Soma Design for NIME

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ABSTRACT
Previous research on musical embodiment has reported that expert performers often regard their instruments as an extension of their body. Not every digital musical instrument seeks to create a close relationship between body and instrument, but even for the many that do, the design process often focuses heavily on technical and sonic factors, with relatively less attention to the bodily experience of the performer. In this paper we propose soma design as an alternative approach to explore this space. Soma method aims to attune the sensibilities of designers, as well as their experience of their body, and make use of these notions as a resource for creative aesthetic design. We report on a series of workshops exploring the relationship between the body and the guitar with a soma design approach. The workshops resulted in a series of guitar-related artefacts and NIMEs that emerged from the somatic exploration of balance and tension during guitar performance. Lastly we present lessons learned from our research that could inform future Soma-based musical instrument design, and how NIME research may also inform soma design.

Author Keywords
Soma design, augmented guitar, breath control, bodily experience

CCS Concepts
• **Applied computing** → **Sound and music computing**; • **Human-centered computing** → Interaction design theory, concepts and paradigms

1. INTRODUCTION
Playing a musical instrument is a performative bodily act. Some parts of the body are used to excite or control the instrument while others shape an overall bodily posture that enables but also constrains instrumental technique. Some instruments require many years of training and attuning of the body to reach a state of expertise. In the process, skilled performers often come to consider the instrument as an extension of their body [22]. The musical body is also aesthetic, moving with the instrument in ways that may both look and feel good. However, the body can also pose problems for musicians through injury, tension and symptoms of anxiety that can affect immediate performance or long-term wellbeing.

There have been many discussions about the human body within NIME literature, especially on how the body can be used to control new kinds of musical instruments, either directly through touch or indirectly through gesture or even sensing its internal state. However, the dominant focus of attention remains in the instrument. In other words, NIME research often talks about what the instrument *is*, what the instrument *does*, and the relationship between the instrument, the performer and the audience. With a few exceptions [2,7,16,25], we seldom refer to the internal subjective experience of the performer's body and the sensations that arise while playing an instrument as a fundamental component of the design process.

However, there has been an increasing interest in body-centred approaches within interaction design, including innovation in more overtly body-oriented methods. One of these methods is soma design, which puts the focus squarely on designing *with* and *through* the body [8]. Soma design is mainly concerned with the first-person perspective of aesthetic and sensuous experiences and on honing the ability of designers to discern such somatic experiences and harness them to devise interactive experiences—in turn honing users' aesthetic skills when engaging in those interactions. Among the tactics of soma design are the exploration of non-habitual movements and estrangement methods [8,27] as well as engaging in various bodily practices thoughtfully and deliberately, including for example *Feldenkrais* exercises, which aim to refocus attention on the fine nuances of bodily experience [4]. It would seem from this description that soma design might potentially speak to the design of NIMEs, offering a route to realising more body-centred and aesthetic musical instruments.

Our paper therefore explores the application of soma design to NIMEs. We report a design process in which we brought together a team of people with expertise in music performance, NIME design and soma design, for two workshops. We focused on the bodily experience of playing the guitar, as a familiar and commonplace musical instrument which is widely available and associated with various bodily practices across different cultures and musical genres, ranging from the formality of classical training to the expressivity of pop and rock. The workshops involved a combination of bodily exercises and exploratory lo-fi prototyping aiming to understand and de-familiarise previous notions of guitar playing. Ultimately, they led to a series of design concepts for new musical instruments—most notably the concept of *breathing guitars*—that refocus musicians on their own bodily sensations and practices and shape a physically tightly coupled bodily engagement between instrument and performer.

2. RELATED WORK
2.1 Soma design
The soma design framework offers a design stance grounded in evolutionary biological models of human morphology [23] as well as theories pertaining to aesthetics, or more precisely *somaesthetics* [24]. Somaesthetics is a term that combines *soma*—our non-dualistic subjective self, body, emotion, and thinking—and *aesthetics*—as in our ability to perceptually appreciate the world around us, what we feel, hear, see and engage with. Beyond providing a firm grounding in human morphology and somaesthetic appreciation ideals, the soma design framework adds an active, creative, design attitude. The fundamental promise of soma design is that if designers train their somaesthetic sensibilities, engaging in form-giving processes, gaining tacit knowledge of the technological

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materials at hand, they can learn how to better shape the somaesthetics of the interaction gestalt [14].

When we hone and care for aesthetic qualities of the technologies we use to construct our interactions and when we attend to our own experiences, the designs we bring forth will orchestrate experiences that in turn spur improved aesthetic engagement for our prospective users. By questioning, deconstructing or simply providing alternative ways of walking, breathing, touching or experiencing in our everyday lives, the meaning and experiential potential of our everyday activities come into focus. From this fertile ground, a whole range of new interactions can be imagined [8].

In this light, guitar playing illustrates an interesting somatic practice to be explored. With growing expertise the player enters into what Ingold frames as a 'correspondence' relationship with the guitar [9]. The guitarist becomes 'one' with the instrument and the sound it emanates. Expertise is gained slowly and it involves developing bodily control, dexterity, musicality and emotional expression. As the whole body is involved, it becomes unclear what comes first: strumming on the strings, hearing the sound, engaging the fingers, the whole arm, the muscles in the back, breathing, swaying—all of it rather becomes an integrated whole.

2.2 The body and embodiment within NIMEs

The human body, its motions and its embodiment relationship with musical instruments have been extensively studied and employed as resources for the design of NIMEs. Within music research there is an extensive corpus of work that explores the relationship between the human body and its interactions with traditional musical instruments, as well as the associated enaction and embodiment of musical activities.

Previous work has addressed the physical and sensory correspondence between the performer's body and the musical instrument, as well as how the latter can become an extension of the body [22]. However, existing arguments call to attention that NIMEs may lack the inherent acoustic affordances of traditional musical instruments, which may affect the resulting embodied experience of the performer [15].

Correspondingly, there have been attempts to imbue NIMEs with the acoustic "feel" of traditional instruments by simulating their vibrotactile feedback [19], with the aim of enhancing the engagement of the performer with the instrument. This discourse however puts the instrument at the centre of the discussion and the design process.

Alternatively, there is extensive work within NIME research which draws the attention towards the human body, such as investigating the bodily gestures of musicians during performance, i.e. musical gestures [12]. These gestures have been abstracted by different means, such as motion capture and detailed observation. As a result, multiple classifications of musical gestures have emerged from this research, which in turn have influenced the design of several NIMEs. For example, ancillary gestures, i.e. the subtle movements of the body that accompany performance gestures but are not directly involved in producing sound (e.g. the swaying of the guitar neck), have been harnessed as a way to control sound effects with a guitar whilst minimizing the interruption of performance [13,21]. Likewise, these measurements of movement are reflected in the abundant use of motion capture and gesture recognition systems within NIME projects [6,26]. Nonetheless, this design approach mainly seeks to repurpose bodily gestures as inputs for sound control in NIMEs.

Yet another area that has been widely explored is the sonification of the bioelectrical signals of the body. In contrast with the external motion-capture data used to map musical gestures to sound, this approach exploits the 'internal' data of the human body. In particular, electromyographic data from the muscles has been frequently used to exploit subtle bodily movements as sonic mappings. In this sense, the performance of music becomes tightly coupled with the human body, arguably transforming it into a musical instrument [11,25].

Nevertheless, we see an absence of works within NIME that explore soma design as an approach to NIME design, or as a resource to inspire new concepts for musical expression based on the somatic experience of performing an instrument, such as the sensations that arise in the body when doing so. To the best of our knowledge, only a few existing projects have considered somaesthetics as a framework for design [2].

3. THE DESIGN PROCESS

Let us now turn to an account of a soma design process as it unfolded over the course of six months, throughout two design workshops, with reflection and prototyping in between. The process involved interaction design researchers with a mixed expertise in soma design and guitar playing. Although the structure of both workshops varied there was a core thread that provided continuity throughout the process as we now describe.

3.1 The first Soma workshop

The first workshop addressed the theme of *bodily balance*, lasted two days and involved 16 participants with strong backgrounds in interaction and soma design. In total, four groups were formed to explore the theme. One of the groups involved the augmented guitar project discussed here. The guitar group consisted of four interaction design researchers: two with substantial expertise in guitar playing (who are authors in this work) and two with soma design.

3.1.1 Bodily explorations

A Feldenkrais practitioner took part in the workshop to lead a session of bodily exercises on the first day. Feldenkrais employs techniques that help deepen one's somaesthetic sensibilities: e.g. disrupting habitual movements, closing the eyes and moving slowly in order to focus and feel every small detail of a movement. One of the exercises encouraged the participants to reflect on how the sitting bones are balanced by doing subtle oscillations of the whole body whilst sitting on the floor. The soma design researchers also brought the *Soma bits* prototyping toolkit [28], which consists of a series of soft and rigid objects shaped in different forms that can be combined with different actuators, including heat and vibration. The shapes can be stacked or chained together and placed on and around the body (Fig. 1).

Figure 1. The Soma bits prototyping kit.

In the guitar group we used the Soma bits to explore different areas around the body whilst holding a guitar. For example, heat pads and vibration actuators were placed at different points of contact between guitar and body such as the torso. Other bodily contact areas explored were the feet and shoulders as they are also engaged during guitar playing whilst standing up—e.g. when wearing a guitar strap and operating effects pedals. Observing the body swaying back and forth or from side to side when strumming the guitar, illustrated the central role of these movements in maintaining balance. Inspired by such movements, we started exploring an elastic exercise rubber band as a guitar strap, observing how this could support the experience of playing the guitar. The stretchy strap affected the balance of the guitarists and allowed them to sway the guitar neck around as they played, encouraging new kinds of bodily movements with the instrument. We also worked with several round-shaped Soma bits with a rigid base but a soft top, allowing the participants to step on top and mould them with their feet, creating a sort of 'cushy pedalboard' (see Fig. 2). Moreover, other materials were also inserted beneath the cushioned parts of these objects to add texture and interactivity to their surface, such as rubber spheres and vibrating actuators with modulated intensity. We also experimented with stacking several of these cushy pedalboards to create a sort of seesaw, which allowed the participants to sway back and forth, as well as balance themselves when standing on top of the stack, again encouraging whole body movements when playing the instrument.

3.1.2 NIME ideation and prototyping

Reflecting on bodily balance by becoming attentive to the swaying of the whole body and the feet when playing the guitar, whilst using the stretchy strap and the cushy pedals, led to a series of design ideas. One was to provide haptic feedback through vibrations beneath the feet or through the strap in order to allow the guitarist to feel the tempo of the music or cues in a performance. Another idea dabbled on the possibilities of vibrations or heat to comfort nervous performers. Likewise, the swaying motion explored with both the stretchiness of the strap and the balancing of the boards led to the idea of potential sonic mappings using these movements.

Figure 2. Playing with the stretchy strap and cushy pedals.

At the end of the workshop each group prepared a prototype to showcase to the other groups. In the case of the guitar group, both the stretchy strap and the balancing mat were presented as concept NIMEs by doing a *Wizard of Oz* performance where one of the guitarists wore the strap whilst balancing on top of the boards, and played an electric guitar running through a digital audio workstation (Fig. 2). Whilst the guitarist played, he pretended to modulate the sound effects of the guitar, through moving the guitar neck and sway on the mat, whilst the other guitarist controlled the effects on a laptop.

3.1.3 Critical reflection and next steps

Reflecting on the workshop, we identified two outcomes that we wished to carry forward. First, the thematic focus on balance and the related body de-familiarisation exercises led us to focus on diverse parts of the body such as the shoulders, abdomen and feet, rather than the fingers and hands which are directly used to interact with the guitar. Second, bodily explorations with the Soma bits helped de-familiarise the experience of playing the guitar and directly inspired two unusual design ideas described above. Another reflection was that relatively little time had been spent 'plucking the strings' or even making musical sounds in the workshop. The focus was more on the embodied sensation of playing rather than the music being played.

We also noted two challenges with the workshop. First, given that some of the designers lacked guitar playing expertise, they struggled to understand the *felt sensation* of playing and expressed some limitations when engaging with this artefact. Second, even though the Feldenkrais practitioner led the bodily sessions at the beginning of the workshop, she did not stay for the whole workshop. As she did not engage in the design work carried out throughout the whole workshop, her valuable somatic expertise was largely absent from the focused design process.

After the workshop, the stretchy strap idea was further developed with e-textiles and Bela during a hackathon [5]. The progress with the prototype motivated us to do a second workshop entirely focused on augmenting guitars with soma design, which we describe in the next section.

3.2 The second Soma workshop

The second workshop also lasted two days and served to deepen our exploration of ideas that had emerged during the first one, especially ideas on balance of the body and associated *tension* when playing the guitar. The thematic focus on tension included ideas of: a) physical tension experienced in various parts of the body when playing the guitar, b) the mental tension of performance anxiety, c) the expressive build-up and release of musical tension in performance, and d) the material tension in the stretchy strap prototype and its potential interaction techniques. However, we were deliberately open to other concepts and technologies to avoid narrowing the scope of design. The workshop involved ten participants; five whom had previously attended the first workshop (two taking part in the guitar group), and all authors of this paper were present. To prevent the 'expertise gap' from the first workshop, we sought to evenly distribute the participants into two groups, in terms of guitar playing and soma design expertise. We also brought along several guitars: two acoustic guitars and a 'silent guitar' with an open frame that allowed for other materials to be attached to it (see Fig. 4).

3.2.1 Bodily explorations

We invited a Feldenkrais practitioner with expertise in guitar playing, and soma design, who skilfully designed bespoke bodily exercises to address the theme of tension in guitar playing. He led two sessions of exercises (one each day) but also was an active participant during the entire workshop. The workshop started with the Feldenkrais session, led by the practitioner. The exercises performed were focused on self-awareness of tension, firstly by working individually and then by working in pairs, reflecting on tensions located on the arms, palms and fingers together. By slowly moving the fingers the participant explored the micro-movements of the hand and reported their impact on other parts of their bodies. The exercises helped us understand the boundaries of pleasant/unpleasant experiences when

focusing on tension, as well as opportunities for shared physical control and the interconnectedness of different body parts, as reported on the subsequent sharing of experiences.

3.2.2 Somatic facilitation of guitar playing

In order for everyone to experience guitar playing, the two groups conducted several experiments to enable non-guitarists to 'feel' guitar playing as a guitarist would. Some of these experiments were quite subtle, for example a guitar was passed around so people could tinker with it and become comfortable with holding and touching the guitar. Another approach involved setting the guitar in an open tuning so that chords could be easily performed by simply strumming the guitar. This lead to exploring the sonic range of the instrument, from playing 'clean' to loud and heavily distorted tones.

Other experiments were more radical, for example, two participants taped their fingers together so the non-guitarist could experience the movement of fretting a chord or playing a scale on the guitar whilst their hand was on top of the guitarist's hand, which was doing the actual movement. Another exploration involved two people playing one guitar, with the guitarist fretting the chords and the non-guitarist strumming the strings. Even though the experiments could only partially help non-guitarists gain a first-person bodily experience of guitar playing, they were evocative enough to enable them to contribute insights during the workshop. Most importantly, these experiments made the guitar the core of the design process—the guitar became *present* in the ideation process.

3.2.3 NIME ideation and prototyping

The Soma bits were once again used during this workshop. Design explorations begun by de-familiarising how the guitar is played and held. Explorations included attaching small vibrating actuators to the fingers of the fretting hand to disrupt their movements. Of the different interactive Soma bits, the inflatable shape-changing actuation materials were deemed to be the most evocative during the design explorations by both groups, as they could be placed on different areas between the body and the guitar. One group started placing inflatable cushions near the guitar's bridge, observing how the expansion altered the bodily sensation of playing the guitar with the strumming hand, alongside its sound producing capabilities. The other group focused on the use of the inflatables to alter the bodily sensation and experience of holding the guitar close to the body. Inflatable cushions were placed at various points of contact between the guitar and the body, including the back of the guitar pressing into the stomach or under the shoulder.

During the plenary discussion at the end of the first day, both groups compared experiences and honed in on key themes of interest. One was the significance of breathing as an important—but often overseen—part of the experience of playing the guitar, as it is inherent to the sensation of physical engagement with the guitar which lays across the abdomen. It was also deemed crucial for controlling nerves and anxiety, but also something that could be easily forgotten, given that attention is mostly drawn to the hands.

The participants also reflected in the Feldenkrais exercises that involved a push and pull between the participants fingers, leading to the concept of an autonomous shapeshifting guitar. At this point the soma designers also brought an inflatable corset, an on-going project they had been exploring in the context of singing performance. One of the participants wore it whilst playing the guitar and prompted the idea of a breathing guitar that could synchronise with, and draw attention to the breathing of its player.

3.2.4 Two concepts of a Breathing Guitar

The second day of the workshop began with another Feldenkrais session, which the practitioner designed to focus attention on the bodily experience of breathing. Participants were guided to observe, feel and engage with their breathing, through self-exploration of the abdominal cavity. They were encouraged to feel their abdomens with their own hands, along and under their ribs and down into the pelvis, attuning themselves to their movements and the sensations of moving with, or resisting pressure while breathing. After this, the two groups continued their soma design explorations in this context and developed two different lo-fi mock-ups of concepts of breathing guitars.

Concept 1. Breathing Straps. One group explored the idea of re-designing the strap so that it would foster a more intimate contact between the guitar and the body. An idea was to affix the guitar to the body of the player by wrapping a stretchy strap around the waist and the belly of the guitarist. This was then paired with an additional stretchy strap going around the neck and shoulders of the player, securing the guitar even more firmly to the body, as well as providing a "hugging" sensation to the player (Fig. 3, top). The way one of the straps was attached to the front of the guitar muted the instrument, switching the focus during the testing session from the sound production to perceived physical sensation. Building on previous lessons with the original stretchy strap concept, the group considered how moving the guitar on the horizontal and vertical planes might then control the sound output of the instrument in nuanced ways. Different static shapes and then inflatables were added to the cavity between the guitarist's belly and the body of the guitar, in order to simulate actuation to the horizontal and vertical straps so that the guitar might potentially push back against, as well as sense breathing and other bodily movements from the guitarist. It was then decided to replace the horizontal strap with a big inflatable shape (Fig. 3, bottom), opening up the idea of simultaneously using it as a sensor/actuator; moving the instrument closer to, or further away from the player's body; responding to and mimicking breathing, and interacting with it through squeezing (like a bagpipe).

Figure 3. Group 1's breathing guitar concept enacted through stretchable and inflatable body straps

Concept 2. Breathing Guitar Surfaces. This concept is focused on augmenting the body of the guitar itself by attaching inflatable pressure pads to various points at which it comes into contact with the player's body. It was notable that the Feldenkrais practitioner acted as the test player here, wearing the guitar and reporting on his experience from both a perspective of player and soma practitioner. Ultimately, this led to attaching the pads to three key contact points, one on the back of the silent guitar where it presses into the belly, a second under the arm that leans around the body and holds the instrument stable, and a third under the fretting hand along the neck. Inflation of the three pads to varying extents, and in and out of synchronisation was controlled with a mobile app using OSC (Fig. 4). First impressions were that the pad on the belly gave a gently intimate sense of breathing and a subtle connection to the player's own breathing while the one on the strumming arm gave a sense of the guitar's expansion and possible awareness of the player's hand posture. The latter was perhaps the most remarkable, as it call for immediate attention to the hand, sometimes making it difficult—even

impossible—to play the guitar when extensively inflated. This observation led to the idea of a guitar that might actively push back against the player, for example refusing them to let them play at some parts of the neck, perhaps provoking them to break their habitual playing patterns or to improvise.

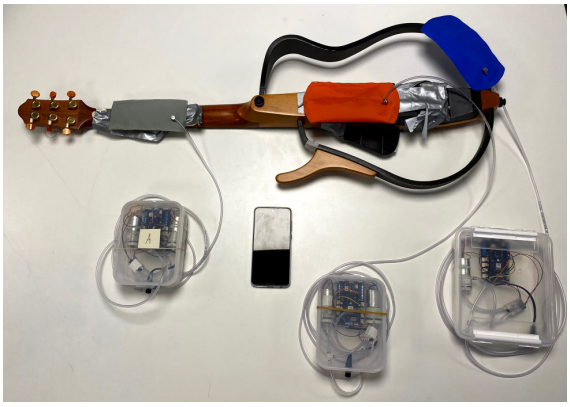

Figure 4. Group 2's breathing guitar concept prototyped through three strategically placed inflatable pads

4. DISCUSSION

Our reflections on the workshops cover three topics. First, we discuss the possibilities for new kinds of *breathing* instruments; next we consider wider lessons for the NIME community that arise from embracing the soma design approach; and finally, we highlight some lessons for soma design in general.

4.1 Breathing instruments

We have foregrounded two new body-oriented design sensitivities for designing new musical instruments: balance and tension. Investigating these though a soma design process generated a new concept, that of *breathing instruments* which we propose may offer two broad benefits to musicians.

Playing music. The first concerns new possibilities for generating and controlling music. Breathing instruments raise possibilities for controlling sound by squeezing them to deflate them or by blowing air into them to inflate them, including being able to act on different parts of the instrument (e.g, squeezing the neck versus the body). This mirrors previous explorations of breath controlled and squeezable instruments [3,17]. However, breathing instruments could also push back, giving feedback and creating control loops. They might also assume an autonomous character, seeking to influence a musician's playing, for example by dynamically making it more or less difficult to fret notes on some parts of the neck of a guitar. Such shape-changing instruments might encourage improvisation by taking the player out of their comfort zone and might even give the sensation of engaging a "live" thing rather than a static object.

Somatic awareness and relaxation. A second potential benefit coming from a somaesthetic perspective is to raise musicians' awareness of their own bodily experience in relation to the instrument. We propose that enhanced somatic awareness might help enhance technique by enabling musicians to acquire better breath control while playing given that breathing is recognized as an important part of playing many instruments (not only those that are driven by it). Breathing instruments might improve musicians' physical and mental wellbeing by nudging them to breathe so as to release physical and mental tension while playing with benefits ranging from improved posture during performance preparation [1] to better coping with performance anxiety. These suggestions reflect previous research into breath controlled interfaces. Studies of a breath controlled flexible tent showed how it could entrain some occupants' breathing leading to relaxation [10]. In contrast, studies of a breath controlled bucking-bronco amusement ride showed how attempts to hold one's breath could increase the sensation of tension [18].

4.2 A fresh perspective on designing NIMEs

Broadening our perspective, we believe that soma design can bring a new perspective to NIME and guitar augmentation alike. While we cannot claim that our concepts might not have emerged from some other design process, we can point to several key points at which soma design clearly shaped our thinking. The initial focus on balance and whole body interaction in Workshop 1 led us to develop the transitional concepts of stretchy strap and cushy pedals. These were carried forward into Workshop 2 and refined by applying the theme of tension. To experiment with tension, we performed relevant Feldenkrais exercises, which in turn helped us to sharpen our bodily awareness of breathing and led to further experiments with inflatables attached to the body of the player and the body of the guitar. Throughout, our design focus was repeatedly brought back to the bodily sensation and aesthetic of playing the guitar rather than the generation of sound that is often the focus within NIME.

The first major shaping factor was the grounding of the approach in the Somaesthetic philosophy which encouraged us to see the musical instrument as an extension of the living body rather than just a mere object or the cognitive extension of our mind [15]. At NIME it is generally accepted that music technology can act as an extension of the body, but the design process often begins by focusing on technology itself and the particular interaction capabilities it affords; we see this in the papers proposing design toolkits or exploring musical applications for recently released commercial technologies like Kinect [26], Leap Motion [6], or Myo [11]. The result is that the idiomatic patterns of the technology exert a strong aesthetic influence on the musical outcome [20]. The soma design method turns this process around, beginning with the body without any explicit focus on technology. In fact in this process, the specific technology used to implement a particular idea remains a secondary consideration. In this way it shares certain features with design fiction exercises as well as improvisational and experimental design processes [5].

Other shaping factors were manifested in the specific soma methods. De-familiarisation techniques put us in a space where we were open to new possibilities, deconstructing the habitual way we move or use a certain artefact. It helped to bring to the surface aspects of playing the guitar, which usually remain involatile and implicit. The use of the Soma bits prototyping kit during the design sessions enabled bodily explorations and lo-fi concept design work by making affordances and properties of these speculative interactions tangible. Soma experts were scrambled into teams alongside musicians. While soma practitioners were naturally less focused on sound production, music making and the other 'usual' perspectives on instrument design in NIME, they brought new perspectives concerned with body awareness and whole body experience. Finally, working with silent or silenced instruments also reduced the focus on sound and created space for other aspects of bodily experience to come to the fore.

4.3 Lessons for Soma design

Our experience also generated some new insights into the soma design process. One was the challenge of the expertise gap. Having guitarists and non-guitarists involved in groups was useful in questioning assumptions about the instrument. However, successful collaboration required techniques for familiarising the instrument to non-players while de-familiarising it for relative experts. In addition we learned that

it was helpful to involve the Feldenkrais practitioner throughout the workshop as he helped to mediate different aspects of the soma design process, such as bodily awareness, somatic facilitation (communicating felt sensations to others) and ideation in response to emerging themes during the sessions.

5. CONCLUSIONS

To conclude, we propose that soma design has an important and distinctive role to play in the design of NIMEs that emphasise the aesthetics of playing an instrument alongside the generation of sound. We have documented an example of soma design in practice and offered evidence for how it shaped the emergence of an unusual design concept—that of a breathing guitar. We believe that there is great potential for further refining and applying the soma design approach within the NIME community

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7. REFERENCES

[1] J.P.M. Avila, A. Hazzard, C. Greenhalgh, and S. Benford. 2019. Augmenting Guitars for Performance Preparation. In Proceedings of the 14th International Audio Mostly Conference: A Journey in Sound. Nottingham, UK. ACM, 69–75. DOI: https://doi.org/10.1145/3356590.3356602

[2] M. S. Bomba and P. Dahlstedt. Somacoustics: Interactive Body-as-Instrument. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2019, Porto Alegre, Brazil.*

[3] P.R. Cook. Real-time performance controllers for synthesized singing. In *Proceedings of the 2005 conference on New interfaces for musical expression, 2005, National University of Singapore.*

[4] M. Feldenkrais. 1972. Awareness through movement. New York: Harper & Row

[5] G. Lepri, A. McPherson and J. Bowers. 2020. Useless, not Worthless: Absurd Making as Critical Practice. In Proceedings of the Designing Interactive Systems Conference, ACM.

[6] J. H. and N. E. Gold. 2014. Lessons learned in exploring the Leap Motion™ sensor for gesture-based instrument design. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2014, London, UK.*

[7] I. Hattwick, J. Malloch, and M.M. Wanderley. 2014. Forming Shapes to Bodies: Design for Manufacturing in the Prosthetic Instruments. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2014, London, UK.*

[8] K. Höök. 2018. Designing with the body: Somaesthetic interaction design. MIT Press.

[9] T. Ingold. 2011. Being alive: Essays on movement, knowledge and description. Routledge.

[10] N. Jäger, Holger Schnädelbach, Jonathan Hale, David Kirk, and Kevin Glover. 2017. Reciprocal control in adaptive environments. *Interact. Comput.* 29, 4 (2017), 512–529.

[11] A.R. Jensenius, V.E.G. Sanchez, A. Zelechowska, and K.A.V. Bjerkestrand. Exploring the Myo controller for sonic microinteraction. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2017, Aalborg University Copenhagen, 442–445.*

[12] A.R. Jensenius, M.M. Wanderley, R.I. Godøy, and M. Leman. Chapter 2. Musical gestures: concepts and methods in research.

[13] O. Lähdeoja. An Approach to Instrument Augmentation: the Electric Guitar. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2008, Genova, Italy.*

[14] Y-k Lim, E. Stolterman, H. Jung, and J. Donaldson. 2007. Interaction gestalt and the design of aesthetic interactions. In *Proceedings of the 2007 conference on Designing pleasurable products and interfaces*, 239–254.

[15] T. Magnusson. 2009. Of Epistemic Tools: musical instruments as cognitive extensions. *Organised Sound 14, 2 (August 2009), 168–176.* DOI: https://doi.org/10.1017/S1355771809000272

[16] T. Magnusson and E.H. Mendieta. The acoustic, the digital and the body: A survey on musical instruments. In *Proceedings of the 7th international conference on New interfaces for musical expression, 2007, New York, USA. ACM, 94–99.*

[17] M. Marier. 2014. Designing Mappings for the Sponge: Towards Spongistic Music. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2014, London, UK*, 525–528.

[18] J. Marshall, D. Rowland, S. Rennick-Egglestone, S. Benford, B. Walker, and D. McAuley. 2011. Breath control of amusement rides. In *Proceedings of the SIGCHI conference on Human Factors in computing systems, 73–82.*

[19] Mark T. Marshall and Marcelo M. Wanderley. 2011. Examining the Effects of Embedded Vibrotactile Feedback on the Feel of a Digital Musical Instrument. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2008, Oslo, Norway, 399–404.*

[20] A. McPherson and K. Tahiroglu. 2019. Idiomatic Patterns and Aesthetic Influence in Computer Music Languages. *Organised Sound Int. J. Music Technol. (2019).*

[21] F. Morreale, A. Guidi, and A. McPherson. Magpick: an Augmented Guitar Pick for Nuanced Control. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2019, Porto Alegre, Brazil.*

[22] L. Nijs. 2017. The merging of musician and musical instrument: Incorporation, presence, and levels of embodiment. In *The Routledge companion to embodied music interaction. Routledge, 49–57.*

[23] M. Sheets-Johnstone. 1999. The primacy of movement. *John Benjamins Pub.*

[24] R. Shusterman. 2008. Body consciousness: A philosophy of mindfulness and somaesthetics. *Cambridge University Press.*

[25] A. Tanaka and M. Donnarumma. 2018. The body as musical instrument. *Oxf. Handb. Music Body 1, (2018).*

[26] S. Trail, M. Dean, G. Odowichuk, T.F. Tavares, P.F. Driessen, W.A. Schloss, and G. Tzanetakis. Non-invasive sensing and gesture control for pitched percussion hyper-instruments using the Kinect. In *Proceedings of the International Conference on New Interfaces for Musical Expression, 2012, Ann Arbor, USA.*

[27] D. Wilde, A. Vallgårda, and O. Tomico. 2017. Embodied Design Ideation Methods: Analysing the Power of Estrangement. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, New York, NY, USA, 5158–5170. DOI: https://doi.org/10.1145/3025453.3025873

[28] C. Windlin, A. Ståhl, P. Sanches, V. Tsaknaki, P. Karpashevich, M. Balaam, and K. Höök. 2019. Soma Bits-Mediating Technology to Orchestrate Bodily Experiences. In *RTD 2019-Research through Design Conference 2019, the Science Centre, Delft, on 19th to 22nd March 2019.*