Please do touch!; exploring differences in perceived affordances by designing an uninviting interaction.

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ABSTRACT

research in interactive materiality acknowledges the importance of user experience in designing interactions, there is however a gap in design approach to interactive materiality and the ux they promise. lab based material driven design approaches are focussed on the possibilities of an interaction not on interaction. we explore this discrepancy with tessi, a prototype which is reluctant to interaction. the study proposes a design case where the interaction experience is not directly coupled to the material experience and highlight the main challenges this brought up. we do not propose designers to radically change their approach to interactive materiality, but rather become aware of the intricacies which could help in the design of meaningful user interactions with interactive materials.

INTRODUCTION

Expressive materiality, shape changing interfaces and aesthetic interaction research in the context of HCI is generally well versed in representing the user's perspective. The interaction frogger framework (Wensveen et al., 2004) and iterations on it in the context of expressivity (Bruns et al., 2021) all consider the users interaction with the product. Of course, regarding feedback as well as feedforward. Alexander et al. (2018) define one of the grand challenges in shape changing interfaces to be understanding users' experiences of shape changing interfaces. Unfamiliar material affordances are subject to difficulties in mapping and reluctance to interaction.

A lot of research in this field is designed based on an introspective design process. Material driven design consists of designer's interaction and exploration with materials (Van Bezooyen, 2014), which allows for new material properties and interactions. Plenty of research revolves around sensitive and fragile proof of concept prototypes which show potential for interaction (Kolvenbag et al., 2022; Veiga et al., 2023; Li et al., 2023; Narumi et al., 2019). Barati and Karana (2019) describe the connection between material and designer as material affordances and describe the intricacies between the two. Moreover, Winters et al. (2022) argue that research in dynamic materials is often artefact focussed, overlooking the human-artefact interaction intricacies. There are a couple case studies that do highlight the users experience within the interactions. SIMON (Winters et al., 2022), as well as FRANK (Bruns et al., 2021) both have a close connection to the user and invite interaction with the artefact. Furthermore, Ross and Wensveen argue for the involvement of users throughout the process and highlight the importance of skills in interaction (2010), the discrepancies between designer and user are however not mentioned. Frens (2006) also talks about skill in interaction and highlights the difficulty of introducing a new interaction narrative. Focussing on the human-artefact interaction, this pictorial aims to iterate on this research with a design case which explores the differences in perceived affordances by designer and user.
In human-product interaction there is often the need to create a pleasant experience, the rich interaction framework aims to capture ways to make a pleasant useful interaction to create more meaningful connection to the outcome (Frens, 2006). Benford et al. (2012) argue for unpleasant interactions creating meaningful experiences, mostly in a social setting. Moreover, Bewley and Vallgårda (2017) further develop this by creating provocative inflatables to research new interaction opportunities in soft robotics. Winters et al. (2022) propose a framework of designing these human-artifact intricacies for material focused interactions. But there is little further deepening in how designers can work around the reluctance of interaction. We aim to highlight this by creating an interactive design that is uninviting to interact with.
The design: "Tessi" was developed during the course "Interactive Materiality", Tessi consists of a fabric origami pattern which is mechanically moved by servos. During the course the designs were evaluated on a weekly basis by two professors and a group of peers, where the perceptual qualities were assessed, and feedback was used as design input. These sessions were paramount as they provided an outsider's perspective on the materials engaged with and highlighted the different perceptions of the material.
During the design process an annotated portfolio of samples and insights was crafted of which this pictorial is a summary. Within this process we highlight the interactional qualities and perspectives of the designers, in the discussion we attempt to formulate and analyse the users perception distilled from the feedback sessions. After which we reflect on the perceived affordances and the reluctance to interact with Tessi.
We conclude by reflecting on the methodological approach to expressive materiality and highlight the importance of the users' perceptions to unknown interaction designs. By exploring reluctance to interaction and aim to show what perceptual misalignments can occur between user and designer bringing awareness to this in designers practice.

METHOD DESCRIPTION

A Materials-Oriented Design approach was used to guide the first steps of the process. The aim of this approach is to "generate an embodied understanding of materials through a playful and sensory discovery of performative properties" (Winters et al., 2022), and to let materials play a more central role in the final design. The materials used for this were mostly natural and sustainable, such as veneer, paper and cotton. The MOD process is iterative and explorative and aims at broad exploration of material qualities and properties. As the process is intuitive, and the experimentation is free, this creates space for unforeseen discoveries. Sample making is considered as an important part of design research (Goveia da Rocha, 2022a; Goveia da Rocha et al., 2022b), and as a process of itineration (Ingold, 2010). A transition was chosen at the start of the MOD process, which functioned as a guide for the material mapping. This transition was *light* < > *dark*, but later developed into *breaking* < > *unbreaking.*

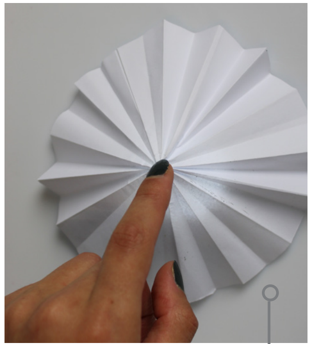
Through weekly feedback sessions with both professors and fellow students, the samples were experienced and assessed. The qualities that were found in the different samples were taken further in the design process towards the final design. Therefore, the MOD process started very broad, and narrowed down throughout the weeks of the course. The final design was developed by mechanizing the movement and designing an interaction storyline and experience. The final design was showcased at a demo-presentation and experienced by our peers.

VISUAL DESIGN PROCESS

The following chapter is comprised of the most inspiring samples and annotations from the design process. Annotations consists of the authors interpretations and key behaviors.

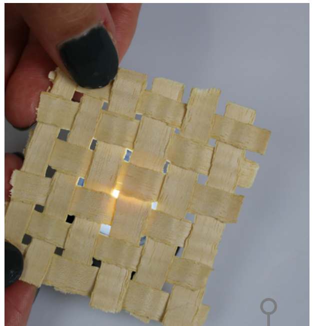
First exploration

The process was kickstarted with a design workshop, during which the transition from light to dark was explored with a whole set of different materials and designs. As designers we were looking for aesthetic experience and interaction opportunties. But overall just exploring. Every sample was documented and the insights were captured with a focus on the aesthetic qualities of the materials.

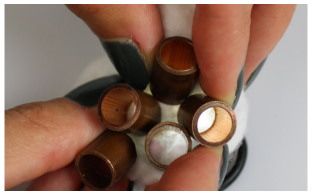


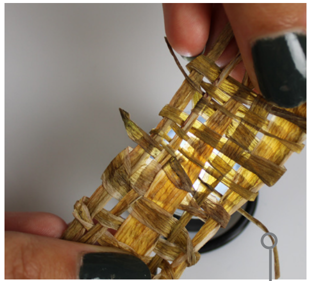
Flat faces create high contrast between adjacent spaces, folds give a very sharp edge

The angle of paper reflecting the light changes the intensity of the transmitted light.



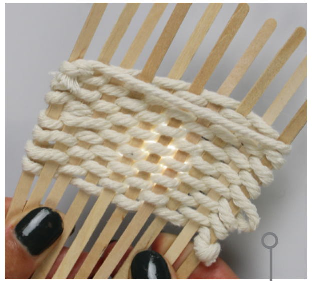
Woven structures present open, double and single layer overlap. Creating different light transperency.





Use of organic material provides challenging properties to make "perfect" patterns

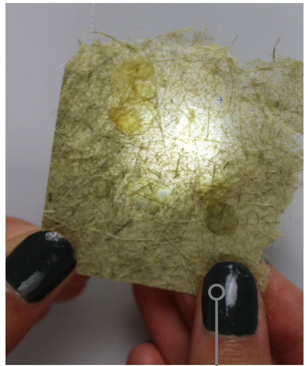
Hidden stucture is illuminated with light



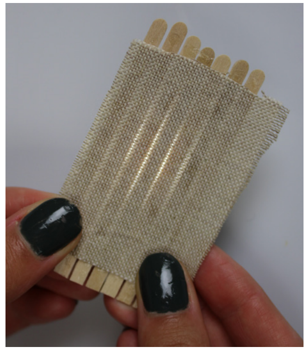
Moving patterns create contstanly changing and new visual aesthetics

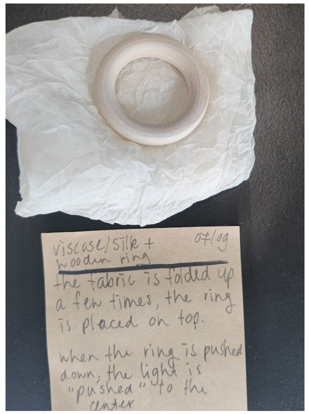
Different materials exhibit different light transfusion, crystal translates light and directs it when directly illuminated.

Documented sample, described method of making and behaviour.



Diffuse materials create very gradual changes in light, natural materials have fibers/ uneven structure

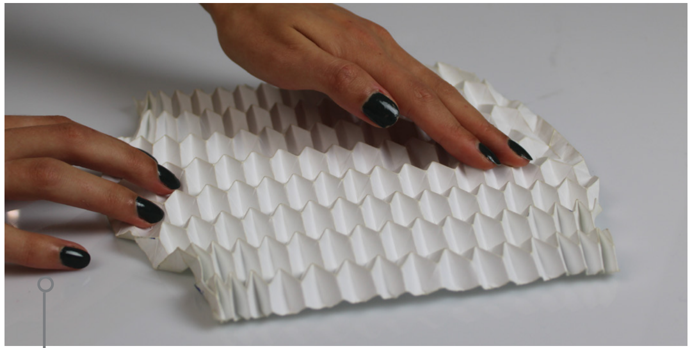




Second explorations

From the first iteration we decided to continue our exlorations into moving structured materials. With interaction in mind the moving structured materials created shifting shadows, sharp contrast and thus most opportunities for physical interaction. The visual aesthetics coupled with the physical manipulation was further explored in this iteration. We explored fabric origami, made by sandwiching fabric between two paper origami layers and steaming these using an iron.

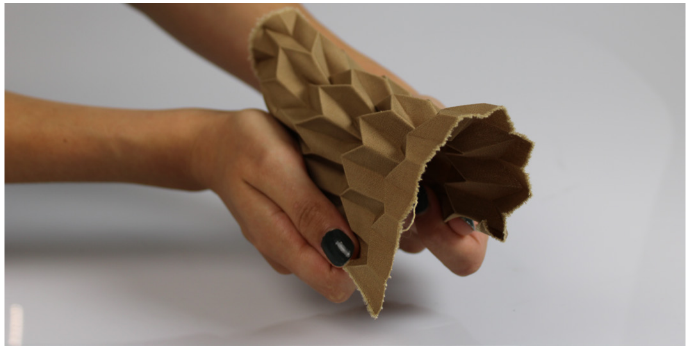
Hand sewn pattern, stretching creates new folds in the fabric. Lines are very mellow because of the fabric bending.

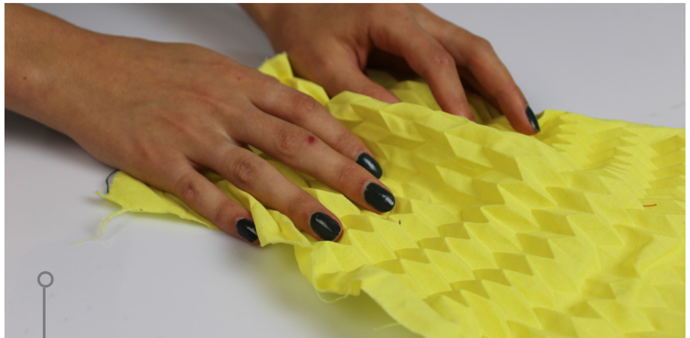


Paper forms very sharp folds and thus the contrasting facets. Translucency is limited, and the pattern is very delicate when manipulating.

Moving across the pattern breaks it, moreover the one-by-one flipping of each node creates a sound and tactile sensation.

Sharp ironed folds in fabric creates the paper aesthetic with the softness and robustness of fabrics.





Different fabrics have different material properties. Stiffness, stability, sound, reflection and softness just to name a few. These change the experienced dynamics of the material.

MATERIAL MAPPING

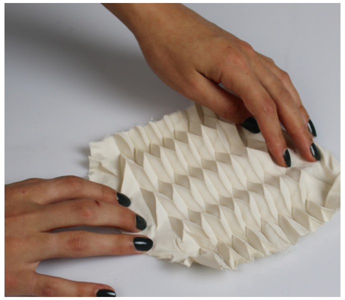
During the material exploration phase of this project, the qualities and interaction characteristics of various fabrics were discovered. Using a combination of textiles, pleading techniques, and origami tessellation patterns, a selection of fabrics was made based on their ability to exhibit the qualities of interest inherently. By creating samples with these materials, and iterating on their size, shape, form, pattern and fabrication technology, this inherent information was augmented to make it stronger, which unlocked new experiences. This process happened intuitively and somewhat parallel to other phases of the design process (Sensing & actuation, frame design). For research purposes a structured overview of the conducted material exploration has been mapped out. A visual representation from a material potential point of view of this mapping can be found on the right. The dark brown, relatively heavy cotton fabric was found to exhibit the most inherent information and was therefore selected to create a moving prototype with. This fabric shows the process of breaking and unbreaking through a subtle popping of its facets and has a substantial thickness with delicate synthetic fibers woven into it, making it effortlessly revert to its original shape after being subjected to interaction. Also, the auditory sensation contributes to the overall experience of the material.

Inherent qualities

- The sound of shapes popping and breaking when movement occurs in tessellation patterns.
- Visual fragility of the fabric in combination with sharpness of the folds.
- Subtleness of shadow play during movement and contrasting facets.
- Materials' ability to return to original state of pattern.
- Pleasing touch of the material.

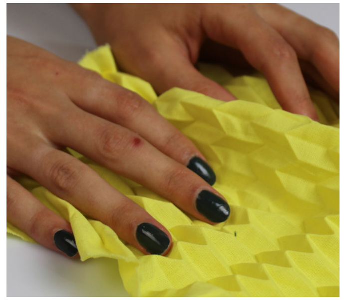
Pleading big; cotton

Pleading small; satin

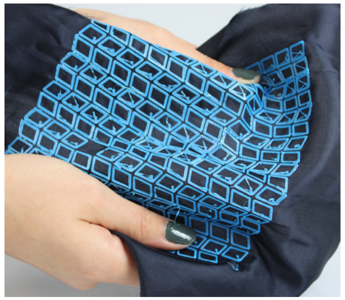


Pleading small; heavy cotton

Pleading small; light cotton

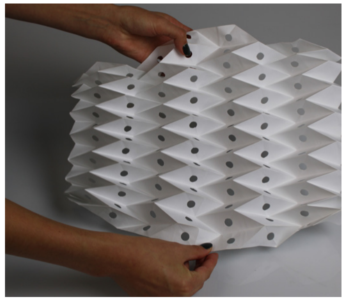


TPU 3d-print small; synthetic

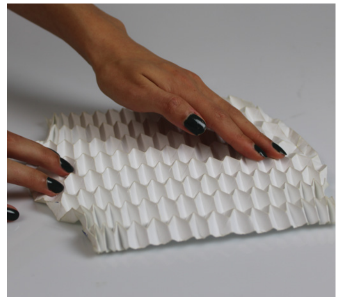


TPU 3d-print big; heavy cotton

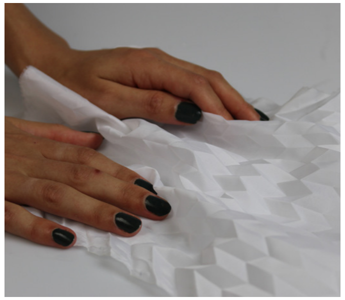
Origami folding big; paper 90g



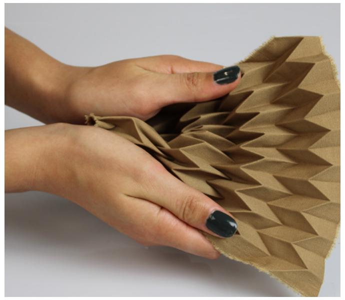
Origami folding small; paper



Pleading small; synthetic



Pleading small; heavy cotton



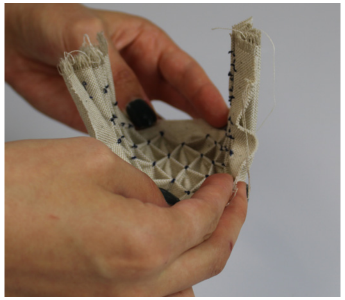
Pleading small; extraheavy cotton

TPU 3d-print large; synthetic

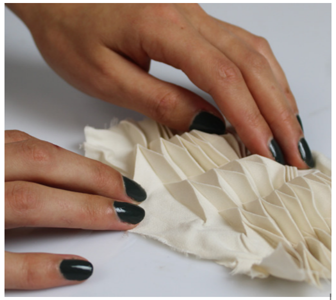
Basic smocking middle; cotton

Basic smocking middle; cotton

Basic smocking small; cotton

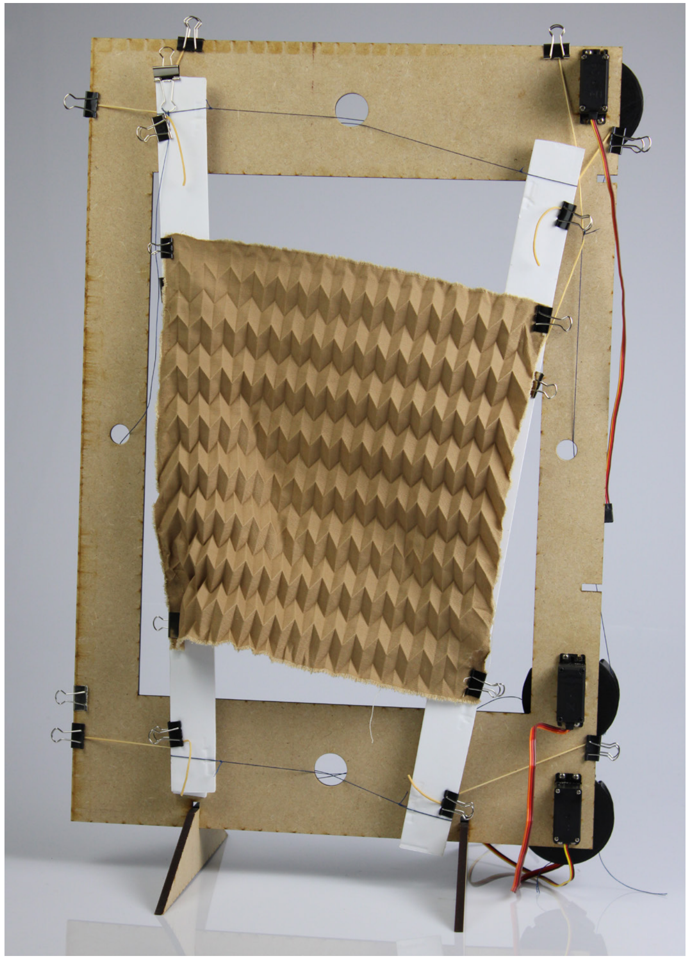


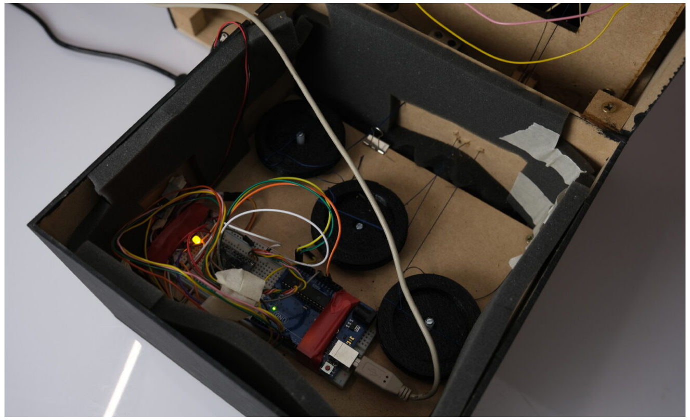
Pleading small; satin



SYNTHESIS

The synthesis of the final showcase can be described from two different directions, the physical prototype and the programming/ behavior of the prototype. The physical aspect consisted of isolating the servomotors from the frame to allow for isolation of sound, integrating the capacitive touch circuitry. And creating a passe-partout covering all the mechanics, showcasing only the fabric pattern. The digital aspects consisted firstly of mapping what the movement limitations were of each servo, after which we could experiment within these boundaries. Furthermore an integration of the capacitive touch sensor and corresponding behavior was programmed.





Check capacitive sensor, Value of touched =

True | False

Block of code which is triggered when the pattern is touched.

- Move servo 1&2 20 degrees in
- Set “factor” to 0
- Lower “Duration”

Block of code that triggers every “Duration” * 50

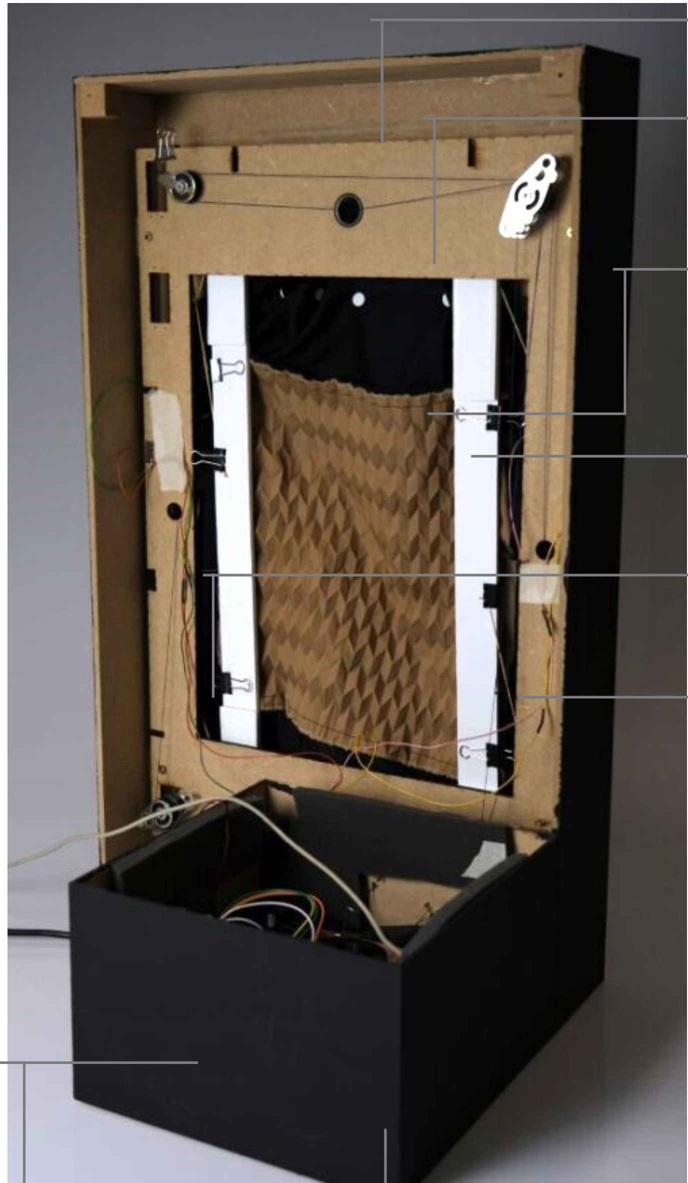
- If duration > 60: Increase “Duration” By 1
- If duration < 30: Decrease “Duration” By 1
- Increase “factor” by 1

Block of code which is triggered every “Duration”
(for every servo it works largely the same)

Value of pos1up =

True | False

- True: Move servo 1 step towars max. Is Max reached? True: Generate random new max between “factor” and Maxpos1. False: End of function.
- False: Move servo 1 step towars min. Is Min reached? True: Generate random new min between “factor” and Min-pos1. False: End of function.



Iteration 3 frame, placed into the new passe partout box.

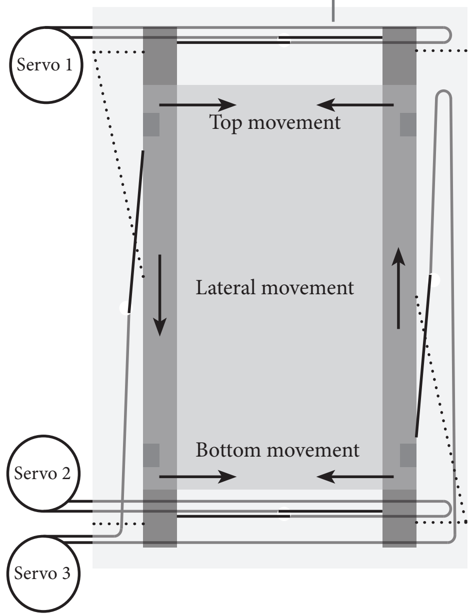
Experimenting with fabric passe partout. Creates a seemless transition from the pattern to the box.

Conductive thread sewn into the pattern. Small protrusion on the frontside. These are connected to a capacitive touch breakout board.

Light-weight foamboard connector bars, low weight to unload the servos and fabric.

Pulleys and low friction rings to ensure smooth movement of the pattern.

Schematic representation of the mechanics, the black lines are ropes, and the dotted lines are rubber bands.



Arduino UNO close to the servomotors, adaptive code. When touched certain factors change the behavior.

Servo motors in a “silent” box with the other electronics.

DETAILING

TESSI reacts to its user’s input and expresses itself through a textile material experience. When there is no interaction with Tessi, the origami pattern moves inwards and outwards, slowly speeding up a bit now and then. The lateral movement is minimal, which has the result that the pattern rarely “breaks”. This remains the same when a user lightly touches the fabric. Only when the user touches the fabric faster, or pulls the fabric, Tessi quickly moves and expresses “shyness” by crumpling up.

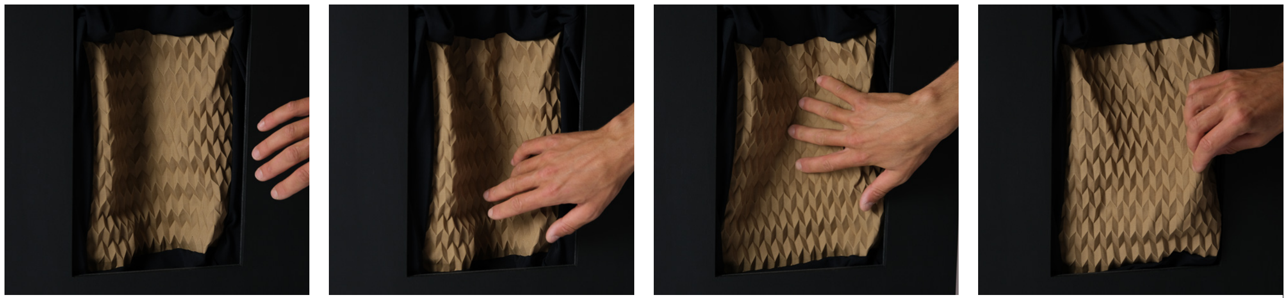
Moreover, the movement becomes more erratic, by speeding up quickly. The lateral movement is increased which makes the pattern break in diagonal creases. This continues as long as the user interacts with Tessi. Once the user stops touching the fabric, Tessi slowly transitions back into its slow behavior. Because of the sudden change in movement when Tessi Is touched, the users are often startled by this unexpectedness, but like the “embrace” of the material once they are used to it.

Since Tessi affords both subtle and fast movements, depending on the user’s input, it allows for freedom of interaction, as the user can lightly touch, quickly touch, or pull the material. There is an unpredictive nature to the interaction as the reaction of Tessi to the user is programmed in the material, soft touches at the right spot can instigate a response while hard touches can also be ignored by Tessi. This is linked with the action-perception loop and the temporal form as described by Bruns et al. (2021).

When TESSI is placed in a quiet environment, auditory cues can be distinguished due to the fabric’s breaking and unbreaking transformation. Together with the sound of operating the pully system and elastics responsible for TESSI’s state adaptations, this provides a second modality of interaction.

FINAL DEMO

After the synthesis of the final “museum quality” interactive material showcase a demo-exposition was held for all participants of the course. During this peers, proffessors and external visitors got to experience the final prototype. We aimed to have as little influence on the interaction however a lot of participants did not start to touch the pattern without elaboration from our side. And looked at it as a “painting”. There was not a structured analysis of the responses but in the discussion we will reflect on the outcomes.



User	None	Light touching	Fast touching	Pulling
Material movement	Slow movement	Slow movement	Fast and sudden movement	Fast and sudden movement

DISCUSSION

Context of the research

Before diving into the discussion on reluctance of interaction we must mention that the goal of the design and the course was to develop and interactive material. The peer review sessions were thus organized in a way that the showcases were designed to interact with. Within this context we reflect on the perceived affordances.

Uninviting interaction

As described by Barati and Karana (2019) the material affordances are perceived by the designer and can be used to explore new behaviours. The conversation between the material and us as designers, were evident while making the first fabric origami patterns, we were surprised by the robustness of the pattern, and how you can crumble, stretch, and repair it. It afforded us to manipulate and interact with it without consequence to its temporality. We were sure that we would surprise our peers in the session, however they were reluctant to touch it because they were afraid to break it. Our perceived affordances differed because we knew the material and were aware of its qualities. In contrast to our peers who saw it for the first time and had not intensively explored it.

When automatic the design some new sounds started to be created by the mechanics, the rubber bands stretching, the threads tensioning and the servo's whining. While not structurally limiting, we envisioned these to be very distracting from the fabric pattern. During the session almost all users noted that the thread and rubber bands created a sound that supported the fragility of the pattern. Thereby strengthening the reluctance to interact with the pattern, while the actual mechanics were quite robust.

Reluctance to interaction

As outlined in the introduction we experimented with reluctance to interaction. The pattern had a fragile appearance, and it made sounds like it was struggling (groaning, tensioning, rubbing etc.). We had designed Tessi to exhibit a "scared" reaction upon being touched. When not being touched the pattern would go into "relaxed" modus, gently moving and not "breaking" the pattern as often. This gave an interesting response at the final presentation, quite a few participants were happy just looking at it from a distance and needed some persuasion to touch the pattern (as intended). Almost all got a fright when the pattern responded for the first time. A tension was created between the fragile creaking machine and the reluctant unsure first touch.

It could be that the temporal form of the material plays a large role in the reluctance to interaction, being afraid to interrupt the movement of the pattern, and creating a new expression. The random movement of the pattern is continually changing and thus a previous visual aesthetic is never repeated. More so tension and release principles are applied in a literal and theoretical sense (Winters et al., 2022), The pattern is constantly slowing down into a predictable movement without breaking the pattern. However, touching it ramps up the tension speed and creates a messy fast movement while continuously breaking the pattern.

We had conversations with visitors about the role of interaction in our design and got responses like "I am notorious for breaking prototypes", and "I never dare to touch a prototype". The notion of prototypes always being fragile can also be a big factor in reluctance to interaction. Which holds even more value to keep interaction in mind as designers and how you can design for participants to have an open mind. In our case showing how robust the protype was by showing the interaction, allowed others to follow.

Methodology of interactive materiality

As outlined in the introduction we are critical of the lab-oriented approach to interactive materiality. Where sensitive prototypes are kept outside users' hands and are aimed to create one specific movement. In the examples there is a high focus on getting the "behavior" to work, and proof of concept interactions are role-played by the authors themselves (Veiga et al., 2023; Li et al., 2023; Narumi et al., 2019). There is off course a place for this function driven interactive materiality research. And the question arrises when proof of concept interaction/ application is evidence enough, and when should one introduce the prototypes to willing participants to explore the interaction.

We the authors would like to stress the importance of getting users hands on the prototypes, not only to see if it works, but more to identify the use cases with an interactive material. Not just for the designers' perceptions and perspective but for an outsider as well. Not role-playing "designed" interactions, but exploring real world applications with users.

CONCLUSION

In this pictorial we present Tessi, a fabric origami patterns which explores the differences in perceived affordance by designer and user. This allows a discussion of the importance of user perceptions of interactive materiality and reflects critically on the lab-oriented approach. We conclude that perceived affordances are very important for interactive materiality and stress the importance of being aware of the intricate interaction dynamics new materials have in interactive materiality, and that the potential for interaction does not translate in interaction.

PEER REVIEW

The project/course started quite interestingly with a very awkward generation of the teams, we were all standing in a circle, explaining a bit what we were looking for in a team until it got silent. After a while I said I'm an engineering focussed designer and looking for some aesthetics-oriented designers, Julie and Taïssia quite quickly said let's go! And the team was formed, quite a good way to form a team with peers not afraid to take initiative.

In retrospect this relaxed motivated attitude continued throughout the project. We were all happy to experiment, explore, work together, and find interesting behaviours. What really helped was that we were all quite comfortable with research through design and material-oriented design. This made the process smooth and fast paced at the start.

When we started experimenting with the fabric origami pattern, we were all exited and motivated to get it to work. When integrating it all into a final "museum quality" prototype it became clear that I was the engineering-oriented designer. Taïssia was happy to learn about soldering and I was happy to explain. We had a great Vertigo session where we made the box and all the small parts. As always towards the end you tend to work more efficiently and divide tasks according to expertise. Which meant that I made the electronics and physical aspects of the prototype work, while Julie and Taïssia worked mostly on the fabric aspects (conductive thread and fabric connection to the box).

While writing the pictorial we had some great discussions on the assignment, and the difficulty of writing a different contribution with a similar body. It was interesting to have a team with developed opinions on the structure and meaning of a pictorial. Unlike often in teamwork where I get the feeling I have to pull the wagon.

Overall, it was a great team to work with, with a similar attitude towards literature, making and aesthetics.

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