Portfolio Interactive Materiality

Thilly Coppelmans
TU Eindhoven
Department of Industrial Design
P.O. Box 513
5600 MB Eindhoven
The Netherlands
t.m.j.coppelmans@student.tue.nl

Vera Smoor
TU Eindhoven
Department of Industrial Design
P.O. Box 513
5600 MB Eindhoven
The Netherlands
d.l.smoor@student.tue.nl

Daborah Pules
TU Eindhoven
Department of Industrial Design
P.O. Box 513
5600 MB Eindhoven
The Netherlands
d.pulles@student.tue.nl

Tim Treurniet
TU Eindhoven
Department of Industrial Design
P.O. Box 513
5600 MB Eindhoven
The Netherlands
t.s.treurniet@student.tue.nl

Abstract
Interactive materials consists of a combination between inherent material properties and smart materials. Inherent material properties are the properties a material already has. Smart materials are materials that have sensing and actuating properties. The interactive material developed in this portfolio, represents the notion 'History of Use': a visible history of use which creates a greater sense of familiarity and personality towards the user. Besides this, the final material is designed to be used as part of multi-sensory therapy, which is meant for people suffering from dementia. The end result is a material that triggers people to touch the material. After touch the material shows the most favourable path. This in order to show the user his/her use of the material.

Authors Keywords
Interactive material; materiality; interactive; history of use; dementia; multi-sensory; snoezelen

ACM Classification Keywords
H.5.2. User Interfaces: Haptic I/O

Introduction

This portfolio describes the results of the course 'Interactive materiality' given by S.G. de Waart and ir. B Goveia da Rocha. The focus of this course is to develop knowledge of materials, their patterns and textures, and the interactivity.

Materials can be seen as the interface of a product. When these interfaces change according to certain input and/or output we talk about interactive materials, e.g. deforming, touching or manipulating [3]. In other words, an interactive material, also called hybrid material, consists of a combination between inherent material properties and smart materials (figure 1). Inherent material properties are the properties a material already has. Smart materials are materials that have sensing and actuating properties. According to this, computers can be seen as potential interactive materials [12]. Computers can give the material a programmable behaviour and interact with the inherent properties the material already has.

Therefore, this portfolio describes interactive materials as a material which is enhanced by a computer which gives it a certain behaviour. At the end of the portfolio a detailed description of this final material that is developed within the course will be given. Next to this, an overview of the corresponding process will be described.

Context

The created interactive material can be used within the context of dementia. Dementia is characterised as the loss of cognitive functioning [4, 10] . Multiple sources describe symptoms of dementia [1, 4, 8, 10, 11], e.g. the loss of memory, mood changes and communication problems [10]. The process of the disease consists of three stages: early, mid and late. Especially during the late stage, people with dementia will become dependent on others. In this

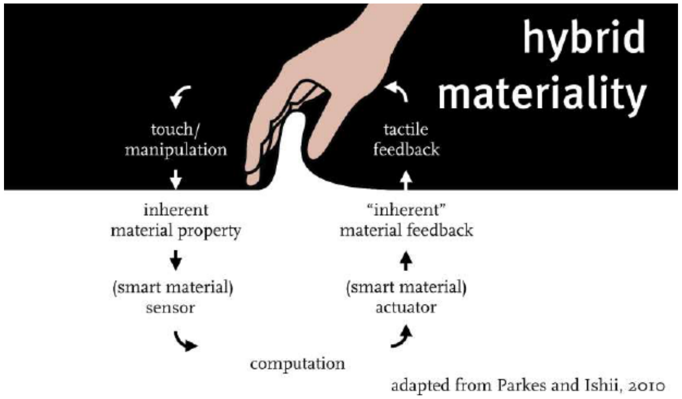

Figure 1
Explanation of hybrid materiality, which consist of a combination between inherent material properties and smart materials. This figure was part of the presentation by S.G. de Waart.

stage of the disease, their memory only consists of older memories and it is difficult to recognise people and/or objects. Besides this, dementia will make it difficult to communicate [11].

If there are no suitable activities for those who suffer from dementia, there is a possibility that they become *"increasingly isolated, frustrated, bored and unhappy"* [5]. Resulting in people becoming distressed or walking around. Besides this, it can affect their ability to maintain everyday skills. To keep people with dementia active and included, it is important to design suitable activities and/or stimulations [5]. Multi-sensory therapy (snoezelen) is an example of a therapy that can stimulate people with dementia via "the sense of touch, sight, hearing, smell and taste" [2]. According to Baillon, van Diepen and Prettyman, multi-sensory therapy can have a positive effect on the mood of people suffering from late stage dementia [2].

Notion

In order to find the right notion for the interactive material, pictures of objects were made, showing traces of use: interaction, time, aging and wearing. After collecting the pictures, an analysis was conducted in which the firstness, secondness and thirdness was analysed. This in order to get an understanding about which subtleties evoke what kind of reaction and how this reaction is associated with the properties of a material. It was found that signs of wear and usage resulted in more personal and trusted items. These signs indicate that the product has grown together with the user over an extended period of time, which creates a sense of familiarity and personality.

Based on this first analysis of the material mapping of found objects, the 'History of Use' notion was chosen. A visible history of use creates a greater sense of familiarity and personality towards the user. To support the 'History of Use' notion, a second collection (figure 2) of pictures of objects was made in order to find materials, that are able to store the user's history of use. Having a material that can capture and show this personal interaction a user has with a product, over an extended period of time, can support in creating a personal connection between the user and the product.

Looking into the direction of already existing materials that can support this notion, there are two major characteristics for such a material:

1. The material should capture the interaction from the user, and over time gradually show more traces of this interaction.
2. The material should support these traces in a way that the material looks heavily used, but avoid making it look worn out and dirty.

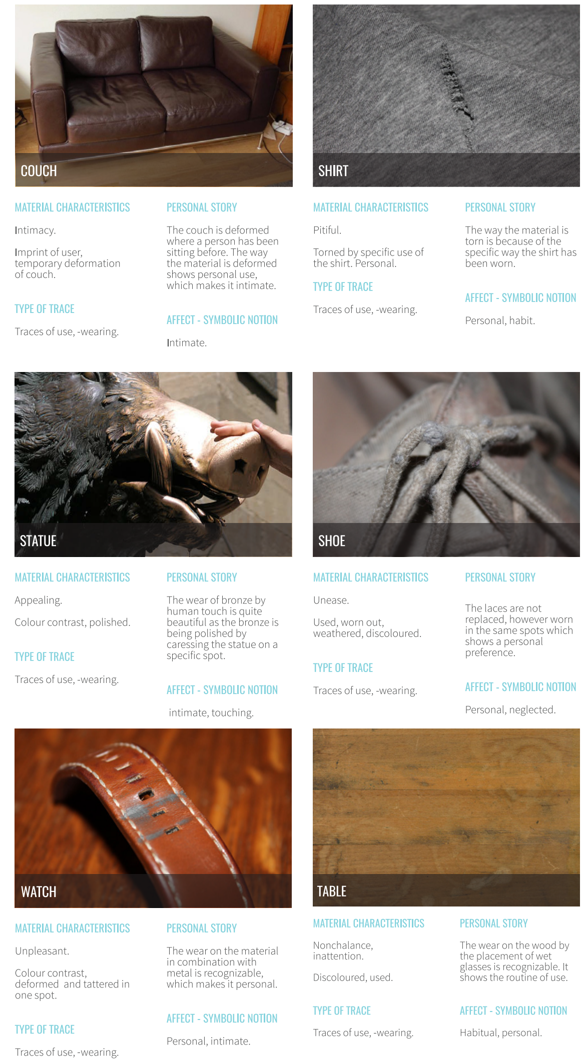

Figure 2
Material mapping and analysis belonging to notion used during the development of the interactive material.

Explorations

Texture paths
Based on the 'History of Use' notion, two ways of showing previous times of use of the material, were explored: texture paths and direction paths. The goal of the explorations was to find out what the possibilities and the effects are of the different types of paths.

Figure 3
Pieces of felt with a physical, but invisible, pattern in between.

For exploring the texture paths we used different kinds of materials. One of the first explorations included two pieces of felt with a physical, but invisible, pattern in between (figure 3). By fiddling with the material, the pattern became visible, because the felt got stuck in the physical modules of the pattern.

This first exploration inspired other explorations, including two panels with elastic fabric stretched over the panel. On top of one of the panels, beneath the fabric, pompons are glued, shaping another type of tangible pattern (figure 4). The other panel, has on top, beneath the fabric, small wooden spheres, forming a tangible pattern (figure 5). By pulling on the strings, attached to the fabric, the patterns of the panels became visible in a particular spot, visualizing where the user had touched the material before.

Another texture exploration included the use of magnets. Little magnets were glued to an elastic piece of cloth, which was stretched over a plastic panel (figure 6). By using another magnet on the side of the plastic panel, the path made out of fabric is able to pop against the panel creating a visible path.

Figure 4
A panel with pompons glued on top of it beneath the fabric.

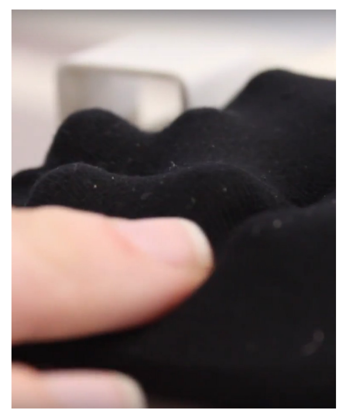

Figure 5
A panel with wooden spheres glued on top of it beneath the fabric.

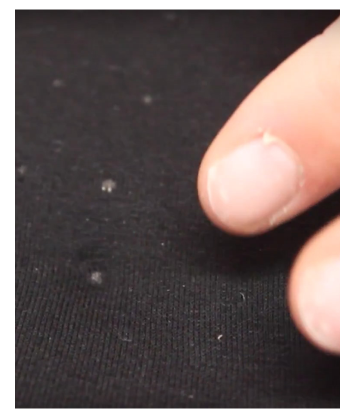

Figure 6
Little magnets glued to an elastic piece of cloth.

Click on the pictures for a short video of the exploration.

Direction paths
Besides the texture explorations, two explorations on direction paths were performed: one exploration, using double sided coloured rings and one, using cottons swabs.

The wooden rings have a different color on each side. They are attached to a piece of felt in such a way, that they can flip in two directions, which means that the rings can show both colors (figure 7).By stroking the material, the user flips the rings to one of the sides, showing one of the colors. The characteristics of the rings make it possible to show how the material has been used the last time.

The cottons swabs were cut halfway and inserted into a piece of felt (figure 8). This resulted in the tips of the cotton swabs sticking out of the felt. Each stick received a plug to make them heavier. The plug caused the cotton swabs to bounce back after touch, which was perceived as a pleasant feeling by people who tried out the material.

The resulting materials of both explorations were not fit to be tested with the target group, because of their lack of context, which would be cause for confusion. The materials were evaluated among the team and other fellow students. Through testing the different explorations, it was concluded that the feeling of the material with the cotton swabs was enjoyed best, considering touch.

During these initial explorations it was concluded that in the case of dementia it could be interesting to look at traces in the way of guiding how the user has always used the product. This could act as a reminder or a manual of the product.

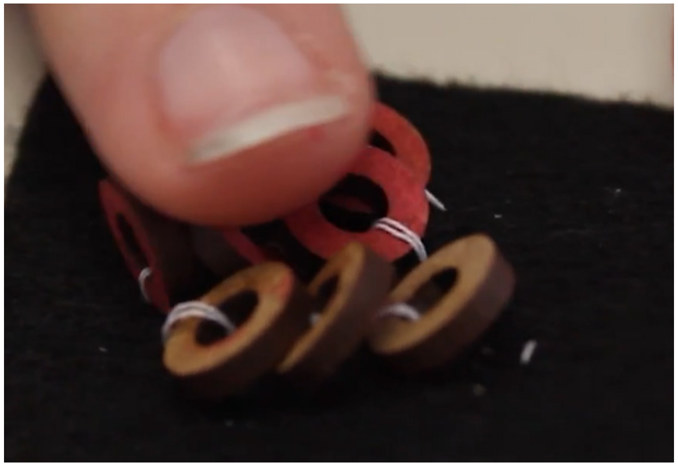

Figure 7
Pieces of felt with colored rings with a different color on each side.

Figure 8
Cotton swabs inserted into a piece of felt.

Click on the pictures for a short video of the exploration.

Feedforward

After the initial explorations we decided to integrate a more specific context, multi-sensory stimulation. Along with the context, design choices and explorations were aimed more towards a product for this context. In the next exploration we looked into feedforward more intensively. A major quality of the designed material would be its ability to show traces of a previously indicated path. The intention of this exploration was to look into ways of subtly showing this path in a material. Furthermore, appeal in aesthetics and touch was taken into account.

The cotton swabs from the previous exploration were chosen as the main material for this exploration. The combination of a large quantity of small soft objects with a springy response proved rather appealing, especially to the touch. Two interaction prototypes were created, both consisting of a tightly sprung cloth on a wooden box, with several hundred cotton sticks in it. Light was chosen as feedforward for the first one (figure 9), movement for the second (figure 10). LEDs were placed underneath the sticks, resulting in lit sticks when turned on. The path was shown by subsequently switching on groups of three LEDs, resulting in a movement in a certain direction. In the other prototype, a linear actuator was placed underneath the material. A carriage on the actuator moved from one side to the other, during which it touched and moved the sticks in the material. On the surface, this led to a wave of motion, again indicating a path.

Similar to the previous exploration, the resulting materials were not fit to be tested with the target group. The lack of context and abstractness of the material would only cause confusion. The materials were evaluated among the team and other fellow students. From testing the material, we discovered that we lost some qualities due to the electronics, the main quality being the response of the material when stroked. In order to keep this quality intact, the material needs some room for movement underneath the surface. By adding electronics such as sensors and actuators, a risk of restricting this movement occurs. Especially in the light experiment, this movement was largely lost.

Furthermore, durability should be considered. The current material is vulnerable to wear, with visible effects on short term. The wear, consisting of pilling cotton, greatly affects the visual appeal of the material, resulting in restraint for interaction.

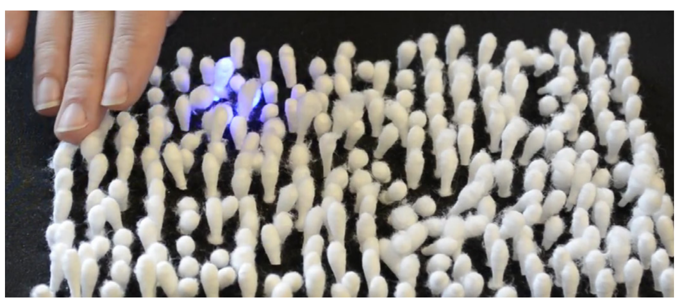

Figure 9
Cotton swabs with implemented light as feedforward. The light path shows how to interact with the material.

Figure 10
Cotton swaps with a linear actuator that moved the cotton swabs in a certain direction as feedforward.

Click on the pictures for a short video of the exploration.

Subtleties

The next exploration focused on implementing the characteristics of the previously used cotton swabs in other materials. As mentioned, there were some drawbacks with the previous material which could potentially be solved using different materials or techniques. Furthermore, the problem of additional electronics impacting the physical properties of the material was examined by exploring different ways of creating paths, specifically through vibration, as it was found that haptic interaction with a physical object can stimulate the sense of people with dementia [7].

In order to maintain the bounciness of the material, the explorations consisted of different materials attached to sticks, which could be combined in a material similar to the previous explorations. The materials consisted of felt, wool and additions to the cotton swabs, such as paint (figure 11).

Another way of creating springiness was explored through iron wire covered in fabric (figure 12). The created material was then curled into a spring. Small vibration motors were added to various materials to test the effect of vibration to indicate paths.

Similar to the previous explorations, the created materials were tested among the team members and various fellow students. As for the sticks that were created, it became clear that many of the options negatively impacted the touch and feel of the material, resulting in a less soft touch, especially when applying more pressure on the material and feeling the hard material underneath. In the end, the material that maintained the intended qualities the best were still the cotton swabs, after being dipped in paint. The paint decreased the wear of the cotton and allowed for customization in color of the material, in order to optimize it for contrast and aesthetic attractiveness.

Figure 11
Exploration of different materials and combinations to find out the best material for the final interactive material.

Figure 12
A new way of creating springiness with the use of iron wires covered in fabric.

Click on the right picture for a short video of the exploration.

Final interactive material

Concept

The final material, which is based on the 'History of Use' notion, is designed to be used as part of multi-sensory therapy, which is meant for people suffering from dementia. The final material is used in a cushion that can be placed on the lap of a person with dementia. The goal of the material is to engage the user and stimulate the user's brain by triggering varying senses, including vision and touch, in different ways.

To explain the concept of the designed material, the Frogger Framework [13] is used, which can be seen in figure 13. The material gives augmented feedforward to the user about where it wants to be touched with use of a pulsing light body (5). When the pulsing light body has been touched by the user, other lights will start to shine of which one will shine the brightest (4). The augmented feedforward of this brighter light is that this light is part of the path which is preferred according to the user's history of use. The inherent feedforward, which is given by the characteristics of the sticks of the designed material, shows that the user can play with the direction of the material (6).

When the material is being touched by the user, haptic feedback (augmented) is received by use of vibration (1). The path that lights up light-by-light, gives augmented feedback to the user that they should follow this path of the lights (2). However, this enlightened path gives also augmented feedforward by showing the user the direction of the path (4). The sticks, which are part of the designed material, give inherent feedback on the user's way of touching by the way they are bouncing back and forth (3).

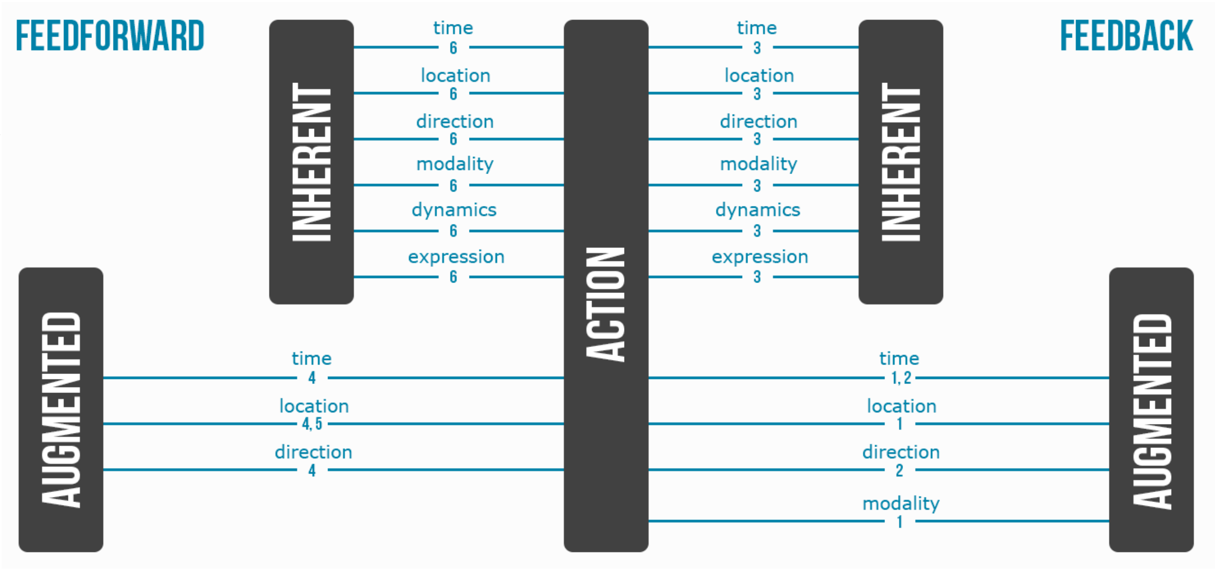

Figure 13
Frogger Framework [13] filled in for the elements of the final interactive material:
1. vibration
2. path of lights
3. the reaction of the sticks after the touch of the user
4. the transition from pusling light to light path
5. pulsing lights
6. the charateristics of the sticks

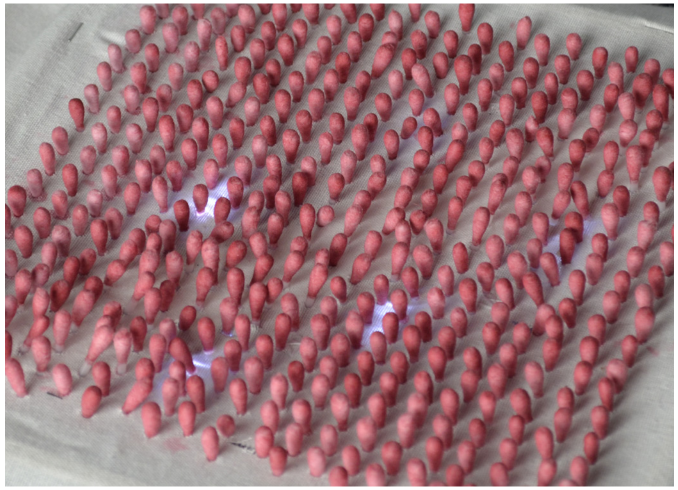

Figure 14
The lights are pulsating to grab the attention of the user.

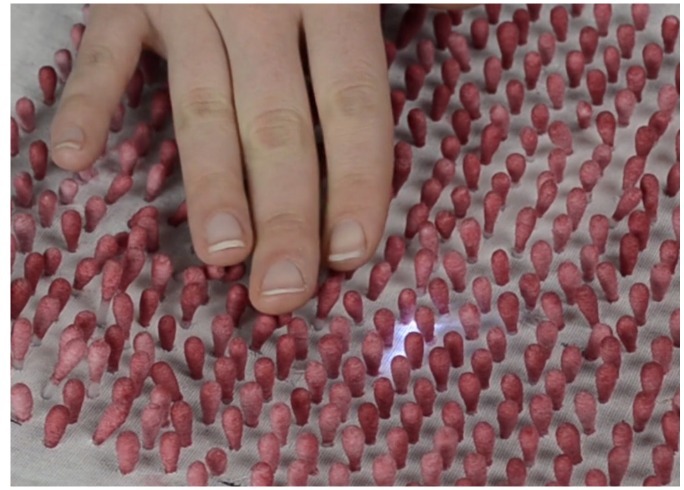

Figure 15
When the path is touched, the ligths and vibration stimulate the user the follow the path.

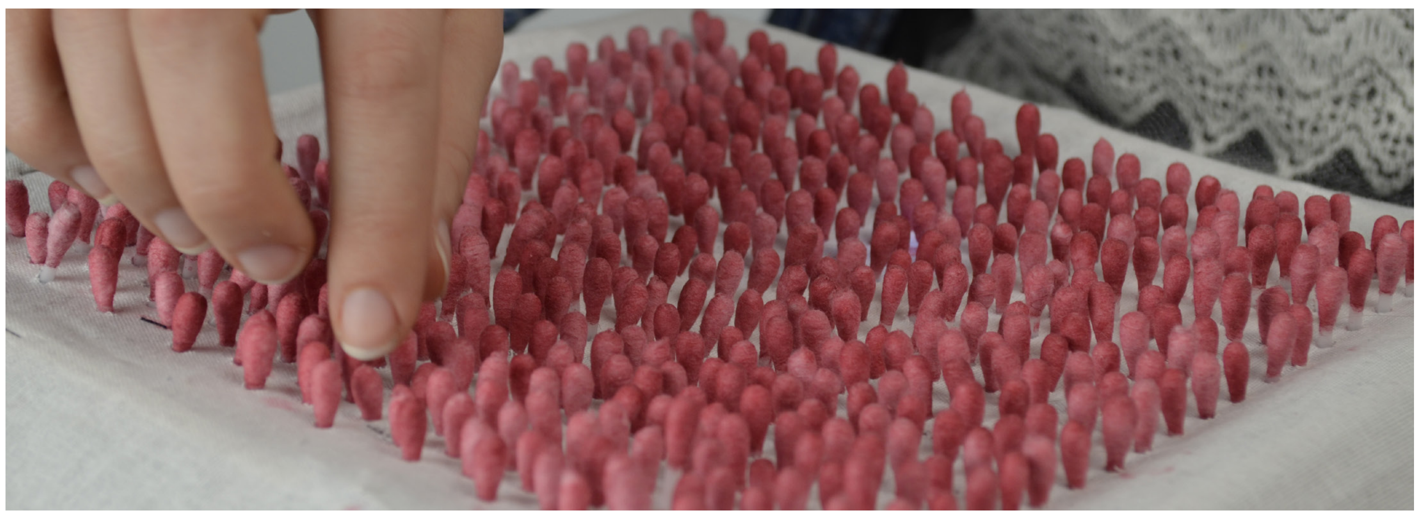

Figure 16
The material itself, will triggers the user to touch it.

Click here for the video of the final interactive material.

Final prototype

The final prototype consists of a pillow with the designed material on the top side. From the various options of the earlier explorations, the colored cotton swabs have been selected as material of choice. For the color it is import to choose a vivid color to compensate for the decline of the ageing eye [4]. Therefore, red was chosen as color for the sticks (figure 17), as it is a color that can still be distinguished as eyesight decreases. The pillow is white, in order to optimize contrast.

Small vibration motors beneath the cloth were used to provide haptic feedback. These vibration motors were used to stimulate the senses of people with dementia as they follow the path. Due to their small size, the motors did not affect the movement of the sticks. Furthermore, white LEDs were placed underneath as well, serving as an indicator of previous paths and a guide for showing the selected path. The prototype serves as a demo for a scenario where one path has been pre-recorded, this is also the only path that can be selected for the demo. Using a capacitive sensor underneath the pre-recorded path, the material detects when the user is following it.

The material is capable of showing two different modes. When the sensor does not detect anything, the material is idle. The LEDs will slowly pulsate and the vibration motors are not activated. When it does sense a hand along the path, the LEDs will start blinking one at a time, following the direction of the path. Furthermore, the vibration motors will provide pulsating haptic feedback as the user follows the path.

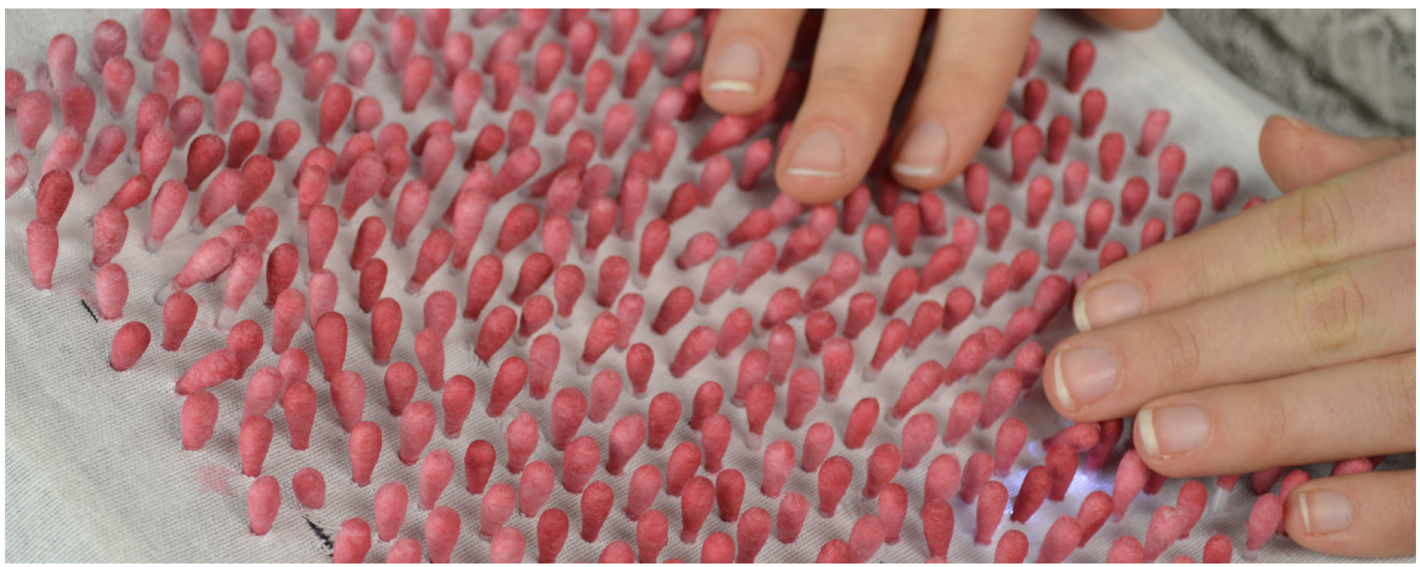

Figure 17
The use of red sticks, especially for elderly to compensate for the decline of the ageing eye.

Material discussion

The goal of the final material was to create a material which could be used in a multi-sensory therapy session, supported by using the history of use as a way to stimulate multi-sensory interaction. If we reflect upon how the final material reaches this goal, there are some points of improvement.

Looking at the concept, the material now uses light paths as a way to show the history of use and to trigger the user to follow these paths. For the prototype we made the sticks of the material a red color, while having a white base and light color. When other people interacted with the material it was noted that now the attention of the user goes more towards the sticks, rather than the path. In order to align the material more with the idea of using this path as an extra guidance and stimulus to interact with the material, it may be better to look into having the sticks and the base the same color, for example white. If we would then have the lights in for example a red color, since red is the color that is distinguished the longest, the paths would stand out more. It was also mentioned that having the lights in the sticks, like in the feedforward exploration, would be more visible and inviting to touch. This discussion also links to the type of interactions that would be triggered by these different type of options which will be discussed in the literature discussion.

Next to seeing which quality of the material has to stand out in order to stimulate the wanted interaction, it is also important to look into the quality of the material itself. Especially looking at the sticks, which will be the part you touch and interact with. In the final prototype they were made a color, which also prevented them from wearing down. Although as suggested by Vallgårda [12], the wear and tear of a material can also help to create this stronger personal relation. The coloring of the sticks also led to them feeling less soft and did not help with removing the association with cotton swabs. For these reasons it would be interesting to still look into a substitute for these cotton swabs. These would focus on creating a softer feel, whilst not losing the feeling of having individual sticks. Next to that it should also be taken into account that the wear of a material can stimulate the personal connection and show the history of use. Testing out different options with the target group will help to get a better idea of which material properties are more intuitive to touch.

We also want to discuss the Frogger Framework as presented in the concept. This framework helped us to analyze the different types of feedback and feedforward incorporated in the product. By adjusting or adding coupling aspects that can couple action and information - feedback and feedforward- to each other, the intuitiveness of the interaction can be improved [13]. When looking at the framework for the final material, we noted that an aspect that could be added would be a coupling between action and augmented feedforward and feedback. This would be done by having the light path react in the same speed as the user’s hand movement. Another coupling that is interesting, is to look at functional information. We think that especially functional feedforward has great benefits when added to the material. This could for example be done by adding visual feedforward on an extra stimuli when completing a task. This could be a different music piece at the end of each path, or an extra effect with other sounds, movements or lights.

Lastly we received feedback on the application of the final material. For now we choose the simple form of having an individual cushion to stimulate multiple senses of the user. However since the focus was on designing the material, and not the product, there are more interesting applications for this material. For example linking two cushions so that you do not follow the lights, but the other person's movement. It could maybe even be interesting to take the material away from the cushion form and implement it on for example a blanket or even a table. When further developing the material it is interesting to look at these different applications and test how they can be used during multi-sensory therapy sessions.

Literature discussion

When we look at how to design an interactive material, there are 3 main components. The physical form, the interaction gestalt and the temporal form [12]. The physical form is the shape and size of the product, the interaction gestalt is the interaction the user will have with the product and the temporal form is the behaviour changes of the product. As also explained by Vallgårda [12], we noticed that these components are always influencing each other, which pushes you to making small steps in each of the components and reflecting upon how they influence each other. In our exploration on finding a replacement for the cotton swabs, we noticed that it was difficult to see how a change on these cotton swabs would influence the interaction you have with the object. This was because the interaction with the sticks changes when you have a lot of them. Next to the amount of sticks, changes in color or perceived softness of the sticks also influenced if and how you would interact with them, even on a small scale. In the same way how soft materials can manipulate the perception qualities of a mechanical movement [9] we see that the subtleties in material properties can change the perception qualities of our interactive material.

Looking at the interaction gestalt of the final material, we discussed that how the sticks are standing out right now would trigger a different type of interaction compared to if we would make the sticks blend in and only have the light standing out. Choosing one over the other depends on which type of interaction would be more suitable for what one wants to accomplish with the material. In the case of using the material in multi-sensory stimulation session for people with dementie, we can look at interaction types as different hand movements. Lederman and Klatsky [6] identify different types of hand movement patterns (figure 18). These can help when making decisions on what the material should stimulate. For the final material we wanted to mainly support the lateral motion. Stimulating that people will follow the path using, a big part of, the hand for this interaction. Looking at the final material, we

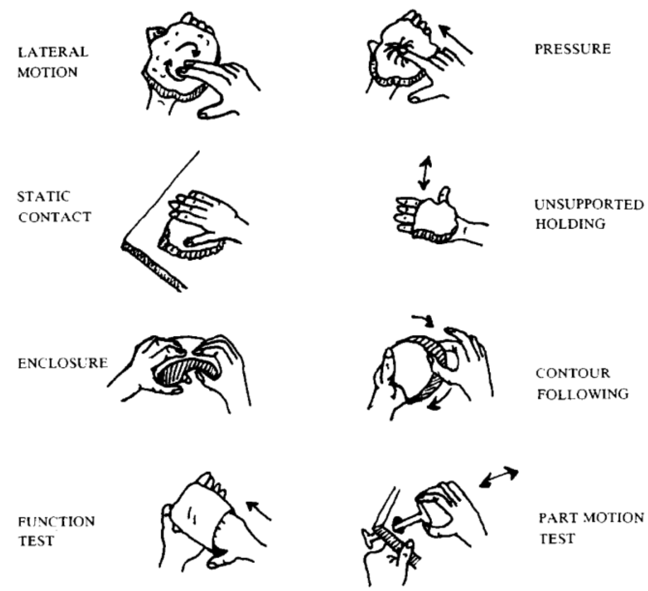

Figure 18
Different types of hand movement patterns identitief by Ledermand and Klatsky [6].

noticed that having the sticks stand out may have a bigger stimulation on the enclosure movement of people going to fidget with the separate sticks. To stimulate the lateral motion we think that having the lights highlighted and the sticks blending in with the rest of the pillow will support this better.

Looking at material with the literature in mind helps you to take a more critical look at the -interactive- materials. This helps you to see why a material triggers a certain reaction and how and what subtle things you can alter of a product to change these reactions.

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