

BREEZE: Feel Every Breath

Vera Hijkoop

Department of Industrial Design
Eindhoven University of Technology
The netherlands
v.a.hijkoop@student.tue.nl

Julia van Zilt

Department of Industrial Design
Eindhoven University of Technology
The netherlands
j.v.zilt@student.tue.nl

Ahmad Issa

Department of Industrial Design
Eindhoven University of Technology
The netherlands
au482994@uni.au.dk

ABSTRACT

Nowadays most user interfaces contain screens and buttons that are not really natural in their use. The way we use these products do not relate to our instincts, they do not really rely on our sensory and perception motor skills. In this paper we explored the possibilities of a shape changing interface which relies to the sensory and perceptual motor skills that would interact with the user in a more intuitive meaningful way. We approached this challenge by designing an artefact that contains human characteristics by mimicking breathing and allowing the user to interact with it in a continuous action-perception loop. This paper aimed to explore how an interactive artefact can rely on sensory and perception motor skills by especially focussing on an aesthetic interaction.



ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI):

INTRODUCTION

Nature is by far the richest source of inspiration and knowledge, what if we use this as a inspiration more while designing everyday products? Nowadays user interfaces contain screens and buttons that are not really natural in their use. The way we use these products do not relate to our instincts, they do not really rely on our sensory or perception motor skills. When looking at nature and looking at the way we as humans are designed, user interface designs, the products we use daily could be designed more meaningful when they are inspired by the element that is the most closed to ourselves. Fortunately there is a shift happening in the interaction domain. Technological developments are expanding the interaction possibilities for the haptic domain [5]. There is a growing interest into possibilities of interactive systems that go beyond the visual domain. Tangible interfaces can create more meaningful interactions by taking full advantage of the perceptual motor skills. While GUIs offer input devices that are used to control information that is visible on screens, tangible user interfaces offer physical objects that represents the digital information that can be manipulated, it integrates input and output in tangible objects. This will create a more meaningful intuitive user experience [7].

However tangible interaction is in my opinion not only about embodied interaction. Embodied interaction is described as the creation, manipulation and sharing of meaning through engaged interaction with artefacts [6]. It is also about communicating through materials. The structure of materials can communicate and indicate the use of products. Material affordances can signify a variety of qualities that are the source of rich sensory experiences. A greater range of aesthetics, tactile and perceptual qualities emerged in interaction design by the discovery of materiality [12].

A great way to communicate and evoke certain behaviour by users using a more tangible approach are the explorations of shape changing interfaces. Shape changing interfaces draw attention, provide physical feedforward and feedback, and convey information through physical change. The use of functional and augmented feedback and feedforward provided

through visual systems is widely explored. The Interaction Frogger Framework provides opportunities to make the interaction for the user more intuitive. By correct coupling of time, location, direction, dynamics, modality and expression inherently exhibits a natural relationship between the in and output of the activities in interaction [15] [19]. The exploration of inherent feedback and feedforward is a magnificent movement in the interaction domain. While functional feedback is generated by the system when performing its function and augmented feedback is the information not coming from the action itself. Inherent feedback is feedback arising from the movement itself. Inherent feedback and feedforward relies more on the perceptual motor skills of the user and are more naturally ways of interacting with systems [19].

A product that changes its shape can give rise to a feedback loop playing on the action-perception possibilities, offering a dynamic interaction between the action of the user and the reaction of the product, which has been named interactive materiality [9] [15]. Although there are a lot of examples of which the relation between user actions and product movements are explored, this domain is an underdeveloped design area [14].

Related work

A design domain that already is inspired by nature is called biomimicry. Biomimicry is literally translated into the imitation of life. Biomimicry is the design and production of materials, structures and systems that are modelled on biological entities and processes. It is an approach that seeks solutions to human challenges by emulating nature's patterns and strategies. [3] A great example of biomimicry are the buildings inspired by the termites mounds to ventilate buildings without using air-conditioning systems, like the Eastgate centre in Harare, Zimbabwe [8]. Or the wings of an butterfly that inspired designers of solar panels so that they can harvest light twice as efficiently [4].

PneUI is a magnificent example of shape changing interfaces that can evoke certain reactions and behaviours by changing the structure of the material. For example an tablet cover that changes behaviour while playing a game to indicate and evoke movements of the user [20]. The paper: The Design Space of Shape-changing Interfaces: A Repertory Grid Study

studies how users experience shape-change by eliciting personal constructs about shape change. [9]

This paper builds on the vision of Marks in which she describes Haptic visuality. Haptic visuality is also interpreted as Touching with the Eyes, it appeals to the senses. Marks stated that "Haptic visuality sees the world as though it were touching it: close, unknowable, appearing to exist on the surface of the image" [10]. Advertisements apply haptic visuality to rely on our senses, evoke certain emotions by consumers and captivate them [10]. Through providing human characteristics and properties to materials an specific emotion can be evoked, that are way harder to evoke through visual interfaces like cell phones or tablets. This is for example done by Kevin Anderson, with his research project: kinetic folds. With this project he studied what happened to our relationship with objects when we have the perception of the objects coming to live. He designed a prototype that breathes and responds to the presence of humans [1].

The related work consider important aspects of interactive materiality, one on focussing on the aesthetics and haptic visuality of the design, the other captures the user's view of shape changing, however they do not necessarily combine the two. The work of Kwak et al. shows little effort to take the aesthetics and herby haptic visuality into consideration while capturing the user's view of shape changing. The other one focuses on the aesthetics and haptic visuality of the design, however it lacks attention to the action-perception loop. The team believes the aesthetics of materials can rely on haptic visuality while the interaction can be more intuitive and closer to natural instincts of human beings. The present paper attempts to combine these aspects and explores the experience of users when an artefact has human characteristic, through focussing on the aesthetic qualities of materials, it relies on the senses of human beings and changes shape to provide input and output in a more intuitive meaningful way. This paper approach this challenge by focussing on the transition of expansion and contraction by mimicking breathing.

The design process of Breeze is described in four phases in which the material, technology and interaction is described. The Interaction Frogger Framework with the action-perception loop which is presented in the work of Stienstra et al. is used as a method in the design of the interaction of Breeze.

DESIGN PROCESS

Phase 1

How can we develop a perception of human characteristics with materials? The team explored the transition of expansion and contraction to mimic breathing. We chose the action of breathing changing into a heart beat. In order to find a suiting material for this transition we mapped different characteristics of breathing in order to get a clear overview of what qualities the material and its interaction used should possess. Within the first phase of our exploration we tried to get familiar with the characteristics of different materials and their behaviour when these would be manipulated.

At this point, our explorations were mainly static. The focus was on mimicking breathing at this phase, the behaviour of the user and the possible interaction with the artefact is taken into consideration but was not explored. This was done by cutting patterns from different kind of fabrics, exploring movements and differences in paces (fig. 1). Also fabrics and materials with different characteristics and qualities were contracted and expanded in different paces to visualise and mimic breathing. Furthermore a breeze is blown towards a construction of paper to mimic breathing (fig. 2). At a certain moment the team was inspired by the movement of waves created by two or multiple separate compositions (fig. 3).

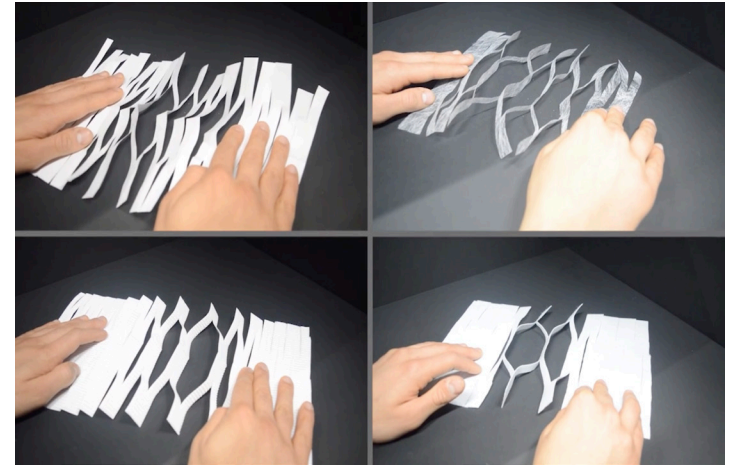


Figure 1: Exploring the transition: breathing

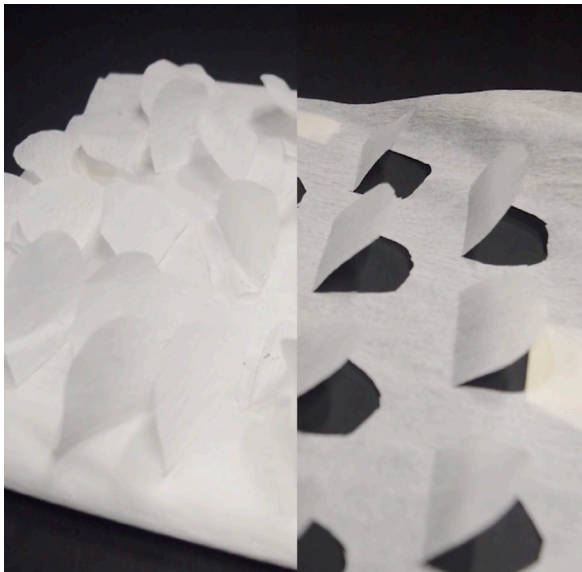


Figure 2: Exploring the transition: breathing

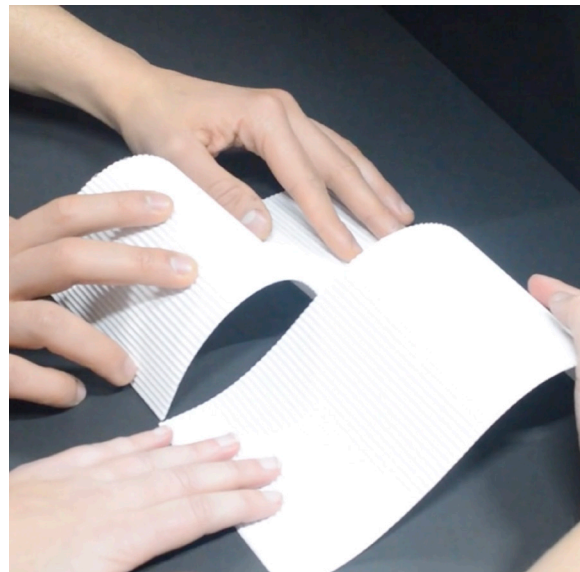


Figure 3: Exploring the transition: breathing

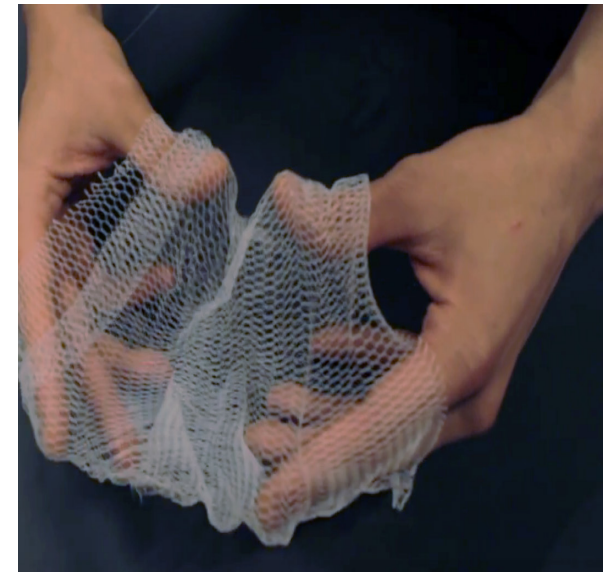


Figure 4: Exploring the transition: breathing

Phase 2 - Composite materials

The movement of these two separate elements was explored further in phase two. Furthermore we were inspired by the paper of Isabel P.S. Qamar et al. to combine different materials to see how the behaviour of these could change [13]. We created different composite materials as one can see in fig. 5, 6, 7 and 8.

Besides the composite of materials, the dynamic quality of the design still had to be defined. Again an attempt to mimic breathing with composite materials was made and the idea of bulges that would pop up and pop down again was initiated (Fig. 8). At this point the team started constructing the intended behaviour of the user and the interaction with this artefact. We wanted the user to interact with these bulges by approaching and pressing it. The bulges would provide feedback by increasing its pace. Feedback would be provided through feeling the increase in pace and finally feeling the heartbeat of the artefact.

We mainly worked with foamy materials and soft “fur-like” textiles. At the end of these experimentations we realised that using a “fur-like” textile would be a very literal translation of our transition. To show more depth we moved away from these materials and

tried to see if we could convey the same qualities with a different approach.

The team considered two different ways to actuate the bulges which were respectively by the use of rotational servo motors and by the use of electromagnets. The idea of using servo motors was based on an exploration that created bulges in the material that can be seen on fig. 9. Strings were added at the ends of an x-shaped plastic structure that when pulled would create a bulge.

To realise this mechanically the string would be wound tightly around a spool and then be attached to the moving part of the servo motor, which would then rotate clockwise and counter-clockwise. A proposal on how to create this system is seen on fig. 10.

A limitation of conventional, cheap rotation motors is that they are imprecise and because of their clunky movements, it is difficult to apply Disney’s 12 principles of animation [16] which are considered essential for mimicking life. Since the explorations are heavily based on organic movements such as breathing, we considered other options for actuation.

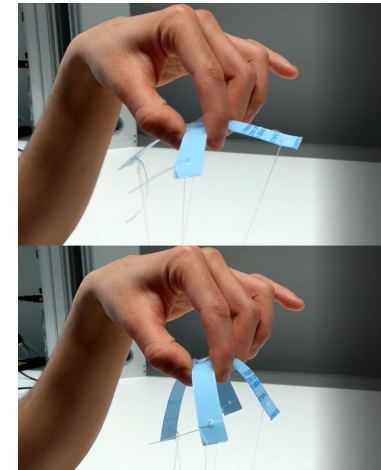


Figure 9: Plastic structure with strings in resting position (top) and with strings pulled (bottom)

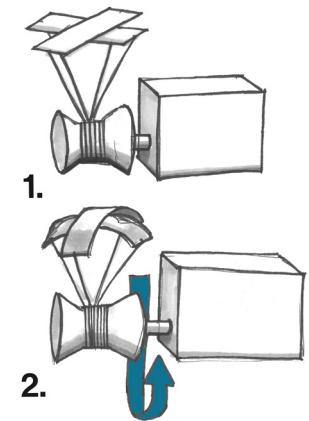


Figure 10: 1) The structure in a resting position. 2) The structure rotated clockwise to create the bulge.

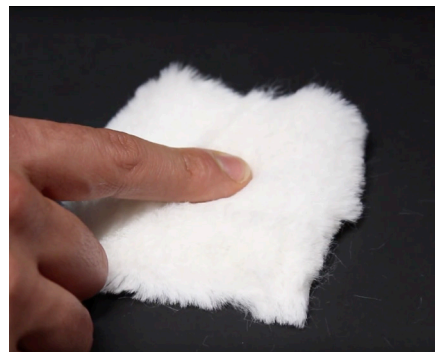


Figure 5, 6 and 7: Exploration of composite materials

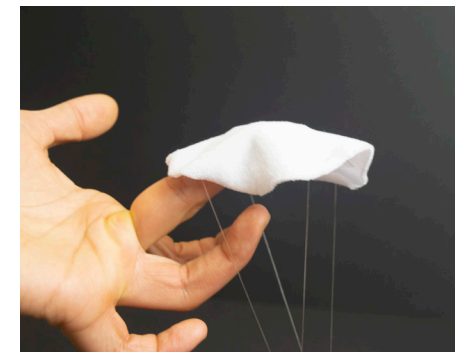


Figure 8: Representation of a bulge

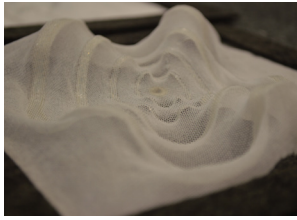


Figure 11, 12, 13, 14: 3D printing on textiles



Figure 15: Affinity diagram

Phase 3 - Flexible textiles + beginning of 3D printing on textiles

The idea of breathing bulges with the servo motors and plastic skeletons as actuators was proposed to fellow industrial design students and faculty members. They provided valuable insights for potential other methods of actuating our intended behaviour and achieve the appropriate dynamic qualities. After considering the different opportunities, we chose to use an electromagnet and a magnet in combination with a ultrasonic sensor to actuate the bulges to breath.

Electromagnets were chosen for the actuation since their field of actuation is based on the power they receive. Controlling the power provided to the magnet can be done accurately unlike with the servo motors and their cheap motor drivers. Furthermore when the electromagnet repels the normal magnet attached to the fabric it naturally creates bulges in the materials when unobstructed, where you have to create a structure for the servo motors to function.

Since the actuation has to change pace at different distances between hand and system a distance sensor was needed. An infrared sensor and an ultrasonic sensor were both options to consider, since both of them are time-of-flight sensors, which implies that distances are calculated based on the time it takes for the sound pulses/laser to return. The ultrasonic sensor was chosen since the infrared sensor has a few use-case limitations such as the inability of use in sunlight due to interference in the signal and difficulty in reading darker surfaces.

A capacitive sensor was also considered for the system since the current iteration of the system is unable to tell whether a hand is very close to the field of interaction or if it is actually touching it, but was ultimately not implemented.

With the dynamic quality of the actuator in mind we tried to find different flexible textiles with different properties. These textiles would have differences in, for example, opacity, flexibility and shininess. Fabrics can be flexible on their own, but when being submitted to a pulling force they have a bouncing effect which is very close to the desired behaviour of the material. By showing people the different textiles we noticed how shininess helped when attracting a person to interact with it, while transparency made the material look very delicate and non-inviting to touch.

A quality that we discovered when starting to 3D print was that, firstly, we could manipulate the way that the material moves, and secondly, the 3D print filament would have a shiny effect once printed on the transparent textiles that could potentially persuade a person to want to touch it. The first shapes we 3D printed unto textile were concentric designs. They would

make the textile bounce nicely from the centre. Although it seemed to give the desired behaviour, the aesthetics did not attract people to want to interact with it (Fig. 11, 12, 13, 14).

The interaction necessary to provoke a change in behaviour or state of these materials was to touch the material. The interaction was designed with the use of the Interaction Frogger Framework. The Interaction Frogger Framework couples person's action and the product's function through the use of inherent, functional and augmented information, i.e. feedback and feedforward [19]. The framework provides six practical aspects, time, location, direction, dynamics, modality and expression that describe the relationship between a person's action and the perception of the product's reaction. A natural coupling of action and function allows for an intuitive interaction [19].

During this phase we were striving for an intuitive interaction by unifying action and reaction on as different aspects through functional and inherent feedback and feedforward. Functional feedback is the information generated by the system when performing its function, e.g. sound, light or motion. Augmented feedback is the information not coming from the action itself (which is inherent feedback), but from an additional source. Inherent feedback It is feedback arising from the movement itself. It appeals primarily to the perceptual-motor skills of the user [19].

In the chapter final design the implementation of the Interaction Frogger Framework is described in detail. In this phase the interaction was based on functional feedforward by showing the movement and pace of the material, this is coupled via time, location and modality to functional feedback by showing increase in pace and inherent feedback of feeling the heartbeat and hearing the increase in sound.

Evaluation

The artefact is evaluated by fellow students in phase 3 of the design process. An affinity diagram is constructed to analyse and organise the different types of feedback, as one can find in fig. 15 and fig. 16. The feedback was arranged by the following categories: Transition: breathing, inviting, interaction, aesthetic qualities, noise, actuators/sensors, process and future. This feedback is used to fine-tune the qualities of the material, its' behaviour and the interaction.

Transition: breathing

There were some interesting comments about the transition we chose for our artefact. One mentioned the consideration of rhythm of the movement of breathing as one can find in figure 15 and figure 16, this resulted in fine-tuning the movement of the material to express the transition of breathing

in a more natural way. A comment stated that just because the movement runs in phases it does not necessarily resemble breathing, so the team looked into how often a resting person breathes per minute. The average human being breathes 12-18 times per minutes [2], with around two seconds of inhalation and three seconds of exhalation. The system was adjusted to run at similar pace between no power and full power.

Inviting, interaction and aesthetic qualities

Whether the material was inviting to touch was a big concern with our students during this evaluation moment. The material should be inviting to touch or should express the intended transition to some extent. The material looks fragile and sensitive which may result in defending attitude with the user. The team worked on the aesthetic qualities of the artefact by experimenting with different kind of patterns on the material which might alter a more engaging attitude. Furthermore the team thought of more meaningful ways of interacting with the artefact as well as alternatives to include feedback and feedforward to achieve the intended behaviour.

During the feedback session with our fellow students we were advised to consider future opportunities and applications of this product into account when designing the interaction and look. We decided not to take this advice on due to us wanting to focus on the interaction that the material could provoke and not what a potential future application might need.

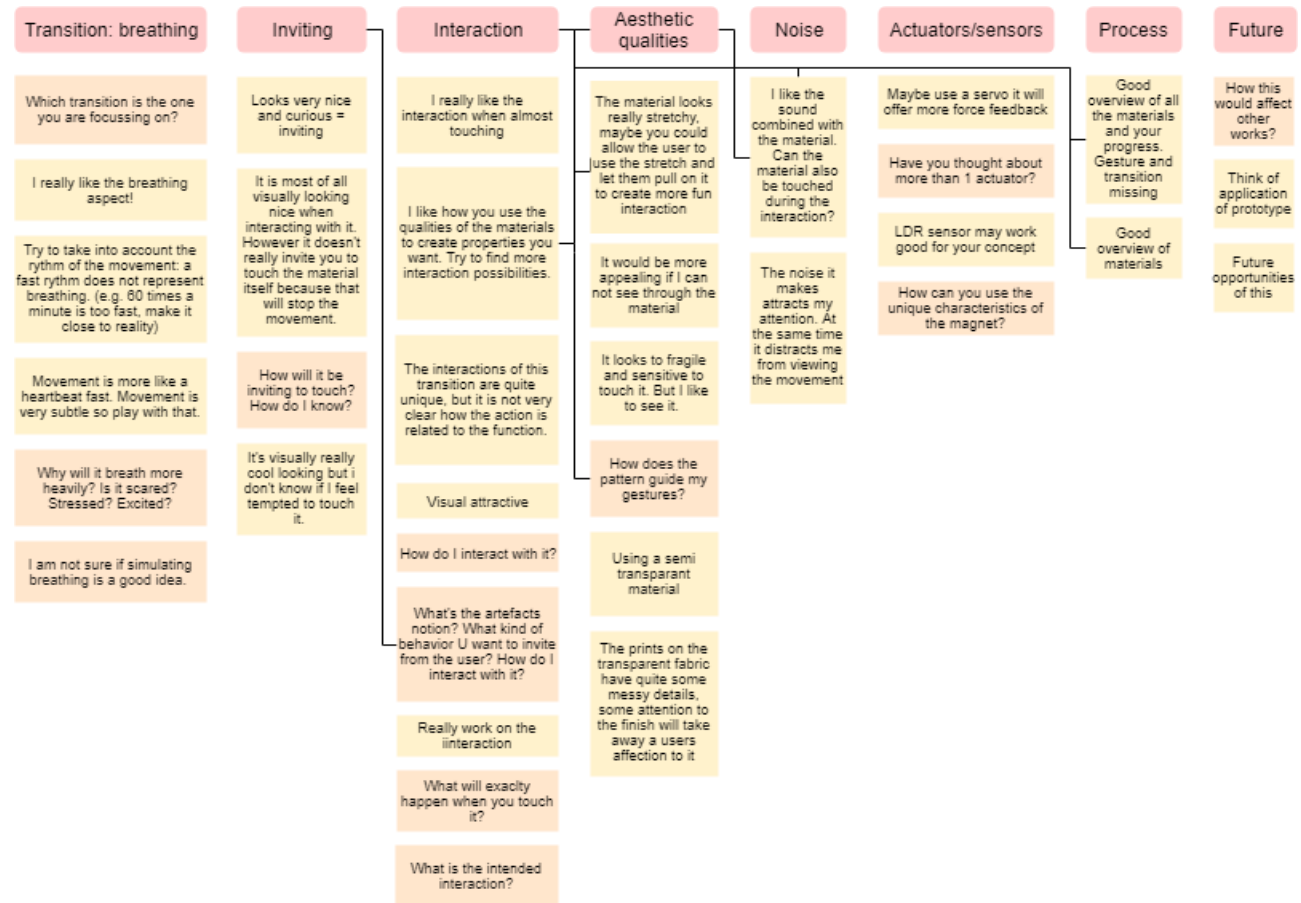


Figure 16: Affinity diagram

Phase 4 - 3D printing on textiles

When working with the electromagnet we soon noticed that as the fabrics that had more opacity would be too heavy for the technology. This, next to aesthetics, was the reason why we chose mesh as our material.

Having decided that flexible transparent textile, mesh, was the material we would work with allowed us to go more in depth in shaping the behaviour of the material as we would want it. Instead of totally changing the behaviour of the flexible textile, we looked for ways to amplify this behaviour.

The aesthetics of the 3D print on the textile and how the textile would react to it was extremely important since it would be a key factor to the interaction. Not wanting to lose the “delicate” aspect of the aesthetic, we tried to find a way to use this in our favour and make it look so interesting and/or beautiful that people would want to touch it even though it looked delicate.

Process of creating the 3D prints was as follows: (Fig. 17)

Draw by hand/think of design

Draw it in illustrator

Exporting it into Rhino to give it 3 dimensions

Exporting it into Cura to prepare for 3D printer

Stretching fabric unto building plate

Starting the Print!

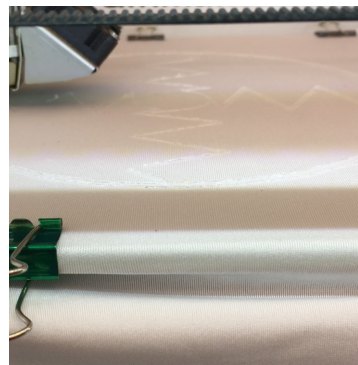
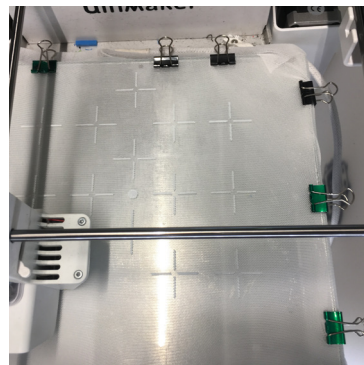
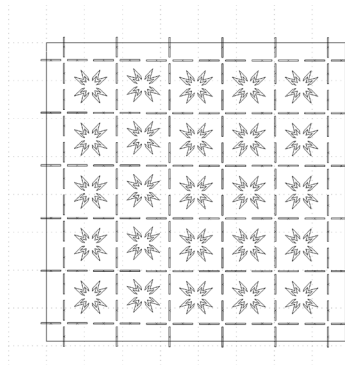
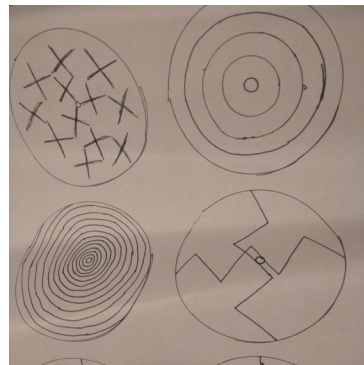
Remove print from the build plate

Letting the fabric settle back to its non-stretched state

Repeat!

The 3D print started out having concentric shapes, this evolved into more geometrical designs, eventually finding a midway creating structured designs with organic shapes.

The geometrical shapes made the fabric pulse all over, which was a good effect since we wanted to make it seem as if this fabric was breathing all over. A downside to these geometrical shapes is that it did not quite connect to the concept of breathing from a biological/organic perspective.



When creating the structured organic shapes we saw that the all over bouncing effect remained. An even better aspect of this design was the fact that it moved even more organically and bounced even more. This is why we eventually chose for this design.

During the feedback-session at phase three, we received a lot of concerns about the interaction of the artefact. The relationship between the action and the function was not very clear by our participants. Also the consequences of executing the behaviour on the artefact were not clear. We fine-tuned the interaction based on this and stumbled on the work of Jelle Stienstra et al. which introduces the action-perception loop. A product that changes its shape can give rise to a feedback loop playing on the action-perception possibilities, offering a dynamic interaction between the action of the user and the reaction of the product. [15] [19]. We enhanced the interaction by exploring the Interaction Frogger Framework more and changed the interaction, in order that an action-perception loop endured. One can find the final design of the interaction at the next chapter.

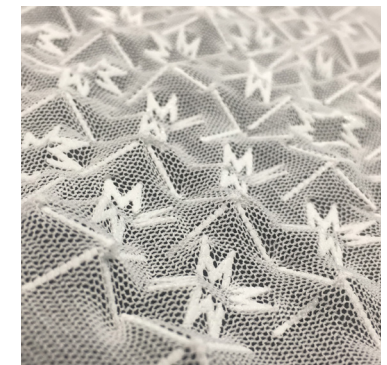
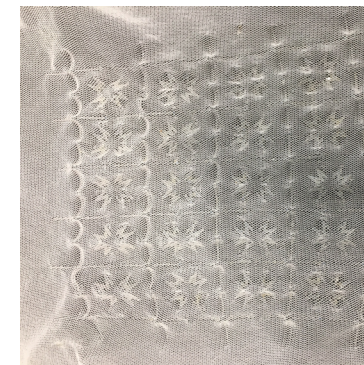
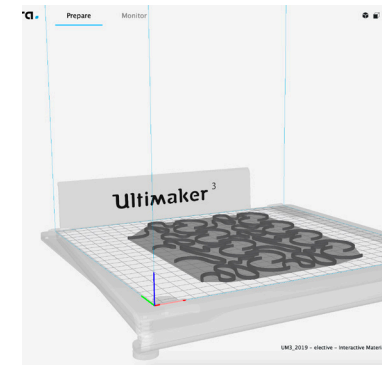
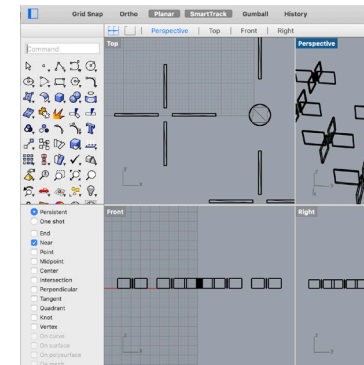


Figure 17: Process of creating the 3D prints

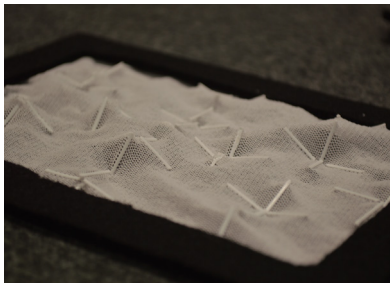


Figure 18, 19, 20, 21: 3D printing on textiles

Final design

Breeze is an artefact which breathes, as one moves closer and touches it, it reveals its heartbeat to you. Breeze is made out of a mdf shell and a soft breathing top. This upper part is made out of a flexible semi-transparent fabric printed upon with filaflex. The pattern is made out of repetitive organic shapes that are printed upon the fabric when in its expanded state. This textile, after printing and removal of the textile from the 3D printer, then contracts and a hilly surface appears.

The artefact invites the user through functional feedforward, the functional information is coupled via time, location and dynamics to the inherent information. By approaching the artefact the user will receive functional feedback through seeing that the fabric reacts immediately and that it increases pace. By touching the material the user will receive inherent feedback, by feeling the increased pace and feeling the mimicking heartbeat of the fabric. Time: There is no delay in time when the user approached the artefact and the increase in pace the material will show. Furthermore there is no delay in time when touching the material and feeling the heartbeat. Location: The movement of the material is in line with the movement of the user, this is forced by the place of the ultrasonic Sensor. Modality:

By approaching the artefact the user will receive functional feedback through seeing that the fabric reacts immediately and that it increases pace. By touching the material the user will receive inherent feedback, by feeling the increased pace and feeling the mimicking heartbeat of the material. When the user contracts his hands away from the material, the material will respond via time, location and modality through functional and inherent feedback by decreasing the pace of the breathing again, creating an action-perception loop.

Important to note is that the changes in behaviour of the material between the different stages are subtle changes. It is essential not to grasp attention through disrupted behaviour. The mappings are unobtrusive and subliminal designed [15]. Furthermore this technology is chosen, because of the fact it does not distract the user. It adds subtleness to the artefact through the modalities of the magnet. As described in the work of Vallgarda [17] the task of programming behaviour should be seen as a form giving practice. An in depth



Figure 22, 23, 24: Final prototype

understanding in sensitivity of the chosen sensory modality and sensorial system being addressed is required for the designer [15].

With this artefact Inherent feedforward is combined with functional feedforward. As described in the work of Wensveen et al. ‘When the inherent trace is coupled to the functional feedback it offers information about the current state of the product, i.e. in which functional mode it is in. ‘ [19] The slow breathing invites the user to come closer, the qualities of the material and the aesthetics invites the user to touch the fabric.

Implementation:

A circuit diagram of the final system can be seen on fig. 25 and a discussion of actuators and sensors is found in phase 2 of the report.

The system has two steps to make it work. In the first step the system determines whether something is hovering over the ultrasonic sensor. There’s a programmed threshold in the Arduino sketch that controls how large a distance away from the ultrasonic sensor that is considered hovering. Depending on the distance to the sensor, the Arduino will return a fading speed that determines how quickly the power will shift for the electromagnet. To reduce sensor noise and extreme sensor values an average of the last ten sensor readings is used for the distance variable. At a long distance it will shift slowly like breathing and at a close distance it will shift quickly like a heartbeat. In the second step of the system the calculated fading speed is used to control the shifting of power. The system will shift positively from no power to full power and when full power has been reached it will shift negatively back until it has reached no power again. At no power the electromagnet is still magnetic, but only when two objects are physically touching, which is why the normal magnet is suspended to the fabric at a certain distance above the electromagnet. When the electromagnet is powered the opposing magnetic forces will repel the magnets away from each other. However the electromagnet is suspended into place and many times more powerful than the normal magnet, this is the reason why the bulges are created.

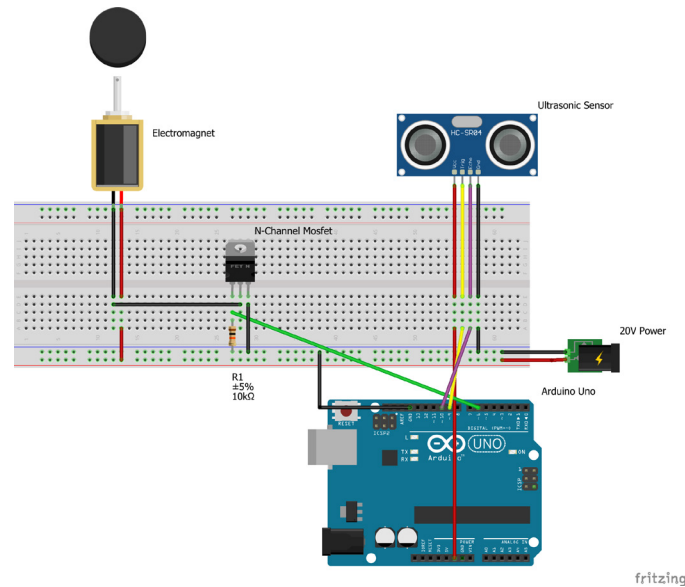


Figure 25: A circuit diagram of the Breeze system.

Link to process video:

<https://vimeo.com/313207121>

Link to final video:

<https://vimeo.com/313182740>

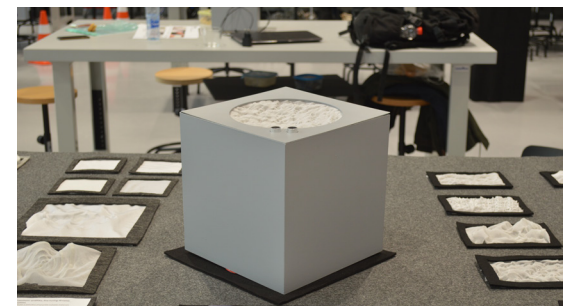
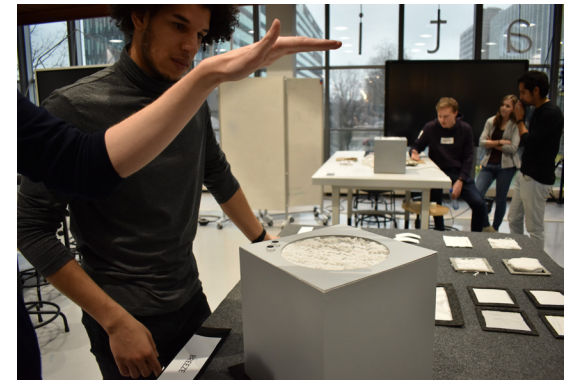


Figure 26, 27, 28: Final prototype

DISCUSSION

Limitations of the study and missed opportunities

Several limitations of our study need to be discussed because they shape the conclusion that is drawn. The artefact is designed in a period of 8 weeks. Due to time limitations, technical issues and missed opportunities the final design appeared to be slightly different than the envisioned design. Furthermore the Interaction Frogger Framework of Wensveen et al. is used in the design process to design the behaviour and interaction of the artefact. When you look at the 6 aspects of natural coupling through inherent, functional and augmented feedback and feedforward to make the interaction more intuitive and meaningful, there are some opportunities that were not taken within designing the interaction for this artefact. For instance when the user approaches the artefact the material will increase in pace, mimicking faster breathing. However the aspect dynamics and expression are not taken into consideration when designing this interaction. The dynamics of reaction is not coupled to the dynamics of the action. It might be meaningful when the user could guide the breathing material by moving his hand up and down and receive immediate similar reaction in the same speed/pace of the artefact. That brings us to the coupling aspect direction, the direction of the material is up and down. When the user approaches the material, the pace will increase, however the direction of the material will not be guided by the user, which is a missed opportunity.

The artefact invites the user through functional feedforward, the functional information is coupled via time, location and dynamics to the inherent information. One can argue that inherent feedback and feedforward could have been integrated in the artefact to a greater extent. When the material is touched by the user the user feels the heartbeat and hears the sound of increasing pace. However at the first phase of interaction with the artefact the user only receives functional feedforward and functional feedback by seeing the change in movement of the material.

A capacity sensor or LDR sensor could have added more value to the artefact, when the user touched the material, different capacity sensors could indicate where the user touched the material and provide inherent feedback via a coupling of

the aspect location by increasing or decreasing pace at that particular place.

The action-perception loop introduced by Stienstra et al. is used to design a continuous dynamic experience for the user. The material will respond via time, location and modality through functional and inherent feedback by decreasing the pace of the material again, creating an action-perception loop. Although the action-perception loop is integrated in the artefact by decreasing again when the user contracts his hands away from the artefact, the envisioned design integrated the action-perception loop in a greater extent. The envisioned design was that the artefact would provide inherent feedback when the user touches the material by decreasing the pace when the user touches the artefact in a relaxing way or touches the artefact for a longer period of time. When the user touches the artefact in a more aggressive way, the artefact would react with an increase in pace, by coupling inherent information with functional information via dynamics, expression and location. Resulting in a continuous feedback loop, offering a dynamic interaction between the action of the user and the reaction of the product.

Due to technical issues the dynamic quality of the material and the interaction of the artefact was not always as intuitive and meaningful as it was supposed to be. The magnets in combination with the electromagnet weren't as strong as we wanted them to be, to create the envisioned effect. The electromagnets malfunctioned occasionally, which resulted in a confusing interaction. Due to the fact that the magnets weren't strong enough, we were limited in our choice of the material. The material should be very light weighted and flexible. One can argue that the translucent material distracts the user, the 3D printed filament disguised some of the electronics that were hidden behind the fabric. However a fully non-translucent material would have created a more subtle experience with the artefact.

Fields of application

In recent years, the possibilities in adding computational matters towards materials has enabled HCI researchers to actively explore more expressive and intuitive interaction forms [16]. The fields of application for products that are interactive and rely on the sensory and perceptual motor skills of the user seem extensive. One can think of using shape

changing interfaces in the interior of autonomous vehicle to create a more natural intuitive experience, or mobile devices could apply shape changing interfaces like PneuUI to create a more natural intuitive experience[20].

This particular artefact in which human characteristics are applied to rely on senses and interactivity in the form of a shape changing interface is added can be integrated in for example the fields of health or rehabilitation. The artefact can be used as a breathing exercise to enhance the person's breathing pattern. For instance, people who stutter can experience difficulties with their breathing pattern. The current breathing exercises for people who stutter are quite dull and not interactive nor intuitive. With behalf of this artefact people who stutter could imitate the breathing and interact with the artefact to adjust the pace of the exercise. The dynamic and expressive aspects of natural coupling and the inherent feedforward and feedback described in the limitation part should be taken into consideration for this purpose.

CONCLUSION

In this paper we explored the possibilities of a shape changing interface which relies on the sensory and perceptual motor skills of the user that would interact with the user in a more intuitive meaningful way. We approached this challenge by designing an artefact that contains human characteristics by mimicking breathing and allowing the user to interact with it in a continuous action-perception loop. This journey resulted in an explorative overview of the possibilities and difficulties when designing a shape-changing artefact which also relies on the senses/haptic visuality by adding human characteristics to the artefact. Furthermore it shows how the Interaction Frogger Framework can be applied to a design process to create a more valuable intuitive interaction.

REFERENCES

1. Kevin Anderson. 2012. Kinetic folds. (2012). Retrieved December 9, 2018 from (<http://www.kevinandersen.dk/site/portfolio/kinetic-folds/>)
2. Barrett, K. E., & Ganong, W. F. (2012). Ganong's review of medical physiology. New York: McGraw-Hill Medical.
3. Biomimcry NL. 2018. Wat is biomimicry. Retrieved December 9, 2018 from <http://www.biomimicrynl.org/wat-is-biomimicry.html>
4. Angela Chen. 2017. Butterfly wings inspire a better way to absorb light in solar panels. (oktober 2017). Retrieved November 22, 2018 from <https://www.theverge.com/2017/10/19/16503258/butterfly-wings-engineering-solar-cell-energy-biomimicry>
5. Wendy Dassen & Miguel Bruns Alonso. 2017. Aesthetics of Haptics: An Experience Approach to Haptic Interaction Design. 254-259. (June 2017). DOI: 10.1145/3064857.3079156.
6. Paul Dourish. 2001. Where the action is: The foundation of embodied interaction. Cambridge, Massachusetts: MIT-Press.
7. Joep W. Frens. 2006. Designing for rich interaction : integrating form, interaction, and function. Technische Universiteit Eindhoven. (January 2006). DOI: 10.6100/IR608730
8. Gertie Goddard. 2018. Biomimetic design: 10 examples of nature inspiring technology. (April 2018). Retrieved November 22, 2018 from <https://www.sciencefocus.com/future-technology/biomimetic-design-10-examples-of-nature-inspiring-technology/>
9. Matthijs Kwak, Kasper Hornbaek, Panos Markopoulos, Miguel Bruns Alonso. 2014. The design space of shape-changing interfaces: a repertory grid study. In proceedings of the 2014 conference on Designing interactive systems. 181-190. DOI: 10.1145/2598510.2598573
10. Laura Marks. 2004. Haptic visuality: Touching with the eyes. Innovation and social space.
11. Wiliam Odom, James Pierce, Erik Stolterman & Eli Blevis. 2009. Understanding Why We Preserve Some Things and Discard Others in the Context of Interaction Design. Conference on Human Factors in Computing Systems - Proceedings. 1053-1062. DOI: 10.1145/1518701.1518862.
12. Amanda Parkes and Hiroshi Ishii. 2010. Bosu, A Physical Programmable Design Tool for Transformability with Soft Mechanics. 189-198. (January 2010) DOI: 10.1145/1858171.1858205.
13. Isabel P.S. Qamar, Rainer Groh, David Holman, Anne Roudaut. 2018. HCI meets Material Science: A Literature Review of Morphing Materials for the Design of Shape-Changing Interfaces. Conference on Human Factors in Computing Systems – proceedings. 374. DOI: 10.1145/3173574.3173948
14. Majken Rasmussen, Tim Merrit, Miguel Bruns Alonso & Marianne Petersen (2016). Balancing User and System Control in Shape-Changing Interfaces: a Designerly Exploration. 202-210. DOI: 10.1145/2839462.2839499.
15. Jelle Stienstra, Miguel, B. Alonso, Stephan Wensveen, S., and Stoffel Kuenen. How to design for transformation of behavior through interactive materiality. 2012. In Proceedings of the 7th Nordic Conference on Human-Computer Interaction (NordiCHI 2012), October 14-17, Copenhagen, Denmark (pp. 21-30). New York: Association for Computing Machinery, Inc. DOI: 10.1145/2399016.2399020
16. Ollie Johnston and Frank Thomas. 1995. The illusion of life: Disney animation (pp. 306-312). New York: Hyperion.
17. Anna Vallgaard. 2013. Giving form to computational things: developing a practice of interaction design. Personal and Ubiquitous Computing. 1-16. DOI: 18. 10.1007/s00779-013-0685-8.
18. Peter Paul Verbeek. 2005. What Things Do – Philosophical Reflections on Technology, Agency, and Design. The Pennsylvania State Press.
19. Stephan Wensveen, J.P. Djajadiningrat & Kees. C.J. Overbeeke. 2004. Interaction frogger: A design framework to couple action and function through feedback and feedforward. DIS2004 - Designing Interactive Systems: Across the Spectrum. 177-184. DOI: 10.1145/1013115.1013140.
20. Lining Yao, Ryuma Niiyama, Jifei Ou, Sean Follmer, Clark Della Silva, and Hiroshi Ishii. 2013. PneuUI: pneumatically actuated soft composite materials for shape changing interfaces. In Proceedings of the 26th annual ACM symposium on User interface software and technology (UIST '13). ACM, New York, NY, USA, 13-22. DOI: 10.1145/2501988.2502037
21. <https://vimeo.com/313207121>
Link to process video
22. <https://vimeo.com/313182740>
Link to final video

REFLECTION

Interactive materiality was a quite new concept to me, due to my background as an interaction mainly screen-based designer. It grasped my attention through the work of Joep W. Frens, that explored rich interaction. [7] User interfaces exist of screens and buttons that are not really natural in their use. The way we use these products do not relate to our instincts, they do not really relate to our sensory and perception motor skills. When looking at nature and looking at the way we as humans are designed, user interface designs, the products we use daily could be designed more meaningful when they are inspired by the element that is the most closed to ourselves. I believe the awareness of the importance of choosing the right material and designing a meaningful interaction is lacking in a lot of products. I must admit, my prior work in industrial and interaction design is more focussed on function and visual feedback/feedforward, than on sensory and perceptual skills and materiality. Therefore I decided to accept the challenge and picked the course interactive materiality.

My learning goals consisted out of appreciating aesthetics more, especially aesthetics of interaction. Furthermore I wanted to work in a greater extent with physical materials, materials in different forms and shapes. I wanted to learn about manipulating materials, in such a way that they create an intuitive meaningful experience for the user.

I teamed up with Julia van Zilt and Ahmad Issa, we all came from different backgrounds and had different learning goals. I appreciated the fact that our background differed, because we have learned from each other considerable. Unfortunately we also differed in our working style throughout the process. I struggled with the fact that some team members were remarkably relaxed, especially throughout the first phases of the design process. I wanted to also in the early process execute at lot of explorations, however it seemed that they were only really committed to the project when there was a strict deadline. That does not take away that they delivered high quality work, however it frustrated me that everything was last minute work. Looking back at this process, my approach on this problem did not help the project further. My frustrations got the better hand of me and I might have pushed them to hard at moments they did not find it necessary, which resulted in frustrations at their side. This experience taught me that it would be better if I invest my energy in excelling

my own work instead of making sure the others will be done on time for the deadline. That said, because of the difference in background, we were also able to learn from each other a lot. Julia had quite an advanced feeling in aesthetics and had experiences with working with materials, especially textiles. With her aesthetics expertise she helped me gain appreciation of aesthetics in physical products more and taught me how to 3D print on textiles. Ahmad has a background in computer science and shared his expertise in electronics, sensors and actuators, so that we could achieve our envisioned interaction through the material.

My main contributions within this project contained the following aspects. Firstly exploring the transition of breathing, investigating the development of a perception of human characteristics through materials. Secondly exploring with different fabrics, materials and paces in behaviour and interaction. Thirdly exploring ways to achieve the dynamic qualities of the artefact by investigating possible sensors and actuators and designing the patterns for the 3D prints. Fourthly applying literature to design an intuitive interaction with the artefact. Fifthly communicating haptic visuality and subtlety into video presentations. Lastly developing an affinity diagram, translating the insights into the aesthetics interaction of the artefact and fine-tuning sensitivities into the interactive materiality.

I dived into the literature and investigated, analysed and explored designing for an aesthetic interaction with an interactive material experience. At first I had quite some difficulties to understand the literature and apply this to the design process. To be honest I found most of the literature vague, woolly and not practical or down to earth at all. Further in design process while reading and investigating more literature, I began to understand the meaning of it and more important the added value of the design domain. Especially the work of Wensveen et al. About the Interaction Frogger Framework accompanied my learning experience for designing aesthetics interaction. I learned about inherent feedforward and feedback and the 6 aspects of natural coupling. I learned to apply the framework to the design process by naturally coupling the action of the user to the reaction of the product to create a more intuitive and meaningful interaction [19]. Furthermore the work of Verbeek taught my more about material qualities, 'the

sensorial in the broadest sense' [18] and the work of Marks introduced me to haptic visuality [11, 10]. Which is used as inspiration for the artefact we created. Although it also adds a haptic interaction to it, it relies on the user's sensors by focussing on the aesthetics of the material and by adding human characteristics to it. Through exploring a large variety of materials, textiles, interactions and behaviours, I learned to map material qualities and make a selections based on our developed qualifications. Furthermore I learned to apply my findings from literature into the design of an interactive artefact. I gained knowledge about sensors and actuators which could possibly be integrated into the design to achieve the envisioned design. Furthermore I learned to create an artefact that could be deformed or manipulated by the user, to create a more intuitive, natural interaction experience. At the end of the design process I learned to fine-tune the interactive materiality in a subtle way, based on the insights we received from our fellow industrial design students and experts.

To conclude, this course was quite a challenge for me, but it helped me with my journey of becoming a great designer. I will further develop the knowledge I learned in this course to design more meaningful and intuitive interaction with my concepts and products. Furthermore I can apply the knowledge about material qualities and dynamic qualities I gained through this course in my future design projects.