Teaching Soma Design

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ABSTRACT
We devised a Soma Design curriculum with accompanying teaching approaches for a seven-week course at a technical university. In our analysis of students’ design concepts and process accounts, we found that they had opened an unusually rich and aesthetically engaging design space. But we also noted how they sometimes struggled with processes such as: “staying in the undecided” long enough to engage deeply with somaesthetic design imaginings; finding, refining and repeatedly returning to an aesthetic quality through the different phases of their design work; liberating themselves from pre-existing practices or objects in order to find entirely novel design possibilities; shifting from a more rationalistic design process, mainly based on argumentation, into a felt engagement were imaginations are acted out – not talked about; and lacking a technical toolkit for somaesthetically experiencing interactive sociodigital materials. Based on these insights, we provide a set of recommendations for how to teach Soma Design, and we have created an accompanying Soma Design toolkit that will support exploration and design.

Author Keywords
Soma Design; somaesthetics; teaching; interaction design curriculum.

CSS Concepts
• Human-centered computing–Interaction design theory, concepts and paradigms

INTRODUCTION
Teaching students effectively in the rapidly changing fields of interaction design and HCI is a growing concern within the CHI community [7]. The classical approaches of training students are deeply rooted in foundational concerns of the HCI domain; those of usability, learnability, error-reduction, mainly focusing on graphical interactions [12]. However, they often fail to take into account the proliferation of technologies in contexts that shift us beyond the glass interface: the experience of engaging with smart materials, movement-based interactions, Internet of Things, and hybrid combinations of digital and physical materials [50]. New materials shape interactions that feed off end users’ movements, touch, hearing and haptic engagements. As interaction designers, we need to train our ability to “imagine what could be” [35] through our senses, movements and rich engagements with these novel materials. We want students to have more tools in their toolbox, to design and evaluate whole experiences with aesthetics in mind, to design for their passions, emotions and motivations, and to design for body and movement [27].

Soma Design has been proposed as one path towards such engagements [22,30,37,40]. A soma design process is a holistic approach to aesthetics in design [22] building on ideas of somaesthetics [44]. Somaesthetics is a way to examine and improve on all connections between sensation, feeling, emotion, and subjective understanding and values [30] – in short: improving on our somas. Soma design requires training your ability to aesthetically appreciate through all your senses, but also to imagine – through your senses, movements and material encounters – what could be. The materials being shaped in a soma design process are not only the digital and physical materials used to build an interactive artifact, but also your own and your prospective end users’ somas, as their movements, experiences and sensual appreciations will be changed/extended/molded through their interactions with the system. A soma design process therefore thrives off the “aesthetic potential of the sociodigital materials and the creative process of shaping these into dynamic gestalts, orchestrated experiences” ([22], p.127).

We asked ourselves if we could devise a curriculum and a set of teaching tactics for a course on soma design at a technical university, KTH Royal Institute of Technology, Stockholm, Sweden. While designing and planning our course, we had certain concerns regarding its reception by the engineering and computer science students.
In our technical university, the prevailing design paradigm is the ‘Double-Diamond’ model of human-centric approaches introduced by the British Design Council [10]. Our students are trained to first ‘understand the problem’, then narrow down the problem area into a problem definition. Students sketch and prototype before implementing a working solution to the brief problem. This approach conforms with the popular textbooks within the field such as Interaction Design: Beyond Human Computer Interaction [38] and Human Computer Interaction [12]. Soma design, on the other hand, starts with experiencing, feeling, engaging with your own experience, employing a first-person perspective [23], carefully honing an experiential quality that will color your whole design. Touching, smelling, feeling the materials to extract their aesthetic potential and affordances take the front seat. Our concerns were around how such a design stance would clash with our students’ expectations from prior design knowledge?

Below we first report on the Soma Design curriculum and teaching strategies we devised for a seven-week course (corresponding to 7.5 credits in the ECTS system [16]). We then turn to an analysis of four out of nine design concepts and design process accounts created by our 28 students. In the analysis, we note how our students opened an unusually rich and aesthetically engaging design space. But we also note some of the struggles they had to overcome the clashes between soma design methods and their prior user-centered design knowledge. We conclude with some recommendations for how to organize soma design courses, including a soma design toolkit that we have been developing for supporting such processes.

BACKGROUND

HCI is an expanding field that both adapts to and shapes changes in technology. As HCI becomes more interdisciplinary, the traditional perspective of computer science and systems engineering is complemented by other disciplines [9]. Teaching HCI is an increasingly complex task since it must be aimed at a heterogeneous audience of engineering, design and social science students in both universities and in the industry [8].

Here we extend HCI curricula by developing and applying methods in the classroom that build on two recent turns in HCI research and practice. The first one is an increased attention to materiality and aesthetics, to what has been called the aesthetic turn [51]. Building on this turn, a number of approaches aim at increasing the vocabulary of HCI practitioners and students when it comes to appreciation of the aesthetic qualities of different materials. For example, [1] presents a method called Aesthetic Labs where students are encouraged to become more sensitized to materials with haptic interactions. Lim and colleagues [31] present a method for increasing the vocabulary of design students regarding the affordances of different materials.

The second turn is what many have called the somatic turn [26,33] in the third wave of HCI, where practitioners shift to methods of thinking through doing and moving. This turn privileges experiential first person methods [23] along with traditional empirical observation and evaluation of users and user experience. In addition, it encourages a cultivation of somatic knowledge among the practitioners, as a new and essential type of a design skill. In order to train the somatic knowledge, the designer needs to incorporate movement as part of a design process, and switch to sketching through the movements instead of using pen and paper [27]. Recent workshops at CHI [24,25] also aimed at exploring and deepening the method space for designing somaesthetic interactions and increasing somatic mastery of HCI practitioners. Below we expand on related theories and methodologies in HCI that accompany both the material and somatic turns.

Why Engage with and Through our Bodies?

The importance of movement in our lives and thereby in the area of design can hardly be overestimated. According to Sheets-Johnstone [43], movement is not separate from the world, in which it takes place. Being aware that thinking and movement are not separated, we must engage and create meaning through our movements with the world, as the world dynamically changes [43].
n-aboration work [44]. For the world to become the world. Movement is the basis, premise and start of our space, are capable of shaping experiences and guiding us in Our bodies, placed in their physical, social and temporal remedy a problem that is a fundamental misunderstanding has been notably absent from both theory and practical d-e-
-ways the living, the actual corporeal, pulsating, live, felt body have been central tenets in HCI for quite some time, in other Although embodiment [34] and embodied interaction [14] becomes a resource in the design process.

In recent years scholars have reached out to different areas in an attempt to overcome the absence of the living body. The problem is that interaction designers are not skilled in designing with movement, emotion and holistic engagements. To overcome this problem, several different methods and techniques have been suggested. To engage with one half of the sociodigital material, the soma expertise, Schiporst [41] suggests engaging with Somaesthetic Connoisseurs (e.g. choreographers, yoga instructors, culinary chefs) to support the design team. To engage with the other half of the materials, the computational materials, Akner-Koler suggests approaching the materials in a structured manner, feeling, touching, tasting, in order to extract its affordances [1]. Both approaches were used in our course. We combined them with methods of making strange [32].

SOMA DESIGN COURSE: CONTENT AND METHODS

The postgraduate course was taught in Spring 2018 to students enrolled in the Media Technology and Interaction Design Master’s program at the KTH Royal Institute of Technology. This is a technical university and the particular Master’s program builds on computer science and HCI theories and methodologies focusing on problem solving, as mentioned in the Introduction. That year Electrolux, a leading company expert in the domain of domestic appliances, was involved as an external “customer” providing the design brief. Through a soma design process, they wanted the students to develop and document a design concept of a new somaesthetic experience for the home environment, targeting one, or a combination of the following four categories: home comfort, cleaning, laundry, or cooking. 28 students participated in the course activities, working in groups of 3-4 people. In total 9 design concepts were developed. At the end of the course an exhibition and presentation took place at the main office of Electrolux.

The soma design teaching approach we proposed, as part of the course curriculum, included the exposure of our students
to a variety of exercises and activities. In the early phases of the course, we emphasized training somaesthetic awareness of your own soma. Later, we introduced some digital and physical materials alongside structured methods by which the students could touch/feel/smell/taste them to extract their aesthetic affordances and potential. Other activities aimed at broadening the students’ creativity, imagination and their toolbox of design possibilities. Finally, some activities focused on the specifics of the design brief.

**Week by Week Activities**

The course lasted for seven weeks, with eight hours of scheduled activities each week in which students had to be physically present. Twenty additional hours of homework were expected per week. Each student was asked to keep a workbook throughout the course where they documented their design process. Before and after each exercise, we asked them to fill in a body sheet (see example in Figure 1a). They were also expected to upload a one-minute video of their first-person experience in doing soma design every week.

The course schedule and the planned activities were allocated as follows:

**Week 1:** The course started with a lecture introducing the course content and design brief, somaesthetics and soma design. It included somaesthetic theory [45], examples of soma designs that can be found in the HCI-literature [3,4,28,47,49], and examples of first-person methods [22]. Then the first bodily activity of thinking through the body was introduced, which was a Feldenkrais exercise [17], led by an expert practitioner. We picked Feldenkrais as it is typically a form of bodywork that few have experienced unlike jogging or yoga. Feldenkrais also has some of the qualities that help deepen your somaesthetic sensibilities: disrupting habitual movements to make the habitual ones more clear in your mind, closing your eyes in order to focus on the other senses, slowing down in order to feel every small detail of a movement experience. The exercise introduced was a breathing exercise called Seesaw Breathing. It involves breathing in a non-habitual manner aiming to experience the air as a “ball” that is moved from the chest down into the belly and back – in a seesaw manner. Our Feldenkrais practitioner verbally guided the students, all lying on the floor on yoga mats, to do smooth and slow exercises of lifting and subsiding the ribs and sternum, followed by an exercise of tightening the diaphragm to its lower position and then returning to its higher resting dome position. The point here is not the particular breathing pattern. We could have chosen some other Feldenkrais exercise. The aim was to provide a different experience of your body, where you have to turn all your attention inwards to carefully observe what is going on.

In the same week there was a lecture on how to document a design process through mixed media, including mood boards, collages, material samples and other visual elements. This lecture Pictorials were also introduced, as a paper format that supports rich visual documentation. Finally, the second bodi-

ly exercise was conducted: a slow walk in the forest. The slow walk was inspired by work by Feltham and colleagues [18], as well as Ståhl and colleagues [48] who have explored walking in different contexts, on different surfaces, slowing down or speeding up – all in order to increase body awareness and spur creative processes. We divided the students into three groups of about ten students per group. A teacher was leading each group, walking slowly on a path chosen beforehand, so that the group of students could follow without worrying about exactly where or how fast to walk. Students were asked to walk in silence and squint their eyes to focus less on the visual stimuli, and more on the rest of their experience: how their feet were touching different textures on the ground, such as snow, soil or stones; the rhythm and sound of their walking pattern; or the weight of the arms swinging along their torso.

Before and after the slow walk in the forest (apart from filling in the body sheets mentioned above) we conducted a body scan. A body scan is done with closed eyes and involves a set of questions to focus your attention to particular body parts. Returning to the classroom, each student had to express and document the slow walk in the forest experience with a collage by using materials picked from the forest after the slow walk, such as dried leaves, branches from trees or stones. An example of such as collage can be seen in Figure 1b.

**Week 2:** The second week started with a Contact Improvisation led by an expert practitioner in this domain. Contact Improvisation is a form of improvised dancing that involves exploring one’s body in relationship to others by using the fundamentals of sharing weight, touch, and movement awareness. We chose this particular bodily exercise because it moves from experiencing only one’s own body, to introducing a social element. The particular exercise chosen is named leading and following. The students were grouped two and two. Facing one-another, they were asked to raise their arms and touch palms. One of them was asked to initiate movements – in a smooth and gentle manner – and the other was asked to follow. They were asked to switch roles. Step by step the movements were made bigger, sometimes leading all the way down to the floor, sometimes swirling around, sometimes slowing down, flowing in gentle, smooth gestures. Finally, the pairs were asked to not think about who was leading or following.

This was followed by the first reading seminar focused on autobiographical design, in which a list of papers (5,15,21,23,36) had to be read in advance and then discussed in the classroom. That week also included a Magic Machines [2] workshop. Participants were initially prompted with a “ridiculous request” that serves as point of committing to imagining the unimaginable – the magical – without questioning or reflecting too much. This liberates creativity from following the normal paths and ideas that typically pop up in brainstorming sessions, and from the normal constraints of
that machines viably do. In this class students were asked to play ‘a game of housework’ with the following prompt: “You arrive home. Something is not right. Some chores need to be done. You pick up your appliance and use it to fix the problem. You use your appliance. You fix the problem. You feel better. The problem is solved. Make the magic appliance that does this chore, and gives you this feeling using straws, paper plates, string and plastic cups.” After building their imagined magic machines everybody had to present it in front of the others in the form of a performance or demonstration (see example in Figure 1c) to explain how the magic worked to address the prompt.

This workshop was included in our soma design curriculum as we have previously experienced through our own design research practice that it serves as an evocative way of overcoming fears of working with materials and giving to thoughts and emotions a tangible, material form. Additionally, as mentioned by Andersen [2] this method offers a shift from language-based ideation methods to a making-based one. Finally, students were asked to go to a big electronics shop to look at and explore different products for the home, as well as collect marketing materials, both from Electrolux and other companies. Following this, each group created a collage which documented the products and spaces related to Electrolux’s brief and any associating feelings with different appliances they use in their home (see example in Figure 2a).

Week 3: The third week started with practical and hands-on explorations of physical- and computational materials. We structured this as an Aesthetic Laboration (A-Lab) [1]. In an A-Lab, a structured protocol for exploring and articulating what a combination of, for example, a heat element and a piece of fur feel like. The A-Lab is done in groups of three: one is blindfolded, exploring the combined material, trying to verbalize what they feel, the second person runs the process, including the software to e.g. starts/stop or vary the pattern of the heating/vibration/shape-changing material, and the third person takes notes. The three take turns in these roles. The blindfolded person is asked to first feel the combined material through another objects (here a ruler), then to feel it on different parts of their body (administered by the second person), then taste it, listen to it, and only at the end touch it with their hands and look at it (Figure 2b and 2c). In our A-Lab, we provided two prototypes of vibrotactile and heat actuators, alongside a range of different cloth materials, wood, memory foam and plastic membranes.

The week also included a second reading seminar on aesthetics in HCI (including papers [19,37,39,46,51]) and finally a visit to the head offices of Electrolux. There, the students got the opportunity to get a better understanding of their particular brand identity and discuss with designers working at Electrolux about the project brief.

Week 4: The fourth week started with a third reading seminar on making the familiar strange (including papers [1,6,13,32,54]). Then the students were asked to go somewhere relevant to their group’s chosen design brief, where they had to observe and document this experience based on their first-person perspective. Finally, there was a guest lecture on Design Fiction as a research method in interaction design.

Week 5: The fifth week focused on prototyping, firstly through a workshop on imagining interactive experiences from a first-person perspective. The second half of the week the design work and prototyping process became more intense, and the students finalized their design concepts. Parallel to designing, this week was also dedicated to documenting the design process by using various mediums such as design fiction product brochures, 3D modeling or collages.

Week 6: The sixth week started with a closing lecture on the course, connecting the overall process back to its starting point, to soma design and to the course brief. This lecture was aimed to help students to connect the experiences

Figure 3. (From left to right): a) Inhubator is a somaesthetic prototype placed on the hallway and embracing a person entering the apartment with a cascading cloud of humidified air, along with other modalities, aiming for a feeling of refreshment, b) MELLA (top) responds to human presence in the kitchen with color-change and BLEAUTOP (bottom) is a somaesthetic way of cleaning the kitchen counter, reflecting on colors that emerge on its surface, c) Sblender is a handheld food blender, enhanced with a pressure sensitive handle for controlling the speed and intensity of the blender, and d) Dr. Octopus is a vacuum cleaner worn as a backpack, with an exoskeleton system for controlling the direction of the nozzles through body movements.
throughout the course with the design brief and their creative engagement with their design work. Scheduled supervision meetings with each group were done, in order to discuss their final struggles and confusions, suggesting exercises and engagements that would be specifically related to the design concept they had started to shape in their group. Finally, this week included presentations in the form of a mini-conference in the classroom, where each group presented their process and final design concept.

*Week 7:.* The course ended with a presentation of the student projects and an exhibition at the head office of Electrolux. At the exhibition each group showed a poster, a working prototype or parts of the conceptual experience they had developed, and other material that was necessary in order to convey the somaesthetic experience of their idea. Each student group delivered a paper in the form of a Pictorial, presenting their design process and final outcome.

**FOUR DESIGN CONCEPTS**

Let us now turn to what the students produced. We focus on four out of the nine student design concepts, as they reveal some of the strengths and problems in how we chose to teach Soma Design. The material available for our analysis below is based on their project descriptions and reflections on the design process, as presented in the Pictorial submissions. Additionally, our analysis is based on discussions we had with each group after the final course exhibition, and on our first-hand experiences on parts of the conceptual designs demoed at the final student exhibition in Electrolux. This makes us, to some extent, be able to judge the concepts beyond only imagining the experience and only focusing on the visual aesthetics of the designs. But also to account for understanding how the somaesthetic experience unfolds through interaction. Important to mention here is that even though the concepts were demoed, they were not fully functioning prototypes. An interaction experience is something that arises *in use.* As students only produced rudimentary design concepts, the somaesthetic experience of a fully orchestrated interaction cannot be fully judged. Our critique below is therefore judging their *soma potential.*

**Inhubator**

The Inhubator consists of two interconnected objects placed in the hallway of a flat. One is an interactive lamp, containing a humidifier and a loudspeaker, placed in the ceiling, and the other is a mat placed on the floor underneath. When a person enters the hallway (Figure 3a) stepping on the mat, the Inhubator is activated dispersing a mist from the top module. The person is embraced by a cascading cloud of humidified air, along with a scent, sounds and light aiming for a feeling of refreshment and relaxation. The envisioned interactive experience of the Inhubator is a ritual for transition between places, shedding the experiences from the outside world as you come home, leaving stress and worries behind. It offers a moment of reflection, or purification, addressing the desire to leave work stress at the doorstep before entering the safe and relaxing space of the home.

**Analysis of the Inhubator**

As we followed this student group through their design journey, our experience was that they understood and enthusiastically engaged with the key concepts and values of a soma design process. Parts of the design in the Inhubator can be traced back all the way to the first-person experiences of the slow walks in the forest. They did not lose sight of that experience and it kept informing their design process. They allowed themselves to “stay in the undecided”, slowly crafting their idea over several weeks without falling back into the design processes they had learnt in other courses that would emphasize a faster design process instead of carefully crafting the experience to make sure that all the materials are “emptied of their potential” and come together into a whole [11].

In the resulting Inhubator design, we note how carefully they engaged with different bodily sensations. For example, their idea was that the mat would have different textures, such as stones for massaging tired feet. The concept uses multisensory output as a path to shutting out the external world, creating a “transition space”, a room for slowing down and reflecting. All of these are strong soma design values that come through in the design.

But where the design possibly goes a bit too far is in their overemphasis in engaging *all* the senses. Based on how we had been teaching soma design, this group understood soma design as a requirement to provide stimuli for all the senses. The experience of the Inhubator became almost overwhelming through the cascade of stimuli. In our course, we were so eager to emphasize engagement with all the senses that we forgot to discuss and show how soma design might very well engage with only one sense, but more importantly, that making different modalities come together into a whole requires quite some crafting and orchestration.

Second, as mentioned above, slowing down or disrupting habitual movements or sensing might well be a path to discovery and understanding *during* the design process. But this does not mean necessitate designs where the end-users have to literally move slowly or engage in subtle, gentle interactions. Shusterman himself speaks of his own preference for gentle, subtle somaesthetic experiences, but recognizes that a path to improving your ways of being in the world might go through all sorts of experiences – including the fast, fun, scary or painful ones [45]. This said, in the case of the Inhubator, it makes sense to try and make the person coming home to slow down in the hallway in order to shed their outwards facing self and reconnect with other aspects of their persona. The idea of a ritual for coming home and in particular the use of mist is both innovative and creates for a truly somaesthetic engagement. A third observation is how nicely this student group connected to the design brief without latching on too strongly to the already existing products. The Inhubator builds loosely on the air purification technologies...
at Electrolux, but the form factor and interaction envisioned is entirely different.

**MELLA and BLEAUTOP**

MELLA and BLEAUTOP (Figure 3b) are two systems that build on the same idea of adding interaction to different surfaces in the kitchen, but the interaction feeds off different processes in the home. MELLA takes as input the presence and implicit interactions between people as they move about in the kitchen, leaving colorful traces on different kitchen appliances, such as the fan, fridge or oven. When there is more physical activity and presence in the kitchen, the color on these surfaces shifts gradually and smoothly from matt silver to orange-red, and then, as the activity decreases, the colors shift into hues of green and blue, finally returning to matt silver. BLEAUTOP requires a more explicit interaction. Here surfaces, like the sink or kitchen table are painted with thermochromatic color. When a countertop surface comes in contact with water or the temperature is changed, colors temporarily appear, and the surface starts to resemble a canvas. The surface becomes interactive and, depending on the heat and movements of your fingers or palm and their pressure on the surface through the wet dishcloth, different patterns will occur. Wiping off the kitchen table becomes a moment of creativity that might spur somaesthetic reflection.

**Analysis of the MELLA and BLEAUTOP**

This student group also connected the experiences spurred by the different bodywork sessions to the design brief challenge. As part of their design process, they spent time in a kitchen, slowing down and disrupting the habitual movements typically done in a kitchen. The resulting designs are firmly grounded in the rich soil of sensory and movement-based somatic experiences, not in rationalization or solely adhering to the utilitarian aspects of cooking and cleaning in your kitchen.

While MELLA looks a lot like many other social presence solutions, BLEAUTOP is a more mature design concept from a soma design point of view. It more clearly thrives off the sociodigital materials, involving user’s body movements into what can be imagined as a tightly coupled interactive loop, where the wiping movement may become “one” with the rendering of the color shifting modality. In MELLA, the risk is that the implicitness of the interaction can spur an initial burst of trying out what might influence the colors, and then after a while, it no longer engages as much. There is nothing in the shifting of the colors that (subtly) guides people in the kitchen towards particular movements or social interactions that could deepen their somaesthetic, sensual engagements with one-another (or with their own bodily presence). The design concept could have been further developed in that direction.

BLEAUTOP on the other hand, builds firmly on an evocative and playful sensation of painting. The design deliberately puts the user’s attention to the countertop, the movement of the hand and arm as they wipe, and the simple color-changing experience offers an enjoyable experience that might even absorb and make users lose track of time. The thermochromatic color, movement, and wiping activity come together into an evocative whole. BLEAUTOP connects nicely to the design brief from Electrolux, without slavishly adhering to the form factor of their existing product lines nor to the utilitarian aims behind cleaning. The idea to use thermochromatic color is a key component in this project – a choice of smart materials that went beyond what we had introduced in the course.

**sBlender**

sBlender (Figure 3c) is a handheld food blender, enhanced with a pressure sensitive coating on the handle. In order to control the speed and intensity, the user applies different levels of pressure to the handle – the more pressure, the more speed. The interaction is also visualized through a LED light that increases its brightness based on the squeezing intensity. The subtle feedback from the coating on the handle while using sBlender creates a feeling of control and intimacy with the food being processed. The interaction experience was inspired by the qualities of a car’s gas pedal that evokes a feeling of unity between driver, pedal and car – you feel like you are “touching” the car and it touches you and the interaction is immediate. The students also wanted sBlender to remind of felt sensations and memories of playing with food in one’s childhood. They wanted users to feel almost as if they were touching the food through the handle.

**Analysis of the sBlender**

The sBlender idea very much grew out of the A-Lab exercise where this student group experimented with vibration covered by memory foam. The memory foam has evocative, physical properties changing its form in an organic manner when loosen a grip on it. When we went to Electrolux for the design brief, this student group saw a possible marriage between the memory foam experiences with the blender products. From their written report we understand that our students connected with their childhood experience of touching food through doing some kind of workshop at home. But they did not report and describe in detail what they did or whether and how those experiences informed their design decisions. Extracting experiential qualities from engaging with, in this case, touching food, requires attention and structured engagements as you need to transfer and alter/extend on those experiences to what the sociodigital materials afford.

Furthermore, the somaesthetic potential of this concept really lies in the tiny, tiny details of how the hand grips the handle, how much force is needed to render a certain speed, the duration of squeezing, and the different feedback loops that the handle provides in return as a path to “feel” the food. As we tried their prototype, we unfortunately felt that some of the traces of rediscovering playing with the food qualities – the structure, density, temperature – were lost, or maybe not considered. If the handle had included feedback actuation through e.g. a shape-changing material, or vibrators or heat elements placed around the blender shaft, covered with the
memory foam, the connection to the actual physical food could have been made stronger. As it was implemented now, the interaction became a speed controller. In a sense, the students did not liberate themselves from the form factor of existing blenders, even though they succeeded in engaging with a soma design process.

**Dr. Octopus**

Dr. Octopus (Figure 3d) is a vacuum cleaner designed to make cleaning a new experience. The product is worn as a backpack and it has two sucking tubes attached to the arms of the user. This concept envisions an exoskeleton technology that senses the user’s movements and translates these into the control of the vacuum. Dr. Octopus has an additional control, in the form of a glove that steers the cleaner arms through gestures towards a floor space. By being wearable and controlling the cleaning through the user’s movements, Dr. Octopus becomes an extension of the user’s body. A user interaction that typically consists of bending or twisting to reach awkward areas of the home is turned into something playful and potentially enjoyable, through performing richer bodily movements. The students imagined Dr. Octopus to incorporate aspects of gamification. They imagined that the vacuum could project spots in different areas in the room while using it, which would have to be reached and vacuumed. After such an action would be successfully completed, the backpack unit would respond with a rich sensory feedback to the user, including haptic, auditory and visual feedback. This rich and playful interaction thought by the students as having the potential to be an incentive to clean, since the sense of gamification can add fun to the vacuuming experience.

**Analysis of the Dr. Octopus**

In the first lecture of the course, we introduced Svanaes and Solheim’s Tail [49], which is a mechanical body extension designed for theater settings. It responds to the swaying of the actor’s hips, using an inertial measurement unit with an accelerometer and gyro. Dr. Octopus has a similar aim: to create an “extended lived body” [49] through strapping on an exoskeleton of sorts. Conceptually it connects with works on the existing Electrolux vacuum cleaners.

In the incarnation we tested, Dr. Octopus was not very well-developed as a somaesthetic concept. One could easily imagine a design where you could feel the weight and warmth of the vacuum on your back, and the weight and agility of the nozzles across your shoulders and arms. As detritus makes its way up the nozzles, feeling these items rattling along your arms and into the cleaner itself could be evocative and interesting. A lost opportunity to connect to the material, the dust and dirt, that enters the vacuum cleaner with a somaesthetic and playful feeling of catharsis.

What we failed to communicate in the course both to this group and the sBlender group was the need to really firmly stay with crafting and refining the somaesthetic experience of every small detail of the interaction. Our students are accustomed to quickly bringing out a design concept – not to stay with and carefully craft all the bits and parts that together create the soma experience. But unlike the sBlender group, this group really liberated themselves from the form factor of the existing Electrolux vacuum cleaners.

**LESSONS LEARNT ON HOW TO TEACH SOMA DESIGN**

First of all, while the analysis above points to issues with the design projects, we would like to emphasize that we were very pleased with the nine design concepts our students produced. As we saw in their design work, some were able to engage and stay in the land of the undecided long enough: to improve their own aesthetic appreciation skills; to disrupt the habitual and thereby find the familiar in the everyday home practices; to touch, feel, explore and exploit the affordances of the various technological and other materials provided in the process; thereby, finally leading to an improved ability to express some of their insights in design. Some of the groups reached further in this process. But overall, our students opened an unusually rich and aesthetically engaging design space compared to a typical design course at our university.

**Shifting from Rationalizing to Experiencing**

Through widening the students’ design repertoire, they may gain tactics to design for technologies that account for the living body and for our everyday lives and contexts. But as they engage with a first person, lived experience, they clash with the positivist worldview otherwise taught at a technical university. Still, shifting from a more “rationalistic” design process, mainly based on argumentation, into a felt engagement where imaginations are acted out – not talked about – is challenging and we noted that we had to repeatedly ask students to not only talk about possible interactions but to enact them. A key component of a soma design process is to repeatedly return to and feel the fine-grained details of the interaction filtered through a first-person engagement. In fact, it would be more important to see one small part of a design concept done carefully to achieve the somaesthetic experience sought, than to spend time on imagining the whole concept and implementing it. We refer to this as a process of staying in the undecided long enough to properly engage with your own experience, your own senses, educating yourself, feeling/touching/tasting the design materials repeatedly in order to fully profit from their aesthetic potential, before you decide on the design concept. This said, to properly do soma design, one needs to extend on their own somaesthetic sensitivities. This takes time – attending to your senses and deepening your ability to appreciate requires a longer learning process. A short course like the one we provided here can only give a taste of what it would mean to properly train your ability to somaesthetically attend to one’s own body.
Influences by Existing Form-Factors of Products and Materials Chosen

While your own soma is always there for, and as Schiphorst phrases is “generous with tips” (pers. comm.) the other half of any design concept lives in the aesthetic potential of the digital and physical materials. The materials we put on the stage both inspire and restrict the design process. In this course, Electrolux invited us to explore their product lines in home comfort, cleaning, laundry, and cooking. In the analysis above, we clearly saw how the form factor of their products had a strong influence on our students. Sometimes this spurs really interesting combinations of somaesthetic considerations with an existing product. Sometimes it constrains their imaginations too much. In a course like this, it might be important to help students see how the form factor is of key importance to the somaesthetic experience and how they may have to “deconstruct” what is the current form factor of a product, in order to uncover new possibilities.

Another aspect has to do with the additional materials students have available to design with. As we only provided some quite simple computational materials (heat pads, vibrators and various physical materials), it became quite a struggle for our students to imagine and feel the aesthetic potential of e.g. exoskeletons or thermochromatic color. Beyond the specifics of a technological material, somaesthetic design imaginings include figuring out how an interaction unfolds, from intro, to experience, to outro – the whole orchestrated experience. We found that a soma design toolkit with richer possibilities to more quickly create sensor-actuators couplings, and in particular, with a means to orchestrate an experience unfolding over time, would have benefited our students. Based on our experiences in this course, alongside a set of workshops with different research groups, we have since started to develop such a soma design toolkit [55], which we will describe briefly later.

Honing a Somaesthetic Experience

The other important insight is the importance of carefully honing the somaesthetic experience of a design concept throughout the different activities of the course. Our students did not know how to connect their experiences from slow-walking in the forest, Feldenkrais-breathing, contact improv, material explorations in the A-Lab and so on, all the way into their design concept. Halfway through the course we realized that they were struggling with what it really meant to bring out an experiential quality and then sticking to it, explore it, change it, letting it guide the whole process. We added a lecture in week 4, where we tried to help them make the connection.

The underlying issue here is an interesting challenge to soma design processes: while documenting your design sketches when you aim to provide a graphical design has well-established accessible tools. But documenting a somaesthetic experience so that you can later return to it and “feel it” again and again is difficult. In fact, this has been a stumbling stone in our own design processes as well. We have learnt to always start our design sessions through doing a body scan and then remind ourselves of the somaesthetic experience before returning to the crafting. We believe that there is a space for innovation here and we are speculating that combining a micro-phenomenological account [52] with some embodied representation (perhaps using our envisioned soma design toolkit) of the sought experience would be beneficial. That could serve as the touchstone for project members to repeatedly return to, during the design process [20].

Beyond Calm and Slow

When doing soma design, a double process of increasing your somaesthetic appreciation needs to take place [22]. On the one hand, designers need to slow down, disrupt their habits (making strange [54]), discern all those small engagements [31] that make up the practice they aim to change, disrupt or create. This requires a break with how HCI and interaction design is taught, and furthermore what is required by industry.

We addressed this by including activities for slowing down in order to reflect on the body, such as through the slow walk in the forest exercise, the slow body movements as part of the Feldenkrais exercise, or the body scan activities. Even though such activities could be considered as being very few and scattered throughout the course, and one can question whether the students engaged in similar processes by themselves during the overall design process, it was definitely an approach that broadened their design space and understanding of their body. At the same time, as part of the course curricu-
lum, we introduced activities of making strange habitual routines at home such as preparing a meal very fast and then very slow and reflect on each experience. However, one concrete reflection from teaching soma design was the fact that focusing mainly on slow or calm activities for experiencing somaesthetic design from a first-person perspective, can highly influence the design process and consequently the final outcome – overemphasizing slow end-user interactions. One question to ask ourselves and which we would like to bring to our future teaching processes of soma design is: how would the design process and its outcomes be affected (from a somaesthetic perspective) if we also introduced ways of engaging with fast or intense bodily activities?

Creating genuinely novel form factors and somaesthetic experiences is challenging. The emphasis on pleasurable or playful bodily experiences, involving more of our senses beyond vision was sometimes taken too literally. As we noted with Inhubator, students assumed that their task was to care for all of our senses, overwhelming the user with stimuli. In the case of Dr. Octopus, vacuum cleaning became gameplay thriving off ideas of gamification – taking the design concept a bit too far into the world of gaming instead of staying with the somaesthetic pleasures of the vacuuming activity in itself. It can be easy for latch on to ideas such as gamification as students have been exposed to systems like that. Slowing down the design process even further, making it even more somaesthetically ‘deep’ and reflective might be needed in our course. In future courses we plan to improve and update our curriculum based on the feedback we have received from the students.

ADAPTING HOW WE TEACH SOMA DESIGN

By detailing and sharing our curriculum and experiences of teaching soma design, colleagues can use and adapt it in their own teaching practices. Through our analysis of student design and teaching soma design, colleagues can use and adapt it in their own teaching practices. One way of doing this is to work with experiential qualities extracted from the bodily experiences in the design. Following this, one concrete reflection is that one has to remember the experience that they are aiming for. Since the experiences that are in focus in soma design are bodily, it can be hard to remember those, without doing them over again. We should have encouraged our students to do the body works they found interesting repeatedly, to keep the experience as a common thread throughout their work.

**A Soma Design Toolkit**

We learned during the A-Lab in week 3 that the heat and vibration prototypes needed to be developed further into a toolkit. We designed a soma design toolkit, which is comprised of a growing library of 3D physical soft shapes and a collection of heat, vibration and shape-change actuators made as standalone devices [55]. Those actuators can be put inside the soft shapes and combined (Figure 4). By combining several actuators with shapes, students or researchers engaging in soma design methods can start to orchestrate an experience by changing the parameters of the actuators and placing the shapes on different parts of the body. We tested this combination of shapes and actuators during three workshops with interaction design researchers and students. We observed that as soon as the soma toolkit focused on actuation and shapes was introduced to the design process, the participants shifted their attention on how the technology is experienced through their bodies, rather than just on a conceptual level. We are currently expanding the toolkit by integrating biosensors and an orchestration unit to able to create tighter couplings between soma experiences and the sociodigital material.

**Bodily Practices Throughout the Course**

We used a range of bodily practices, from slow walks to Feldenkrais, and Contact Improv throughout the course. Initially we emphasized slow movements as a way of tuning into the body, and paying close attention to experiences and sensations. In many ways the bodily practices that we chose were not a natural fit for the design brief from Electrolux (who wants to do slow housework?). We do not consider this to be problematic – those slow practices were chosen exactly because our previous experiences have shown they can successfully engage people in new ways of knowing their body – but we should have complemented these slow bodily activities with more structured ‘fast’ activities, or those with more specific relevance to the brief to better support the students in relating these activities to the final outcomes of the course.

**Connect, Repeat and Remember**

We provided the students with a variety of bodily exercises and related theory in lectures, based on the idea that this should feed into their design concepts, and it partly did. But there should have been some guidance in how to make the connection of the experience in the bodywork to the related theory. And even more, how to make the connection to the next exercise with related theory, and finally how all these parts feed into their design concepts. We need to help the students to extract and abstract insights from the different parts of the course so that they feed into the next exercise and finally sum up to a coherent whole. One way of doing this is to work with experiential qualities extracted from the bodily practices that are introduced. But also to return to those qualities in the design work, while observing how those come through and are experienced in the design. Following this, one concrete reflection is that one has to remember the experience that they are aiming for. Since the experiences that are in focus in soma design are bodily, it can be hard to remember those, without doing them over again. We should have encouraged our students to do the body works they found interesting repeatedly, to keep the experience as a common thread throughout their work.

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REFERENCES

[1] Cheryl Akner-Koler and Parivash Ranjbar. 2016. Integrating Sensitizing Labs in an Educational Design Process for Haptic Interaction. FORMakademisk - forskningsstidsskrift for design og designdidaktikk 9, 2. https://doi.org/10.7577/formakademisk.1269

[2] Kristina Andersen. 2013. Making Magic Machines. In Proceedings of 10th European Academy of Design Conference-Crafting the Future. https://doi.org/10.13140/2.1.1280.1285

[3] Simon Asplund and Martin Jonsson. 2018. SWAY - Designing for Balance and Posture Awareness. In Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction (TEI ’18), 470–475. https://doi.org/10.1145/3173225.3173262

[4] Ilias Bergström and Martin Jonsson. 2016. Sarka: Sonification and Somaesthetic Appreciation Design. In Proceedings of the 3rd International Symposium on Movement and Computing (MOCO ’16), 1:1–1:8. https://doi.org/10.1145/2948910.2948922

[5] Janne Mascha Beuthel and Danielle Wilde. 2017. Wear.X: Developing Wearables That Embody Felt Experience. In Proceedings of the 2017 Conference on Designing Interactive Systems (DIS ’17), 915–927. https://doi.org/10.1145/3064663.3064799

[6] Laurens Boer and Jared Donovan. 2012. Provotypes for Participatory Innovation. In Proceedings of the Designing Interactive Systems Conference (DIS ’12), 388–397. https://doi.org/10.1145/2317956.2318014

[7] Elizabeth F. Churchill, Anne Bowser, and Jennifer Preece. 2013. Teaching and Learning Human-computer Interaction: Past, Present, and Future. Interactions 20, 2: 44–53. https://doi.org/10.1145/2427076.2427086

[8] Elizabeth F. Churchill, Anne Bowser, and Jennifer Preece. 2016. The Future of HCI Education: A Flexible, Global, Living Curriculum. Interactions 23, 2: 70–73. https://doi.org/10.1145/2888574

[9] Elizabeth Churchill, Jennifer Preece, and Anne Bowser. 2014. Developing a Living HCI Curriculum to Support a Global Community. In CHI ’14 Extended Abstracts on Human Factors in Computing Systems (CHI EA ’14), 135–138. https://doi.org/10.1145/2559206.2559236

[10] Design Council. 2005. Eleven lessons: managing design in eleven global brands. Retrieved from http://www.designcouncil.org.uk/sites/default/files/asset/document/ElevenLessons_Design_Council%20(2).pdf

[11] John Dewey. 2005. Art as experience. Perigee, New York, NY.

[12] Alan Dix, Janet Finlay, Gregory Abowd, and Russel Beale. 2004. Human-computer interaction. Pearson/Prentice Hall.

[13] J. P. Djajadiningrat, W. W. Gaver, and J. W. Fres. 2000. Interaction Relabelling and Extreme Characters: Methods for Exploring Aesthetic Interactions. In Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques (DIS ’00), 66–71. https://doi.org/10.1145/347642.347664

[14] Paul Dourish. 2001. Where the action is: the foundations of embodied interaction. MIT Press, Cambridge, Mass.

[15] Carolyn Ellis, Tony E. Adams, and Arthur P. Bochner. 2010. Autoethnography: An Overview. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research Vol 12: No 1 (2011): The KWALON Experiment: Discussions on Qualitative Data Analysis Software by Developers and Users-. https://doi.org/10.17169/fqs-12.1.11589

[16] European Commission. 2015. ECTS users’ guide 2015. Retrieved January 16, 2019 from http://bibpurl.oclc.org/web/75797 http://ec.europa.eu/education/library/publications/2015/ects-users-guide_en.pdf

[17] Moshé Feldenkrais. 1990. Awareness through movement: health exercises for personal growth. Harper-SanFrancisco, San Francisco.

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

[19] Shad Gross, Jeffrey Bardzell, and Shaowen Bardzell. 2014. Structures, forms, and stuff: the materiality and medium of interaction. Personal and Ubiquitous Computing 18, 3: 637–649. https://doi.org/10.1007/s00779-013-0689-4

[20] Ulf Hagen. 2009. Where do Game Design Ideas Come From? Innovation and Recycling in Games Developed in Sweden. In Breaking New Ground: Innovation in Games, Play, Practice and Theory: Proceedings of the 2009 Digital Games Research Association Conference, 11.
[21] Kristina Höök. 2010. Transferring Qualities from Horseback Riding to Design. In Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries (NordiCHI ’10), 226–235. https://doi.org/10.1145/1868914.1868943

[22] Kristina Höök. 2018. Designing with the body: somaesthetic interaction design. The MIT Press, Cambridge, MA.

[23] Kristina Höök, Baptiste Caramiaux, Cumhur Erkut, Jodi Forlizzi, Nasserin Hajimejad, Michael Haller, Caroline Hummels, Katherine Isbister, Martin Jonsson, George Khut, Lian Loke, Danielle Lottridge, Patrizia Marti, Edward Melcer, Florian Müller, Marianne Petersen, Thecla Schiphorst, Elena Segura, Anna Ståhl, Dag Svanaes, Jakob Tholander, and Helena Tobiasson. 2018. Embracing First-Person Perspectives in Soma-Based Design. Informatics 5, 1: 8. https://doi.org/10.3390/informatics5010008

[24] Kristina Höök, Caroline Hummels, Katherine Isbister, Patrizia Marti, Elena Márquez Segura, Martin Jonsson, Florian “Floyd” Mueller, Pedro A.N. Sanches, Thecla Schiphorst, Anna Ståhl, Dag Svanaes, Ambra Trotto, Marianne Graves Petersen, and Youn-kyung Lim. 2017. Soma-Based Design Theory. In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA ’17), 550–557. https://doi.org/10.1145/3027063.3027082

[25] Kristina Höök, Martin Jonsson, Anna Ståhl, Jakob Tholander, Toni Robertson, Patrizia Marti, Dag Svanaes, Marianne Graves Petersen, Jodi Forlizzi, Thecla Schiphorst, Katherine Isbister, Caroline Hummels, Sietske Klooster, Lian Loke, and George Poonkhin Khut. 2016. Move to Be Moved. In Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA ’16), 3301–3308. https://doi.org/10.1145/2851581.2856470

[26] Kristina Höök, Anna Ståhl, Martin Jonsson, Johanna Mercurio, Anna Karlsson, and Eva-Carin Banka Johnson. 2015. COVER STORY: Somaesthetic design. Interactions 22, 4: 26–33. https://doi.org/10.1145/2770888

[27] Caroline Hummels, Kees C. J. Overbekee, and Sietske Klooster. 2007. Move to get moved: a search for methods, tools and knowledge to design for expressive and rich movement-based interaction. Personal and Ubiquitous Computing 11, 8: 677–690. https://doi.org/10.1007/s00779-006-0135-y

[28] Martin Jonsson, Anna Ståhl, Johanna Mercurio, Anna Karlsson, Naveen Ramani, and Kristina Höök. 2016. The Aesthetics of Heat: Guiding Awareness with Thermal Stimuli. In Proceedings of the TEI ’16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI ’16), 109–117. https://doi.org/10.1145/2839462.2839487

[29] Pavel Karpashevich, Eva Hornecker, Michaela Honauer, and Pedro Sanches. 2018. Reinterpreting Schlemmer’s Triadic Ballet: Interactive Costume for Unthinkable Movements. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI ’18), 61:1–61:13. https://doi.org/10.1145/3173574.3173635

[30] George P. Khut. 2006. Development and evaluation of participant-centred biofeedback artworks. Retrieved January 16, 2019 from https://researchdirect.westernsydney.edu.au/islandora/object/uws%3A2425/

[31] Youn-kyung Lim, Sang-Su Lee, and Da-jung Kim. Interactivity Attributes for Expression-oriented Interaction Design. International Journal of Design 5, 3: 113–128.

[32] Lian Loke and Toni Robertson. 2013. Moving and Making Strange: An Embodied Approach to Movement-based Interaction Design. ACM Trans. Comput.-Hum. Interact. 20, 1: 7:1–7:25. https://doi.org/10.1145/2442106.2442113

[33] Lian Loke and Thecla Schiphorst. 2018. The Somatic Turn in Human-computer Interaction. Interactions 25, 5: 54–5863. https://doi.org/10.1145/3236675

[34] Maurice Merleau-Ponty. 1996. Phenomenology of Perception. Motilal Banarsidass Publishe.

[35] Harold G. Nelson and Erik Stolterman. 2003. The Design Way: Intentional Change in an Unpredictable World: Foundations and Fundamentals of Design Competence. Educational Technology Publications, Englewood Cliffs, N.J.

[36] Carman Neustaedter and Phoebe Sengers. 2012. Auto-biographical design in HCI research: designing and learning through use-it-yourself. In Proceedings of the Designing Interactive Systems Conference on - DIS ’12, 514. https://doi.org/10.1145/2317956.2318034

[37] Marianne Graves Petersen, Ole Sejer Iversen, Peter Gall Krogh, and Martin Ludvigsen. 2004. Aesthetic interaction: a pragmatist’s aesthetics of interactive systems. In Proceedings of the 2004 conference on Designing interactive systems processes, practices, methods, and techniques - DIS ’04, 269. https://doi.org/10.1145/1013115.1013153

[38] Jenny Preece, Yvonne Rogers, and Helen Sharp. 2015. Interaction design: beyond human-computer interaction. Wiley, Chichester.

[39] Johan Hallnäs Redström. 2002. From use to presence: on the expressions and aesthetics of everyday computational things. Interactions 9, 4. https://doi.org/10.1145/543434.543441

[40] Thecla Schiphorst. 2009. soft(n): toward a somaesthetic of touch. In Proceedings of the 27th international...
conference extended abstracts on Human factors in computing systems - CHI EA '09, 2427.
https://doi.org/10.1145/1520340.1520345

[41] Thecla Schiphorst. 2011. Self-evidence: applying somatic connoisseurship to experience design. In Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11, 145. https://doi.org/10.1145/1979742.1979640

[42] Maxine Sheets-Johnstone. 2011. The corporeal turn. Journal of Consciousness Studies 18, 7–8: 145–168.

[43] Maxine Sheets-Johnstone. 2011. The Primacy of Movement: Expanded second edition. John Benjamins Publishing Company, Amsterdam.
https://doi.org/10.1075/aicr.82

[44] Richard. Shusterman. 2008. Body consciousness: a philosophy of mindfulness and somaesthetics. Cambridge University Press.

[45] Richard Shusterman. Somaesthetics. In The Encyclopedia of Human-Computer Interaction, 2nd Ed., Mads Soegaard and Rikke Friis (eds.). Retrieved January 17, 2019 from https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction

[46] Vygandas Šimbelis, Anders Lundström, Kristina Höök, Jordi Solsona, and Vincent Lewandowski. 2014. Metaphone: machine aesthetics meets interaction design. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14, 1–10. https://doi.org/10.1145/2556288.2557152

[47] Anna Ståhl, Martin Jonsson, Johanna Mercurio, Anna Karlsson, Kristina Höök, and Eva-Carin Banka Johnson. 2016. The Soma Mat and Breathing Light. In Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16), 305–308. https://doi.org/10.1145/2851581.2889464

[48] Anna Ståhl, Jakob Tholander, Jarmo Laaksolahti, and Elsa Kosmack-Vaara. 2017. Being, Bringing and Bridging: Three Aspects of Sketching with Nature. In Proceedings of the 2017 Conference on Designing Interactive Systems (DIS '17), 1309–1320. https://doi.org/10.1145/3064663.3064764

[49] Dag Svanaes and Martin Solheim. 2016. Wag Your Tail and Flap Your Ears: The Kinesthetic User Experience of Extending Your Body. In Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA ’16), 3778–3779. https://doi.org/10.1145/2851581.2890268

[50] Vasiliki Tsaknaki and Ludvig Elblaus. 2019. A Wearable Nebula Material Investigations of Implicit Interaction. In Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI ’19), 625–633. https://doi.org/10.1145/3294109.3295623

[51] Lars Erik Udsen and Anker Helms Jørgensen. 2005. The aesthetic turn: unravelling recent aesthetic approaches to human-computer interaction. Digital Creativity 16, 4: 205–216. https://doi.org/10.1080/14626260500476564

[52] Francisco J. Varela, Evan Thompson, and Eleanor Rosch. 2000. The embodied mind: cognitive science and human experience. MIT Press, Cambridge, Mass.

[53] Danielle Wilde. 2012. hipDisk: Experiencing the Value of Ungainly, Embodied, Performative, Fun. In CHI ’12 Extended Abstracts on Human Factors in Computing Systems (CHI EA ’12), 979–982. https://doi.org/10.1145/2212776.2212365

[54] Danielle Wilde, Anna Vallgårda, and Oscar Tomico. 2017. Embodied Design Ideation Methods: Analysing the Power of Estrangement. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI ’17), 5158–5170. https://doi.org/10.1145/3025453.3025873

[55] Charles Windlin, Anna Ståhl, Pedro Sanches, Vasiliki Tsaknaki, Pavel Karpashevich, Madeline Balaam, and Kristina Höök. 2019. Soma Bits: Mediating technology to orchestrate bodily experiences. In Proceedings of the 2019 Conference on Research Through Design - RTD ’19. https://doi.org/10.6084/m9.figshare.7855799.v2