Designing wearable interactions through playful on-body explorations

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Abstract
This workshop proposal aimed at provoking novel ways for full body interaction with interactive soft materials. Building on learnings from previous experiences on playful interaction with soft materials as a starting point, we focused on experimenting with full body interactions. We applied embodied design methods from soma design and material-led interaction design research. Together with the participants, we wanted to investigate the role of material characteristics in the interplay with body, movement and technology. The provided methods fostered novel full body material explorations which were presented to other participants in a performance setting at the end of the workshop. We extended the group of researchers being aware of the role of material characteristics in playful interactions of soft materials.

Keywords [1]
Embodied Interaction, Soft Technology, Playful Interaction

1. Introduction

E-textile design research combines domains from textile and technology development and contributes significantly to material-related research in HCI. Researchers have employed new methods to design embodied experiences and to connect with users in a playful manner [1], [2]. For instance, by creating lab settings to guide participants to interact with various materials in new modalities [1], [3]–[5] and to communicate bodily experiences through novel frameworks or media [2], [6].

In a previous interdisciplinary online workshop, we explored the role of materiality in playful interaction with soft materials at TEI'21 conference [7]. The workshop aimed at learning about how participants engage in playful ways with soft materials - with and without added technology. In this workshop, the materials' agency was the main source of playfulness, and the various characteristics of soft interactive materials gave rise to play scenarios. In our current workshop-proposal, building on our previous findings, we aim to explore interactive soft materials and their playful characteristics to trigger new types of interactions through focusing on the body as an experimental territory. We propose a workshop that brings soft materials into alternative, unusual and, beyond all, ludic interplay with the body, to explore new whole-body interactions with textiles and e-textiles. We aim at provoking new ways of bodily interactions, that combine textile with technology towards a playful interactive engagement with materials.

Our aim is to focus on the exploration of new ways of full body interaction by using a tubular and circular soft probe in a physical workshop setting. By providing materials in bigger size and shape, we provoke the participants to involve full body and large movements in their interaction with the material. Our previous workshop, using video-conferencing tools resulted in limited body movements mainly focusing on the upper body interaction to fit the screen frame. The added technology was limited to the smartphone or other simple technology simulations, which in were not embedded fully in the soft material and therefore degraded the characteristics of the interactive material. In our current workshop, we aim at exploring playfulness with soft materials, where the soft characteristics of the materials would be augmented with embedded technology such as light, sound or vibration - together with the participants in the shared space. Our idea is to introduce methods that allow the participants to explore bodily interactions with a wearable soft probe on the body. Body movements (micro or macro) would be a driving force for an interplay between body and wearable item, a link between the physical and the digital worlds.

Our goal is to better understand how to design wearable interaction, in this case through playful on-body explorations, while answering the following questions:
- How can body movement become triggers to new types of play(ful) on-body interaction with soft wearables?
- What is the role of material agency in designing interaction on the body?
- How can body and material co-become, collaboratively act in a playful manner?

2. Background

This workshop involves the research about e-textiles on the body, material related interaction and bodily interaction frameworks. Some of those have been applied in the previous workshop at TEI 21 "Design for Playfulness with Interactive Soft Materials" [7], and the learnings are the basis for this workshop.

Bergström et al have introduced the characteristic "becoming" of interactive materials: soft materials that change shape and appearance by property and technology in micro and macro level, and their traces of use [8]. We extend this notion with the body as a part of a shape changing component, therefore proposing a "co-becoming" experience through whole body experimentation.

The material turn in HCI has initialized the understanding for material related interaction and brought a focus on materials' characteristics as drivers for new interaction scenarios [9], [10, p. 34]. From the perspective of a material designer, this has not yet been researched to its extent: Researchers introduce different concepts of material related interactions which we aim to contribute to. On the other hand, while material designers focus on the material, they often neglect the whole-body experience, and generally work in a more fragmented way with various senses (touch, vision, sound, etc.).

2.1. E-textiles on the body

E-textile materials on the body are mostly explored in the fields of performance costumes and technical applications in sports, wellness or safety [11], [12]. The textile material is often only considered as a carrier of technology, disregarding the potential of its tactile experience. Other examples of everyday tech-garments are therapeutic light wearables, providing mobile light therapy [13], [14]. Besides these applications, e-textiles in daily life clothing have not found a ground.

How interactive materials on the body are actually perceived has not been explored in depth [15]. The authors criticize, that designers tend to treat textiles in interactive applications only as a carrier for the technology, but do not make use of the textile's characteristic in the interaction concept disregarding the potential of its tactile experience.

In our workshop, we will invite the participants to play with larger textiles (tubular and plain) on the body to reflect on the interplay of textileness, closeness, tactility and playfulness related interactive features, and how material-led interactions (not only technologies) can be integrated with soft materials.

2.2. Material-led interaction

In the shift of the "material turn" in interaction design, Robles and Wiberg mention ubiquitous computing, tangible interactions, and computational materiality as strategies to relate the full integration of the digital and physical [9]. Other researchers argue to see the computer as a material and call the combined interfaces "computational materials/composites" [16], [17].

Bredies and Gowrinshenkar have explored and discussed material led interactions based on the textileness of e-textile objects such as "stretching, folding, piercing" and "turning inside out, rolling up, and stuffing" [18]. They stress for a material related interaction design process. Tholander et al [19] highlight the importance of the agency in interactive novel materials through underlining "how creativity emerges in the situated interactions between designers and their materials." Winters refers to material-led design thinking through focusing on the importance of embodied and speculative experimentation in designing wearables [20]. By following these approaches, we will use material-methodological strategies to involve the participants and the material properties of the textiles by manipulating them in a playful manner. Thus, we (textile and our bodies) "co-become" hybrid entities.

2.3. Bodily interaction framework

Applying the theory of somaesthetics [21] to the practice of interaction design, relations between designed interface and bodily engagement with a designed object are described. According to Höök, Somaesthetic Design could help to "improve on all connections between sensation, feeling, emotion, and subjective understanding and values" [3] and therefore can provide a more holistic understanding on interaction design.

Beyond the somaesthetic approach that requires in-depth preparation of the design team and ongoing engagement with their inner lives [22], we strongly draw our practice on embodied design methods, particularly for the ideation process [5]. In doing so, it becomes possible to create new interactions from bodily activities, through/with/on the body. Other research has revealed that designing wearables and exploring materials on the body has an impact on the use context and on meaning-making [23].

Inside this situatedness and process, our embodied approach for the proposed workshop enables participants to engage with (un)known materials and shapes in a playful way, and through that, to (mis)use these materials to (re)design interactions enhanced by technologies.

3. Results from "Design for Playfulness with Interactive Soft Materials" [7]-workshop

In the previous workshop, we had 16 participants from different fields in HCI (computer science, interaction design, e-textile design). Prior to the workshop, each participant analyzed three soft materials based on sensory perception.

For task 1 (Table 1), everybody chose one material as "the most playful" and described the reasons with help of the PLEX-framework [2].

Table 1
Tasks previous Workshop

Task	Description
1 Material Explorations	Choose three soft materials, how you perceive them and what kind of playful aspects they have.
2 Material Selection	Which material is most playful and why?
3 Soft Tech Material Exploration	Team task after "Sensitizing-Labs" with test person, observer and interviewer.
4 Ideate with tech-enhanced soft material	Creation of a playful experience interaction cycle.

Task 2 was a group work done by three people in each group, derived after the "Sensitizing Labs" [1]. One was the test person, playing with the material, one was "the interviewer" posing the given questions, and one was the "documenter" taking written notes. The final assignment was to create an individual interaction with the chosen material and tech, again using the PLEX set of categories to describe the playful experience.

In total, 15 final designs were gathered focusing on different body interactions: 5 whole-body interaction and 10 upper-body interactions (including head and fingers/hands).

The PLEX-framework only filled in for task 2 and 3 by seven participants. They shifted from analyzing material properties to exploring interactive experiences with them. Qualitative results concerned mostly the properties of materials. Main finding was that elastic and thin, flexible material in combination with high- or low-tech actuation (vibration or air) invites to play with the material. Moreover, strong elasticity was perceived as a technological characteristic. One participant said: "material with many details/tentacles is more inviting than "clean" shapes", this features the quality of texture that can enhance interest and curiosity. Due to the workshop being online during the Covid-19 pandemic, the participants were limited to materials they had close-by, for tech add-on most of them used their phones which changed the properties of the material with an imbalance of weight, which often destroyed the playfulness. Also, due to attending the workshop online through their computers, participants mostly restricted themselves to work with their upper bodies only, although we tried to encourage them to stand up and explore the materials with their whole bodies while using the space they were situated in.

One of the crucial insights from our first workshop is the size of a material. We documented a range of interactions: due to size of the individual materials, the spatial volume of the movements was very different. Additionally, the manifold properties of soft materials, in particular textiles, make it worth exploring how much technology is needed, moreover, when the body can be the actuator.

We learned that the PLEX method may be too complex and focused on too many aspects, including negative experiences as well. In contrast to that, some other approaches to understand playfulness in adults [24] and children [25] draws on positive emotions and outlines that it is connected to a state of mind. Furthermore, it makes action and reflection easier instead of framing them with negative aspects.

4. Workshop Implementation

The workshop aimed at exploring bodily interactions with soft materials applying methods from embodied-design and performing arts. We applied embodied methods as the main activity of the workshop through first-person [26] and third-person perspectives to bring the body into the center of ideation and experimentation with materials. Moreover, to explore the playfulness of these bodily experiences, we adapted "LevelXplore" method [27, pp. 131–132], and activated the participants by answering the following questions:
1. Look: Looking at the material from outside and define,
2. Interact: Interact with it and define,
3. Explore: Explore it through your body: what can it do?
4. Manipulate: What can it become? - with technology and the body
5. Perform: Put the playful experience on stage, perform the final outcome.

Tubular, elastic and plain, non-elastic textiles of undyed cotton, together with tools and SamLab Actuator Kits [28] were provided for the participants, and adhesive loop tape, white duct tape, safety pins for simple wearable tech construction. We chose SamLab Actuator Kits because they are easy to integrate with the fabric, to keep the barrier low for non-tech or non-textile affine participants.

In addition to theoretical and practical input from our side e.g. on design ideation methods and methods from performing arts, the participants started with defining the given textile material by looking at it and afterwards interacting with it (Phase 1-2). After this analyzing and defining phase, they passed to an explorative stage to create ideas for playful interactions through embodied design ideation methods (Phase 3).

The next task was to consider how this material shall be changed with high- or low-tech manipulations (e.g. embedding actuators, like light, sound or vibration (Phase 4)).

Next input was a physical exercise to open the idea to bigger movements and novel forms of interaction. Participants worked on realizing their ideas with the material and got some time for rehearsing their interaction to be presented later to the group (Phase 5).

We expected to gain results that are body related, as the provided textile is already wearable and the exercises activating the body as a whole. As this was an onsite workshop, we expected that more feasible actuators provide better integration of tech and textile to keep its soft characteristic. However, it was observed that it needs a longer workshop timeframe to make participants grasp different technical skills, such as stitching, circuit making, programming, etc.

Methods we applied are primarily taken from the performing arts (improvisation, following) and embodied design ideation (material props in context [23], props for undesigning [5]), to engage participants in bodily activities and designing with/on the moving body. See table 2 for details.

Table 2
Workshop Schedule

Time (CET)	Preliminary schedule actions
9.30-10.30	Introduction and Check-In with the participants, Task 1-2 (Look & Interact) - Defining the material.
10.30-13.00	Introduction to embodied design methods, using with provided materials (group) - Task 3 (Explore)
13.00-14.00	Lunch Break
14.00-16.00	Exploring playful aspects of technologies (group) and low-fi prototyping - Task 4 (Manipulate)
16.00-16.30	Coffee
16.30-17.00	Preparation of final performance and technical preparations for staging the results
17.00-17.30	Final performance (open to other participants of the conference) and reflections

5. Workshop Results

The workshop participants had mainly technical design or engineering background. We asked them to tell us about their favorite movement which disclosed activities apart from their professional life, like cello playing or dancing. All participants mentioned they had no experience with embodied methods, but all of them mentioned a physical/performative activity they regularly do. Some participants referred to dancing/theatre acting experiences they had made during their childhood.

Groups of two or three participants were formed. All groups explored both textile materials, although the stretchy tube was more appreciated as the most inspiring one. All of them played single- and multi-player interactions. The participants used the outside space of the conference to have more space for the exploration. The participants were very open-minded and experimented freely with material experiences and the introduced methods. The overall feedback about the free exploration of textiles was that it was challenging but effective in leaving the comfort zone and thinking about interaction in a very different way (Figure 1). For example, one participant reported, that while she explored the materials on her body, features of the environment, e.g. wind, also shaped her experience with the materials.

In the second part of the workshop, technology was added to the textile material (Figure 2) by simply hiding it under or attaching it with pins onto the textile. The participants employed full-body movements like circular, up-down, slow-fast or twist.

Sound was used by two groups as feedback for bodily activity (stretching the body or variety in movement). Two groups used light as an output for the interaction with the textile, both times as a communication signal. In one of the groups, the light was involved in the method of following. There

we could observe the co-becoming of material and body. Both outputs (light and sound) became commands for the players to change movement.

The motor was used to create kinetic feedback with the textile as a response to a social interaction. Only one group created a scenario for single play (a textile fitness device with sound output) whereas all other groups formed multiuser play scenarios.

Feedback from most participants was, that the technology in the second part of the workshop felt limiting to them and that they had almost forgotten the free exploration of material-experience and interaction from the first part. After being free in exploration, the technology required a program that was based on the schematic of input and output and most participants immediately created use cases rather than creating a pure playful interactive material. Some explorative play scenarios were not implemented due to the feasibility reasons with the technology. However, in the end they managed to simulate and perform their playful ideas that they explored in the first session.

Figure 1: Exploration Phase

Figure 2: Placement of technology in textile

6. Discussion and conclusions

In this workshop, we focused on the design of on-body interactions based on a given, specific wearable probe and provided a defined set of technology to be added. This guided the design process to be inclusive of people of all backgrounds and the workshop to be results oriented.

Having the activity conducted onsite, we had the chance to create an atmosphere for the group where participants felt safe to play and explored materials with their bodies. With methods from the performative arts sphere and embodied interaction design, we extended the comfort zones of the participants to explore materials, body movements and their playfulness. Moreover, the interactions between participants during the workshop led to novel and playful multi-user soft wearable on-body interactions.

We learned parameters about how body movements trigger new types of playful on body interactions with soft wearables, for example flexibility of materials - both textile and technology - to allow open ended play. Learnings about the role of the materials' agency with or without technology were that textiles are easily put in the role of a textile functional object. By wearing it, storytelling started by association of costume stereotypes (e.g. superman-cape) and then evolved into more playful body extensions. The tubular shape inspired some participants to use the restriction of wearing it with e.g. arms inside the tube or both legs together. We observed that in some examples the body and material co-become a hybrid entity in a playful manner by wearing textiles as costumes or extension of the body in an interplay with technology. But, when technology was added, many participants went back to their usual ideation practice and did not involve the beforehand material experiences. E-textiles and sew-able electronic parts could be a solution to avoid that in another workshop, this with longer timeframe.

An overall outcome of the workshop was that the activity of play led to joy, the groups were able to stretch their knowledge about design methods and involve embodied experience into play. Textile as a material was giving them the freedom to move and explore bodily interaction while also providing a playful basis for design though its responsive and tactile features. On the other hand, technology functioned as an augmentation and gave the possibility to simulate possible responses from the movement and interaction with the textile.

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