, shifting the focus from individual control to listening to the movement and internal state of the other. Combining this prior somatic preparation with simplified technical setups allowed users' attention to rapidly shift from operating the device to the affective relationship between their bodies, the auditory feedback, and others presence.

Ultimately, these results suggest that Joakinator's impact does not depend solely on its technical design, but on the methodological framework, the affective sound materials, and the situated context. This ecosystem perceptibly influences affective agency, interoceptive attention, and the quality of the embodied experience. This configures Joakinator less as a tool oriented exclusively toward expressive production and more as an instrument of perceptual transformation.

V. Limitations and Future Work

A key study limitation is the difficulty of isolating the interface's individual impact from the somatic techniques and affective sound stimuli. However, this reflects Joakinator’s design as an integrated ecosystem where hardware, auditory feedback, and methodology form a cohesive unity; the affective experience emerges from entangled relationalities between body, sound, and context, rather than technology alone. Additionally, potential sensory exhaustion from prolonged stimulation [49] necessitates integrating progressive adaptation and desensitization strategies [50], [51] in future protocols.

Consequently, future research must employ controlled experimental designs—keeping sound materials and assessment instruments constant—to empirically isolate variables and clarify the role of situated, emotionally meaningful auditory stimuli in transforming bodily perception. Furthermore, longitudinal studies within real artistic processes are required. These lines will elucidate situated sound effects and broaden our understanding of Joakinator’s ecosystem as a perceptual interface beyond experimental settings.

VI. Conclusions

While we anticipated Joakinator would create a sonic machine embodiment—granting the body a new expressive organ—what emerged was profoundly different: an expanded "cyborg" proprioception, as if muscles possessed built-in speakers. This positions Joakinator as an interface for sensory and affective expansion, rather than merely a performative tool.

Auditory feedback drove this shift. Returning to our initial metaphor, sonification acted like incense smoke revealing hidden currents—making the micro-movements of muscular tension and relaxation continuously audible. Making these hidden physiological processes perceptible altered the users' relationship with their bodies, shifting focus from external movement manifestations to internal states. This perspective broadens the interface's applicability beyond the performing arts into educational, rehabilitative, and accessibility contexts, where sonifying internal movement can significantly expand interoceptive awareness.

Throughout the process, the role of sound also evolved. While basic muscle sonification altered attentional states, introducing situated auditory stimuli extended this effect into symbolic and emotional dimensions. This intensified somatic immersion, revealing sound's potential as a powerful mediator between physiological perception and affective meaning.

Ultimately, while movement expressiveness was modified, it became secondary to heightened bodily awareness. The primary contribution of Joakinator’s ecosystem lies not just in expanding physical expressivity, but in making internal bodily states audible. While generalizability was not the aim of this exploratory work, and future experimental studies are needed to make causal or generalizable claims, giving sound to what normally remains invisible integrates it into conscious awareness, opening new avenues for affective computing research at the intersection of body, sound, and emotion

ETHICAL STANDARDS

A. Human Subjects Research, Privacy, and GDPR Compliance

This research involved voluntary participation in workshops, demonstrations, and artistic residencies conducted in artistic and educational contexts. All research activities and data management protocols strictly comply with the European Union's General Data Protection Regulation (GDPR), ensuring the highest standards of privacy and data protection for all participants. Participation was based on explicit informed consent, and individuals were free to withdraw at any time without consequence. The study employed qualitative methods (body maps, group discussions, written reflections); no personally identifiable information (PII) or sensitive biometric data were collected or retained for identification purposes. All participant quotations have been fully anonymized. The research did not involve vulnerable populations, medical interventions, or animal subjects.

B. Open Source Philosophy and Data Transparency

In alignment with the principles of open science and transparency, our technological developments adhere to an open-source philosophy. All research conducted within this project is strictly non-profit, and findings are disseminated through open-access publications whenever possible to ensure broad accessibility and facilitate scientific reproducibility.

C. Limits of Generalizability

We acknowledge that the findings of this study are contextually specific. The participant demographic consisted primarily of dancers, performing artists, and HCI experts, which limits the generalizability of the findings to broader populations or different cultural contexts. Furthermore, our methodological reliance on qualitative self-reports captures subjective embodied experiences rather than objective "ground truth" readouts of internal emotions, and is subject to the inherent biases of self-reporting.

D. Potential Societal Impact and Misuse

While Joakinator was developed as a perceptual interface to enhance artistic expression and interoceptive awareness, we recognize the moral obligation to consider potential misuses of physiological sonification. Technologies capable of reading muscle tonicity and physiological arousal could potentially be misused for non-consensual surveillance or monitoring of affective states, thereby restricting individual autonomy. To counter this, the philosophy and architecture of Joakinator are explicitly conceived as a disruptive instrument intended to provoke critical reflection on technological mechanisms of power. While this conceptual framework does not render the technology immune to co-optation or misuse, a deliberate seed of critical reflection regarding philosophical power relations is embedded within its very design. By subverting traditional biometric monitoring into a tool for subjective self-awareness, the system is actively designed to foster embodied agency rather than passive external surveillance. We strongly advocate that future applications building upon this framework strictly prioritize transparent consent and safeguard users' affective privacy.

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