MusiCushions: Designing interactive cushions that integrate with the home environment

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Design av interaktiva kuddar som är integrerade i hemmet

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ABSTRACT

This paper is about MusiCushions: Interactive cushions to control external speakers in a living room. The interactive cushions are made of smart and interactive textiles, which acceptance has been profoundly investigated. Several studies have come to the conclusion that the most important feature for acceptance of smart and interactive textiles is the aesthetics of the textile interface. Therefore, this study investigates the question: How is integration of interactive cushions in the home environment affected by design concepts with different levels of explicit interaction and types of use cues? The method used in this study is based on constructive design research (CDR), where the design process consisted of moodboarding, sketching, prototyping and evaluation. Three prototypes were built and tested in two different user observations. The interactive cushions were considered well integrated in the home environment but there is room for improvement of usability. The evaluation showed that visual cues were the most important feature for usability but that there is a trade off between use cues and aesthetics.

SAMMANFATTNING

Denna studie handlar om MusiCushions: Interaktiva kuddar att kontrollera externa högtalare med i ett vardagsrum. De interaktiva kuddarna är gjorda av smarta och interaktiva textilier, vars acceptans har varit grundligt utforskad i tidigare studier. Flera studier visar att den viktigaste faktorn för acceptans av smarta och interaktia textilier är estetiken av ett textilt gränssnitt. Därför undersöker denna studie frågan: Hur är integrering av interaktiva kuddar i hemmet påverkad av design koncept med olika nivåer av explicit interaktion och typer av use cues? Metoden som denna studie är baserad på är "Constructive design research" (CDR) och design processen bestod av utformande av moodboards, sketcher, prototyper och utvärdering. Tre prototyper var utvecklade och testade i två olika användarobservationer. De interaktiva kuddarna ansågs vara väl integrereade i hemmet, men det finns utrymme för användbarheten att förbättras. Utvärderingen visade också att visuella use cues var den viktigaste faktorn för användbarhet, men att det måste göras en avvägning mellan use cues och estetik då den ena påverkar den andra.

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ABSTRACT

This paper is about MusiCushions: Interactive cushions to control external speakers in a living room. The interactive cushions are made of smart and interactive textiles, which acceptance has been profoundly investigated. Several studies have come to the conclusion that the most important feature for acceptance of smart and interactive textiles is the aesthetics of the textile interface. Therefore, this study investigates the question: How is integration of interactive cushions in the home environment affected by design concepts with different levels of explicit interaction and types of use cues? The method used in this study is based on constructive design research (CDR), where the design process consisted of moodboarding, sketching, prototyping and evaluation. Three prototypes were built and tested in two different user observations. The interactive cushions were considered well integrated in the home environment but there is room for improvement of usability. The evaluation showed that visual cues were the most important feature for usability but that there is a trade off between use cues and aesthetics.

Author Keywords

Interaction design; Smart and interactive texiles; Tangible interfaces; Prototyping;

ACM Classification Keywords

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

INTRODUCTION

Objects made of textiles are a very natural and common sight in our surrounding environment. Textiles come in different colors, structures, forms and sizes and are often recognized as soft, fluffy, warm and smooth. Smart and interactive textiles are the ones where you integrate technology and sensors into textiles to create interactive garments or artifacts. Textiles are one of the oldest materials that we use in our everyday lives and they can be used both as clothes for protection and expression of the body and in interior design for functional and decorative purposes. Textiles have played a significant role for humans throughout the history and they´re a reflection of the technological development at a certain time [1]. Smart and interactive textiles allow us to expand the intended use of textiles. By integrating sensors and actuators, textiles can be used for more than protecting our bodies or decorating our homes. There has been a lot of research done in investigating the integration of smart textiles in different usage contexts for wearables and smart clothing, but there is still a need to explore the design space for smart textiles for interior design. To create acceptance of an interactive design for home textiles, the aesthetics of the textile is the most important feature [2].

In this paper, I have investigated the research question: How is integration of interactive cushions in the home environment affected by design concepts with different levels of explicit interaction and types of use cues? I have chosen to work with cushions, since they are broadly used, cheap and interchangeable. My definition of the intended use of a cushion is: "A soft pillow usually used for sitting, comfort or decoration." The integration of sensors and actuators will add a new dimension to the intended use. But how do we design objects with multiple purposes? The aim of this paper is to create different design concepts for interactive cushions with different levels of use cues and explicit interaction to understand how this affects integration in the home environment. The use case for this project is as follows: Interactive cushions to control music from external speakers in a living room. This study was conducted in collaboration with Latuperissa (2018) where different design concepts for interactive cushions were realized and tested for technological feasibility, usability and visual appearance. The project is called MusiCushions and three prototypes were made, where the cushions work together as a composed set or can be used individually. Since the aesthetichs is the most important feature to users for acceptance of smart textiles, the goal was to investigate how different design concepts affects the integration of interactive cushions.

The interaction will be based on the affordances of a cushion since they can be used to ubiquitously embed sensors into textiles. One example of this is Hamdan, et al. (2016) [3] who integrated textile sensors into an embroidered 2-dimensional pattern; they used the aesthetics of the textile to integrate the sensors. A cushion is soft and it can have different shapes, colors, patterns and other decorative elements, such as buttons. It is possible to physically interact with it in different ways.

RELATED WORK

There has been earlier research done in the field of interactive pillows. Redström et al. (2010) [4] have explored the design space around IT and textiles and they developed a concept about interactive pillows, where they wanted to explore ways of nonverbal communication of feelings. The pillows come in pairs and work as an "emotional broadband". If you hug one of the pillows, the other one will light up and get warm, connected via a wireless mean. The target group was people in a long-distance relationship, parents not living full-time with their children and people who travel frequently. The researchers choose to work with pillows to investigate acceptance of new technology but also to understand what happens to an existing object in our everyday life when it get computerized. They made two versions of the pillows and in the second iteration they put more effort into how to craft the pillows. Their results showed that the aesthetic qualities of the second prototype gave the users a better understanding of the concept. Within their target groups there was a high acceptance of the concept. In my study I will therefore focus on the aesthetics, how does different design concepts affect integration of a cushion in the home environment.

Several studies have investigated the acceptance of smart and interactive textiles. Ziefle et al. (2014) [5] analyzed what characteristics and functionality interactive textiles should have in order for users to adapt to it. The study was conducted with 72 participants and showed that the aethstetics was the most important characteristic. Controlling media, for example changing the volume of a TV or speaker, was the most important functionality. The study also shows that users would prefer to use smart and interactive textiles in less private environments in their homes, such as a living room or a kitchen. Hildebrandt et al. (2015) [6] also investigate acceptance of the use of smart and interactive textiles by locating what features that are important in order for the users to accept it. They state that users find the most important feature for acceptance to be how the objects were technically realized. The users wanted the electronics to be seamlessly integrated into the textile. The second feature that had the most influence on acceptance was where the technology was being used. This study showed that users preferred to use smart and interactive textiles in the living room. In a living room, we have several artifacts partly or completely made of textiles, such as sofas, cushions, blankets, carpets and curtains. The previous examples investigated the user's acceptance of smart textiles in home environments on a cognitive level. In addition, Brauner et al. [7] used an armchair and tangible textile prototypes to explore acceptance and usability of different interactions with smart textiles. Both textile interfaces and a plastic remote control were tested during the user study. Participants found the plastic remote control to be a disturbing element in the home environment "It is an ugly unappealing design and it is a cold element"[1]. Their results showed that users wanted the electronic sensors to be seamlessly integrated to the textile and that the aesthetics and attractiveness of the textile interface had the highest impact on user experience. Brauner, Van Heek & Ziefle (2017) specify a smart cushion as an application scenario to develop and evaluate an acceptance model for smart and interactive textile surfaces [8]. They conclude that textiles have the potential to be widely accepted and used as interactive surfaces to control the home environment. Gardeene! [9] is another study where smart and interactive textiles have been used in the home environment, in this study intuitive gestures were mapped to closing and open a curtain. Previous studies are focusing on acceptance, which shows that aesthetics is the most important feature. In this study I will therefore focus on the design of interactive textiles and how the integration in the home environment is affected by design concepts with different levels of explicit interaction and types of use cues.

When designing and building interactive objects made of textile, one of the challenges has been the ability to keep the soft appearance and aesthetics when integrating the sensors and actuators. LilyPad Arduino is an example of a fabric-based construction kit that has been designed for building and programming wearable computers, which has been used for making and designing ubiquitous e-textiles [10]. "Project Jacquard" is one of the latest research projects where they developed a new type of smart textile, where the conductive thread is incorporated into the weaving process, which enables "invisible ubiquitous computing" [11]. Project Jacquard collaborated with Levi's, which resulted in the Levi's commuter trucker jacket. It is especially designed for bike commuters and the jacquard fabric in the jacket can be washed up to ten times and woven in different structures and colors [12]. Research on smart and interactive textiles has mostly been done within wearable systems and there is a potential of combining sensors and actuators with objects made of textiles in the home environment. Technology like this facilitates the merge of technology and design, but there is still a need of designing and testing smart and interactive textiles for home environments.

When designing tangible user interfaces (TUI), there are design guidelines that should be considered. Fernaeus, Tholander & Jonsson (2008) discuss the design challenges in tangible interaction research [13]. They talk about "shifting ideals" for TUI that should be used as guidelines when designing tangible interactive systems. These guidelines concern the areas: Information-centric to action-centric, from properties-of-system to interaction-in-context, from individual to sharable and from objective to subjective interpretation. The information-centric to action-centric shift is about seeing the physical artefact as a resource for action instead of just transforming data from people to

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[1] Brauner et al. (2017) page 156

[2] Hornecker, E. (2012)

devices. It is focusing on the user control, social action and creativity. From properties-of-system to interaction-in-context is a shift from the system functionality to focusing on the context in which the interactive artefact is used, what can a user do with the artefact within a specific setting. From individual to sharable means a shift from designing for individual use to collaborative and social use. The collaborative use is something that often occurs naturally when we interact with many everyday artefacts and that can be applied to the design of tangible interactive systems. From objective to subjective interpretation is a shift from focusing on designing good and usable systems to the understanding of how users make meaning through the interaction. When designing for a TUI there are also different types of interactions to consider. Ju (2015) [14] write that traditional interaction design has focused on explicit design, which means that users interact with computational things with explicit input and output. Implicit interaction on the other hand, is when a user interacts with an interactive object without being aware of the input and/or output. The article state that implicit design can help designers to make designs that is more socially appropriate. Implicit interactions take less cognitive attention and that can also be achieved through the style of interaction.

There are different types of interactions for interactive textiles to consider when designing for TUI. Touché is based on capacitive touch sensing which is a technology that is scalable and can be used to provide rich gesture and touch sensitivity. The human body can interact with gestures and touch, which makes it well suited for soft and stretchable objects and materials, like textiles [15]. Rus et al. used capacitive sensing electrodes to show how smart textiles can be integrated into furniture [16].

The design concepts in this study will be based on the affordances of a cushion. *"Affordances denote the possibilities for action that we perceive of an object in a situation"²*. Hornecker [17] discusses the use of affordances when designing for TUI, where the literature has tended to see affordances and mappings from the real world as a perfect match for tangible systems because of its physical aspects. The author questions this certainty and argues that this is a benefit, but also a design challenge, because the affordances of a physical object are potentially endless. The study develop a use case study to investigate this challenge and concludes that there is a need for support for reflection and learning for the user when designing for physical systems. In this study, I will design concepts based on the affordances of a cushion because it is intuitive because of the users prior knowledge of the object, but I will try to support the need for reflection.

METHOD

The work presented in this paper is based on Constructive design research [18], which in this study meant a variety of activities including material explorations, sketching, high-fidelity prototyping, as well as user observations. An overview of the methodological setup for the main project activities is presented below.

Constructive design research

In constructive design research (CDR), the construction of the product itself is the mean to create new knowledge. The product can be a prototype or a detailed scenario or concept. To start with, researchers should gain knowledge about the interaction from practice-based investigation of how people experience their environment. The social and bodily interactions are crucial for design research practice. Therefore, the study started with informally observing some users behaviour towards cushions in a living room. After that I started to conceptualize the design using moodboarding and sketching. These methods are established tecnniques and used to describe design ideas; how can people interact with the design concept. Further, three working prototypes were made to ground the design concepts in experience. Koskinen et al. phrase it like this: *"Prototyping is the only way to understand touch, materials, shapes, the look and feel of the idea, details of user interface, or details of how the concept functions"³*. The prototypes were made in collaboration with Latuperissa (2018), where the technical aspects of the prototyping in this project are covered.

Evaluation

Two user observations were done to ground and evaluate the prototypes in the real world. The first observation was around 90 minutes and conducted with eight participants, they were student colleagues that study or are familiar with technology and interaction design (see figure 1). The observation was conducted in a living room setting, where the interactive cushions were mixed with regular cushions (see figure 2). Since all participants in the first observation were familiar with technology and interaction design, a second observation was conducted with participants with a different background. The second observation lasted for 60 minutes and was conducted with three participants, which were friends with a great interest in interior design. Due to technical problems with bluetooth connection, this observation was done around a table, where the cushions were laying on the table (see figure 3). All participants were between 23-30 years old. During both user observations, the participants did not get specific instructions; they were asked to explore the cushions on their own. The explorations were recorded with image and sound and qualitative data was collected.

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² Hornecker, E. (2012)

³ Koskinen et al. (2011) page 134

Figure 1. User observation 1

Figure 2. Living room setting with the interactive cushions (red circles)

Figure 3. User observation 2

Moodboarding

Moodboarding was used during the brainstorming stage of the project. Moodboarding is a used technique for exploring how the design should look and feel and for giving a general idea of the topic. Figure 4 shows a moodboard over different contexts were cushions could be used. These pictures were found in different magazines for interior design. Since this project focuses specifically on technological integration with the home environment, the context scenario that was chosen for this project is a living room setting, where cushions are laying in a sofa or armchair. Cushions are being used in a lot of different settings such as workplaces, outdoor spaces, cafés and bedrooms. It is a highly adaptable object that can be easily placed and moved in different types of spaces.

Figure 4. Moodboard of cushions in different contexts

Figure 5 shows a moodboard of the mapping of the ecosystem and characteristics of a cushion. It shows the identified affordances, interactions, contexts, relationships, technological misuses and definitions of the object. The mapping was used in the next step of the design process when the sketching of the different design concepts was done. Especially the identified affordances and interactions were taken into consideration when developing the different concepts.
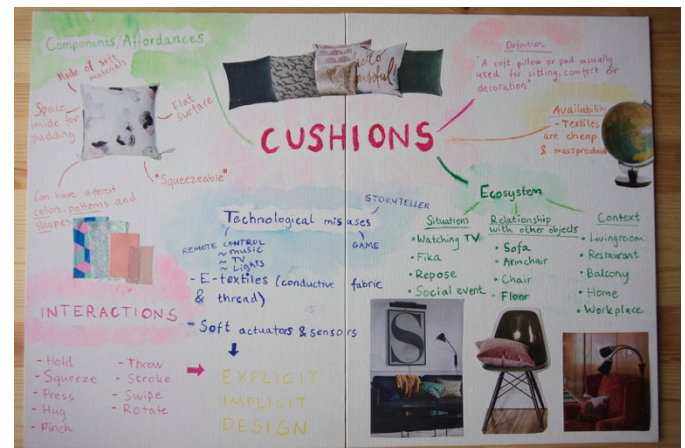

Figure 5. Moodboard of the ecosystem of a cushion

Sketching

Figure 6 shows the sketches of the different design concepts that were created for this project. All designs are based on that a cushion can have various shapes, colors and patterns. The designs also show different ways of integrating actuators and sensors into textiles and they explore both implicit and explicit interactions. Visual, tangible and "invisible" use cues are explored in the different concepts. The concepts are named stroke, swipe, capacitive touch,

pressure, rotating, play/pause and pinch pillow. The concepts show different types of use cues and levels of explicit user input and the designs that were technically realized were intended to be different in this aspect.

Figure 6. Sketches of different design concepts

Prototyping
Three prototypes were built; cushion 1, cushion 2 and cushion 3. The prototypes were based on the design concepts that were produced during the sketching. The idea was to produce three prototypes with different types of use cues and levels of explicit user input. All of them had a fabric based push-button for the function play/pause. The button was placed in one of the corners, on the inside of the cushion (see figure 7). When the button is pressed for three seconds, a song is played and the cushion goes into interactive state and different inputs will trigger different functions. An additional click sound was added as feedback when pressing the button correctly, so that the user can reflect on the interaction. All cushions have bluetooth connection, which makes them wireless and possible to interact with at the same time. As seen in table 1, the functions that were used for controlling music were: play/pause, raise/lower volume, next/previous song, shuffle and raise/lower play rate.

Figure 7. Sketch of fabric based push-button

Cushion	Interaction	Use cue	Function
#1	Touch, Swipe	Conductive thread	Swipe up/down
	Pinch	Tangible button	Play/pause
#2	Pressure	Neopixel, softness of pillow	Raise/lower volume
	Pinch	Tangible button	Play/pause
#3	Rotation	Fabric with a pattern of squares	Next/previous song
	Shake	Weight and softness of pillow	Shuffle song
	Pinch	Tangible button	Play/pause

Table 1. Interaction mapping

Cushion 1 (see figure 8) was based on the affordances that a cushion has a flat surface, which you can touch and stroke. The surface can also have different patterns, colors and features. As shown in the "capacitive touch and swipe pillow sketch" (see figure 9) the idea was to use conductive ink to paint symbols and lines as visual cues to explicitly communicate user input. The combinated rectangle and triangle sign was supposed to be the input for play and pause. For the lines, we used conductive thread. The inputs are based on capacitive touch, which are connected to the lines of conductive thread. The user can touch the lines by swiping up or down to raise or lower the play rate. A double tap on one of the lines will neutralize the sound. For testing, the conductive ink did not work, but were still kept for the user observations. Cushion 1 was developed as the most explicit cushion with visual use cues.
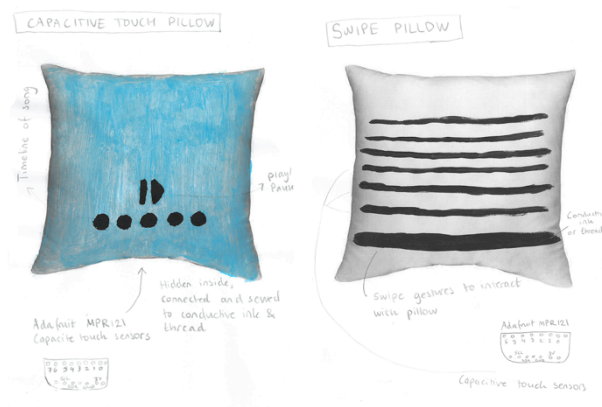

Figure 8. Cushion 1

Figure 9. Sketch cushion 1

Cushion 2 (see figure 10) was based on the "pressure pillow sketch" (see figure 11). It is based on the affordances that a cushion is soft and squeezable; it is possible to press, squeeze and hug it. The bird print on the fabric is used to incorporate a neopixel in the design, which is green in a neutral state to match the colors of the cushion. Beside from the play/pause button, two fabric based pressure sensors were used to raise/lower volume. The fabric-based sensors are built completely out of soft materials, which makes the pressure interaction pleasant and natural for the user. When the left side is pressed, the volume goes down and the neopixel turns red. When the right side is pressed, the volume goes up and the neopixel turns blue. For this cushion, both visual and audio feedback was given. When the pressure sensors are pressed, the volume will go up or down and there is an additional hackpicking sound to let the user know that the interaction was successful. Cushion 2 was in the middle of cushion 1 and 3 when it comes to levels of explicit input and types of use cues.

Figure 10. Cushion 2

Figure 11. Sketch cushion 2

Cushion 3 (see figure 12) was based on the "rotating pillow sketch"(see figure 13). It is based on the affordances that a cushion is lightweight and soft, which enables you to rotate

and move the cushion in different directions. This cushion can detect position by using input from an accelerometer. The pattern on this cushion was chosen to be "rotatable", which means that you can't see any difference in the pattern regardless of position. That means that it will keep its aesthetics even when it is rotated. The pattern on the fabric is used as a visual cue for indicating that the cushion can be rotated. The functions previous/next song is mapped to rotating the cushion left or right. Audio feedback is given in form of that the track is changed and there is also an additional "swipe sound" so the user gets feedback that the interaction was successful. Since changing track is also associated with shuffle song, the interaction shaking the cushion is mapped to shuffle. This prototype is the least explicit cushion and the pattern is the only cue when it comes to communicating how to interact with the pillow.
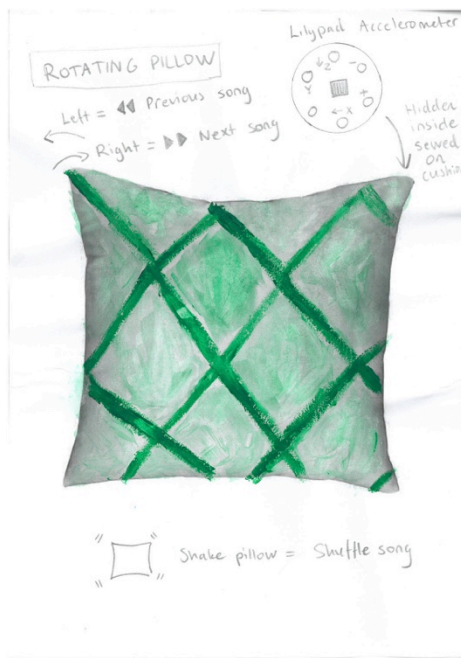

Figure 12. Cushion 3

Figure 13. Sketch cushion 3

RESULTS: MAIN DESIGN INSIGHTS
In this section, I will present the main design insights that were collected during the user observations. In order to this, the qualitative data on the video footage from the user observations was transcribed.

Impact of visual cues
Out of the three pillows, cushion 1 has the most explicit visual cues. During both observations, the participants were asked to try to interact with the cushions to play a song. In observation 1, one participant starts with observing the three cushions and says "*This one is a mystery (cushion 3), this one has a LED (cushion 2) and that one has some signs and thread on it (cushion 1)*". In both observations, the participants start with trying to play a song by touching and pressing the explicit signs on cushion 1. When that does not work, the participants tries to press and hug different areas on the cushions. One participant tries to push the neopixel on cushion 2. Users are immediately drawn to the visual cues in both observations. When they can't get the visual features to work, one participant says "*Should we try to shake or move them?*" and they start to press, hug and move the cushions without any progression. The pattern on the fabric on cushion 3 was supposed to work as a visual cue, but it was very hard for the participants to interpret how to use it. Instead, after exploring and playing with the pillow for a while, they manage to rotate it and change song. The audio feedback makes the participants conscious about the interaction, but they still do not know how to rotate the pillow in order to successfully perform the interaction. The pattern seems to be to vague to work as a signifier and to indicate how to interact with it correctly, one participant says "*I think it has something to do with the pattern on the pillow*" but can still not understand how to interact with it. With cushion 2, the participants try to press and interact with the bird and the neopixel (birds eye). The neopixel also gives visual feedback, which guides the users on where to press on the cushion. After some exploration and feedback from the light, the users figure out where to press.

Little experience required for learning
In both observations, the first task was to find out how to use the cushions to play a song. The participants found the button in the first and second observation, but in both cases they did not understand that they had to press the button for three seconds in order to play a song. The interaction had to be explained in order for the users to know how to use the button. This interaction was therefore not clear or easy for the user to find, but after it was explained the participants knew exactly what to do. Each time a participant was asked to play or pause a song after the instructions, they could do it, which means that learning the interactions required little experience. The other interactions had the same threshold. With cushion 2, the participants understood that the interaction was connected to the bird and the neopixel, but it took some exploring for them to understand how to use the function correctly. Once they knew, they could easily lower or raise the volume. Same for cushion 3, it took the

user lots of exploration, but when they managed to successfully interact with the pillow, they could easily repeat it.

Trade off between use cues and aesthetics

As a participant phrased it "*The more feedback you give on the cushion, last of just a cushion it is and that's a trade-off*". Another participant made a comment about the aesthetics on cushion 1 "*Usability wise, I think that cushion 1 is the best, because you can see what to do with it, with they play-sign for example, but that is the one that I least wold like to have in my sofa*". There are also mixed reactions about the light that is integrated into the design as the bird´s eye. One participant from observation 1 said that it looks like a "*terminator bird*" while a participant from observation 2 liked the design and thought that it *"looks good"* and said that *"The neopixel is conspicuous and I think that everyone that would see it in my sofa would ask what kind of pillow it is, which makes it interesting."* The participants found it easier to use and understand how to interact with the cushion that has more explicit cues, but thought that this at the same time removes the aesthetics of the pillow.

The use of design patterns and consitency

The users found it helpful when the interactions were mapped to existing design patterns. One example of this was the shuffle-function on cushion 3. When the cushion was shaked, the external speakers played a random song from the playlist. When one participant shaked the pillow, the reaction was *"Cool, is that a random song, like shuffle?"*. Participants from user observation 2 especially discussed and liked this function and another comment was *"I like it, I know at least that on the phone, on a recipe-application that you can shake it to "shuffle" a random recipe".* Another design choice that was commented on was the choice of colors for the light. A green light was chosen for the neopixels neutral state because of the colors of the fabric. The red and blue color that appeared when pressing on the cushion was randomly picked. One participant in observation 2 said this about the choice of colors "*But I am thinking, design wise, I understand the the light is green since it is matching the pillow, but I would use the color green as raising the volume and the color red as decreasing the volume and blue as the color in its normal position. Because I think that you associate green and red with positive and negative. And maybe yellow could be the starting color, when nothing is pressed.".*

DISCUSSION

The purpose of this study was to investigate how integration of interactive cushions in the home environment is affected by design concepts with different levels of explicit interaction and types of use cues. In order to do this, different known techniques for design was used, such as moodboarding, sketching, prototyping and evaluation. The results from the user observation shows that users would use the textile interfaces as an integrated part in their home environment, but that there is some problems with the usability due to lack of visual cues. This could be improved by taking the insights from this study and do further iterations. During the observations, the participants needed guidance and instructions to understand how to interact successfully with the cushions. All participants were immediately drawn to the visual cues; it was their intuitive way to interact with the prototypes. Second, they tried to squeeze, press, hug or move the cushions in different directions. In this project, mostly audio feedback was used. The only visual feedback that was given was the light on cushion 2. The participants that had a big interest in interior design appreciated the visual feature and even if some participants from the first observation found the light a bit intimidating, they appreciated it as feedback. Since this study was about designing different design concepts to see how it affects the integration of the home environment, it is interesting to see that light was appreciated and can be used in the design for visual feedback without interfering with the aesthetics of the cushion. The audio feedback was appreciated and supported the use case and the functions of the cushions, but the possibility of using haptic feedback could also be further investigated. Users were also guided by the visual and audio feedback that was given, and even if they were not successful with the interactions until they got instructions, it shows potential in using the affordances of a cushion for mapping different types of functions because feedback can be used as a way for the user to reflect and learn.

Reflection on use case and user observation

The use case that was chosen for this particular study was: Interactive cushions to control music from external speakers in a living room. There are a multiple other use cases that could have been investigated but living room and cushions was chosen since they are a natural setting and object in our everyday lives. Controlling music was chosen since it has defined functions that easily can be mapped to different interactions. Also, you could ask the question why you would like to control external speakers with a textile interface like a cushion. As a participant phrased it during the observation *"Yes, if you think about a living room, what you have in it, you never want to have remote controls on the table or something, it is super ugly, then things like this is very good cause they are replacing the control".* The cushion as an object is more integrated into the home environment and it it also more aesthetically appealing then for example a remote control. Another participant also mentioned a social aspect *"Yes and you dont need to use your phone when you are in a social context and get disturbed by it, you can use the cushion instead".*

The design process consisted of moodboarding, sketching, prototyping and evaluation and was done in one iteration. Further iterations could have given deeper insights in how to design a textile interface that integrates with the home environment. During the evaluation, both the user

observations were supposed to have the same setting. The setting for the second user observation had to be changed, due to technical problems with the bluetooth connection that was incorporated in each cushion. This was unfortunate, but also part of the testing and something that could have been solved in a next iteration, where other solutions for wireless connection could have been used.

Let the user map interactions to specific functions
After giving the participants instructions in how to interact with the cushions during the observations, it required little experience for the users to learn what to do. It might have been easy for them to remember how to use the functions, since the interactions were meant to be intuitive. One way of solving the high threshold for understanding the interactions could be to let the user map the functions to certain interactions. One student in interaction design suggested during the first observation that: *"What if you could easily adapt the control to other things, now its for applied for music, but obviously these kind of controls can be applicable to other things like controlling the tv, what if you could give it to the user and let the user decide what they want to control things with, then it is not very static, you can apply it to anything you want"*. This is being done with the Levi's commuter trucker jacket, which was produced in collaboration with Project Jacquard by Google. The user can map the interactions and gestures that can be performed on the sleeve of the jacket with different functions on the phone, e.g. answering calls or control music. A similar mapping of interactions to specific functions could be done with the cushions.

Shifting ideals for TUI
When designing the cushions, some of the shifting ideals for TUI were taken into consideration. Since the living room is a setting where you often interact with other people, the cushions were made for a collaborative use. During the user observations, the participants were using the cushions collaboratively, but I would not say that this is a natural way of interacting with a remote control, when you often dont want to do many things at the same time. To be able to interact with the cushions at the same time is probably more appropriate for other use cases, such as using the cushions as gaming controls or other socially engaging activities. The prototypes have also focused on how users make meaning through the interaction, how would a user intuitively interact with a cushion and what would be the purpose of such use rather than designing a usable system.

Explicit vs. implicit design
Implicit interactions have, according to Ju [14], the possibility of taking less cognitive attention for the user. However, in this study, different levels of explicit interaction were investigated, where the results show that the cushion with least cognitive load was the most explicit one. This is an interesting finding, but it would be necessary to compare the explicit designs with implicit ones to draw any conclusions.

Some of the design concepts in this study were designed to have implicit interactions, but it turned out to be too advanced to technically realize them in a prototype. One design concept that was not realized was that the cushion would notice if the user would lay its head or other body parts on it by sensing pressure. By doing so, the user would not have to explicitly turn off the remote control function for only using the object as a cushion. During the observations one participant said *"Maybe the control should also take into account that you should be able to lie on it and use it as an actual cushion"*. Therefore, designing for a dual use where the cushion is used both as a remote control and as an actual pillow is something that should be considered in further iterations and a good solution would be to use implicit interactions.

FUTURE WORK: FINAL DESIGN PROPOSAL
To visualize recommendations for the future, I have initiated a second iteration of the sketching stage. Here I have developed two different design concepts (figure 14 and 15). They are based on the results from the user observations in this study. The first sketch (figure 14) is a cushion that controls volume, just like cushion 2 in this paper. Since the visual cues and feedback were very important for the usability, this cushion has both of it. If the user strokes the green tassel, volume will increase and if the user strokes the red tassel, the volume will decrease. The colors (green associated with positive and red with negative) together with the buzzing and silent bees indicate that the user can interact with those parts of the cushion. The string of flowers work as visual feedback, with hidden neopixels under and the flowers will light up the more the volume increases. Visual cues, visual feedback and design consistency have been taken under consideration in this sketch. I choose not to use pressure for the functions in this concept so that implicit interaction, like lying down on the cushion, could be investigated for dual use. The second sketch (see figure 15) is inspired by the Levis collaboration with Google Jaquard; the jacket that they developed has an interactive grid on one of it sleeves. This cushion also has an interactive grid, made of conductive ink or fabric, where the user can map interactions to different functions. The interaction that has been chosen for this sketch is based on touch, where the user can swipe left/right/up or down and tap or double tap. Any function could be mapped to this interactions, an example could be play previous or next song. As feedback, audio can be used like in cushion 3 in this paper, but also haptic feedback in form of vibration. This cushion therefore takes visual cues and design consistency into consideration, together with haptic feedback and mapping of interactions. These design concepts are just some examples of what could be done in a next iteration and it is an interesting design space to explore further.
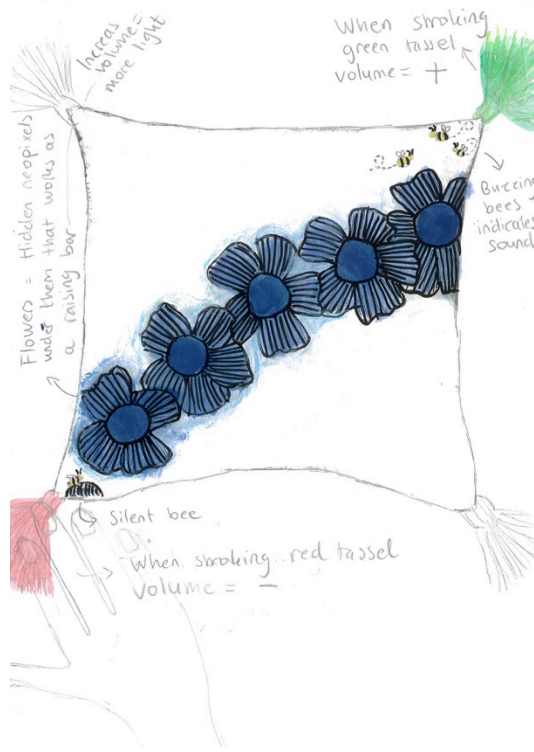
Figure 14. Sketch 1 of future recommendation

Figure 15. Sketch 2 of future recommendation

CONCLUSION

The aim of this study was to investigate how integration of interactive cushions in the home environment is affected by design concepts with different levels of explicit interaction

and types of use cues. To be able to do this, different design concepts were developed and three prototypes were built. The design process was based on using the method constructive design research, which meant the activities of moodboarding, sketching, prototyping and evaluation. I started with informally observing some of my friend's behaviours towards cushions in a living room. After that I tried to gather where cushions are used, by making a moodboard of cushions in different contexts. The next step was to map the characteristics and ecosystem of a cushion in an additional moodboard. Possible and identified affordances and interactions were mapped and then used in the next phase of the design process, which was sketching. I made several sketches of different design concepts, with different types of use cues and levels of explicit interaction. Some were chosen for realization and tested for feasibility and integration in the home environment. The three prototypes that were developed were different in the aspects of levels of explicit interaction and types of use cues, to try to see what impact it had on the integration of the cushion in the home environment. Two user observations were conducted to ground the study in the real world. The findings from both observations show that users both appreciate and think that the different design concepts integrates with the home environment but that there is a trade off between use cues and aesthetics. Also, the cushion that was considered as the most integrated one was also the one that lacked most usability. All three cushions required little experiences for learning, which shows that the chosen interactions, based on the identified affordances, were intuitive.

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