About TIME: Textile Interfaces for Musical Expression

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ABSTRACT

Research in new musical interfaces includes exploring sometimes unconventional materials, drawing from a wide range of sources, but typically affiliated with the computing industry. These interfaces are made out of plastic, metal, glass and rubber, built with sensors that seek precision and ergonomic control. However, there are other more unconventional interfaces, such as flexible and soft instruments that allow for different types of interaction. One of the materials that has not been explored extensively in this context, are textiles, in particular e-textiles. Here, we survey the NIME archive and provide an overview of the work on non-rigid interfaces. Further, this paper presents a new textile based musical interface and evaluates its potential as a malleable, expressive instrument through a case study with 6 musicians. The findings of the qualitative analysis conclude a set of guidelines for the development of future e-textile interfaces.

Author Keywords

textile interfaces; soft materials; soft instruments; e-textiles; human-material interaction; textile synthesizers

CCS Concepts

•**Hardware** → Analysis and design of emerging devices and systems; •**Human-centered computing** → Sound-based input / output; •**Applied computing** → **Sound and music computing;** Performing arts; •**Information systems** → *Music retrieval;*

1. INTRODUCTION

Designing musical instruments has established a set of materials we are used to interacting with. Traditionally, they are made of primarily rigid materials such as wood, metal, or glass. Interfaces for digital music making often feature hard plastics, rubbers and other synthetics, which often provide little malleability or softness. More recently, makers, musicians, and researchers have experimented with less conventional materials, seeking to expand the possibilities of sonic interaction. Wearable, small scale sensors as well as flexible, soft circuit technologies have allowed designers to turn a large variety of materials into musical interfaces [6, 51]. An example of a widely used wearable interface are the *MiMu* Gloves[1], enabling control of sounds through gestural movement [34]. Similar designs in less commercial settings have also been explored by others [46, 23]. Paradoxically, this sort of wearable might be seen as eschewing contact entirely as in the case of distance-sensing instruments like the theremin or computer-vision based systems [31, 26, 17, 20].

Here, we embrace a material-driven approach to developing musical interfaces. Although there is a long tradition of marrying interactive textiles and computational audio [42, 51, 45], we review specifically how the NIME community has explored this field and look at ways of interaction between humans and materials.

In this paper, we ask, what role soft, malleable materials have played in the 24 years of NIME history, what materials fulfil these properties, and how they are embedded in musical interfaces. Further, if instruments can be soft, how does that affect our interaction with them? What can we learn from the works in this field so far? The paper addresses these material questions by closely examining one material that has only marginally been exploited in this context and offers not only flexibility in its tactile sensation, but in its form factors and application areas: Textiles.

They come in different structures, materials, and characteristics. We can stretch, squeeze, stroke them, wear them and wrap them around us. For more than a decade, they have been an increasingly popular material in HCI and have been proven suitable as interfaces for musical interaction [51, 49, 18, 54, 46]. As such, we abbreviate textile interfaces made for musical expression as *TIME*. As with other non-rigid materials, they are infrequently represented within NIME, as pointed out by Boem et al. [4].

In pursuit of addressing this gap and establishing textiles as a material for soft, musical interfaces, we offer the following contributions:

- First, we survey all NIME proceedings to date using a set of search keywords for soft material interface designs.
- Second, we present the design and qualitative evaluation of two new textile interfaces (hand crocheted and machine knit) for musical expression and aim to coin them as *TIMEs*.
- Finally, the paper concludes with a set of design considerations for developing future *TIMEs*.

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[1]https://www.mimugloves.com

2. TEXTILES IN NIME

The first part of this paper gives an overview of the use of interfaces made of soft materials within the history of NIME. While there is a multitude of 'TIMEs' outside of the NIME proceedings (and in recent years increasingly in general HCI conferences, art and design venues), we focus our search criteria around this conference's proceedings to understand its community's approach to the use of textile materials better.

All proceedings from 2001 to 2023 were scanned using a set of keywords appearing in paper titles indicating potential design of e-textile interfaces. In total, 7 keywords were selected and yielded a collection of 39 papers used in this survey:

1. textile – 5 papers – [11, 10, 61, 47, 60]
2. fabric – 4 papers – [27, 8, 48, 43]
3. soft – 1 paper – [63] (although in total 26 results yielded, all but one software related works)
4. non-rigid – 2 papers – [4, 53] (of which 1 is a survey paper rather than presentation of a design)
5. flexible – 5 papers – [9, 3, 33, 1, 22]
6. wearable – 19 papers – [59, 58, 62, 30, 7, 24, 44, 56, 16, 23, 13, 38, 50, 39, 29, 21, 36, 12, 28]
7. malleable – 3 papers – [25, 15, 19]

The papers included in this survey relate to presented interface designs, and do not include e.g. the words flexible or soft in relation to software applications. Further, in the rare occasion of two or more keywords co-occurring in a paper title, the first one that appeared in the title was used to add to the allocation above.

2.1 Surveying the NIME Proceedings

The first two years of the NIME proceedings show no mention of any of the listed search parameters or key words. The first time one of the above keywords was used was in 2003 ('wearable') [44], followed by 'fabric' in 2006 [27], with one paper each. To emphasise again, we include only use of keywords to describe material properties rather than 'flexible' *use of* something [57, 14]. It was not until 2007 that musical interfaces began to be referred to more commonly as soft, wearable, flexible, and so on. Most papers acknowledging these properties were published in the 2010 proceedings (7 in total: 3 'wearable', 2 'flexible', 1 'malleable' and 1 'fabric').

The first use of the term 'textile' in NIME was in 2017, then with two papers [11, 61]. Since then, 'textile' has been used in titles only three more times, once in 2019 [10], and twice in 2020 [47, 60]. While in other domains, such as robotics, 'fabric' is more commonly used than 'textile', in NIME, it appears equally few times, including one paper using both terms [61].

The term 'non-rigid' yielded only two papers, both in 2020 mentioning it in their title [4, 53]. While this was expected, the results of papers describing soft interfaces also using 'soft' in their title was surprising. On a first glance, 26 papers are filtered, but only one of them refers to the materiality of an interface [63], and not to 'software'. On the other hand, the term 'wearable' is by far the most popularly used amongst the selected keywords of this survey. Most 'wearable' papers, however, introduce a piece of electronic hardware that is modified to be worn on the body, but has nothing 'soft' or 'textile' about it.

After examining how the keywords were used in the NIME context, we looked at other terms often associated and used together with soft, textile or fabric interfaces. The keywords that were observed to co-occur with the ones defining the search criteria include the following: 'touch' [48, 27, 13, 7], 'multitouch' [43, 11], 'multimodal' and 'deformable' [61], 'physicality' [44, 16], and lastly 'haptic' [59, 30]. Specifying the words further, more explicitly indicating the use of soft, textile materials gathered these: 'stretch' in [8], 'knitting' and 'knitted' in [60], 'mesh' [47], 'fiber' [15].

Other, additional keyword categorisations amongst the surveyed 39 papers emerged, too. For example, titles referencing the type of embodied interaction associated with interface, such as 'breathe' [24, 30], 'gesture' [58, 48] or 'hand' [36]. Also mentioning the body part involved in the interaction appeared with the use of 'finger' [12] and 'foot' [28]. Also the design object itself was often referred to, like 'glove' [23, 29], 'sponge' [33], or 'shoes' [39].

2.2 What actual textile NIMES are there?

Examining the interfaces of the surveyed papers further shows that only a handful of them are actually *made of* textiles. Among them, there are some that use textiles without attending to or discussing their material role and characteristics. Most interfaces featuring textile elements within the proceedings archive therefore don't contribute to the design of fabric or textile interface designs, but rather evaluate existing textile sensors [27], or the development of appropriate software of piezoresistive fabrics as a touch interface [48].

Other works included in our keyword search suggest other, non-textile materials with similar properties. This ranges from foam [25], to velostat [53], to a sponge [33]. While these materials can all be labelled as soft, the survey teaches us that also not all flexible interfaces are soft, as we see in the saw instrument by [9]. Nor are the the majority of wearable interfaces and controllers, for example wearable wooden shoes [39].

In the category of wearable musical interfaces of the NIME archive, textile materials often serve as a casing for electronics [59, 62, 30], or accessories like straps to mount wearable sensors to the body [7, 24]. In these examples, the use of fabrics is not discussed, nor is the material described in the design process. An example of fairly known wearable musical interfaces featuring fabric without being talked about explicitly are gloves. They always use fabric as a base layer at least, which is rarely pointed out or discussed for the soft, flexible, yet robust properties coming with these designs [23, 21, 36], or only marginally when a series of different designs is presented [29]. In general, gloves are a popular interface for gestural musical control, even more so in the universe outside the NIME proceedings, while for example shoes or foot-mounted controllers are represented with only two papers of the proceedings [28, 39].

So, what are the actual textile interfaces for musical expression, or as we call them here, *TIMEs*? Starting with the first paper using textile in their title, a pressure sensor matrix was designed [11], leading to many adaptations in the years followed. This was, however not the first sensor matrix introduced to NIME using commercially available conductive fabric [43]. In the same year of the word 'textile' in a paper title, a knitted keyboard was introduced [61], also followed by future iterations [60]. Designing textile interfaces for musical control began before the term was prominently used. For example, a wearable felt pouch was described in 2010 [3], and a stuffed knitted ball in 2013 [19]. Even earlier than that, a stretchy fabric sheet was presented in 2007 [8], and fabric sensor prototypes were introduced in

2008 [15], also made of commercially available conductive fabric. More recently, designs using optical fibre based woven fabrics in 2019 [10], and a large scale silver mesh fabric in 2020 [47] were included. Since then, no papers in the proceedings have featured textile based interfaces anymore. (Until this year, 2024.)

2.3 Summary

Why are there so few interface designs that exploit the textile properties in the history of NIME so far? While we have seen an increase in popularity and interest of wearable, flexible interfaces over time, material exploration seems still limited. This may be due to a lack of malleable, soft electronic components widely available on the market that we need to build these interfaces. It may also be due to easy access to suitable textile materials to this community. Many practitioners and researchers have a background in engineering, computer science, or composition. While there has been a more interdisciplinary and collaborative approach in recent years, involving material experts, such as textile designers, is still not very common. Lastly, the non-presence of textile interfaces may suggest that textiles are, generally speaking, no desirable material in this community. With so far developed wearable and flexible controllers there is already a lot of potential for embodied sound design through postural movement, or marked gestures demonstrated in the history of NIME, even without textiles.

Nevertheless, textiles being such an integral element of our everyday material interactions, we have a unique relationship to them, culturally and functionally [45]. They encourage material communication in addition to embodied interactions. Moreover, they can be used as a bridging element to open audio technologies to a more diverse audience, as has been shown [52]. Numerous works outside NIME proceedings also show that textiles have long found their way into musical expression [51, 46, 18, 55, 54], not least thanks to developments of 'textile friendly' electronics like the Lilypad [6], educational initiatives like *Fabricademy*[2], or the tutorials and open sourced work of Irene Posch [40, 41] and Kobakant [46]. We therefore believe it is worth exploring textiles further in the context of NIME.

3. TEXTILES FM

We address the above discussed gap of textile instruments in NIME by developing two e-textile interface designs and test them in a first, exemplary study. The two interfaces we produced are: a crocheted and a knitted one, both particularly elastic and soft textile structures consisting of interlocking loops. They were connected to a soft circuit and turned into FM synthesizers using the *Bela* platform [35]. This section describes the design process of this soft, interactive system, including its integration to an electrical circuit, and the sound design for these interfaces.

3.1 Design and Fabrication

3.1.1 Tools and Materials

Both interfaces are made from locally sourced Icelandic sheep's wool, making them sustainable and affordable designs. While the crocheted loops are handmade and require a single crochet hook, the mat is produced on a computerised knitting machine (a *Kniterate*[3] commonly available at Fab Labs and Textile Centers and a domestic version of the far more expensive industrial counterparts). Therefore, the tools and materials needed to replicate these designs are accessible to a large community. To turn these textile structures into interactive musical interfaces, conductive yarn made from stainless steel and synthetic fiber is used alongside a woollen base yarn. It creates a piezoresistive surface and can be connected to the circuit.

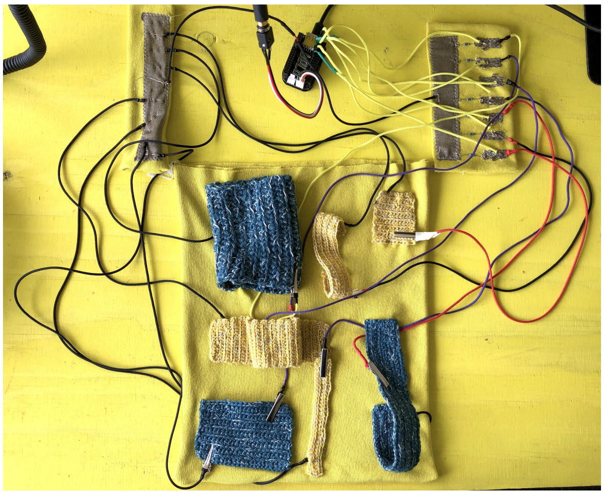

Figure 1: The 'Crocheted Loops' interface connected to the textile circuit as presented to participants

Figure 2: The 'Knitted Mat' interface with the positive-negative Jacquard pattern, the lighter one including the piezoresistive yarn.

3.1.2 Crocheted Loops

This yellow and blue design features 7 crocheted samples in the form of loops and strips of different widths, thicknesses and lengths, sewn onto a jersey knit fabric, see Figure 1. Each crocheted sample presents one sensor that is later connected to different sound modifying effects. These sensors are placed and attached to the base fabric and signify semi-predetermined gestures such as stretching, pulling, squeezing, slipping in, out and through them, and pressing them (demonstrated in Fig.5. Where on the sensor the connections to the circuit are placed is flexible and can be easily unplugged and changed.

[2]https://textile-academy.org/
[3]https://www.kniterate.com/

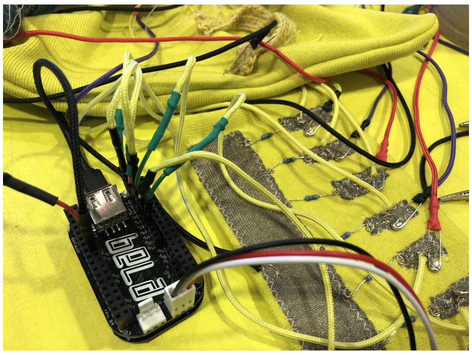

Figure 3: Close up of the textile circuit featuring textile cables with safety pin ends connected via resistors to the Bela Mini.

3.1.3 *Knitted Mat*

This is a double-bedded knitted fabric produced in a technique called a 'positive-negative' Jacquard. This interface is a flat piece of fabric (or mat) designed so that the entire surface becomes touch sensitive without distinguishable sensors. Here, the sensing area is determined by where the connectors are placed, with two corresponding cables per output. For example, they can be connected at opposite corners of the fabric like in Figure 2, or close to each other, on the same edge or different edges, or clipped to the centre of the fabric.

3.2 Textile, Soft Circuit

For both designs, the same circuit, the same amount of sound outputs, and the same sensing type (piezoresistive sensing) was used for further mapping. To connect to the circuit board, textile based, soft cables were produced adapting the principle of [41, 40]. The ends of the cables consist of safety pins and metal clips, that make it easy to plug and unplug interfaces, or change a sensor's mapping. The wire itself is made from highly conductive yarn, insulated with a braided paracord. A close-up of this is shown in Figure 3. This technique allows for an entirely soft, bendable circuit without compromising on the textile properties of the interface. The only hard, rigid component is the computer itself, to which the textile cables as well as the sound output are connected, a *Bela Mini*[4], also seen in Fig.3.

3.3 Sound Design and Mapping

To explore a variety of different mappings from textile state to sound, four PureData patches were designed by different researchers. A repository of them is available online[5]. Each patch uses a different strategy for mapping the six raw signals from the piezoresistive textiles.

Some patches use FM synthesis as a primary sound source, while others use field recordings of sewing, kitting and felting machines made during development of the interfaces at the Icelandic Textile Center. In some cases each input controls a different sound, so that the textile objects behave more like a collection of instruments, while in other cases each controls one parameter of a monophonic synth, so that the textiles acted as one entangled controller. Finally, some patches make sound continuously, while others filter the input signals so that sound is only produced as the textiles are manipulated. We aimed for variety in the macro-scale behavior [2] of the interface so as to be able to triangulate insights about the role of the textile materials, distinct from that of the sound mapping.

[4]https://learn.bela.io/products/bela-boards/bela-mini/

[5]https://github.com/Intelligent-Instruments-Lab/about-time-patches

4. USER STUDY

The two interfaces were put to test in a qualitative user study. We recruited musicians who had experience with digital interfaces and MIDI controllers and invited them to explore the interfaces in a jam session, which forms the base for observational studies using ethnographic methods; as well as for a "think-aloud" approach [37] where participants comment on their actions and explorations while interacting with the interface. All sessions were given consent to be recorded and were later reflected upon together with the musician in a semi-structured interview for qualitative assessment.

4.1 Participants

Six electronic musicians were recruited for this study. All of them are practising musicians, and at the time of the study locally resident, however from different cultural backgrounds, representing different nationalities. Their educational background is in music, too, ranging from electronic music studies to composition.

None of them has a background in textiles or related fields, and were not familiar or had any prior experience with electronic textiles and textile sensing. One participant has previously performed with the *MiMu* Gloves, and three other participants have encountered other custom made interactive musical gloves before. However, they have not considered these gloves to be e-textile artefacts.

4.2 Experimental Setup

4.2.1 *Data Collection*

The study sessions were video- and audio-recorded using a static camera and a mobile phone. To preserve the privacy of the participants, only their hands were captured. No sensor data from the e-textile interfaces themselves were captured, nor were the sound experiments. The audio output from the computer was perceived via headphones. (This way we hoped the participants would feel less pressure to deliver a polished or advanced performance of some sort.)

4.2.2 *Procedure*

At the start of the session, information of participants' background and prior encounters with e-textiles was gathered. Then, the crocheted interface was introduced (Fig.1) and participants were given a few minutes to freely explore it with one of the sound patches. This served the purpose of initial familiarisation with the interface's material properties, and interaction paradigm. Participants were then asked to continue to play with the interface while continuously commenting on their actions and decisions. This evaluation method of verbalizing thoughts is known as the "thinking aloud" protocol [37]. In this phase, the different patches were introduced, presenting the different sound mappings.

At the end of this exploratory jam session, the participants were prompted to explore the same patches with an additional, third interface: a 'classical' MIDI controller (Korg NanoKontrol) with sliders and knobs as seen in Fig.6.

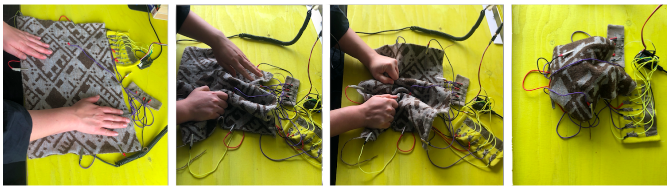

Figure 4: A participant exploring the knitted mat in the "think aloud" phase

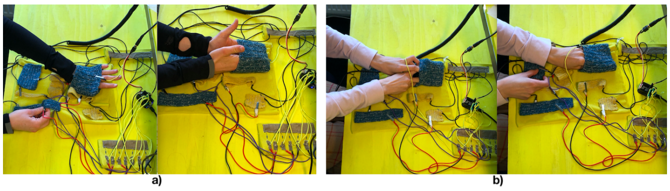

Figure 5: Two participants interacting with some of the sensors of the crocheted loops interface

4.2.3 Interview

The last part of the study consisted of a semi-structured interview, suggesting to reflect on the experience with the e-textile interfaces, as well as comparing this experience to the interaction with the MIDI controller. All participants were asked the same set of open ended questions, covering their interactional and aesthetic preferences amongst the two e-textile interfaces, their thoughts on the sound design and mapping to the textiles, their tactile perception and sensation of the crocheted and knitted interfaces, as well as general thoughts on the jam session as a whole. Finally, they were given the opportunity to add any additional comments. The interviews lasted between 20 and 35 minutes per participant, and were audio recorded only.

5. STUDY FINDINGS

We divide the findings of the study into the received, voiced feedback by participants (results drawn from audio data), and observational findings based on annotated videos (results drawn from nonverbal data). Participant citations in this section are anonymised and referred to as P1-P6.

5.1 Participant Feedback

5.1.1 Think-Aloud Commentary

Here, participants talked about the relation between their gestures and other postural movement and the sound output of the interface. Some expressed expectations in regards to the gesture-sound mapping, such as performing a large scale gesture or applying increased force on the fabric would map to equally "extreme" or "drastic" changes in the sound modification. Participants also took these mappings further and suggested additional representations that would appear natural or direct to them. For example, pressing the fabric down with the entire palm instead of individual fingers causes the sound to slow down. Pulling a loop would commonly be linked to increasing volume or amplitude, and stretching in various ways to stretching the sound, too. Auditory distortion was imagined through creating material tension, like holding the fabric in both hands, pulling it apart as a whole and in different directions.

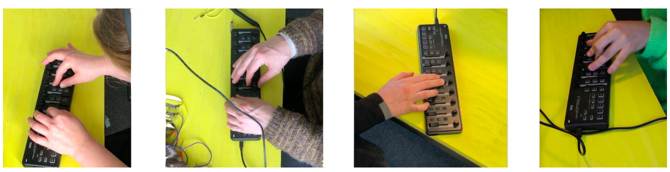

Figure 6: Four participants interacting with the MIDI controller.

Many comments included analogies to other musical instruments, interfaces or devices, too. Scratching the knitted mat surface, experiencing the sensation of the raw wool the interface is made of, reminded of scratching a record (P1), or relating the gestural "elegance and finesse" to playing a harp (P3). Moreover, the crocheted loops as well as the knitted mat were imbued with character while being explored. Sometimes, the knitted mat "went crazy" when bulking and folding it up, or the crocheted loops were "hiding" the sound until they liked the participant's performed touch. In general, the participants' language suggested an anthropomorphism of the textiles as a soft, collaborative instrument.

5.1.2 Interview Results

Reflecting on the jam sessions after completing the study in a semi-structured interview gave participants the opportunity to elaborate and add to their thoughts expressed in the "think-aloud" method.

Describing their experience with these interfaces yielded a different vocabulary and metaphors compared to rigid controllers, appearing coherently throughout the interviews. In addition to being talked about as emotional interfaces, fabrics were said to have different moods and characteristics commonly assigned to female attributes (P2). Both, sounds and fabrics were 'scratched' (P1), 'wrapped' (P3), 'scrunched' (P1-3), 'stretched' (P1-4, P6), 'compressed' (P1-3), 'sculpted' (P6), and 'folded' (P1, P3). Also perceptions of touch and sound effects were described as 'open' rather than switched on, and 'gentle' or 'rough' rather than quiet or loud. Similarly, the sound interaction was perceived as 'weaving in and out of the performance' (P3, P5).

In regards to the tactile sensation, the relived experiences with the textiles prompted participants to draw emotional connections to the material. While they described the MIDI controller as generally feeling cold, touching the woollen fabrics were described as emotional, warm (P2, P3, P4), rich in cultural association (P2), and even 'genuine' (P5).

When asked about a preference between the two e-textile designs, most preferred the knitted mat. This was explained by its association to improvisation friendly performance attributes (P1-3, P6), and feeling more 'jazzy' (P1). For most participants, it presented a 'blank page', encouraging more adventurous interactions and overt gestural movement.

Talking about potential applications of interactive textile surfaces, participants were creative with their suggestions. Expanding on possibilities of the knitted mat, future designs like large blankets and towels were envisioned (P1-3, P6), as were multi-functional pillows or smart covers for classical instruments (P4). Also wearable objects were of interest, imagining a performances with the entire body interacting with the textile material (P4, P6). Performances with e-textile interfaces were associated to noise machines (P4, P5), as well as material and object focused sound art installations (P1,P6).

5.2 Observational Results

In addition to the feedback voiced by the participants, the recorded videos were analysed using ethnographic methods. They were imported to the transcription software *Elan* [5] (commonly used in Conversation Analysis and Linguistics). The videos were annotated for their gestural information, focusing on differences between the textile interfaces and the MIDI controller. We hand coded different gesture types (for example, whether one or both hands were used, whether only two or more fingers were in contact with the controls), which helped to identify patterns of interaction when using the different interfaces.

5.2.1 Gestural Interaction

The observations of the video recordings gave nonverbal clues in addition to the verbalised thoughts about the quality of the human-material connection while playing with the crocheted and knitted interface. In addition to paying attention to how fingers and hands were used, we also examined the rest of the arms and the upper body in relation to interacting with the interfaces. Ranging from using one finger alone to leaning onto the fabric with both arms and forward leaning torsal posture, participants challenged the designs to see “how much they can get out of it” (P1-3), using more marked gestures and larger scale movements.

In Figure 6, different participants can be seen interacting with the MIDI controller. In comparison, Figures 4 and 5 show gestures while playing with the two textile interfaces. Here, the interface as a whole can be deformed, compressed, scrunched up, folded or stretched. The pressure applied to the material determines the sound output, so using one or two hands, or even just one finger, would change what the textile sensor captures. It was also possible for different sensing surfaces to be in contact with each other, which could be achieved by bulking the entire interface up, as seen in Fig.4

5.2.2 Comparison with the MIDI controller

The interactions with the MIDI controller yielded a different set of gestures. Here, a smaller part of the human hands is needed to achieve an effect. While the fabrics are sometimes grabbed with both hands to be compressed, interactions with the MIDI controller sometimes involve one finger only, yielding smaller scale movements, limited to fingers and forearm, rather than more marked postural shifts. Most participants used only one or two fingers during the entire interaction, only one participant (P5) used 3-4 fingers at the same time. Yet, the gestures performed with multiple fingers in use is simultaneous and parallel pushing of sliders. An example of this can be seen in Fig.6.

Common gestures performed with the sliders and knobs, given their form factor and affordances resulting therefrom, are pinching and turning with two fingers, and pushing and pulling with one finger (rather than, for example, stretching and squeezing).

The videos also reveal that the overall posture of participants if often very slumped over the controller, with their face very close to the interface, almost as if leaning forwards and into it. This may be enhanced due to the session being performed while seated.

Also when asked about the comparison of working with the two interfaces, participants noticed that despite having more precise control with the MIDI, it is “not fun to watch” (P1). Furthermore, the aspect of control, as was noted by participants P1-4, is not necessarily prioritised when it comes to musical improvisation and live performances.

6. DISCUSSION

The findings of this preliminary user study, together with the findings of the survey of the NIME proceedings how e-textiles can contribute to and potentially form a new path for the NIME community.

Given the relative rarity of e-textiles in these proceedings, while they become ever more prominent in other HCI disciplines (not least through an interdisciplinary network including sound artists), it is worth pointing out some of the demonstrated perks of using e-textiles for musical interfaces. Textiles expand ergodynamic possibility spaces [32] in the sense that they contribute to the possible operations when playing them, as well as the possible use cases or functions.

Textiles as malleable, soft, sometimes fuzzy surfaces can encourage new ways of thinking, creating different conceptual models, building on different sets of affordances and constrains than other interface materials. Especially in comparison with other controllers, the material affordances of textiles have shown to facilitate an extended set of interactional gestures. This can lead to new paradigms in interaction design.

6.1 Impossible MIDI Gestures

Commented on by participants, and observed in video annotations are the differences in gestural movement when playing with the textiles. While the MIDI controller affords limited movement of fingers and forearms, the textiles seemed to “unlock” an expanded, new set of gestures, largely some that would be impossible to perform with a rigid interface, as it appears larger muscular groups are in use (for example when stretching a fabric). Arguably, all instruments and musical interfaces embody the constraints of their use by design, the experienced and observed differences in interacting with the interfaces suggest that the textile designs impose a wider range of possible bodily movements during interaction. Gestural movements that may feel natural and intuitive in music performance become restricted, if not impossible on traditional MIDI controllers. Together with the suggestions of some participants to involve the entire body, the set of possible musically interactional movements can go beyond gestures.

The interactions with the e-textiles resulted not only in a much wider range of gestures, but also in a shift in language, an established emotional connection to the material, and interestingly also a tendency to anthropomorphise textiles seemingly easily. Assigning personality traits like “moody” (P2), or describing the fabric to react and gesture itself (P6) are just two examples of how participants talked of the interfaces.

6.2 Design Considerations for TIMEs

The participant feedback and conducted observations of the test sessions leaves us with a set of design considerations for future textile interface designs for musical expression (TIMEs). We can summarise them in the following bullet points:

- Exploit the affordances of different sizes: the majority of participants expressed the idea or desire to scale the textile interface up, e.g. as a blanket or a fabric to wrap the whole body. Working with textiles easily allows to create larger (as well as smaller) interfaces, which can further facilitate a wider range of interaction gestures.

- Natural Mapping: Energy input should correspond to energy output, gestures directly aligned with sound effect (e.g.stretch) appeared desirable and more intuitive to participants. This can be incorporated by the sound design, but also by the position and design of the textile sensors, as well as the use of different textile materials.

- (Textile) Quality Over Quantity: the mantra gathered from participants seemed to be: one sensor with more nuanced sound effects rather than many sensors that may not work as anticipated. One piece of fabric could have multiple effects mapped to different gestures or manipulation intensities.

These suggestions are by no means finalised guidelines, as they derive from a small sample set of users and two interface designs. Nevertheless, they give us an indication of what musicians may look for when encountering textile instruments.

7. CONCLUSION

There is a lot more to be explored about the textile interfaces than possible here. We aim to carry this research further and better understand the material impact on gestures, affective interaction, sound design, and last but not least, the linguistic metaphors emerging from the engagement with expressive e-textile interfaces. As this analog interface to a digital world, textiles also fit this year's conference theme of "tactility in a hybrid world".

A final lesson learned from this preliminary user study included the briefing of the participants. None of them had experience with interacting with e-textiles, and some expressed that while encountering such "untouched" interface, it would have been useful to get an induction and learn about gestures and materials in a similar way that classical instruments are learned; opening a question around virtuosity of textile instruments that is yet to be investigated.

If nothing else, fabrics as instruments should prompt a playful, fun interaction. Hereby, the absence of high precision control was a low cost to carry for the benefit of a conversational, anthropomorphised material collaboration. In that context, it appeared as such anthropomorphism of devices happens more easily if we encounter a material like textiles, that are warm and more familiar. Also the often mentioned emotional material connection and associated textile products (blanket, towel, garment) is a design aspect that other MIDI interfaces don't provide and that can be beneficial for sound art performances.

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9. ETHICAL STANDARDS

To ensure the welfare and data protection of all involved participants, the study was approved by the ethics committee of the University of the Arts Iceland and the University of Iceland. Participants were handed information sheets and signed consent forms.

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