aasenhi

Exploring Expressive Ambiguity through a Materials-Oriented Design Approach

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1. ABSTRACT

During the course Interactive Materiality we were requested to investigate interactions through one of a pre-selected set of materials from which spacer fabric was chosen. This fabric was explored through a materials-oriented design approach as a guideline for iterations and design goals. The interaction was constructed and evaluated at the hand of interaction design contextualised around the framework of expressivity to distinguish and design for an aesthetic interaction. This approach to design in combination with the focus on expressivity intends to result in a coherent aesthetic experience based around a thoughtful interaction. This was eventually formulated as the transition of consensual physical interaction which materialised in the final artefact, aasenhi. Aasenhi's design stimulates empathy with non-human entities by reciprocating exploratory behaviour whilst evoking an holistic experience designed around haptic ambiguity and subtly.

These chosen qualities were inherent to the spacer fabric and guided the iterative process towards the final design. aasenhi illustrates the value of this approach by providing a rich intuitive interaction with a multitude of potential applications to be researched and developed.

2. INTRODUCTION
Design research is exploring new and innovative ways on how to connect emerging technologies to people in their everyday life. Examples of this are how we could interact with artefacts, how they should behave, and what the relation between the user and artefact could be. One way to do this is trough 'freedom of interaction' explained through a framework by Wensveen et al. [2004]. The framework elaborates on different types of functional information that an artefact can give to the user to communicate the user's possible actions through inherent and augmented information. Haptic interaction design uses dynamic haptics to enrich the interaction. Dassen et al. [2017] started from an experience perspective designing haptic interaction due to the relevance of experience in interaction design. Ross et al. [2010] go beyond the notion of interaction and elaborate on the aesthetics of behavior and expressivity in the context of interaction, challenging dynamic form, sensory-motor implementations, and social implications. These previous works all show ways to enrich interaction to create new relationships with users and artefacts.

Creating relationships can become better if the expression of feelings within the communication between the user and artefact could take place. As mentioned above, Wensveen et al. [2004] do this through 'freedom of interaction', or the user's expressivity, and Ross [2010] does this though interaction itself. Vallgarda [2014] rather confines to expressivity of the artefact, creating temporal forms in combination with physical forms and its interaction gestalt. Bruns et al. [2021] takes these notions of expressivity in interaction and built a framework around it to combine the three in one process, introducing certain qualities that designers can use when designing expressive interaction. With this a user can express their emotional state through expressive interaction with a system or embodiment of a system. The system then changes its temporal form and materiality over time according to a user's action to convey its own expressions.

Tools and methods to achieve this goal can be split into shape changing interfaces and the use of materials or smart materials. Previous work on shape changing interfaces focusses on the different challenges of this technology. This includes the design of the artefact, the interaction, the overall user experience and how to achieve its goal using new technologies [4, 7, 2]. More work shows interesting discussions about the design space of shape changing interfaces and how its understood [8]. Furthermore, ethics and policy making of this technology are described similarly as challenging [4]. The active use of material in design and what this material embodies and what it communicates is important to understand what we can do with material in the future [3, 5]. This work about shape changing interfaces and materials focusses on the practicalities of these applications in design and misses a touch of human computer relationship research.

I describe the post-human notion of human computer relationship as the place and role design takes in the environment of humans, but at the same time the place and role humans play in the environment of a design. This entitles not only the relationship humans have and can express with an artefact, but also the relationship artefacts have with humans and how they can express it. Here arises an interesting discussion about what artefacts should be able to express and how they can assess their expression about a relationship with a human, in other words, have emotions. Moving from a monological human computer interface, where the human controls everything, towards a more dialogical interface, such as shape changing interfaces using smart material and expressivity, gives reason to research this post-human notion through using these technologies themselves.

During this project we take a speculative, material-centred approach to discover new possibilities for human computer interaction with spacer-fabric in a three dimensional and voluminous interface. The process consists of a material behaviour exploration and analysis to learn what is possible with the material, find the qualities, and use this as a starting point. Next, we apply a design for expressivity framework to create an in-depth interaction strategy. Finally, we will design an interactive material experience using sensors and a complex actuator to research how this mutual human computer relationships exists.

3. RELATED WORK
The science in which the concept of Interactive Materiality is established is characterised by rapid development and emerging approaches. The theory of Interactive Materiality is constructed as a complementary marriage between the materials-oriented design (MOD) design approach and expressivity in interaction [1,2]. This methodology encourages hands-on exploration of materials as a design guideline to experience and use the inherent qualities of a material. The design process is shaped by the haptic qualities of the material and stimulates the creation of engaging and reciprocal design grounded in the intuitive experience of the material. To formulate a comprehensive understanding of materiality we will analyse and contextualise three design perspectives in this section which are integral for the understanding of Interactive Materiality.

3.1 Interaction Design
In the practice of Human Computer Interaction (HCI), the emergence of interaction design aims to advance the holistic shaping of artefacts with computational capabilities to improve the overall human experience as it relates to the design [3].

By encompassing temporal form-giving, physical form-giving and the theory of the interaction gestalt a framework is proposed to dissect the practice of interaction design by lining out these aspects and their relative composition given the context of the interaction [3]. This framework gives an abstract understanding of the relation between user and artefact and is useful to understand and improve the interaction.

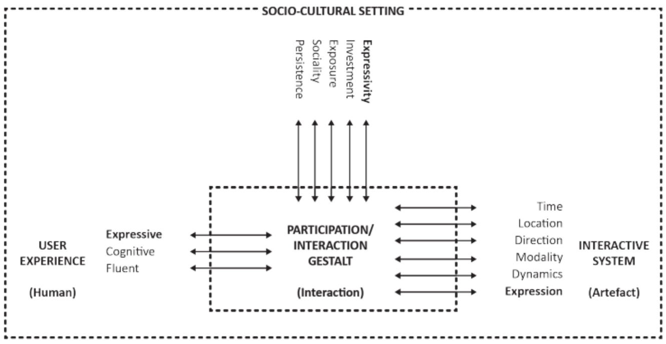

Figure 1
Interaction Design. Image retreived from [1].

Wensveen [4] suggests another framework exploring a deeper understanding of the interactions themselves. Unfolding the actions of the user into abstract levels of feedback and -forward to illustrate how the design of a product is able to shape the interaction.

These core understandings are fundamental for the comprehension of the framework of expressivity [1]. This framework explores how different modalities shape the ability of a design to convey thoughts or feelings through simulated behaviour. Interactive materiality heavily depends on this deeper expressive awareness as it relates to interaction design. Our explorations and iterations are heavily dependant on the modalities and setting as described in this framework

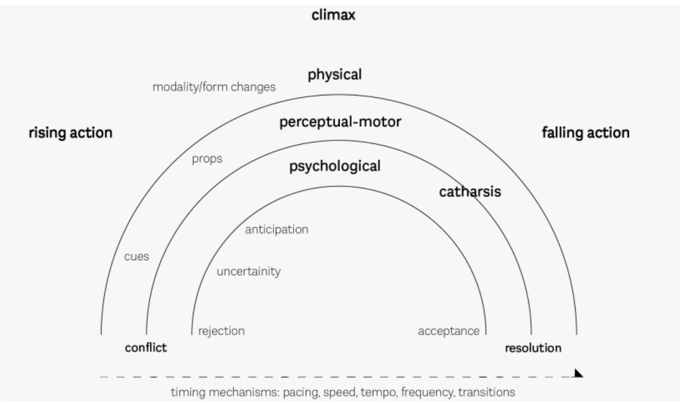

Figure 2
Material Oriented Design. Image retreived from [2]

3.2 Materials-Oriented Design

This approach to design is based on the predisposition that a holistic explorative methodology regarding temporal and reciprocal qualities encourages a more nuanced coexisting between human and design [1,2]. MOD has been devised to stimulate a deeper understanding of materials through sensorial exploration. Through this approach the material passively provokes the designer to be more engaged with its inherent qualities as a source of design inspiration. The aim of MOD is to guide designers in creating more nuanced artefacts through a comprehensive awareness of the material they are working with.

Our evaluations of the inherent material qualities and the sensory characteristics of the spacer fabric were imperative to the design iterations as described in the design process section.

3.3 Theory of Haptic Experience

The haptic perception of an object shapes the user's mental representation of it. Marks [5] illustrates the importance of haptic visuality in its relation to optic visuality. The important divergence for us between the two perceptions lies in the interpretation of the information.

The haptic approach to understanding aesthetic qualities shapes the expectations of the sensorial experience. This awareness in the context of interactive materiality can function as a tool for designers to amplify or play with the material qualities to shape the totality of the interaction. Additionally Lederman and Klatzky [6] provide a methodical approach to systematically analyse the haptic experience by exploring how haptic representation is processed through human cognition. The haptic understanding and language provided a guiding context through which explorations were evaluated and proceeded on during this project.

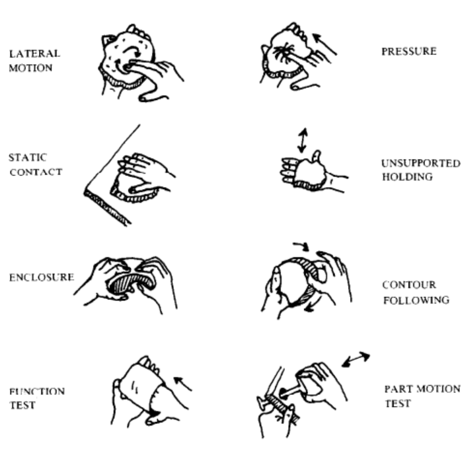

Figure 3
Theory of Haptic Experience. Image retreived from [6]

DESIGN PROCESS

MOD Approach

This project was based on a Material-Oriented design approach, therefore the first step during the design process was to explore the various materials to better understand their characteristics (Figure 1), to do so the researchers classified and deeply analysed the correlation with different elements and forces applied.

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Research

This phase involved pairing different materials with different peculiarities, experimenting with folds, and analysing the shades that the fabric created under different types of light (Figure 2). This initial exploration focused on covering the pure qualities of the different materials and was documented and preserved as necessary information for the next stages of the design.

Concept development

Starting from the transition movement of opening and closing, researchers explored different meanings of it (figure 3). The correlation between a consensual and non-consensual act, starting from the basic concept of acceptance and denial. It is from these concepts that aasenhi's personality evolved, including aspects of ambiguity, rejection, and surprise.

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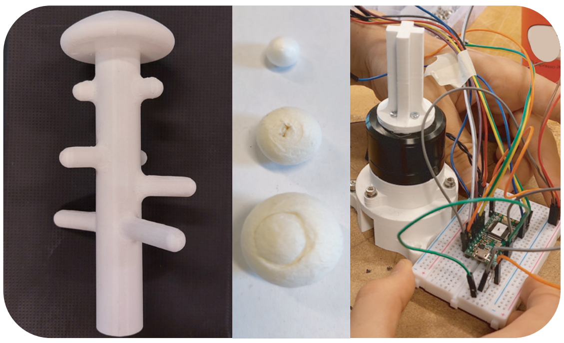

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Prototype

One of the most interesting aspects of Aasenhi, is the quality of movement. The addition of random spheres inside the body and the use of Feelix as the main motor (Figure 4) created a movement that was both random and controlled. The central rod was designed to be able to move the spheres with a random pattern.

Interaction

Through the schematization of different scenarios, the researchers identified different patterns of interaction, to which aasenhi responds differently through the Feelix. The result is a system that can create different movements based on pace, direction, and timing. (Figure 5)

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5. ANALYSIS

In this process, we took a material focussed approach. In our first exploration, we broadened our vision by looking into a big variety of materials. We explored the qualities that the material had to offer, and looked into different support structures and materials. Based on these explorations with the material we continued to select a fitting transition.

5.1 Main material

The first explorations started off with feeling and experiencing the spacer fabric. The material consists of three layers. The top, bottom and the 'spacer material' in between. In our case, the material consisted of black outer layers and white strands in between. To discover the white hairlike structure we decided to cut the fabric open, revealing the plastic strings inside. (Figure 9)

Figure 9
Plastic strings inside spacer fabric

Continuing to explore this cut-open space fabric we found that the two halves had similar as well as contradicting qualities to it. One half would stretch in two directions in contrast to the other half which would mainly stretch one way. When stretching this second material it would curl up its' edges as seen in figure 10.

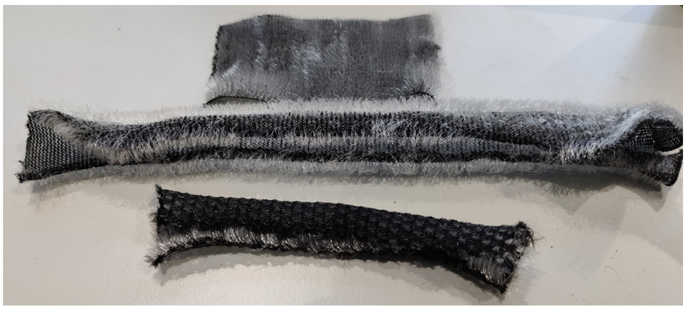

Figure 10
Different stretching directions

Whether the hairs curl inward or out depends, almost seems to happen randomly. This aspect of the material made us perceive fabric as if it had its own personality and autonomy.
This inspired us to discover more about stretching and contracting the material. Moreover, something that the materials had in common was the hairy structure created by the plastic strings. The material looked almost like the skin of an animal when touching it; some perceived it as prickly where others thought it was soft and pettable. This gave us the incentive to make a 3D structure as it would be more engaging and touchable. When rotating the fabric you could see different angles of the hairs, changing your perception of the colour and density of the material. This provided inspiration to start working with supportive materials.

5.2 Supportive material

We looked into a range of supportive materials using the cut-open spacer fabric. We started off with a piece of spacer fabric that was only cut open in the middle, leaving the edges attached allowing us to flip it inside-out. We filled the inside with a balloon, as the fabric was fully stretched and kept at tension by the balloon it provided a prickly tactile sensation. In addition, we worked with an ultrasonic welding machine, which mainly resulted in some hairs being laid flat by the welding machine, or cuts into the fabric.(Figure 11) Lastly, we chose to explore elastic support. We first attached it to the edges of the fabric by stretching it over wood. In the middle of the wooden base, a hole allowed us to pull the middle of the fabric into the wood, creating a wrinkled surface texture. (figure 12)

After this we wove elastic into the spacer fabric, creating a glooming pattern. These two variations created similar results, the fabric would appear normal until stretched or released. The glooming is emphasized by the hairs reflecting the light and changing direction in respect of the other hairs.

Figure 11
Different sewing patterns

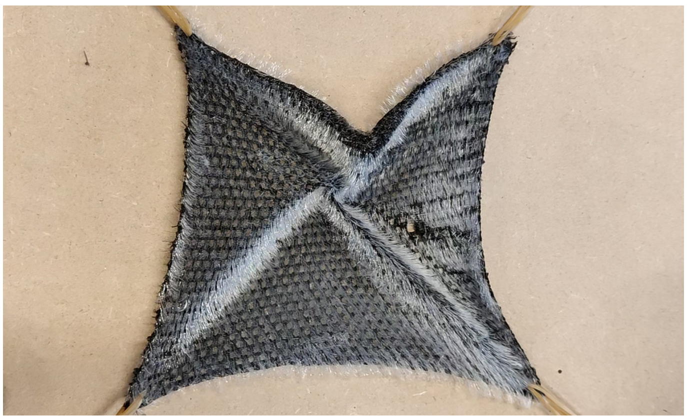

Figure 12
Wrinkled surface texture

5.3 Summary

Main material

Some of the qualities that stood out for us were the hairs found when the spacer fabric was cut open.

Supportive material

These hairs were able to create different patterns by the way they were positioned, their density, and the amount of light reflected off of them.

Combined qualities

These wrinkles could be moved by an inside support structure making the fabric gloom as it was being stretched in different directions.

6. SYNTHESIS

The synthesis is where all of the data from the analysis is collected and used to create a better understanding of the design research challenge and how to design the artefact. This section is divided into an elaboration on material performance, physical form, temporal form, haptic experience and the symbolic notion.

6.1 Material Performance

The cut-open spacer fabric created the most interesting material qualities due to its visual glooming effect and its tactile experience. Furthermore, the material possesses sensorial incongruity through this visual look and haptic feel. The first design was a large piece of lycra which was stretched and then sewn on the spacer fabric (figure 13).
This created the visual and tactile qualities we wanted to communicate.

Explorations were done with different ways of sewing and stretching and a good balance was found for the material.

Figure 13
Fabric sewn and stretched

6.2 Physical Form

Previous work designed the physical form mostly in a 2D plane or surface area and we challenged ourselves to design a more voluminous and spacious physical form. Qualities of this were defined as being able to interact with it with both hands and thus embracing it to give more meaning to the interaction. We designed this using an egg shape as a biomimetic inspiration to communicate life, fragility, and caringness. Explorations of this process can be seen in Figures 14.

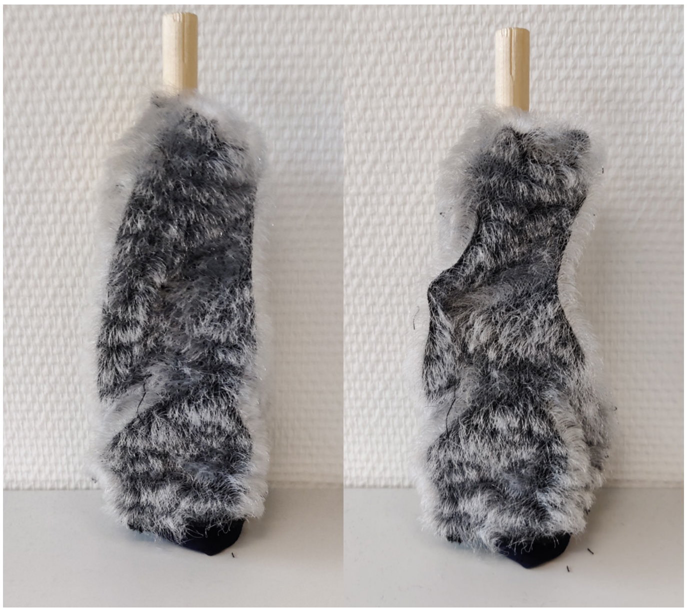

Figure 14
Different styles used to organize appointments

In the centre of the physical form we designed a rod that could rotate. Perpendicular to the rod, another material was attached and loose material was added in between the rod and the main material which pressed against the main material. This afforded the material to stretch and be pressed outwards, increasing the glooming quality of the cut-open spacer fabric. (Figure 15)

Figure 15
Movement of the rod

6.3 Haptic experience

The main material had a certain haptic experience on its own but we explored more ways of making this material feel different. We designed the haptic experience through developing the visual experience by exploring different supporting materials such as the rod design and the loose material.

From iterations of different combinations with the materials we decided on a balance between a visual experience with enough glooming and a haptic experience well enough. Different iterations on this can be seen in figure 16 and 17,18.

Figure 16
Different combinations for the central rod

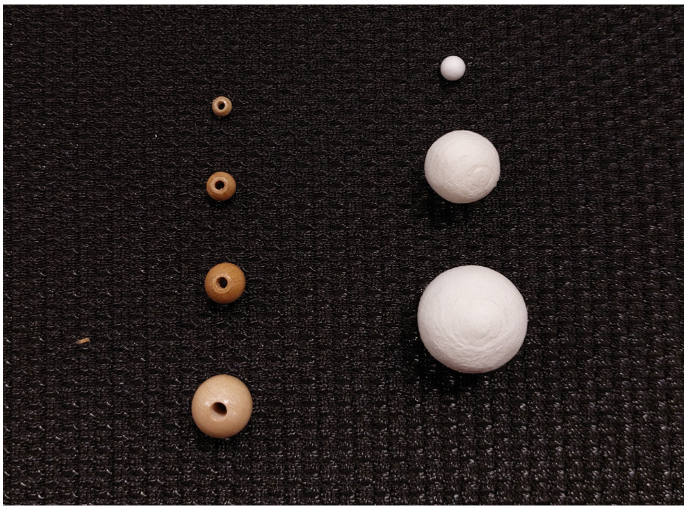

Figure 17
Different spheres material and size

6.4 Temporal form

For the design to show ambiguous and subtle qualities in the material itself we wanted the material to move around and show a subtle change of behaviour. The strategy of creating temporal forms was explored by rotating the centre rod at different speeds, directions, and change of directions to communicate different expressions of the artefact. The random movements of the loose material supported ambiguous feedforward and feedback through the different morphing and glooming of the material, and through different haptic experiences.

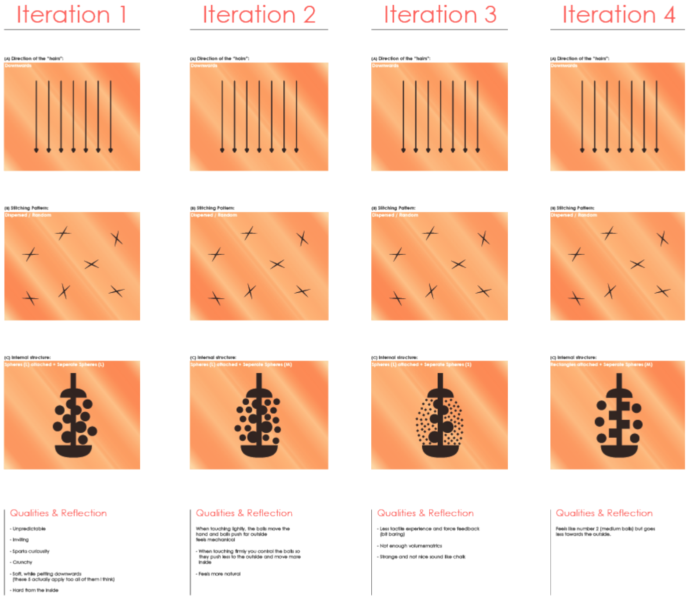

Figure 18
Multiple iterations possibilities

6.5 Symbolic notion

The expressional behaviour states came from the symbolic notion of consensual interaction based on mutual exploration and interpretation between the user and the artefact. This came from our view that we as users often overshadow technological artefacts without building relationships with them. To support this notion we made use of the framework for expressive interaction [1]. We designed a decision tree (figure 19) including action-perception loops and multi-modal change through subtle visual and haptic expression of both the artefact and the user.

Three interaction variables of “seeing”, “petting”, and “holding” were made and from these variables five states were designed. These states corresponded to the behaviour of the artefact through subtle and ambiguous change of movement to support skill development.

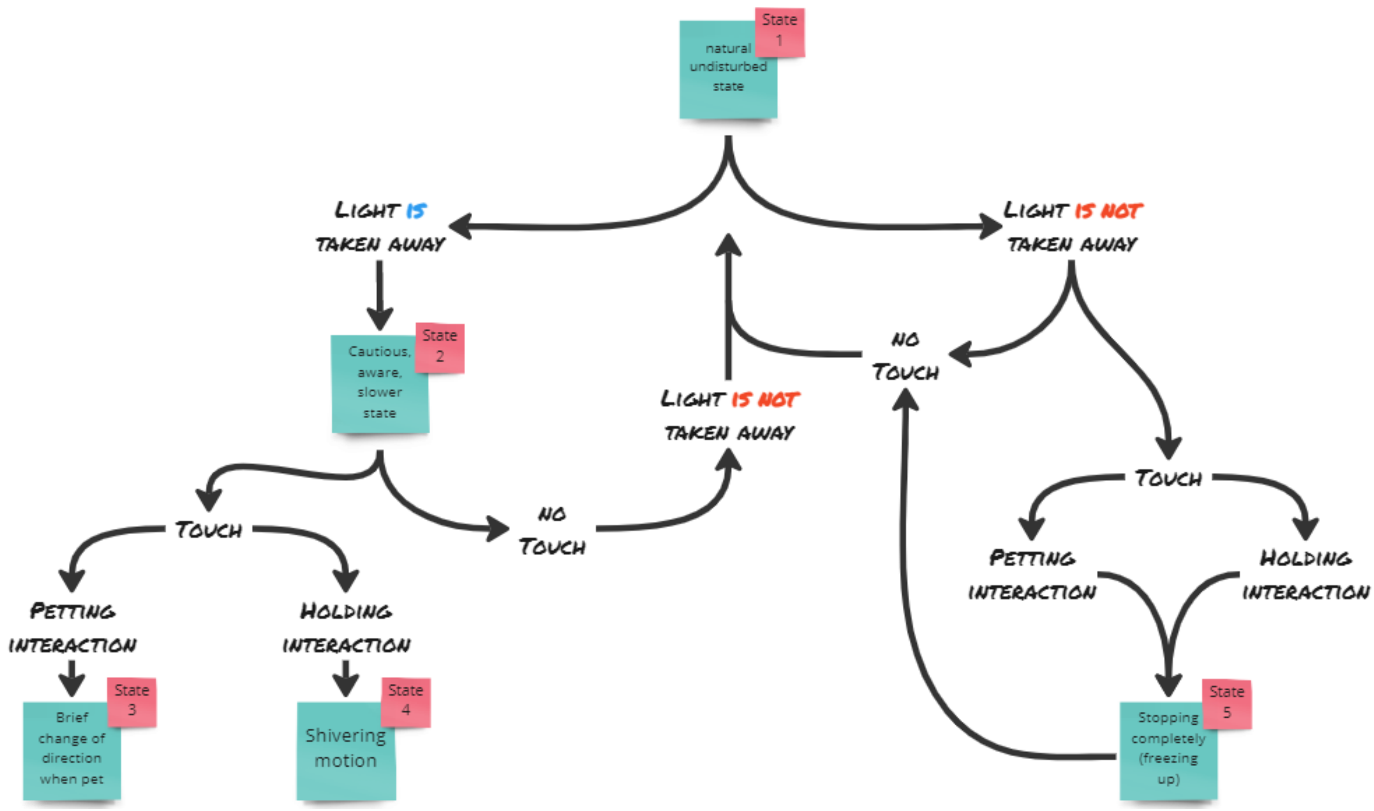

Figure 19
Decision tree

Figure 20
Overview of the structure

7. DETAILING

In this part of the design process all of the separate design solutions were put together into one coherent design prototype and were iterated upon to convey the material qualities and interaction qualities we wished to achieve.

7.1 Main and supporting materials

The final design was modelled using 3D modelling software and supportive materials were 3D printed. The base for housing the electronics and Feelix motor was made from MDF and covered with the same cut-open spacer fabric to create a similar look and feel as the interactive artefact. After assembling the fabric some adjustments had to be made to the 3D printed rod due to the tension that the lycra put on the Feelix motor which constrained it from moving smoothly. The amount of loose materials in the form of paper balls also had to be limited due to lack of torque in the Feelix motor. (Figure 20)

7.2 Sensors and code

For the artefact to "see" the user we used an ultrasonic sensor and for the artefact to "feel" the user we used conductive thread. The sensor was embedded in the base and the electrical thread was sewn all across the top part of the artefact (figure 21, 22). The code measured the variables of "seen", which was a certain distance threshold of the ultrasonic sensor, "pet" which was the short repetitive touching of the conductive thread, and "hold" which was the continuous touching of the electrical thread. These were put in booleans and combined different states and communicated the corresponding effect to the Feelix motor (see appendix A).

7.3 Feelix movement design

Using the Feelix software five different effects were designed to communicate the temporal form of the artefact through visual and haptic feedback and feedforward. Overall the effects were designed with keeping the material qualities in mind or even strengthening them through the use of subtlety of change of movement, and ambiguity through the random movement of the balls as loose material. Iterations on the states were done by experiencing the amount of movement the rod and the balls would allow. In addition the aim was to make the movements appear natural, by speeding up and slowing down the curves smooth but over a different time length the rod would gradually speed up and slow down, creating a flowy motion. Contrast was created by making more consistent fast movements.

Figure 21
Proximity sensor at the base of aasenhi

Figure 22
Conductive thread placement

State 1 represents the aasenhi moving freely and undisturbed; a slow, ada, flowy, and inconsistently change of direction was designed to represent this independent and unexpected free-moving state.

State 2 represents the aasenhi experiencing the presence of a user and it starts moving a bit more exciting. A faster and more staccato movement was designed meaning more short and separated movements to communicate this excitement. (Appendix A)

State 3 represents the aasenhi when it experiences petting. Making it rotate consistently to allow the user to experience the touch without being scared of it or feeling more trusted. As the user can develop can recognise of the movement pattern.

State 4 represents the aasenhi being held by the user causing it to start shaking, a motion similar to state 3 however being more staccato and aggressive. Vibrating the had, asking the user to let go. So the fabric can continue to gloom.

State 5 represents aasehni being touched without perceiving a presence, turning into a state of shock. Aasehni stops moving at all. Allowing the user to freely continue to touch it, however not being able to experience the added layer of haptic experience.

8. Design - aasenhi

For the final demonstration we presented aasenhi as the culmination of our exploratory research and hands-on design process. aasenhi is an Ambiguous Artefact for Stimulating the Evolution of Non-Human Interaction.

The design explores the transition of consensual physical interaction by simulating an interaction between the user and aasenhi which is based in mutual expressive exploration and interpretation. The design incorporates sensorial incongruity by utilising the haptic ambiguity inherent to the spacer fabric as a tool to enhance the transition. A strong emphasis has been placed on the modalities of ambiguity, subtlety and skill development as contextualized in the framework of expressivity.

A distinct sense of designed uncertainty has been built into aasenhi to force exploratory behaviour from the user. This exploratory behaviour is reciprocated by aasenhi intending to create manufactured empathy between both. Ambiguous haptic form and dynamic shaping has been used to support the transition by creating an unknown haptic image which demands the user to apprehend the tactile experience and explore aasenhi.

Figure 23
User experiencing aasenhi during demo-day

Concretely the desired interaction was based around the user seeing and feeling aasenhi and aasenhi seeing and feeling the user as well through the implemented sensors. The user approaches aasenhi

in its natural undisturbed state.
Initially, the user haptically experiences aasenhi which stimulates them towards tactile exploration of the artifact. If this touch occurs without aasenhi having “seen” the user, it goes into a shock state, freezing up, and intuitively communicating to the user its feelings towards this interaction. However, if the user would be seen by aasenhi, it would animate and different tactile interaction would result in differing, yet ambiguous interacting which the user has to interpret themself. This sequence of exploratory interactions creates a reciprocal experience where the user is tasked to understand the artifact while the artifact, seemingly, has a comparable encounter, evoking empathy.

Figure 24
User feeling aasenhi during demo-day

9. DISCUSSION

A voluminous and three-dimensional artefact was created using spacer-fabric as its main material through analysing, synthesizing, and detailing. The analysis cared for a better understanding of the material and its qualities through taking a materialistic approach. This created an iterative material exploration where certain qualities were valued and built further upon. The approach started very wide and quickly shifted towards a focus of one quality of the material which could be supported with other material. To convey this quality more, and include interaction possibilities, a synthesizing process was done. Here the notions of material performance, visual form, haptic experience, temporal form, and symbolic meaning were defined and further developed. In the final detailing phase, the different elements came together and formed the interactive artefact aasenhi.

Freedom of interaction, expressivity of the artefact, expressivity of the interaction, and the expressivity framework were attempted to all be incorporated [1, 6, 9, 10]. This could be seen through the use of “hidden” sensors to create freedom, expressive state changes of the artefact, and the shape and material that led to an expressive interaction.

The final artefact was given an animalistic identity throughout the design research process but still was seen as ambiguous due to its shape. A discussion about the humanizing of the animalistic artefact was interesting because certain human responses depended on the interaction variables that were envisioned by humans. This relates to the exploration of what material can embody, what it communicates, and how it communicates [3,5]. These responses were designed to be animalistic, however still had a touch of human interpretation to them. Furthermore, the human computer relationship that was designed could be seen as a non-human symbiotic relationship, where both actors had to cooperate in the form of respecting each other expressions to be able to benefit from the interaction.

Future work can be done on the way we design certain non-human expressions and the idea that this designed expression is a correct representation of the non-human. Due to the focus on interaction, it would be interesting to look deeper towards the mutual relationship between humans and technology and how they relate to each other if they both could express themselves towards each other.

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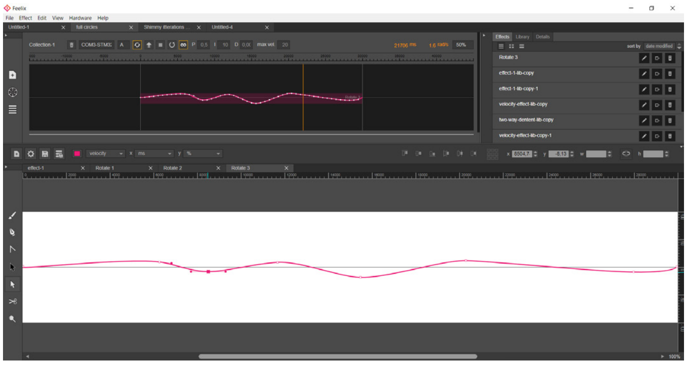
Appendix

A

State 1



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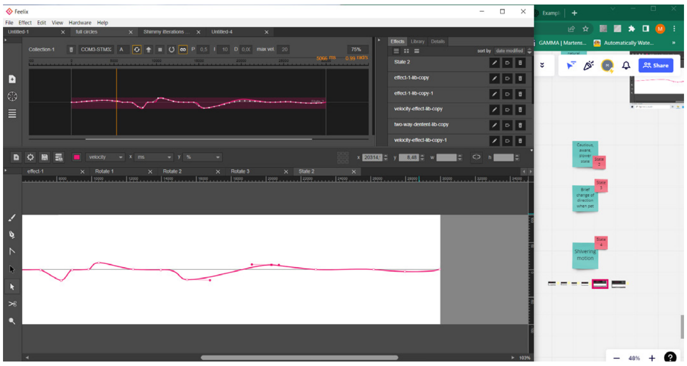
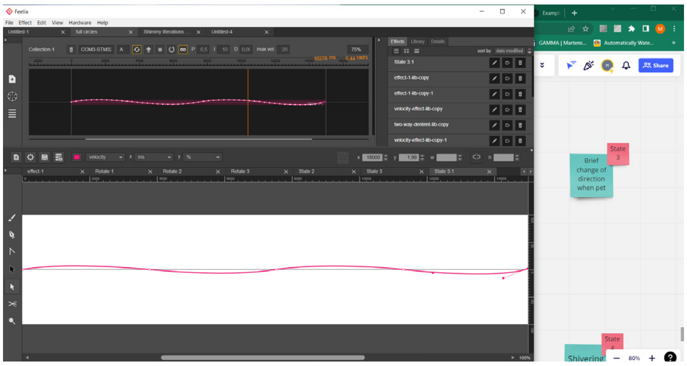


State 3



State 4