TU Delft

JAN 2019

PRIVACY-DRIVEN INTERACTION DESIGN

Creating Transparent Characters for Smart Objects

Graduation Project

MASTER DESIGN FOR INTERACTION

Student

F.D.H. QUAEDVLIEG

Tutors

M.C. ROZENDAAL & A.I. KELLER

COLOPHON

Graduation Project
MASTER DESIGN FOR INTERACTION

DELFT
JAN 2019

Student:
FELIX DUSAN HUBERT QUAEDVLIEG
Student no. 4114485

Delft University of Technology
FACULTY OF INDUSTRIAL DESIGN ENGINEERING

Graduation Committee:
DR. ING. M.C. ROZENDAAL
DR. ING. A.I. KELLER

PRIVACY-DRIVEN INTERACTION DESIGN

Creating Transparent Characters for Smart Objects

ABSTRACT

As more consumer products and services are getting intelligent and collect data about the user, privacy has become an important topic of debate in society. New rules and legislation are being implemented to safeguard the user's privacy. In addition, from a technological perspective, developments like the creation of the seven principles of '*privacy by design*' for systems engineering aim to ensure that privacy is embedded within the functioning of these '*smart objects*'. However, there has not yet been given much attention to creating privacy through interaction design.

This project aimed to create a design approach which has the user's control over their privacy at its core: The **Privacy-Driven Interaction Design approach**.

Through the creation of a conceptual framework, this project started with an analysis of existing theory of Human-Computer Interaction. It proposes three design strategies for creating smart objects that give the user control over their privacy:

1 | Design smart objects with **Character**;
2 | Design smart objects with **Expression of Presence**;
3 | Design smart objects with **Frictional Feedback**.

Through cinematic prototyping, this project explores these strategies and implements them in a case study.

For the case study, two smart gloves were created which aid veterans during their therapy for post-traumatic stress disorder. Both of the gloves have different characters to show the impact of the smart object's character on the interaction between the user and the object. The smart gloves have both a conceptual purpose, which is to demonstrate how the design strategies can be implemented in a design process, and a functional purpose, which is to put the disclosure of information about the veteran's stress levels and therapy progress in the veteran's hand.

The conclusions from the creation of the conceptual framework and the smart objects during the case study lead to a guide for the *Privacy-Driven Interaction Design approach*. This guide is presented in the form of a checklist with '*design questions*' and '*design strategies*'.

This report aims to present the potential of this design approach and the smart gloves for veterans. However, more extensive research is recommended to further develop both the design approach and the design concepts.

TABLE OF CONTENT

INTRODUCTION

Nowadays, many intelligent products are designed and produced that collect data about their users. They are able to make decisions and act based on this data, and share it in a network without human intervention. These products are called 'smart products' or 'smart objects.' The data they collect is used for various purposes. For example, a smart object requires that data in order to perform its tasks, for user profiling to optimize user experience, and for performance. However, the collected data is sometimes also used to be shared and transferred to third parties. Companies can collect so much data which is traceable back to the user that it constitutes a serious risk for the privacy of the user. The end-users of intelligent products therefore have various privacy concerns, for example when it comes to smart wearables (*Motti & Caine, 2015*).

But the user's concerns are much broader. The WODC published a report on the protection of personal data in 8 European countries (*Custers et al., 2017*). For example, they found that only 9% of Dutch people feel in control of their online data. In addition, in a referendum in 2018, almost 50% of the Dutch population voted against the proposed 'Wet op de Inlichtingen- en Veiligheidsdiensten', which is a law that would increase the capabilities of the Dutch secret services to collect data about the Dutch citizens (*NOS, 2018*). The public debate surrounding the referendum exposed a lot of discomfort about privacy.

While in some parts of the world, privacy is being abolished in favor of total control over citizens (*Zhao, 2018*), the European Union attaches a great value to its citizens' privacy and aims to protect it (*European Commission, n.d.*). All citizens of the EU have privacy rights embedded in Article 7 and 8 of the EU Charter of Fundamental Rights (*European Union, 2010*). In addition, the EU adopted the new General Data Protection Regulation, that went into effect in May of 2018, setting new global standards for privacy protection (*Scott & Cerulus, 2018*).

Apart from efforts to improve privacy regulations and legislation, there are developments in the tech industry as well, for example in creating seven principles of 'privacy by design' for systems engineering (*Search Encrypt, 2017*). However, there has not yet been given much attention to privacy by interaction design. Users also need to be made more aware of the increasing intelligence of smart products by making it visible and part of the interactive experience. An example of this invisibility of intelligence are the conversational agents like Apple's Siri and Amazon's Alexa. The last few years, these virtual voice-controlled assistants embodied

in physical products got mainstream acceptance in society through their implementation in smart speakers (*National Public Media, 2018*). However, the physical design of such smart objects does not reflect the immense difference between a traditional speaker, which simply plays music, and a smart speaker with a microphone which is constantly listening to its environment while in the meantime sending data to its master company. Its intelligence remains a 'black box', meaning that we know its input and output, but we don't understand nor experience what goes on inside of the smart object (*Sentient, 2018*). This graduation project aims to use interaction design in making the user aware of the intelligence of smart objects and providing the desired transparency to its functioning.

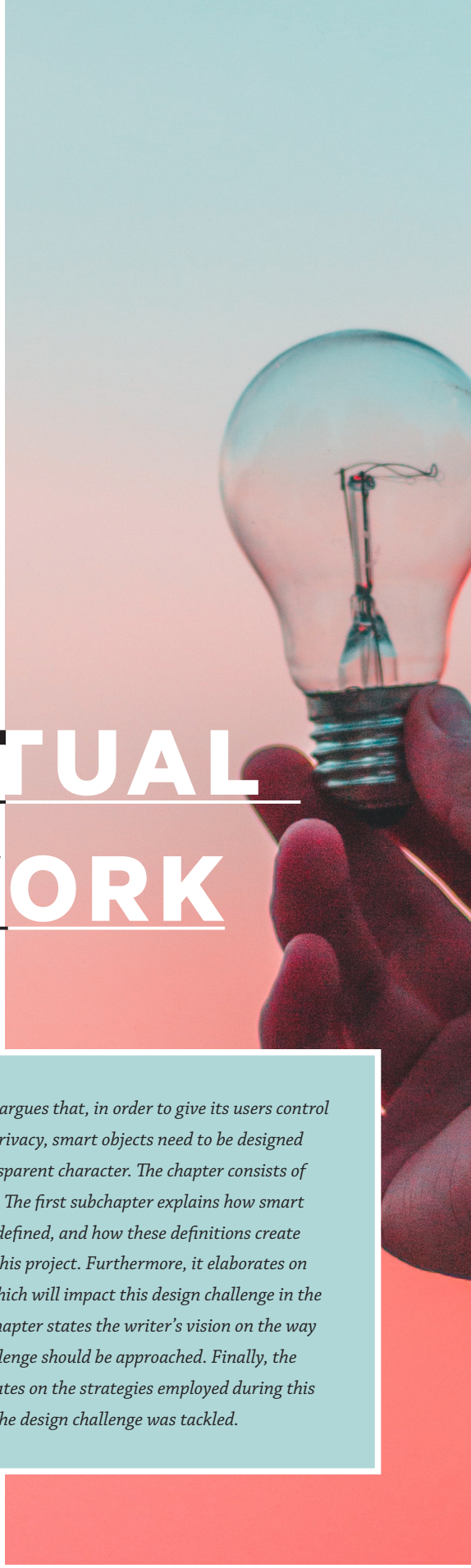
This project, titled '**Privacy-Driven Interaction Design: Creating Transparent Characters of Smart Objects**', will explore new design strategies for designing smart objects with the aim to ensure transparency of the interaction and the object's intelligence. It aims to give users full awareness and control of a smart object which will strengthen their sense of privacy and trust. This project handles the term 'smart object' rather than 'smart product' to emphasize that intelligence is implemented in everyday objects as well, and to avoid the probable association with common smart products like smart phones and smart watches.
The design strategies developed through this project, have been applied in a healthcare context by creating a smart wearable for veterans with PTSD to aid them during their psychotherapy. The healthcare sector is particularly relevant for this project, as it works together with tech companies (*Apple, n.d.*) and seeks to implement new technologies for e-health modules (*Versluis, 2015*), while at the same time having to guarantee the security of privacy-sensitive data.

This graduation report consists of 4 parts. The first part, encompassing chapter 1, explains the conceptual framework that forms the basis for the entire project. It defines the design challenge and design vision, and it presents the designing of transparent characters of smart objects as a design strategy. The second part, which covers chapters 2 and 3, elaborates the project's proposals of specific design strategies related to smart objects. Part three, consisting of chapters 4 through 6, presents the case study in which a smart glove is designed for veterans with **Post-Traumatic Stress Disorder** (**PTSD**). The final part, chapters 7 and 8, presents a guide for interaction designers for the creation of smart objects in the future, and an overview of the conclusions and recommendations formulated by this graduation project.

CONCEPTUAL FRAMEWORK

1

CONCEPTUAL FRAMEWORK



This chapter argues that, in order to give its users control over their privacy, smart objects need to be designed with a transparent character. The chapter consists of three parts. The first subchapter explains how smart objects and privacy are defined, and how these definitions create the design challenge of this project. Furthermore, it elaborates on several developments which will impact this design challenge in the future. The second subchapter states the writer's vision on the way in which the design challenge should be approached. Finally, the third subchapter elaborates on the strategies employed during this project, through which the design challenge was tackled.

1.1 | DESIGN CHALLENGE

Smart objects often underperform when it comes to preserving the user's privacy. To explain this, and formulate the design challenge, both of the terms 'smart object' and 'privacy' are defined in this paragraph. After the explanation of the terminology and design challenge, the increasing relevance of the challenge will be elaborated on.

1.1.1 | Defining Smart Objects

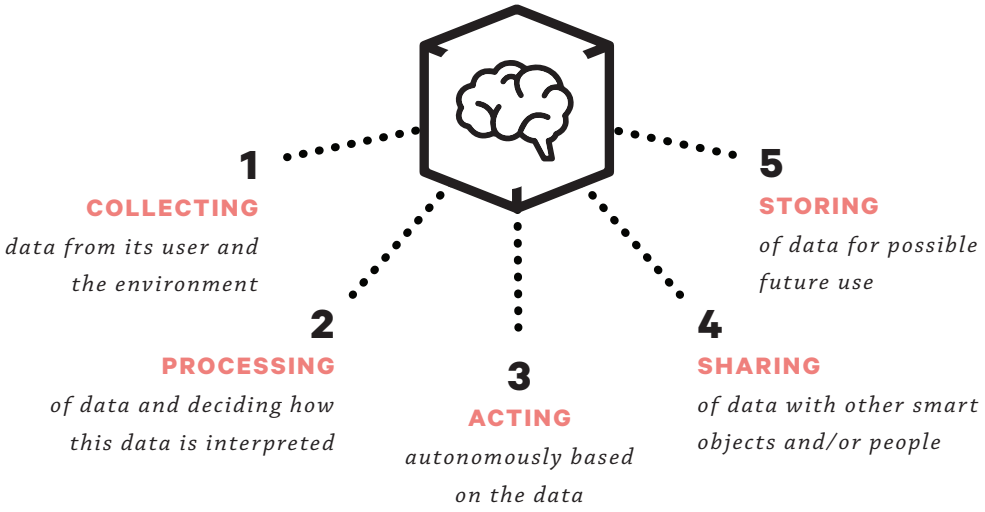
A smart object is an object that handles data, which it requires to function. The functioning of a smart object can be divided in five stages (*Fig 1.1*):

1. **Collecting** data from the smart object's user and its environment;
2. **Processing** data and deciding how this data is interpreted;
3. **Acting** autonomously based on the data;
4. **Sharing** data with other smart objects and/or other people who are not the user;
5. **Storing** data for possible future use.

This definition is constructed during this project by combining several notions about interactive products. An interactive product has an *input – processing – output* flow. In this project, the output entails acting, sharing and storing. All of these three outputs have an impact on a user's privacy. The storing comes last as a product uses it to increase its knowledge. It subsequently influences the smartness of a product as more data stored allows the product to better recognize patterns in the data.

Together, the five stages will be referred to as the '**smart object's functioning**' (**SOF**). These actions have privacy implications, as they involve personal data. The data is personal because it is collected from, and thus connected to, the user and the user's actions. In addition, smart objects influence the amount of data that is available about the user – through the collecting and storing of data - and the way in which it is available. To respect the user's privacy and to increase the acceptance and safety of smart objects, it is important that users know what happens to their personal data during the SOF and therefore they need an understanding of the five stages themselves. A proper design process can help the user in gaining this understanding.

Fig 1.1 | *A Smart Object's Functioning*



There are many questions related to the SOF that designers can ask themselves when creating a product from a privacy perspective in order to facilitate the user's understanding of the SOF. For example: How can users know from the appearance of a smart object how it is collecting data from the user and the environment? How can the user know how the data is being processed and what choices are being made based on the data? How can users influence the object's level of autonomy in making choices and taking action? How do users know with which parties the object shares this information? How can users know how much information about them is stored in the object, or elsewhere?

However, in order to ask all these questions, it is necessary to first provide a definition of 'privacy'.

1.1.2 | Defining Privacy

Privacy can be defined differently depending on the context in which it is used. Two possibilities of such a definition are '*a state in which you are not observed*' (*Oxford Dictionaries, n.d.*) and '*the ability to seclude yourself, or information about yourself, and thereby express yourself selectively*' (*Wikipedia, n.d.*).

This project puts emphasis on the latter definition. Applied to this context, which contains a smart object and its user, this definition focusses on what the user is actively able to do about their own privacy. It requires that users are in control of their personal data in order to enjoy privacy. This is in contrast with the first definition, which describes a passive state in which your privacy depends on what others are - or are not - doing, namely: observing you.

For users to express themselves selectively, they need to be in control of the data about them, so they themselves can make the selection. They need to be able to choose which data is part of their expressions and which data is left out. The ability to control the disclosure of data about oneself can increase one's privacy. Therefore, the definition of privacy that is used in this project is the following:

> **"Privacy is the state in which a user has the ability to control the disclosure of information about themselves."**

'Create a smart object that does not limit the user's control over their privacy, by enabling the user to keep control over the disclosure of information'

DESIGN CHALLENGE

1.1.3 | Defining the Design Challenge

As stated in the SOF, a smart object can act autonomously, based on the collected data. Having an object with autonomy means automatically giving it a certain amount of control over that data, taking it away from the user. Therefore, a smart object by definition impacts the user's privacy, which provides a design challenge.

> **The Design Challenge of this project is to create a smart object that does not limit the user's control over their privacy, by enabling the user to keep control over the disclosure of information.**

Giving control to the object in order to act autonomously while simultaneously giving control to the user over the disclosure of information requires the sharing of control. In such a situation, this project argues that the user should always be able to change the ratio of shared control, and even to be able to take back full control, whenever the user deems necessary. The amount of control should be able to change depending on the context or the changing needs of the user. The user also needs to be able to determine how much control goes to the object in the first place. In this way, the user can fully protect their privacy.

1.1.4 | Increasing Relevance of the Design Challenge

The design challenge stated above is already relevant today. As identified by Motti (*2015*), there are clear concerns about users' privacy while using smart wearables, which show that users do not have the feeling of control. It is likely that with new developments in the field of **Human-Computer Interaction** (**HCI**) these concerns will increase even further in the future. This sub-section covers three developments that will have an impact on this project's Design Challenge, namely:

I. Ubiquitous computing will make smart objects ever present;
II. Increased intelligence of smart objects will increase their agency;
III. Ubiquity and increased agency will create Human-Computer Integration.

This list is by no means the full list of developments that will have an impact in the future. However, these three developments were chosen during the research phase of this project because of their prominence, relevance, and contribution to the forming of design strategies for design for privacy. The reason for this will be explained in the following three paragraphs.

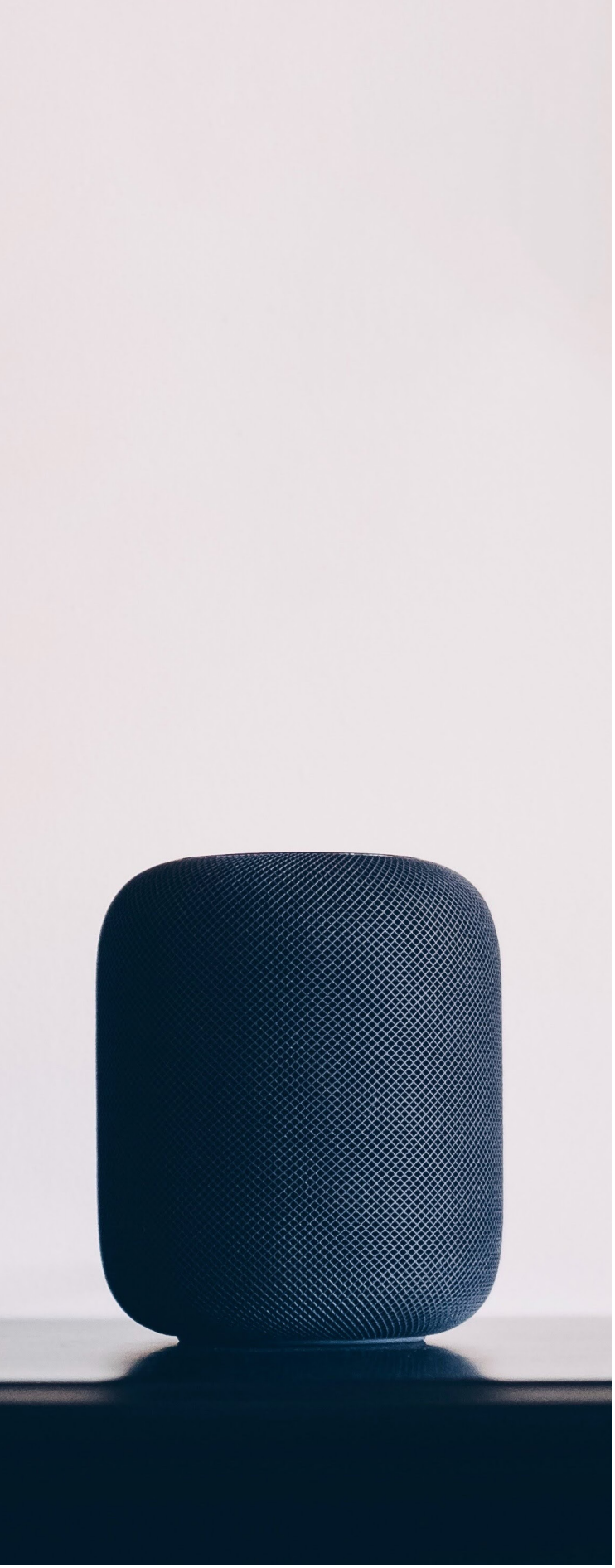


Fig 1.2 | *Apple Homepod Smart Speaker*

I. Ubiquitous Computing

The first of these developments is the approach of **ubiquitous computing**, or **'ubicomp'**. Ubicomp, as conceived by Mark Weiser (*1994*), is a concept that states that computers will be ever present and seamlessly integrated in our everyday lives, and computing will be available during every activity, anywhere, anytime. Weiser (*1994*) explained his efforts in this area, and that of his colleagues, as '*trying to conceive a new way of thinking about computers, one that takes into account the human world and allows the computers themselves to vanish into the background.*' This means that they did not want computers to be the big grey boxes which they were at the time. However, a computer would need to blend into its environment by being integrated in everyday objects. This would decrease the visibility of the computer as a separate machine. Instead, the computing power would become ubiquitous and always present when needed.

With the current wireless technologies and shrinking chip sizes, this concept will become a reality sooner rather than later. When computer chips are embedded in everyday objects, users will not be able to see the difference between a smart object and a 'dumb object' and therefore, users will not know with which type of object they are interacting. Furthermore, they will not have an immediate understanding of the SOF. Both of these issues have a great impact on the user's control over their privacy. For example, *Figure 1.2* shows an image of the Homepod, which is Apple's smart speaker. This speaker has its intelligent voice assistant, Siri, built in. There is a microphone turned on 24 hours a day, which registers the conversations in the room and listens for the words '*Hey Siri...*'. However, the physical appearance of the object does not reveal anything about this functioning. The object looks like a traditional speaker, albeit with a modern design. Smart speakers like the Homepod can perform 'intelligent' actions, but this is not expressed in its material form (Rozendaal et al., 2018).

This project claims that in the future, production companies and designers of smart objects will no longer be able to assume that users know that a product collects data. It will be their duty to design

II. Increasing Agency

a product in such a way that this problem does not occur. This should be done by transparently communicating the SOF to the user.

Not just the presence of computers is increasing, but also their processing power. Smart objects are getting more intelligent and with it, their agency is increasing. To explain the concept of agency, this project utilizes the '*weak notion of agency*', as conceived by Wooldridge & Jennings (*1995*). This states that agency in a hardware- or software-based computer system entails autonomy, social ability, reactivity, and pro-activeness. Systems that meet these criteria can be referred to as agents. However, not all agents have the same level of agency. As agents in HCI increase their processing power, intelligence, and agency, a new taxonomy is proposed by Cila et al. (*2017*) to categorize smart objects. They identify three types of agents:

1. **The Collector**, which only senses (collects) and processes data;
2. **The Actor**, which acts autonomously according to the behavior of users and other products;
3. **The Creator**, a smart object that has become self-aware.

In this taxonomy, every level up entails an increased amount of agency. These three types of agents can be linked to the functioning of smart objects with the five stages of *1. sensing, 2. processing, 3. sharing, 4. acting and 5. storing*. The Collector, the agent with the lowest agency, senses, processes and stores information. The Actor has increased agency and

III. Human-Computer Integration

adds sharing and acting to the mix. The Creator also performs all five actions but includes self-awareness and the highest level of agency.

Artificial intelligence (**AI**) is now so advanced that the term 'Human-Computer Interaction' might not be adequate anymore in describing the present-day processes involving users and smart objects. Instead, Farooq and Grudin (2016) offer the term '**Human-Computer Integration**' which goes beyond interaction, stating that '*the most dramatic change affecting human-computer interaction was invisible: What the computer does when we are not interacting with it.*' This means computers are becoming more integrated in the user's everyday lives and perform more tasks on their own, also when the user is not around. As a result, this adds more importance to the user's ability to control smart objects to ensure their privacy, since a product acting without the presence of the user, it is still acting on behalf of the user. Therefore, its actions are regarded as an extension of the user's actions. If the object acts, it is as if the user acted. The object's action can thus reveal information about user, impacting their privacy.

1.2 | DESIGN VISION

This subchapter covers the two elements of the project's vision on tackling the design challenge. It starts by explaining how there needs to be shared control between users and objects through a negotiable interaction. Next, it argues why privacy should be considered as a design material during the design process of smart objects.

1.2.1 | User in Control

Designing smart objects with greater agency and the ability to make choices on behalf of the user asks for the sharing of control. As argued previously, this presents the design challenge that underpins this project as the user needs to have final say regarding their personal data. Therefore, the concept of **shared control** should be taken into account during the design process of the smart object. To facilitate shared control, a **negotiable interaction** needs to be created. This entails that there is a constant communication between the object and its user, where the object communicates transparently what it is doing, and the user expresses approval or intervenes. After an intervention, a smart object should learn from the interaction and should respond to the following questions: *Why did the user intervene? How can the object improve so the user does not have to intervene next time? Does the user still trust the product? If not, how can the object gain back the user's trust?* The way in which the object reacts and responds to such questions has to be defined by the designer.

As the interaction progresses and the object and user familiarize themselves with each other, a new standard of interaction takes shape, or is negotiated, based on the user's and the object's feedback. A negotiable interaction needs to be carefully designed by creating proactive agents, which ask for user feedback, and a clear interaction which provides the user with control over the smart product, the data and, ultimately, their privacy.

1.2.2 | Privacy as a Design Material

In order for the designer to create a human-computer interaction in which the user is in control, the designer needs to consider privacy as a central component of the design process. In creating new products, designers need to be aware of the function and specifications of various materials in order to create an appropriate design. While designing 'dumb objects' these materials are tangible, such as wood, metal, etc. However, in creating smart objects there are additional, often abstract, components to take into account.

For example, Holmquist (*2017*) proposes that (artificial) intelligence should be considered as a new design material. As this project sees a direct link between increasing intelligence and privacy, it seeks to extend this argument to privacy. Privacy, too, should be considered as a design material. Before doing so, I will elaborate on Holmquist's argument.

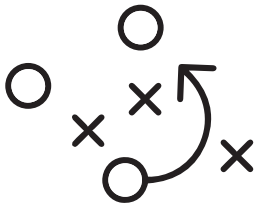
Holmquist convincingly argues that intelligence, although an immaterial concept, should be treated as a material resource for designing a smart object. Artificial intelligence comes in many different forms, just like conventional materials, and therefore the right form should be matched to the functioning of the product, which would improve the user interaction. This means that designers have to carefully consider the adequate level of intelligence that the object requires to fulfil the user's needs.

As previously stated, this project wants to argue that this way of treating intelligence should be applied to privacy as well. Smart objects with higher intelligence collect more data and analyze it more in depth. In addition, smart objects increasingly have greater agency and are making more decisions on behalf of users by analyzing their behavior. Therefore, smart objects with higher intelligence and agency also have a higher potential to reveal private information.

This leads to higher privacy risks and more privacy-related challenges if an object has higher intelligence. HCI of smart objects needs to be designed specifically with these challenges in mind.

If increased, and more advanced, intelligence means that there is a higher privacy risk, then designers should evaluate both the intelligence and privacy implications for a good HCI, thus treating not only intelligence, but also privacy as a design material.

1.3 | DESIGN STRATEGY



This subsection will detail how this project aims to implement the above outlined vision of a negotiable interaction using privacy as a design material. It will present a design strategy to create transparent characters for smart objects to enable user privacy with three components:

1. Design a **smart object's character** to give the user understanding of the SOF and the interaction with the object, which leads to trust;
2. Design an object with an **Expression of Presence** to provide transparency for the user, including when it is turned on or not. This is done to avoid unwanted surprises when the user reviews the private data collected by the object;
3. Explore the concept of **Frictional Feedback** as a means to notify the user about the SOF.

1.3.1 | Designing a Smart Object's Character

To design the right smart object, inspiration can be taken from a comparison with human interaction. People might feel different when sharing certain information if the person in front of them is highly intelligent with a large network, than when the person is likely to forget the conversation. In the first case, people might wonder about such questions as: '*I see the person I'm talking to is listening, but what are they thinking about? What conclusions is this person making based on my story? Will I agree with those conclusions? Is this person likely to talk to other people they know about the information I'm sharing with them? Do I agree with this person's opinions? What other information or experiences will they involve in their response to my story?*' In the design process of smart objects, these questions, among others, should be taken into account and applied to interactions between humans and objects.

It is clear that in human interaction, character plays an important role in shaping the interaction. Rozendaal et al. (*2018*) suggests a design approach where characters also shapes the interaction between people and objects, by having the intelligence be part of, and expressed through, an object's character. This project aims to expand this approach by also using character to communicate the object's impact on the user's privacy.

To define what a character is, this project utilizes the definition formulated by Janlert & Stolterman (*1997*). They define a character as '*a coherent set of characteristics and attributes that apply to appearance and behavior alike, cutting across different functions, situations and value systems – aesthetical, technical, ethical – providing support for anticipation, interpretation and interaction.*' They also argue that people easily attribute characters to objects, elaborating that: '*People are even more prone to apply character descriptions to computer artifacts than to ordinary artifacts. The more complex the artifact, the more there is to gain by reducing the complexities, facilitating our interactions with it.*' Since smart objects are eminent examples of computer artifacts with high complexity, they are in particular suited to have characters applied to them. Designers can use this to their advantage by consciously involving the desired character of the smart object in the design process.

This project seeks not only to support the claim that characters can reduce complexity of computer artifacts, but also to argue that characters are particularly important when users assess an object's impact on their privacy.

Characters subsequently play an important role in our trust in people and our sense of privacy when they are around. When we know the character of the person we interact with, we have expectations on how that person will act in different situations and

how the person will react to actions of your own. When these expectations are reinforced through multiple interactions with that person then our conclusion is that the perception of the character of the person is accurate and can be trusted. As a result, we can start trusting the person with private information, because we know how that person will react and that our information is safe with them.

Through the creation of characters for smart objects, this project aims to create the same trust in objects. In addition, it facilitates the aforementioned shared control. Trust in the smart object is crucial as the user will not give away any control without it.
As trust building is a process, the user's trust in the smart object should be expressed in a changing interaction. This interaction is a manifestation of the changing relationship between user and object. This mirrors interpersonal interaction, where a changing interpersonal relationship can subsequently alter the way they greet each other, for example. When meeting someone for the first time, one might give the other person a handshake. But once these people develop a friendship, they might greet each other with a hug instead, expressing affection, comfort, and trust. The interaction with objects could also be changing over time. For example, when turning on an object that is new, the interaction could be much less intimate than when you activate an object that has been part of your daily routine for years.

To conclude, characters of smart object scan have a positive impact on user privacy. Characters give the user understanding of complex computer artifacts and facilitate the building of trust, leading to a comfortable sharing of control with a sense of privacy.

1.3.2 | Expression of Presence

Apart from understanding the other person through their character, we get a sense of control over privacy because we are aware of that person's presence. A large part of the unpleasantness of a privacy breach can be explained by the fact that it was not known that someone else was gaining information about you. Knowing not only who, but also what is present in the room enables someone to control their actions and adjust them to the level of privacy in the room.

In order to achieve this with smart objects, there should be an *Expression of Presence*, so users know about the intelligence that is present in the room, as well as the possibility of data gathering. This would be a certain feature of the object and if the object is active, the feature should be active.

A key element of building trust with an object is knowing exactly what it is doing at any given moment, so you do not get any unpleasant surprises. This should be taken into account during the design process of the object. Designers should aim for transparent functioning at any given moment in the interaction with the object.

1.3.3 | Frictional Feedback and Taking Back Control

As explained in the previous two sections, creating smart objects with characters that express their presence will lead to trust and shared control. However, to share control with a smart object, a user also needs to be able to take back control. More importantly, a user needs to know when to take back control in order to avoid unwanted data collection.

In this project, the concept of *Frictional Feedback* is proposed as a method to notify the user about both its presence and its actions. This concept is introduced by Laschke, Diefenback & Hassenzahl (*2015*). *Frictional Feedback* means that the object gives feedback in a way that might be perceived as annoying. Because users find this annoying, they intervene to confirm or change the object's behavior. Therefore, the annoyance spurs the user's reaction to the behavior. In itself, this is beneficial because, if the object was not demonstrating the annoying behavior, the user would not have intervened. The aim is that, if implemented properly, the interaction still has a positive user experience in the end, despite intermittent annoyances.

This project seeks to use *Frictional Feedback* to facilitate the aforementioned negotiable interaction and add to the transparent functioning of the object. As explained, when giving smart objects agency and control, it will lead to moments where the user might

want to intervene in the SOF. For example, if the user wants to prevent an object from sharing data. In those moments, it needs to be clear for the user how they can take back control and intervene in the SOF. But for the user to take back control, they should first be aware that the object is doing something unwanted. That is why the transparency of the SOF is crucial. Just like the object can emit an expression of presence, the object can express that it might be about to start an action and that the user should pay attention to what it is doing in case they want to prevent this action. This is what *Frictional Feedback* will be used for.

1.4 | CONCLUSIONS

This chapter argued that, in order to give its users control over their privacy, smart objects need to be designed with transparent characters. For this, it first defined the terms 'smart object', with its five stages of functioning, and 'privacy', which is the state in which a user has the ability to control the disclosure of information about themselves. It explained how these two terms create a design challenge, and that this challenge will increase its relevance in the future. The chapter continued with the writer's vision on how privacy challenges need to be tackled in the future by making sure the user is in control and treating privacy as a design material. The chapter concluded with a design strategy, consisting of the three components which are explored in this project:
1 | a smart object's character;
2 | an Expression of Presence; and
3 | Frictional Feedback.

The next chapter will go further in depth on the design strategies and introduce practical ideas on how to implement them in a design process.

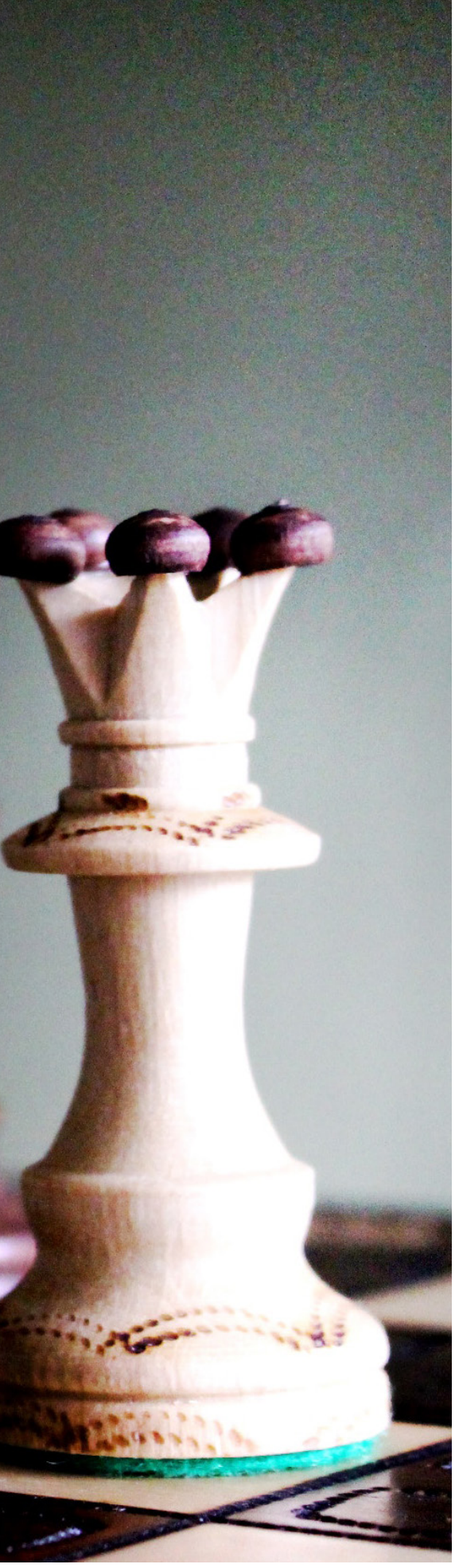
EXPLORING DESIGN STRA

2

EXPLORING DESIGN STRATEGIES

The first part of this report laid out the conceptual framework for the entire project and concluded with the overview of design strategies that will be applied in this project. This second part of the report elaborates on these strategies and explains how they will be implemented.

The main focus of the proposed strategies is to create a character for the smart object that is to be designed. This character will help to make the object's functioning transparent for the user. In order to do this, all the various elements of the character need to be communicated transparently as well. Every paragraph in this chapter adds a layer to the proposed interaction design and explains how the transparency of a character can be achieved.



2.1 | BUILDING BLOCKS OF A SMART OBJECT'S CHARACTER

2.1.1 | The Character's Goal

As a starting point, a smart object's character should have a **goal**; something that it wants to achieve. When the object is turned on, everything its character does will be in service of reaching that goal. Therefore, it will have substantial impact on the way it functions.

For example, the character of smart music speaker A could have as a goal to find the user's favorite song. Speaker B's character might have the goal to find the right song for the particular occasion that it is asked to play music for. Both goals will impact the way in which the object functions. This will be further explained in this sub-chapter.

The goal of the smart object's character will also be used as foundation for the choices that the object will make during its functioning. With every decision that it takes, the object will evaluate what would bring him closer to the goal. The object's character will in turn influence how the object acts upon those decisions.

Providing the user with transparency regarding the character's goal will contribute to the overall transparency of its character. To achieve this, the responsibility to clearly communicate the goal and choices lies with the smart object itself. With clear communication from the object, the user will be able to anticipate on what the object will do with the data it collects. Therefore, the user will be able to evaluate the impact of the smart object on their privacy.

It is crucial to note that the goal of the object's character can be different than the overall goal of the object. The smart object's goal explains its purpose, while its character's goal provides transparency about how it will try to reach this purpose. For example, the goal of both previously-mentioned smart speakers can be to provide the user with a personalized listening experience. However, the characters of both speakers have different goals, which explain that one speaker will put more emphasis on tracking the specific songs you listen to, and the other would track the environment and what is happening in it. Therefore, both characters communicate a very different SOF. Rozendaal et al. (*2018*) explains this as the '*object's intent*'. An object's intent is '*shaped by [the object's] purpose as a product, but also by its motive as an agent.*'

2.1.2 | *The Smart Object's Functioning*

As described in the previous chapter, the object's character should manifest itself in the five stages of its functioning, i.e. collecting, processing, acting, sharing and storing. To explore possibilities of this strategy, nine examples of characters were created to see how they would translate to a *SOF*. These characters were chosen because the person who hears them is immediately triggered and can form an understanding of the character with a set of assumptions.

The first character example on the list is the '**The Explorer**'. When thinking of such a character, multiple character traits come to mind. Some of these traits are positive, but there is always a negative side to a character as well (*Fig 2.1*).

On the basis of these character traits, the transposition can be made to the SOF (*Fig 2.2*):

- A person who is adventurous, curious and perceptive will collect a lot of data;
- A person who is Intuitive and creative will process data;
- A person who is spontaneous and energetic will act upon that data;
- A person who is independent might not share that much data with others;
- A person who is curious will store data for future reference.

This transposition is of course subject to personal experiences. Various people might have different ideas on how an explorer functions. However, there is likely to be a be a general consensus on the expectations from an *Explorer*.

Fig 2.1 | *Character traits of the Explorer*

Positive Character Traits	
Adventurous	Independent
Creative	Intuitive
Energetic	Perceptive
Curious	Spontaneous

Negative Character Traits	
Intrusive	Quicly bored
Insatiable	Unavailable
Impulsive	

Fig 2.2 | *The Explorer's SOF*

5 Stages of Functioning	--|-|o|+|++
Collecting	++
Processing	+
Acting	++
Sharing	o
Storing	+

To come back to the above-mentioned example of the smart music speaker, the character of The *Explorer* can be implemented with this product to clarify its functioning. If smart music speaker A is an *Explorer*, and it seeks to discover what the user's favorite song is, it could be much more proactive in asking the user for feedback or in giving recommendations. It might also ask for a rating after it plays a song. However, if the smart object would have the character of the *Butler*, it would be much less predominant in the interaction with the user, ask less for the user's opinion and try to reach its goal more discretely.

2.1.3 | *The Smart Object's Emotions*

Designing the character of an object with emotions can also provide a comprehensive interaction with the object. A changing emotion of the object is an intuitive way to let the user know that the smart object's functioning changes. An impatient object might lose its temper and become angry at the user, thus changing its decision making and influencing one or more of the five stages of its functioning.

For example, the music speaker A, which is trying to know what the user's favorite song is, can find it annoying if the user doesn't give feedback because this prohibits it from achieving its goal. If it gets angry, it might increase the volume of the speaker, change the frequency in which it is requesting feedback, or it could even start playing songs that the user actually hates. This changing interaction would in turn be shaped by the smart object's character. An '*Explorer*' might get angry at the user, a '*Butler*' will certainly not.

2.1.4 | *Conclusions and Implementation*

Creating a character for a smart object and transparently communicating its goal, decision-making process and emotions to its user will enhance the user's ability to evaluate and ensure their privacy.

This project explores the above-mentioned design strategy by implementing different characters in the same idea for a smart object (**Chapter 5**). This aims to demonstrate how designing based on the smart object's character will influence the final design and impact the interaction.

Sub-chapter 2.1 elaborated the starting point on which the foundation of the smart object's character is based. The following sub-chapters will add new layers to the smart object's character. Therefore, these layers should be designed in relation to the initially established foundation of the character. These design strategies add to the user's understanding of the character and enrich the interaction.

2.2 | CHARACTER LEARNING CURVE

There are multiple stages during which the user can get to know the smart object's character and each stage provides opportunities for transparent communication. This project calls these stages together the '**Character Learning Curve**', where with each new stage, the user gains exponentially more understanding of the character. These stages are **I. Form**; **II. Material**; **III. Interaction** and **IV. Decision-making** (*Fig. 2.3*). With the smart object's character in mind, the *Character Learning Curve* can be used in the design process by designing what the user learns in all four stages, as mentioned above. Each of these stages will be elaborated in the following paragraphs.

2.2.1 | Form

The form of the smart object is the first opportunity to introduce the smart object's character to the user. During this first stage, the user gets to know about the visual physical appearance of the smart object, such as form, size, color and its various parts. All the visual elements create expectations about other characteristics of the object, like functionality and quality, and they also create assumptions about the interaction with the object and how it will behave, in accordance with its character. With the information gotten from the object's form, the user can assess how to initiate the interaction.

2.2.2 | Material

The smart object's material can affirm or counter the user's assumptions that were based on the object's form and give further information about the object's character. Getting to know what the object is actually made of gives the user more information about, for example, the quality of the product. This, in turn, gives insight in the intended interaction with the product. Is the product meant to last? Does it need to be handled with care or can it be used roughly? Does the quality of the material match the 'personality' of the form? All these aspects add to the user's understanding of the character.

2.2.3 | Interaction

Interacting with the smart object is the first stage in which the user gains actual knowledge about how this object behaves. Until this point, the user had merely assumptions about the object's behavior. At this stage, the object's character becomes apparent during its everyday use.

2.2.4 | Decision-Making

Learning what choices an object makes creates, within these four stages, the deepest understanding of the object's character. As previously described, choices are made by evaluating the impact on the end goal. Therefore, experiencing the decision-making process of an object explains the foundation of a character, namely, its goal.

The *Character Learning Curve* can be accelerated by transparently communicating the smart object's goal, as is proposed in **sub-chapter 2.1**. In this way, the user can gain better understanding of the smart object's character during the various stages of the *Character Learning Curve* and make the right assumptions about the smart object's functioning.

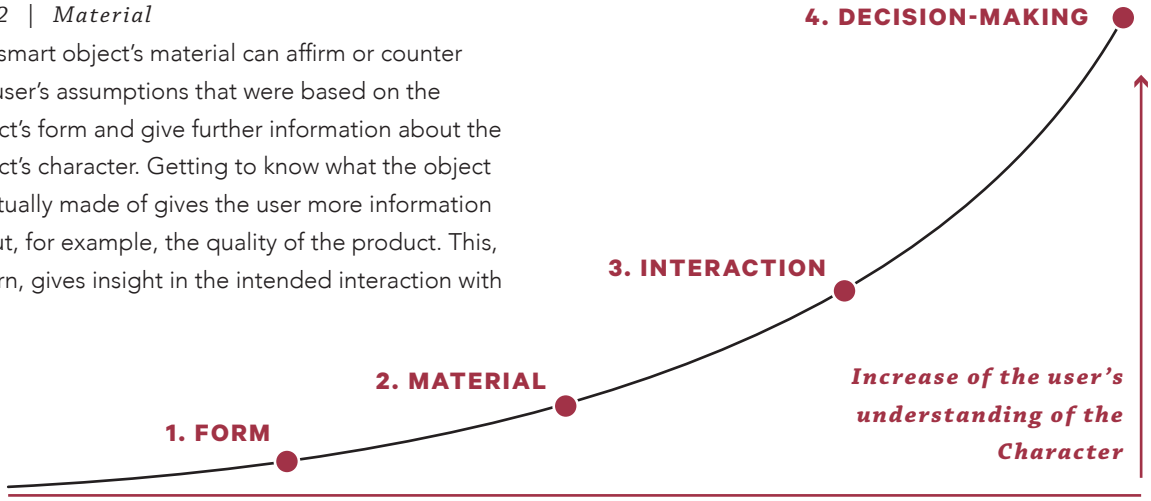


Fig 2.3 | *The Character Learning Curve: With each stage, the user gains more understanding about the smart object's character*

2.3 | EXPRESSION OF PRESENCE

One of the starting points of this project was the fact that users don't know if a smart object is active or not, which is the case with Apple's and Amazon's smart speakers. As a consequence, the user does not know which intelligence is present in a smart object, nor how it handles data necessary for its functioning.

The '**Expression of Presence**' of a smart object should prevent this from happening. Like the breathing of a human being, or the beating of a heart, it would let the object's surroundings know that it is active. An example of a widely-known *Expression of Presence* is a little light next to the lens of a webcam, which indicates that the camera is active and recording (*Fig 2.4*).

The challenge for designing an *Expression of Presence* is not to make it obstructive during daily use, but still make it apparent enough that the user becomes aware of it. This will require careful adjustments in the interaction in order to enable a negotiable interaction where the user can change the objects behavior according to the context in which it is used. Therefore, an *Expression of Presence* requires not only actions to be undertaken by a smart object, but also a way in which the user can have influence and exercise control on the smart object's functioning.

The *Expression of Presence* should be designed in line with the object's character. It is a key element in which the object can provide transparency about its character. As we continue to illustrate the proposed design strategies through the example of a smart music speaker, we can create an *Expression of Presence* for an Explorer-type character that is trying to find the user's favorite song. The speaker could express the collection and processing of information by softly making a noise of the tuning of a radio. The object will be looking for new songs to recommend to the user, but also evaluate known songs to see if the favorite song might already be in its database. It might also say some names of friends or contacts that have similar music styles or often provide the user with inspiration, to express where it is collecting information from and with whom it is possibly sharing the user's music preferences with as well.

This *Expression of Presence* can be annoying when the user wants silence and is working or relaxing, in which case the user needs to be able to shut off the speaker. However, in other situations, for example when the user is doing other activities or is out of the house, such an *Expression of Presence* could be fine. In any case, the *Expression of Presence* should be something which attracts sufficient attention.

How a product smart object expresses its presence is an essential question that needs to be addressed during the design process. As designers ought to find a balance in the *Expression of Presence* between helpfulness and annoyance, they should realize that the latter could actually be beneficial as well. Annoyance can be used as a trigger for a negotiable interaction, if a smart object's character is designed to allow and invite '*Frictional Feedback*'.

Fig 2.4 | *The little red light expresses that the camera is recording*

'Annoying, but in a nice way'

2.4 | FRICTIONAL FEEDBACK

When two characters interact with each other, friction can occur between them. Since both characters can have different goals, one character can try to achieve its goals, while the other is standing in its way. For such a friction to be resolved, the first character needs to change its goal; the second character needs to change its actions; or one of the character's needs to impose its will on the other.

As explained above, **Frictional Feedback** is a natural consequence of interaction. However, the way it manifests itself can be shaped as part of the *Expression of Presence* of the smart object's character to make it useful in the interaction with the user.

Frictional Feedback can also be a way in which the smart object expresses its presence and expresses what it is doing in terms of its functioning. Through the friction, the object is in fact creating a situation in which the user is prompted to react to what the object is doing. Therefore, it functions as a notification of the object's activities. In this way, the *Frictional Feedback* that the object is giving is not necessarily desirable - it can even be annoying - but it is helpful, because it prevents that the object goes too far.

Frictional Feedback can also be used by a smart object to negotiate its interaction with the user. As smart objects gain more agency and make more decisions, they walk a thin line where some choices might go too far but others not. A smart object needs to identity the boundaries of its agency. How far can it go? *Frictional Feedback* can occur when the current boundary is reached. Based on the reaction of the user, this boundary can then shift or remain the same. This interaction will change according to the definition of this boundary.

The object negotiates with the user what action it can undertake. This is an ongoing process since the user's changing trust in a smart object could also change the amount of agency the user is prepared to give it. In a way, this process is comparable to raising a child. As a child gets older and more independent, it starts to explore what his parents allow it to do. When it does something, it registers the resulting interaction and it asks itself questions: '*Do my parents get angry? Do I get closer to my goal? Will I be allowed to continue doing this? Or will I be punished?*'

2.5 | INTERACTION WILLPOWER

As a result of the *Frictional Feedback* provided by a smart object, the user might want to exercise control over the object and change the interaction. However, to change the interaction, the user will have to put some effort in overruling the object's actions.

This provides a new opportunity to communicate the level of intelligence and the character of a smart object, since these aspects influence the amount of effort that would be required for the user to overrule the object's actions. An intelligent object, or an object with a more steadfast character would have more willpower to resist the user. This project uses the term **Interaction Willpower** to refer to the amount of resistance that a smart object gives when a user wants to overrule an action. For the user, this translates into **the amount of physical and/or mental energy that is required to overrule an action by a smart object**.

Inspiration for this strategy is the project of a graduate student (Rozendaal, 2016). He designed an alarm clock that needed to be twisted if the user wanted to change its behavior. While doing this, the

clock actually resisted harder the more you try to twist it. In the end, the user has to 'break' the alarm clock in order to succeed in changing the behavior.

The above-mentioned interaction indicates stronger willpower from the product to wake up the user and requires stronger willpower from the latter to intervene. *Interaction Willpower* can therefore be applied to both the object and the user. However, for the specific purpose of this project, we will focus on *Interaction Willpower* from a smart object's perspective since it will form part of the object's character that we will be designing.

When the concept of *Interaction Willpower* is applied to the well-known example of a smart music speaker, various interactions can be imagined. Simply turning the volume all the way down could be enough. However, for our object's chosen character, the *Explorer*, a higher *Interaction Willpower* would be more suitable. Therefore, the user would need to pick up the speaker and put it back upside down to stop its functioning.

2.6 | CONCLUSIONS

This chapter detailed the various design strategies that were proposed in **Chapter 1.** It added ideas for the implementation of those strategies in the design process of smart objects. The next chapter will put some of these design strategies to the test and explore the interactions that can be achieved with them.

The amount of physical and/or mental energy that is required to overrule an action by a smart object

INTERACTION WILLPOWER

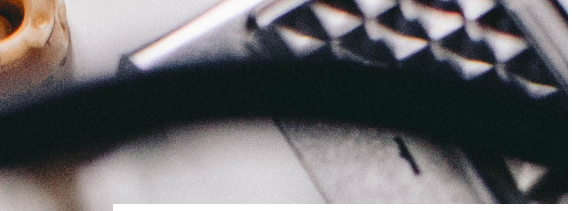
EXPLORING INTERACTION

3

EXPLORING INTERACTIONS

This chapter details 4 ideas that were used to explore different interactions with a smart object. All ideas are accompanied by a short and simple video prototype as illustration. These ideas focus on the possibilities and potential of various interactions. They aim to facilitate a discussion between the viewers after viewing of the videos to help generate new ideas for the project.

In addition, this chapter will present a visual exploration on how materials and surfaces can be used in the design of smart object to facilitate the various design strategies that were presented in the previous chapters.



3.1 | SMART RINGS

As stated in **Chapter 1**, ubiquitous computing leads to the implementation of computing power in everyday objects. This creates new opportunities for physical interfaces that are integrated in the everyday use of the object, instead of having a screen with a graphical user interface.

This idea of an integrated physical interface is illustrated in a video with two smart rings. The smart rings have different '*object states*'. In an object state, the object exhibits a certain behavior. This state can change through interaction with the user or the object's environment. Changing the state would also change the smart object's functioning. The placement of the rings on your fingers determines the object state and thus functioning of the smart objects, translated to the five stages of functioning. As an example, in this video (*Fig. 3.1*), the placement of the rings on your fingers influences the '*sharing*'-stage and determines how the object shares data.

Rings were chosen as an everyday object because of their natural visibility on the hands but also their discreteness as they can blend in with modern fashion and not draw too much attention. Also, the tendency of people to play with their rings or other things they have in their hands is used as interface element. This has potential for creating various interaction states, dependent on ring placement on the hands, where the user is aware of the current state and is constantly reminded of it due to the visibility and tactile presence, but other people and the outside world don't get any information as they simply see the rings as part of the appearance of the user. Therefore, this has an effect on the user's privacy.

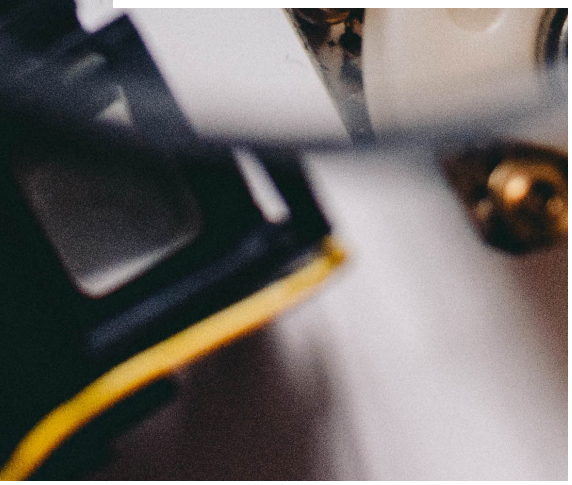
The two rings can be put together on one finger, on separate fingers on the same hand, or on separate hands. Some fingers might also have specific meanings in society (however these will vary greatly in different cultures!). A ring can also turn, which invites different interaction if the ring is for example turned outwards or inwards.

How the rings are worn influences the data usage of the product. If rings are worn on the same finger, and thus close together, the user allows for extensive sharing of data. Wearing the rings on separate fingers means that the product is collecting data and acting upon it, within its level of agency, but not sharing the data to other parties. Wearing the rings on separate hands means that data is being collected but that the product is not making any decisions and is sort of taking a break. Turning the ring inwards makes it hidden from the outside world, shutting down the collection of data and completely turning the product off. The user chooses the desired mode based on their preferred level of privacy in that moment.

These interactions are portrayed in a short video as an illustration.

https://goo.gl/HksQdf

Fig 3.1 | *Smart Rings video* | *Scan QR-code*



3.2 | A GLASS OF WATER

This video prototype was made as a test for frictional feedback. To remind you to drink water, the glass fills itself. But if you don't drink it, it will overflow on your desk. This forces you to drink enough water. The negative experience when a glass of water overflows is paired with the positive effect that you are reminded to do something which is good for you.

This interaction can also be used as transparent communication of the smart object's functioning. Various elements can correspond with the five stages of functioning. For example, the speed with which the glass fills up corresponds with the data collection. The volume of the water in the glass illustrates the amount of data that is stored by the object. The size of the glass is the amount of data that you, as a user, have allowed it to store. In this way, the overflowing of the glass is the feedback the user needs to know that the object is crossing boundaries.

The video can be seen in *Fig. 3.2*.

goo.gl/WKk3Nd

Fig 3.2 | *A Glass of Water* | *Scan QR-code*

3.3 | THE REVEALING HANDSHAKE

https://goo.gl/HksQdf

Fig 3.3 | *Revealing Handshake* | *Scan QR-code*

This video (*Fig. 3.3*) explores the privacy implications of a product which visibly changes based on the state of the user. What happens if bystanders can get information about you from the state of your smart product? This stand in contrast with the first exploration with the smart rings. There, the idea was specifically to have an object which does not give away any information to its surroundings.

In the story, the user has a glove which measures his sleep quality. If the user doesn't sleep well, the glove grows and changes texture. This functions as frictional feedback, reminding the user to get enough rest during the next day and go to bed on time. In this case however, the frictional feedback has impact on your social interaction.

When you greet somebody and shake their hand, it is clear to the other person how you feel, without you having to say anything. This of course assuming the other person knows what the function of the object is. Two reactions are portrayed. In the first, a person reacts by not wanting part of your problems. He takes his laptop and goes to work somewhere else because he doesn't want to work ineffectively with someone who is not well rested. In the second reaction, the other person reacts very understanding and asks the user how he can help.

In the end, how this impacts privacy is that the user doesn't have control anymore over the expression of their feelings in social interaction. It is not possible anymore to hide your physical state, even though you could have the willpower to negate any bad effects from that state.

3.4 | THE SLEEPY SHAWL

This last, and more extensive, cinematic prototype (*Fig. 3.4*) was meant to explore what the object's emotions are in relation to the user and how this changes the interaction. It shows changing emotions and object states based on the user's actions.

In this video, the shawl measures how sleepy the user is, based on how well they slept. If the user has a rough night, the shawl will become more active during the next day and motivate the user to carry on. Thus, at first, the object's emotions are the opposite to the user's emotions: A tired user leads to an active and motivating smart object.

This changes drastically when the user goes to bed late the second night because of his own actions, ignoring the call from the shawl to go to sleep and get some much-needed rest. The user pushes away the shawl, resulting in a second night of little sleep. However, the different cause for this night's sleep shortage triggers a different reaction from the shawl. Now, the shawl becomes sleepy, just like the user is. It is as if the user prevented the object from resting properly. It is not functioning properly which creates a more difficult day for the user. The only solution to get the shawl to work again, if for the user to get a good night sleep himself.

This interaction also battles the notion that products are meant to fix everything for the user, making users lazy and not willing to change bad habits. It is bad if there is a product which helps a user sustain a bad habit. Therefore, products can work for users, but only if they themselves put in an effort to improve!

https://goo.gl/d6vUnN

Fig 3.4 | *The Sleepy Shawl* | *Scan QR-code*

3.5 | MATERIAL EXPLORATION

The form and material of an object has impact on the perception of a smart object. In addition, it facilitates the interaction between the user and the object. As explained in **Chapter 2**, this project will use it in the *Character Learning Curve* to build the user's understanding of the object's character. The form and the material of a product create the first impression of the object's character. Different materials invite for different interactions. Choosing the right material, and implementation of that material in the right form, guides the user to the desired interaction with the object.

Various mood boards were created for exploration purposes and to get inspiration. Every mood board will be presented with the reason behind its creation and its takeaways.

3.5.1 | Surface Shifting

A smart object can have multiple states. In each state, its functioning can vary. This mood board (*Fig. 3.5*) explores visual ways to portray these states, so that the user is aware of the state which the object is in. It shows possibilities in which the material could change its shape or its texture.

Shape shifting materials…

- Create a very physical interaction. This makes it an interesting option for both the implementation of frictional feedback and the expression of presence as it is highly noticeable which strengthens the user's awareness of the object's functioning;
- Provide transparency at all times about the objects functioning;
- Create a challenge for privacy since they are visible to their surroundings.

3.5.2 | (Semi-)Transparent Material

Semi-transparent material provides opportunities for interaction through the variations in visibility that can be created. Information that is portrayed behind the semi-transparent layer becomes more, or less, visible depending on the distance from it and the level of transparency of the layer. This is interesting from a privacy perspective because it can be used by a user to control the information that is available about them by changing either the distance or the transparency.

This moodboard (*Fig. 3.6*) shows various ways in which transparency can inspire the design of smart objects.

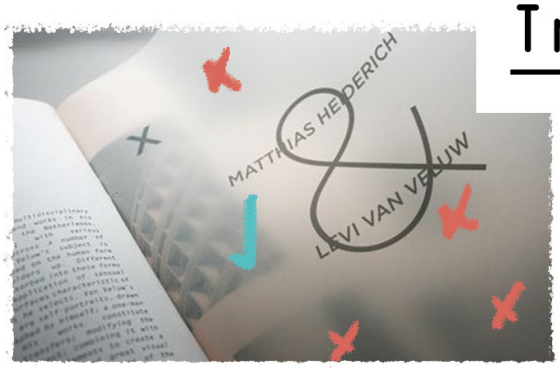
Fig 3.5 | *Moodboard - Surface Shifting: The surface of the material shows the state of the smart object*

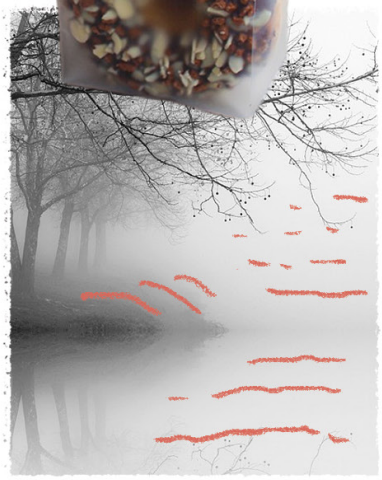
moodboard - Exploration

SURFACE SHIFTING

The pattern on the surface can change which influences the overall form of the product and thus the experience of the wearer and observers.

Transparent Paper





Transparent Clothing

3.5.3 | Smart Clothing

This mood board (*Fig. 3.7*) combines various images of clothing as concepts for smart clothing. They illustrate several ideas for the design of smart objects. Every idea is accompanied by an explanation.

Touch to Reveal

A soft/stretchy material covers the information of the interface. A user needs to press in the material to touch the information behind it. This way, only the user will get the info and it won't be revealed to the public.

Touch to Reveal

Clothing can work as a physical interface where elements can work as metaphors for its functioning. Closing or opening zippers, and this hiding or revealing the body, is linked with the smart object's functioning. In the same way, semi-transparent material can be used.

Surface as an Interface

Clothing elements change their arrangement to share information or provide transparency about their functioning.

Shape Shifting

Changing surfaces indicate different object states.

Breathing Wearables

As part of its expression of presence, this piece of smart clothing opens and closes creating an effect as if it is breathing.

Material Form as Interface

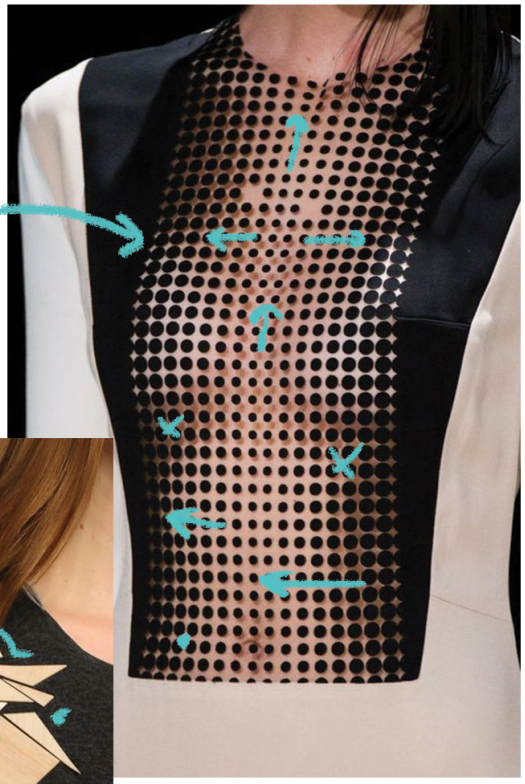
Shape shifting surfaces can be both an expression by the object and the user. By wearing the clothing/ object in different configuration, the user controls the object's functioning.

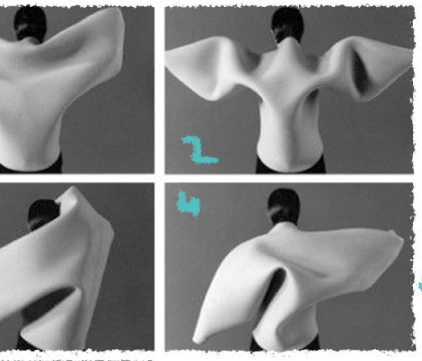
Fig 3.6 **|** *Moodboard - Transparency: The level of transparency and distance of the object to the transparent layer determines the visibility of information.*

Fig 3.7 | *Moodboard - Smart Clothing: Overview of ideas for designing expressive clothing*

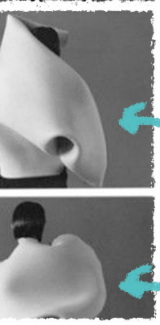
Expressive Clothing

surface as an interface





material form as interface



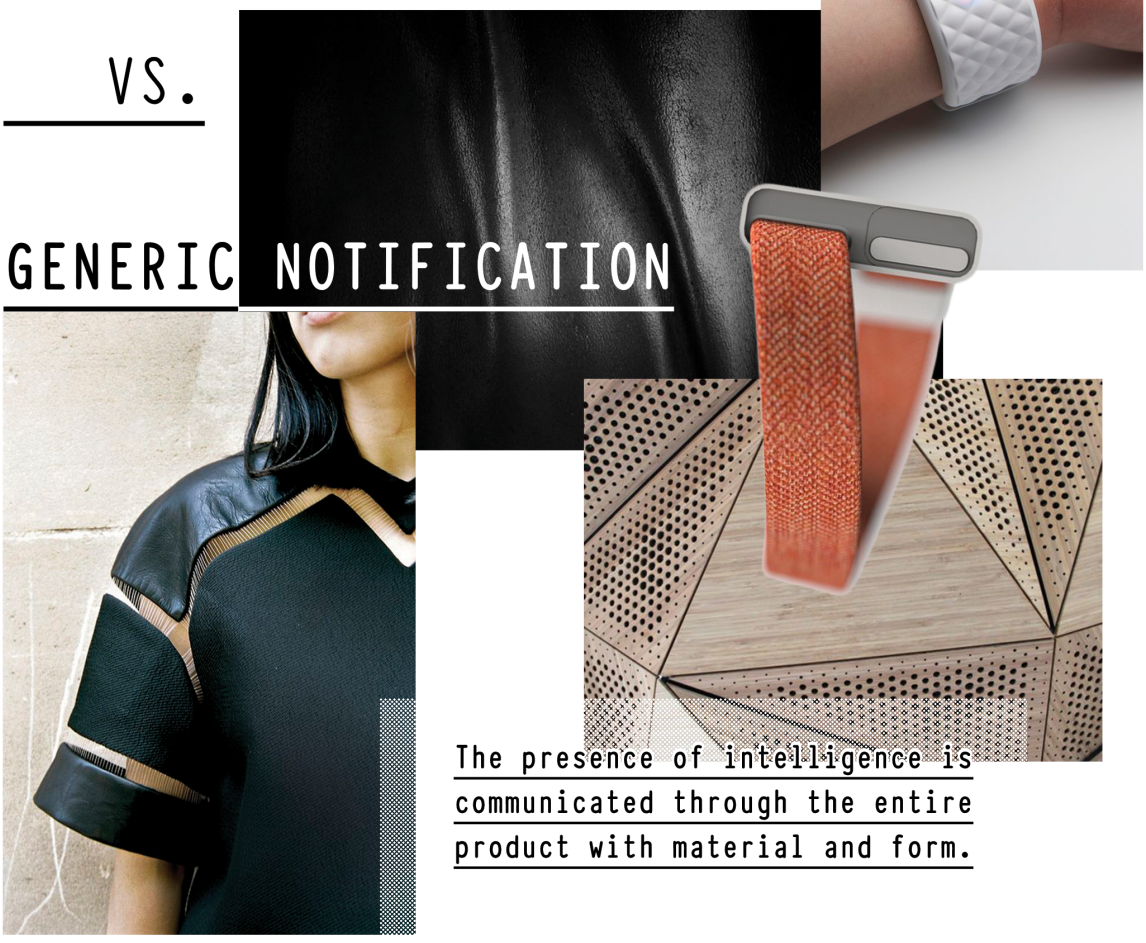
"breathing" wearables

The smart object has clear features which communicate one specific data type to the user in one location.

INDIVIDUAL DATA TYPE

VS.

GENERIC NOTIFICATION



The presence of intelligence is communicated through the entire product with material and form.

moodboard - exploration

3.5.4 | Expression of Presence

The *Expression of Presence* is extensively covered in **Chapter 2**. *Fig. 3.8* adds some examples of how this can be implemented in the design of a smart object. It specifically highlights two different approaches to creating an *Expression of Presence*.

1. The first option is to create an expression which is local. This means that it occupies a specific location of the object, and the user will have to have its attention on that location to register the *Expression of Presence*.
2. The second option is to integrate the *Expression of Presence* in the entirety of the material of the object. This way, the *Expression of Presence* is created by afore-mentioned ideas like shape shifting surfaces, breathing wearables or surfaces/materials as interfaces.

Fig 3.8 | *Moodboard - Expression of Presence: This moodboard shows the difference between individual types of data that are shown locally on the smart object and a more generic notification where the object in its entirety expresses its presence.*

3.6 | CONCLUSIONS

This chapter presented various explorations in the form of videos and moodboards. All of these visual media serve as inspiration for the creation of a design concept.

Based on the four videos and moodboards, several conclusions were drawn to be used in the design process:

- **Smart Rings:** Make the interface physical so the user can interact with real elements of the smart object
- **A Glass of Water:** Frictional Feedback can serve as an exellent design strategy for changing user habits, as the user can't ignore the object.
- **The Revealing Handshake:** Make sure that bystanders don't get personal information through the object's changing appearance.
- **The Sleepy Shawl:** Object emotions are a good tool for explaining the various smart object states in which the object needs to communicate a different SOF.
- **Moodboards:** Without using a graphical user interface (GUI), the materials to build smart objects provide a rich variety of opportunities for interactions. Therefore, this project aims to create a smart object without a GUI, but with the input methods for the interactions embedded in the physical aspects of the object.

CASE STUDY: VETERANS W

4

CASE STUDY: VETERANS WITH PTSD

During this project, the design strategies and insights were applied to the healthcare context of therapy for veterans with ***Post Traumatic Stress Disorder*** *(****PTSD****). This context is relevant for this project's privacy perspective on the design of smart objects. Data that is collected in the healthcare sector is highly privacy sensitive since it contains information about the physical and mental health of patients. As tech companies, research institutes and insurance companies are increasingly using smart wearables in the healthcare sector, designing theses warbles from a privacy perspective becomes extremely relevant* (Apple, n.d.)

In the mental healthcare of veterans with PTSD, e-health is being developed to assist with the therapy of patients (Versluis, 2015). *In addition, concepts are being developed for wearables that help measure the stress of veterans* (TU Delft, n.d.). *This project sees opportunities to further develop these types of concepts. It aims to create a concept of a smart wearable that takes advantage of these developments for a design that is well thought out from a privacy perspective.*

During the course of this project, two interviews have been conducted with therapists who treat veterans with PTSD. They have provided insights in the way a therapy is carried out and they have assisted in identifying opportunities to smart objects in their field. To preserve confidentiality, these therapists will be named 'Therapist A' and 'Therapist B'. In addition, this project has been able to build on previous research by Li et al. (2018).

This chapter will give an overview of the relevant information about the context for creating such a concept. Firstly, it explains what PTSD entails and what are the characteristics of these psychological problems that need to be solved. Subsequently, several insights on the user group of veterans are listed followed by an explanation why this is a unique target group. Thirdly, an overview is given of current therapy methods and what a timeline of a veteran's treatment looks like. Lastly, e-health is covered to give the reader insights in its current implementation in the therapy and to explain what opportunities exist for the implementation of smart objects in this context.

With these insights, this project will build up to the next chapter in which it will present two concepts for a smart wearable for veterans with PTSD from a privacy perspective.

4.1 | WHAT IS PTSD?

Post-Traumatic Stress Disorder (**PTSD**) is a collective name for a group of psychological complaints that can occur after one or multiple traumatic experiences (*gezondheidsplein, 2018*). After a traumatic experience, a person can develop symptoms of PTSD. We speak of PTSD when that person has regular flashbacks of the trauma during unrelated every-day situations. (*Thuisarts, 2016*) Due to these flashbacks, the person experiences stress. This stress can lead to various negative consequences like anxiety, anger and depression.

With these psychological complaints, the person can have a lot of trouble, amongst others, in professional and social situations. Psychotherapy can help people with PTSD to overcome their problems and function again in society.

4.2 | VETERANS AS A TARGET GROUP

The events in conflict situations that veterans have experienced can lead to the development of PTSD. The feelings of fear, horror and/or helplessness experienced during a military mission can persist in their civilian lives after they retire from the military (*Stichting Centrum '45, n.d.*). In the Netherlands, veterans can get specialized care for PTSD, for example at Stichting Centrum '45. Not only veterans, but also family members can be part of the treatment of PTSD since the stress often resonates with the veteran's partner or children (*Stichting Centrum '45, 2018*).

The reason to get professional help for their PTSD varies amongst different veterans. For some, for example, not being able to function in a professional environment and being unemployed for an extensive period of time is the main cause. For others, difficulties in their personal relationships can be a turning point. Sometimes, the veterans start a therapy upon request from their partners.

One element that makes veterans with PTSD unique as a target group is that they often have close contact with fellow veterans, who might also be suffering from PTSD. They are often members of an association for veterans. This is an important element to keep in mind. Veterans value the opinions and advice of their military acquaintances, as they feel that they are the only people in civil society who can truly understand them (*Li et al., 2018*).

POST-TRAUMATIC STRESS DISORDER

PTSD is a collective name for a group of psychological complaints that can occur after one or multiple traumatic experiences

4.3 | PSYCHOTHERAPY FOR PTSD

There are different types of therapy that can be used to treat patients with PTSD (*Stichting Centrum '45, 2018*). This project will focus on **Cognitive Behavioral Therapy** (**CBT**) and **Imaginary Exposure Therapy** (**IET**) as these are particularly common types of therapy used to treat patients with PTSD. In addition, the scope of this project allowed for the gathering of information from one specific treatment center which applied these types of therapy. Therefore, other types of therapy are considered to fall outside the scope of this project.

This sub-chapter gives an overview of a veteran's treatment (*Fig. 4.1*), from their motives to start the therapy until its endpoint.

4.3.1 | Start of the Therapy

Because of the variety in psychological complaints and various reasons for initiation, veterans have different starting points of their therapy. Together with a therapist, a veteran therefore needs to personalize the therapy. This is an ongoing process during the whole treatment. The responsibility for the success of the treatment lies jointly in a therapist's and a veteran's hands. (*Interview Therapist A*)

At the start of the treatment, a therapist and a veteran jointly define a concrete end goal. This end goal can be defined in relation to the event that caused the turning point to start the therapy. For example, a veteran who has nightmares, caused by PTSD, five times a week can decide the end goal would be to experience only one nightmare a week. The end goal applies to the therapy, not to the veteran's efforts to improve their mental health. After the therapy, the veterans will continue to work on improving their wellbeing. In the end, PTSD might not go away completely (*Interview Therapist B*). Therefore, the goal for the veterans is not to cure the disease completely, but to be able to control it and function normally in civilian life.

Apart from defining an end goal for the therapy, a veteran and a therapist create a so-called '*fear hierarchy*'. This is a list of triggers for the veteran's PTSD. These triggers can be, for example, situations, objects, thoughts, activities, locations, or something else which acts as a trigger for the veteran's flashback to the trauma. The list of triggers is ordered according to the intensity of the stress experienced during the flashback. During the treatment, the veterans will work on controlling the stress linked to these triggers, starting with exercises concerning triggers which are lower in the fear hierarchy, and working up towards the ones that are higher in the hierarchy.

4.3.2 | Therapy during the Week - Timeline

Since a veteran and a therapist see each other once every week, a veteran will have to do exercises in between therapy sessions as part of the IET and CBT. These exercises are meant for a veteran to practice controlling the stress that arises from flashbacks. During each therapy session, the veteran and the therapist will discuss how the exercises went, how the veteran reacted to the stress and how to proceed with the treatment. The following paragraphs will elaborate on what these exercises entail.

Exercises for Imaginary Exposure Therapy (IET)
For IET, the veteran narrates to the therapist the traumatic experience that caused - or is part of the cause of - the PTSD. During the narration, the veteran will experience a flashback to a traumatic experience and the stress that is associated with it. The audio from this session is recorded and given to the veteran. The veteran's exercise consists of listening to the recording several times per week, experience the stress again and try to learn to cope with it.

Exercises for Cognitive Behavioral Therapy (CBT)
Since IET is part of CBT, the exercise from the previous paragraph is also relevant for this paragraph. However, CBT contains additional types of exercises, also as part of the afore-mentioned fear hierarchy. During a CBT, the veteran will be asked - as an exercise - to identify the triggers for a particular fear from the hierarchy and learn how to cope with the related stress. For example, a veteran can be asked to visit a certain place or do an activity, such as doing groceries at a busy time of day when a supermarket is crowded and the veteran gets little overview of the store and a lot of stimuli for

the senses. During a therapy session, the veteran's reaction during these exercises will be discussed with the therapist.

4.3.3 | End of Therapy

When the end goal that was set at the beginning of the treatment is reached, veterans and their therapists can decide to end the treatment. The veteran won't have weekly sessions anymore from that moment onwards. However, veterans can of course keep doing the exercises they were doing, albeit without the feedback from a therapist. As previously described, the end goal of a therapy does not necessarily mean that all complaints are completely over. A veteran could still keep having a nightmare every week. Therefore, it is beneficial for the veteran to continue with exercises and with working on self-improvement. This means that a product designed to be used during a treatment can be used also after the end of the therapy.

4.4 | E-HEALTH DEVELOPMENTS

Designing a smart object for veterans with PTSD is particularly interesting within the context of current e-health developments which bring challenges both for the interaction with e-health solutions as well as for privacy of patients. E-health is promoted by the Dutch government, which has set multiple goals and has launched various initiatives for its implementation (*Rijksoverheid, n.d.*). E-health is being developed also for psychological care for veterans. (*Versluis, 2015*). Stichting Centrum '45 uses different e-health modules during therapy. Patients can do self-reporting as part of these modules, learn more about the treatment, and prepare for therapy sessions (*Interview Therapist B*). In addition, therapists cooperate with companies which provide e-health solutions. One of these companies is Biocheck, which analyses the physical and mental capabilities of people with chronic stress or fatigue by measuring various body metrics (*Biocheck, n.d.*). Through the measurements done via Biocheck, patients can get better insights in their physical ability and how their body reacts to stress. In this way, patients will understand better their limits and will know when they need to take a rest. This technology will be applied within the design concepts which will be elaborated in CHAPTER 6 en 7.

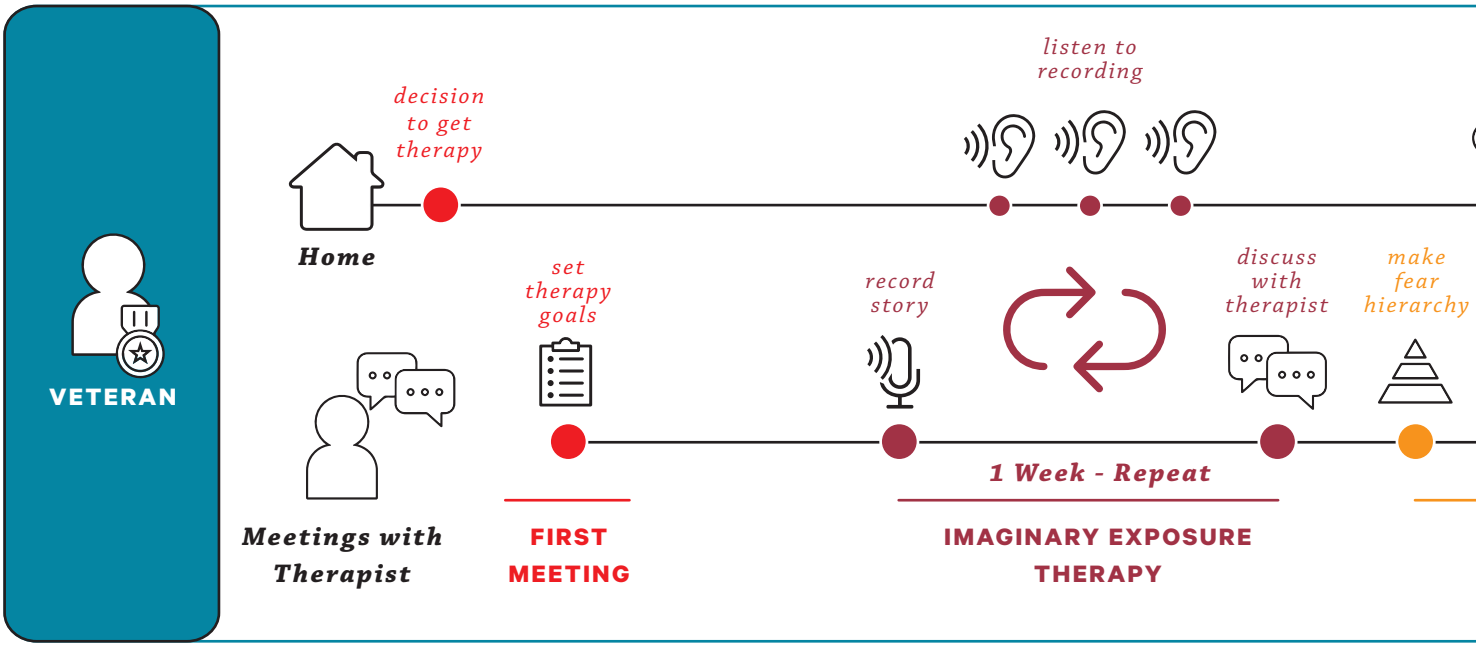


Fig 4.1 | *Overview of a veteran's treatment*

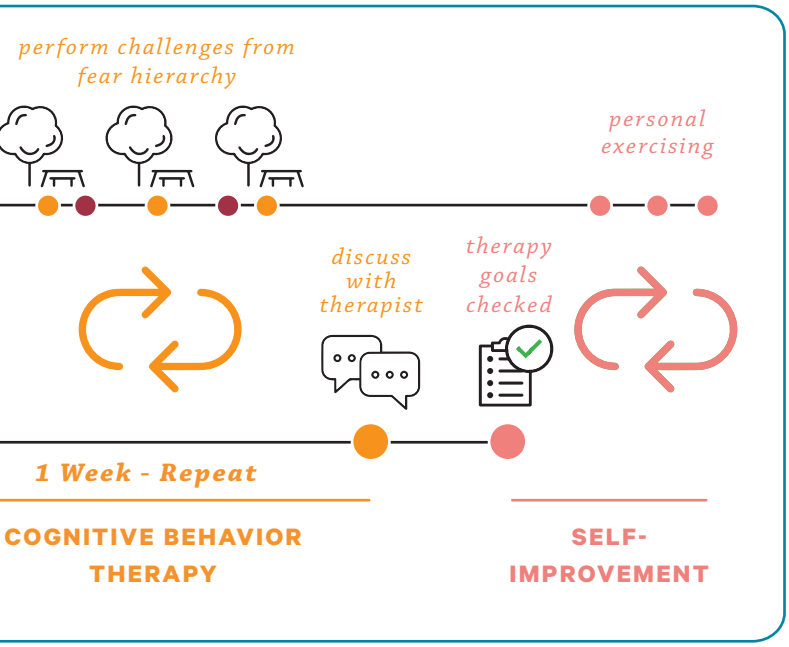
4.5 | PSYCHOTHERAPY & PRIVACY

Privacy in the healthcare sector is an extensive topic, as all health records are considered as confidential data. This project focusses on the specific privacy challenges for the mental healthcare sector that are deemed relevant because of their link with e-health and smart objects.

4.5.1 | Privacy-Related Challenges during Therapy

In general, the healthcare sector has to maintain confidentiality for all data concerning their patients. This is no different for the mental healthcare sector. However, the fact that therapists have to handle all data confidentially does not mean that patients automatically trust their therapist and will be ready to disclose all information that is relevant for the treatment.

Building trust between the patient and the therapist is particularly vital for psychotherapy. It requires full cooperation of the patient for an honest disclosure of the patient's mental experiences and thoughts. This stands in contrast to physical diseases that can be observed by a doctor with, or without, medical equipment. In that case, even if the patient is not honest, the doctor will still be able to make a diagnosis. For example, by looking at a patient's teeth and gums, a dentist will instantly know if they properly brushed their teeth or not, regardless of what the patients will tell them. By contrast, in psychotherapy, the therapist cannot reach as easily a conclusion without the patient's cooperation. Therefore, building trust is essential for ensuring the veterans' sense of privacy and for their readiness to disclose private information necessary for the psychotherapy.



4.5.2 | Relevance of this Privacy Challenge for the Design of Smart Objects

The above-mentioned privacy challenge is relevant for this project because smart objects can influence the patients control on the disclosure of information during therapy. This is because smart objects can start tracking biometrics to visualize psychological processes. This can, in part, reveal the thinking of a patient and show the therapists extensive information about the state of their mental health. If all this information is directly shared with the therapist, it influences the self-expression of the patient and its ability to control the disclosure of information. To avoid this, smart objects which are used in mental healthcare need to be designed from a privacy perspective.

In the specific context of psychotherapy, smart objects pose a threat not just for comfortable disclosure of information by the patients, but for the overall functioning of the therapy. The goal of psychotherapy is not for the therapist to simply tell the patient what to do. Instead, patients should reach a conclusion themselves and realize what their problem is and find intrinsic motivation to solve them. This mental – and thus intimate – process of the patients should not be undermined by external smart objects that share data directly with therapists in order to help them draw conclusions related to the mental health of their patients.

DESIGN CHOICES DESIGN CHOICES

5

DESIGN CHOICES

*Chapter 4 introduced the context of this project, which is 'Veterans with PTSD', and gave an overview of the relevant information about this context. **Chapter 5** details the broader design choices that were made based on the insights from the previous chapter. It also introduces the two designed concepts of this project, the smart gloves. Both these smart gloves are designed with the same goal in mind, but they have different characters. This demonstrates what the impact is of creating a character for a smart object. This chapter gives an overview of what the two concepts have in common. The detailed presentation of these concepts, how the design strategies from **Chapter 1** and **2** are implemented, and what the differences in functionalities are between the two concepts are elaborated in **Chapter 6**.*

This chapter is divided in four subchapters. It will start by briefly introducing the design concept for a smart glove that is developed during this project. This way, the reader will have a visual reference while reading about the design choices. The chapter continues by explaining the conceptual purpose of the design concept, which explains how it helps in developing this project's design strategies. Next, the functional purpose of the final design concept will be introduced, which explains how the concepts benefits the case study. The last subchapter will focus on the implementation of this project's design strategy of transparent smart characters and it will elaborate on the two different concepts that are created.

5.1 | SMART GLOVE CONCEPT

The result of this project is a concept for a smart glove which aids veterans during their psychotherapy for PTSD. The goal of this smart object is to facilitate a transparent and negotiable interaction between veterans and the smart objects that track their stress. One of the two developed smart gloves can be seen in *Figure 5.1*.

The glove works together with an existing concept of a smart vest (*TU Delft, n.d.*). The smart glove will function as an interface for users with which they can influence the SOF of the smart vest. The vest contains multiple sensors and registers biometric data like heart rate and body temperature. With this data, the user's stress is measured and analyzed. After processing the data, the insights can be visualized and used for understanding the veteran's progress during the psychotherapy and improving it accordingly.

Fig 5.1 | *The Smart Glove Concept*

5.2 | CONCEPTUAL PURPOSE

The concept aims to demonstrate how the design strategies proposed in **Chapters 1** and **2** can be implemented in a design process and lead to different outcomes of smart objects. This project calls this the *conceptual purpose*. Through these design concepts, the design strategies can be improved and evaluated. **Chapter 7** will present the result of this evaluation in the form of a design guide for future projects and **Chapter 8** will list the recommendations for future development of the *Privacy-Driven Interaction Design* approach.

5.3 | FUNCTIONAL PURPOSE

In terms of functionality, the design concept has a purpose to provide the user with control over the stress tracking and information disclosure that is done by the smart object in order to ensure the user's privacy. This project calls this the **functional purpose**. It has four elements:

1. Combining Smart Objects and E-Health
2. An Interface to a sensor
3. Tracking Users during Therapy Exercises
4. Data Disclosure in the User's Hands

All three elements will be elaborated in the next subsections.

5.3.1 | Combining Smart Objects and E-Health

As described in **Chapter 4**, the use of e-health solutions is increasing and provides an interesting opportunity for the implementation of smart objects. Creating a smart object that tracks users and performs measurements is a good match with E-Health modules, where the aim is that a person can do more self-reporting, that there can be more feedback from, and contact with, a therapist in between sessions. E-health is being implemented already, but there can be more focus on privacy (*Interview Therapist B*). People put a lot of private information in e-health modules, but at this moment in time, it is simply assumed that patients are comfortable with filling in personal data online.

It is important to realize that, even though exercises done with E-Health modules are part of the therapy, the patient is not talking to, nor experiencing the presence of, their therapist when filling in the modules. This means the trust that is built with the therapist should resonate in the character of the design of the E-Health solution if you want to give users the same sense of trust, and get them to disclose the same level of personal information.

Though there are challenges, E-Health also has great potential. It can help patients prepare for meetings with their therapist, give them more information and explanation about the therapy and they can get emergency help in between therapy sessions. In addition, the self-reporting of patients can benefit their cognitive process during therapy.

5.3.2 | An Interface for a Sensor

The smart glove presented in this project will combine its functionality with an ongoing project at the TU Delft which is developing a smart vest for stress detection. The smart vest and smart glove can form a system together where the smart vest will act as the sensor in the system and the smart glove will act as the interface to the smart vest. This vest is worn under the user's clothes. Through the sensors in the vest, it can then measure various biometrics and use these for analyzing the user's stress. Since the vest is invisible under the users clothing and does not give the user any feedback, there is a need for making the SOF of the vest transparent to the user. The smart glove will facilitate the transparency of the SOF.

5.3.3 | Tracking Users during Therapy Exercises

In addition to providing transparency over the SOF, the smart glove will actively stimulate the veteran in doing their exercises in between therapy sessions. In this way, it will aim to aid veterans with their therapy. Stimulating the veteran will happen by showing them when there are good opportunities to exercise and by providing the user with insights about their progress and capabilities during the treatment. In addition, it will provide the user with an interaction that enables them to control the disclosure of the data from the smart object to the therapist.

5.3.4 | Data Disclosure in the User's Hands

As defined in **Chapter 1**, privacy is the state in which a user has the ability to control the disclosure of information about themselves. This project's design concepts are created to facilitate this ability. The fourth part of the smart object's *functional purpose* is to put the control over data disclosure in the users hands.

5.4 | TWO OBJECT CHARACTERS

5.4.1 | Why Two Characters?

This project presents two variations of the smart glove. Both of them are designed to have different object characters. This has two reasons.

The first reason is to support this project's claim how characters can influence the interaction with products and influence the user's control over privacy. As presented in **Chapter 1** and **2**, designing a smart object's character is the main design strategy in this project. By creating two smart gloves with varying characters, the aim is to show how the design strategy proposed in this project can succeed to facilitate the creation of various product concepts with their distinct interaction and impact on privacy.

The second reason is that these distinct smart objects together can provide a larger target group with a desirable interaction. Both smart objects give users with dissimilar needs and preferences a solution that works well for them. In this project's context, veterans with PTSD are a target group with specific characteristics. This is a group which is used to having difficult assignments and tough. They are very honest and direct in their opinions: 'If they don't like something, they will tell you that it is crap' (*Interview Therapist A*). This also leads to some veterans who indicated their willingness to have a product which is extremely dominant and tells you exactly what you need to do. They even stated that a product could simply give all the information directly to the therapist, preventing them to be able to lie to the therapist. (*Li et al., 2018*).

On the other hand, one could assume that there are patients that prefer a more caring and friendlier product that does indeed stimulate them to perform certain behavior but gives the user more freedom and control to act. These people could not feel comfortable when interacting with a dominant smart object which could lead to them not using the product at all. Vice versa would not have any effect at all either, since users requiring a dominant interaction would not change their behavior through interaction with a friendly and caring product.

5.4.2 | The Friendly and the Dominant Glove

In this project, the choice is made to make both a smart glove concept for a friendly interaction and for a dominant interaction. For both concepts, the design strategies, presented in chapter 2 and 3, were used to make a tailored solution for two groups of veterans with their specific needs. The concepts were detailed using the design strategies presented in **Chapters 1** and **2**. For the two characters, all the elements of the design were worked out individually to match their respective characters. The next chapter will elaborate on the functionalities of the smart gloves and on the characters that were designed around them.

5.5 | CONCLUSIONS

This chapter introduced both the conceptual purpose and the functional purpose of the design concepts. It also explained why this project created two design concepts with two distinct characters. The next chapter will present the design concepts in further detail.

DESIGN CHOICES DES

6

DESIGN CONCEPTS

This chapter presents the two smart glove concepts that were developed for veterans to aid them during their treatment for PTSD. As explained in ***Chapter 5****, the two design concepts have different characters. This chapter will elaborate the difference between the concepts and how the characters influence the interaction.*

The first subchapter will present the concept of the Friendly Assistent, which can be seen in ***Fig. 6.1****. The second subchapter will present the concept of the Dominant Boss, which can be seen in* ***Fig. 6.2****. Both of these subchapters detail how their characters were created using the various design strategies that this project presented in* ***Chapters 2 and 3****. The third subchapter will elaborate on the interaction between the user and the smart objects. In addition, it will explain how the smart object's characters impact the interaction. The last subchapter will present the final cinematic prototype, which portrays the story of a veteran that uses one of the smart gloves during this therapy for PTSD. This video will show all the interactions that a user performs with the glove and give the viewer a deeper understanding of the concepts.*

6.1 | SMART GLOVE 1 - THE FRIENDLY ASSISTANT

6.1.1 | Character

Chosen Character - The Friendly Assistant

Positive Character Traits	
Loyal	Respectful
Agreeable	Trustworthy
Helpful	

Negative Character Traits	
Dependent	Passive

Object's Goal

The Friendly Assistant's goal is: "To aid the user in achieving their therapy goal." Therefore, its goal aligns with the user's goal. They want to help the user to achieve its goals. This means that the assistant is also highly dependent on the user and passive.

Smart Object's Functioning

Collecting | o

The assistant only collects the information necessary for the user to achieve its goal. Only the information that the user specifically asked for is collected.

Processing | +

The Assistant will actively process data. However, it will only look for the conclusions that the user might look for, without much assertiveness.

Acting | -

The Assistant only acts autonomously to achieve the same goal as the user. It will stick to the agreements that were made during the therapy sessions. Therefore, the object's actions will be limited.

Sharing | -

Since the object has no strong and independent goal of their own. Sharing of data will be minimal.

Storing | o

The object will be storing the necessary data to perform tasks for the user. In addition, it will remember what the user wants for future reference.

Emotions

This product will act neutral to the user. It will be relatively passive, as becomes clear from the SOF. Since its goal is strongly connected to others, its own drive is weak. Due to this, emotions will vary less when expectations are being met or not.

6.1.2 | Character Learning Curve

Form

To complement the smart glove's character, the form of the product makes that the user is aware of its presence without it being intrusive. It leaves a lot of space for the user to perform hand movements as it covers only a limited area of the hand. In addition, the colors are muted but pleasant. The light grey gives it a minimal look whereas the light brown suede and cork details add some warmth and friendliness.

Material

The soft felt feels friendly and pleasant to the touch. The material has a positive quality to it. Although it does not tear easily, the material is rather weak and form naturally to the hand when it is worn.

Interaction

The smart glove keeps track of the user's stress and reminds them of their exercise goals for the therapy. The reminders are gentle and the threshold is low, which means that with a relative low stress-level of the user, the glove won't urge them to exercise anymore. The user is in control of the product without much effort. In addition, the product is comforting when the user is stressed.

Decisions

The glove's choices are strictly based on the agreements that were made during the therapy sessions. Not having their own goal leads to a product that won't make unexpected decisions that are not in line with the user's preferences.

6.1.3 | Expression of Presence

The glove expresses its presence in three ways:

1. The glove notifies the user every hour to request an update on the users perceived stress-levels
2. The glove notifies the user immediately when it detects a change in stress levels, making them aware that something is tracking them.
3. The glove vibrates constantly when the user is doing an exercise, letting them know that it is tracking the exercise and that the exercise is not finished.

6.1.4 | Frictional Feedback

This particular object has low frictional feedback since it does not have extensive autonomous abilities. The only feedback that can be perceived as frictional feedback is the constant notifying of the user that something is tracking them.

6.1.5 | Interaction Willpower

The smart glove has a very low interaction willpower. It will notify the user of their goals but it will not force them in any way to perform exercises.

Fig 6.1 | *Smart Glove concept: The Friendly Assistant*

6.2 | SMART GLOVE 2 - THE DOMINANT BOSS

6.2.1 | Character

Chosen Character - The Dominant Boss

Positive Character Traits	
Pro-active	Decisive
Perceptive	Independent

Negative Character Traits	
Intolerant	Dominant
Non-negotiating	Bossy

Object's Goal

The Dominant Boss's goal is to make sure the user does enough exercises during the week. The goal varies from the user's goal, which will influence multiple elements of the interaction.

Smart Object's Functioning

Collecting | +

The Boss needs to have control over the situation and needs to know that the people they are overlooking are doing their job. In this case, the smart glove will be carefully collecting all information about the user to know how they are functioning.

Processing | ++

The Boss will make their own conclusions from the data and process it with regards to their own goal.

Acting | ++

The Boss will draw their own plan when something happens. If agreements have been made, but the boss sees new opportunities, they will take action. If the user and the therapist agree to do a certain amount of exercises and the user completes those with ease, the boss will see the opportunity to stimulate the user to achieve more.

Sharing | +

The Boss will use data for sharing if this benefits the treatment. For example, if the user gives the wrong information to their therapist, then the boss will make sure the right information will still get to the therapist.

Storing | +

The Boss will store all information which is necessary to make relevant decisions. Since they are in charge, they will need to have a large amount of data to use for future reference.

Fig 6.2 | *Smart Glove concept: The Dominant Boss*

Emotions

The Boss has a strong drive and their own goal. They will be unhappy if that goal is not reached. Therefore, this smart glove will react strongly when the user does something unwanted. The boss will get angry or frustrated and start to counter the user if that is required to reach their goal.

6.2.2 | Character Learning Curve

Form

The Boss has a strong visual language. The leather has a more dominating look to the object. The dark color of the leather gives it a stronger look as well. In addition, this glove covers more of the hands and extends on parts of the fingers, giving the impression that it could have more control over the hand.

Material

The leather used for the object gives it a more exclusive feel. The tightness around the hand leads to a clear experience of its presence.

Interaction

The interaction with the Boss will be more dominant than with the Assistant. The vibrations that the user feels during the various notifications will be much more commanding. The Boss will constantly try to get the upper hand in the ratio of shared control. Negotiating the interaction with the Boss is harder and requires more force from the user.

Decisions

Because the Boss has its own goal, the decisions it takes will be evaluated with that goal in mind, not the user's goal.

6.2.3 | Expression of Presence

The Boss expresses its presence in three ways:

1. The glove notified the user every hour to request an update on the users perceived stress-levels
2. The glove notifies the user immediately when it detects a change in stress levels, making them aware that something is tracking them.
3. The glove vibrates constantly when the user is doing an exercise, letting them know that it is tracking the exercise and that the exercise is not finished.

6.2.4 | Frictional Feedback

The Boss's goal has potential to create friction with the user if the user's actions are acting against the glove's interest

6.2.5 | Interaction Willpower

This smart glove has a strong interaction willpower. This will express itself in forceful vibrations when the user needs to practise and the glove will always stimulate a person to practice, even if the stress-levels are high.

6.3 | INTERACTION

6.3.1 | User Actions

The user has four actions to perform with this smart glove. These actions are the same with both of the two smart glove concepts, but the reaction from the glove can vary depending on its character. This will be explained in **subsection 6.3.4**.

Stress-level Feedback

The tightness of the glove's wrist strap corresponds with the level of stress that the user is experiencing in that moment. By changing the tightness of the strap, the user gives feedback to the object about their experience of stress. The smart glove compares this feedback to its own data from the sensors. (*Fig. 6.3*)

Fig 6.3 | *Adjusting the tightness of the wrist strap gives feedback about the user's stress*

Fig 6.4 | *To activate an exercise, the user first presses the button and then squeezes the glove*

Fig 6.5 | *Unbuttoning the glove completely switches off the smart object*

As people have different physical reactions to stress, the smart object can learn what the specific physical reaction is for this user. If the user's experience is the same as the object's measurements, then this gives the object more credibility when the data is analyzed. If the user's experience differs from the object's measurements, then this can be discussed during a therapy session to understand why this is the case. The user could have trouble with understanding their own body's reactions (*Interview Therapist B*), they could be hiding something, or not trust the smart object's measurements. In addition to communicating stress-levels with the smart object, the deliberate act to evaluate your own stress-level can give the user more understanding and awareness of their physical reaction to stress and how it evolves during the day or during an exercise.

Activate Exercise

In order to avoid accidental activation of an exercise, a user has to perform two actions. First, the user presses the button on the glove to initiate the activation. Next, a user has to punch the strap covered in cork. A timer will be set for the exercise, depending on how hard the user squeezes the cork strap. The harder the user squeezes, the longer the timer will be. This creates a very physical interaction, making the user aware of what they are about to do. While squeezing the strap, the user will feel ticking every time a new level is reached. The exercise always has three levels: easy, medium and hard. During a therapy session, when deciding which exercise the veteran will practice during the coming week, the corresponding practicing times are set, leading to three fixed lengths of time which won't change for that week. After setting the exercise difficulty, the glove's button will function as a display for the timer and visualize how much time is left for the exercise. (*Fig. 6.4*)

Full Control

By buttoning and unbuttoning the smart glove, the object is switched on or off. This provides full transparency to the user if they are being tracked or not. In addition, it means that the user can in every situation take back control. If the object does

something the user doesn't like, simply unbutton it, and the action and everything else will stop. (*Fig. 6.5*)

Disclosure of Personal Data

The smart glove, in combination with the smart vest, will be collecting data about the user. As the *functional purpose* of the smart glove stated, one of its purposes is to put the data disclosure in the user's hands. To achieve this, the smart glove functions as a key with which the user can share information, or keep it hidden. This is done in several ways:

- A user can show personal information on a smartphone screen by holding the phone in the hand which wears the glove. Through NFC technology, the phone and glove will be connected and the screen will show information. However, no information will be stored on the phone. As soon as the user lets go of the phone, the screen will go blank. This connection will only work with the user's own phone, as one glove will be synched with one phone. (*Fig. 6.6*)
- The user will also be able to control the disclosure of information to e-health applications. As with the smart phone, information will not be stored in the e-health module, but simply shown as long as the user wants it to be shown. The user controls this by keeping their hand which wears the glove open, or by closing it. Keeping it open discloses information, closing it stops this. In this way, the user will also control the sharing of information with their therapist. When a therapist uses an e-health module with a question, the user can let the glove answer it by opening the hand and sharing the relevant information. This information will be shown during the therapy session but not stored. (*Fig. 6.7*)
- The glove will give the user a special notification when there is a request for disclosure of information: it will give the user a directional vibration. This is a vibration which starts on the outside of the hand and moves to the inside of the hand. The user can then close their hand or keep it open. This vibration will stay active as long as there is a request for information, to keep the user aware of it.

Fig 6.6 | *A smartphone displays information when it is in the glove in the users hand*

Fig 6.7 | *Opening or closing the hand when there is a request for personal information controls the disclosure of it*

Fig 6.8 | *The strip inside the user's hand will tick against the user's hand to ask for feedback*

Fig 6.9 | *When urging the user to exercise, the button will vibrate*

6.3.2 | Smart Object's Actions

The smart glove can also perform multiple actions to initiate an interaction with the user. The intensity and intention of these action can vary based on the object's character. This subsection will first cover the overall interaction which is the same for both concepts and then detail how the concepts vary from each other.

Ask for Feedback

The smart glove wants regular feedback to know if its stress measurements are correct. In addition, it wants to aid the user to be aware of their stress levels. To ask for feedback, the glove therefore notifies the user by ticking on the inside of the hand. The glove does this after 60 minutes without feedback. Thus, if the user gives feedback on their own, then the timer resets again until it reaches 60 minutes. The glove also wants feedback when it detects a stress level which does not correspond with the straps position. In this case, the glove overrides the timer by itself and taps the user to ask for feedback. (*Fig. 6.8*)

Notify to Exercise

The smart glove is constantly monitoring the stress-levels to find a moment where the user can exercise. When the stress levels are low, it provides a good opportunity. In these moments, the glove urges the user to do an exercise by first ticking on the inside of the hand, after which the glove's button will start to vibrate. This vibration is very local and sharp. The threshold after which the glove urges the user to exercise changes during the day. It starts by only notifying the user when the stress-levels are below 20%. However, it is still required that the user practices. During the day, the threshold will therefore rise, and the user will also be notified if the stress levels are higher.

Comfort during Exercise

When the user activates and exercise, the glove will start to vibrate. These vibrations are meant for the user to be followed with their breathing. This has two reasons. The first is that it tries to give the user support during an exercise by stimulating them to focus on their breath to control the stress reaction from the triggers during an exercise. In contrast to

the vibrating button when the glove tells the user to exercise, these vibrations are generated through the entirety of the glove. Instead of sharp and quick vibrations, they are friendlier and more humming. The difference in vibrations can be heard in the cinematic prototype. If the glove senses that the user's stress-levels are rising during the exercise, the intensity of the vibrations will increase to try and reach the users attention.

The second reason for the vibrations is that they provide transparency to the user about the state in which the object is in. The user knows that as long as the glove vibrates, it is tracking an exercise, which also means that the user will easily know when the exercise is ready.

6.3.3 | State Diagrams

Figure 6.10 shows a state diagram of the smart gloves. This is an overview of the various "object states" which the glove can go through. In an object state, the smart object acts in a certain way that is specific for that state. This includes the way the object reacts to data, the interaction that is initiated with the user, and the action that can be initiated by the user.

Measuring

The state in which the smart glove will be most of the time is the "measuring" state. In this state, the object will act in the background and track the user's stress levels. The measuring itself is not being experienced by the user. Apart from measuring, the glove is also analyzing the data that is collected. Depending on the analysis, it decides if it goes in a different object state. In this state, the object is also making sure to get user feedback every 60 minutes about their stress levels, and it registers if the user has already exercised that day.

During this state, the user can perform three actions:

1. Unbutton glove – Turn product off
2. Press button and squeeze glove – Activate exercise
3. Adjust strap – Give stress feedback

Asking for Feedback

There are two triggers that make the glove go in the "asking for feedback" state. The first is when the user has not given feedback for 60 minutes. The glove then taps them on the inside of the hand to notify them.

The second reason is if the smart object has registered a significant change in stress level. It then askes the user for feedback to make sure that the measurement corresponds with the user's experience.

During this state, the user can perform two actions:

1. Unbutton the glove – Turn product off
2. Adjust strap – Give stress feedback

Notify to Exercise

When the day starts, the product will remind the user to practice only if the stress levels are below 20%. Every two hours, the threshold will rise by 10%, meaning that the glove will become more demanding of the user in order to push them to exercise. Reminding the user will also happen every two hours.

When the product changes to this state, the user can perform three actions:

1. Unbutton glove – Turn product off
2. Press button and squeeze glove – Activate Exercise
3. Press button twice – Decline exercise

Initiate Exercise

The user has to perform two actions in order to avoid accidental activation of an exercise. When the user presses the button, the glove will change in this state and wait for the user to either accept or decline the exercise. When the user wants to accept to do an exercise, it will start squeezing the glove. During that action, the glove will measure the strength of the squeezing and register the difficulty of the exercise accordingly.

During this state, the user can perform three actions:

1. Unbutton glove – Turn product off
2. Squeeze glove – Activate exercise
3. Press button – Decline exercise

Exercising

During the "exercise" state, the smart glove will continue to monitor the user's stress levels. In addition, it registers it as an exercise and uses this for further processing. While in this state, the glove will continuously vibrate in a steady rhythm.

During this state, the user can perform two actions:

1. Unbutton glove – Turn product off
2. Adjust strap – Give stress feedback

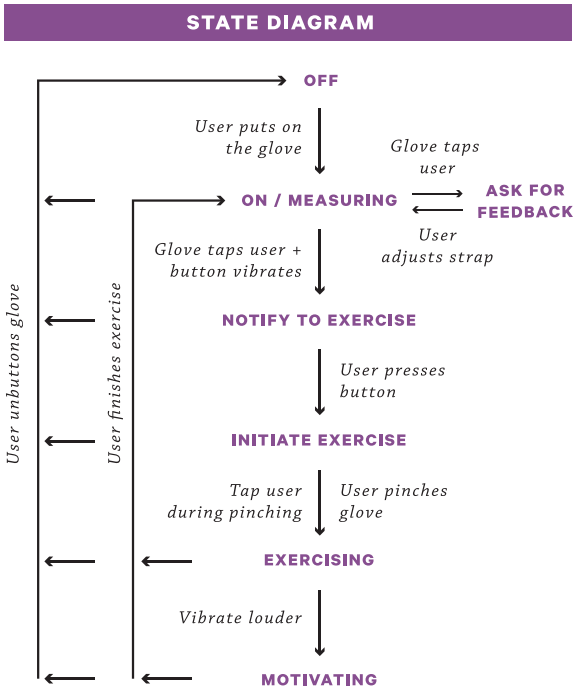
Motivating

The smart glove changes to this state if the user's stress level rises with more than 40%. This threshold is set since there should be a substantial increase before the glove starts to act differently. It is to be expected that the stress level rises when deliberately seeking out the stress triggers. The point of the exercise is that the user tries to cope with the stress on their own. The glove, already helping of course with steady vibrations, will intensify the vibrations to get the users focus back to the breath, but only when the stress rises by the affore-mentioned amount.

During this state, the user can perform two actions:

1. Unbutton glove – Turn product off
2. Adjust strap – Give stress feedback

Fig 6.10 | *An overview of the various object states of the smart glove and how it goes from one to the other*



6.3.4 | Differences in interaction between the two smart glove concepts

Notify to Exercise

The two smart glove concepts have a different threshold for stopping to notify the user to exercise. As explained before, the smart glove will start the day by only notifying the user to exercise when their stress level is below 20%. However, during the day this threshold will rise in order to push the user to exercise, as that is important to make progress for the treatment. The way how the two gloves change their threshold varies.

The Friendly Assistant will increase the threshold by 15% for every hour after noon. That means that at 13:00h, the threshold for not asking the user to exercise will be 35%. At 14:00h, the threshold will be 50%, etc. However, the threshold will stop to increase at 70%. This means that if the user is more stressed than that, the glove will give them rest and it will not urge them to exercise anymore.

The Dominant Boss will not stop to notify the user. This means that after 18:00h, even if the user has maximum stress level, the glove will still urge them to exercise.

Stopping during Exercising

If the user is wearing the Friendly Assistant, when wanting to stop while doing an exercise, they simply need to unbutton the glove. This turns off the smart object and stops the exercise.

If the user wears the Dominant Boss, the glove will try to resist. It will tighten around the hand as soon as the user unbuttons the glove. This will make it more difficult for the user to take the glove off their hand. The glove will loosen again when the user either continues the exercise or after the user has completely taken off the glove.

Disclosure of Personal Information

With the Friendly Assistant, the information will be sent only after the user first closes their hand, and subsequently opens it up. The opening of the hand has to be a deliberate action. This is done to prevent the sending of information when the user simply has their hand open by default.

The interaction with the Dominant Boss is different in that the information will be disclosed immediately if the hand is open, regardless of whether this was a deliberate action or not. This glove won't wait and check that the user closes their hand first. This underlines the dominance of that glove. The user will still be able to stop the disclosure of information by closing the hand. In that case, the dominant glove will vibrate more aggressively than the friendly assistant. The latter will only vibrate as a reminder that there is a request for information, while the former will vibrate out of disagreement.

6.4 | CINEMATIC PROTOTYPE

This chapter will conlcude the presentation of the design concepts with a final cinematic prototype. This video shows an entire user journey of a veteran that undergoes therapy for PTSD and uses the smart glove as aid during the treatment.

Figure 6.11 shows the QR-code that will lead to a video with explanations on the screen during the video. Figure 6.12 leads to a video without further explanation, so the viewer will not get distracted and can immerse themselves in the video. It is advised to watch this video with headphones, as the sound design is crucial in communicating the story and human-object interactions.

https://goo.gl/GhvrEL

Fig 6.11 | *The Cinematic Prototype | Including Explanations*

https://goo.gl/WwiqWG

Fig 6.12 | *The Cinematic Prototype | Without Explanations*

DESIGN CHOICES DES

7

DESIGN APPROACH GUIDE

This chapter is intended as a guide for future design projects that want to create a smart object from a privacy perspective. It presents the insights and questions from the previous chapters in a new format, which functions as a comprehensive and compact template for designers to use in their design process. At the end of this chapter, the templates are presented so they can be filled in by designers.

*The chapter consists of '**Design Questions**' and '**Design Strategies**.' Design Questions are meant as the starting point of the design process where the overall goal and functionalities of the smart object are being developed. The Design Strategies are meant to be used while fleshing out the smart object's character and the various elements of the interaction between the object and the user.*

7.1 | DESIGN QUESTIONS

This sub-chapter presents the overview of the Design Questions. The questions are split in 5 parts:

1. **Goal Setting**: This is the starting point of the design process where the designers needs to determine what the goal of the user is and how a smart object can help reach that goal. Defining both the goal of the user and the object provides insights in how the two relate to each other. They can be the same, however, an object can also just be used in reaching part of the user's goal. Defining a sub-goal for the object is therefore beneficial to understand its purpose.
2. **Data Handling**: In this part, an understanding is formed of all the data that will be involved. This is crucial in providing transparency to the user.
3. **Communicate Intelligence**: By knowing what data is available to the product and how the product will use that data, the intelligence of the object and the requirements of its communication towards the user can be detailed.
4. **Object Agency**: Knowing the intelligence, it can now be determined how much control the user needs to give to the object to perform its tasks and how the user can take back that control.
5. **Character's Purpose**: Now that the overall functionalities and goal of the product are defined, the designer can create a purpose for the object's character. Knowing this purpose and how a character can benefit the user will form the bridge to the Design Strategies where the designer will give substance to the answers of the Design Questions.

1. Goal Setting

- What does the user of your smart object have as a goal?
- What is your smart object's goal? In what way does your smart object aid the user in reaching their goal?
- How do these two goals relate to each other?
- How far can your smart object help the user get to their goal?

2. Data Handling

- Which data do you want your smart object to collect?
- Which data does your smart object require to function?
- Which data is needed to achieve the object's goal?
- Can this goal be achieved without collecting the data?
- Which data is being stored?
- Where is it being stored?
- Who, or what, needs to access the data?
- Who, or what, can access the data?

3. Communicating Intelligence

- How does the object's intelligence impact the user's privacy?
- Is the impact on the user's privacy constant or incidental?
- Which decisions by the object need to be communicated?
- Who needs to be aware of the object's intelligence?

4. Object Agency

- Which autonomous choices is the smart object making?
- How do those choices reveal information about the user?
- How does the user censor these choices?
- Which control does the user need to give up letting the object make autonomous choices?
- When, if ever, should the user be able to take back control?
- Can an object's choice, or the effect of it, be reversed once it has been executed?
- Which unwanted consequences can an object's choice have on the user?

5. Character's Purpose

- How could a character benefit the user's goal?
- What characteristics match with the target user?
- How could a character communicate the object's goal?
- Which elements of the object's functionality can form the basis for its character?

7.2 | DESIGN STRATEGIES

This sub-chapter presents the overview of questions to be asked by a designer while implementing the design strategies. They follow the same order as in which they were presented in **Chapter 2**. The questions related to these strategies aim to complete the object's character.

1. Character

- What is the smart object's character?
- What are positive + negative characteristics of the character?
- What is the character's goal?
- What is the Smart Object's Functioning?
- What is the character's range of emotions?

2. Character Learning Curve

- How is the character expressed in the smart object's form?
- How is the character expressed in the smart object's material?
- How is the character expressed in the smart object's interaction?
- How is the character expressed in the smart object's decisions?

3. Expression of Presence

- What is the importance of expressing the smart object's presence?
- What could happen if the user is not aware of the smart object's presence?
- Apart from the main user, are there other people who should be made aware of the object's presence?
- When should these people be made aware of the object's presence?
- Are there specific parts of the object's functioning which should be expressed in particular?
- When should the object express its presence?
- Is the object's *Expression of Presence* constant or incidental?
- Can the object's *Expression of Presence* disturb the user during other tasks?
- Are there possible negative consequences if the object expresses its presence?
- Are there people who in particular should not be aware of the object's presence?

4. Frictional Feedback

- What are elements of the object's character and/or *Expression of Presence* that can be perceived as annoying?
- Is there a benefit in keeping these elements in the object?
- Can the annoying interaction be used in achieving either the user's or the object's goal?
- How can the user intervene in the annoying interaction?
- How can a new interaction be negotiated?

5. Interaction Willpower

- How would the object character's willpower be described?
- What is the effort that is required by a user to overpower the object's willpower?
- When would the object show/use its willpower?
- What would the object try to prevent with its willpower?
- How does the object's willpower support the object's goal?

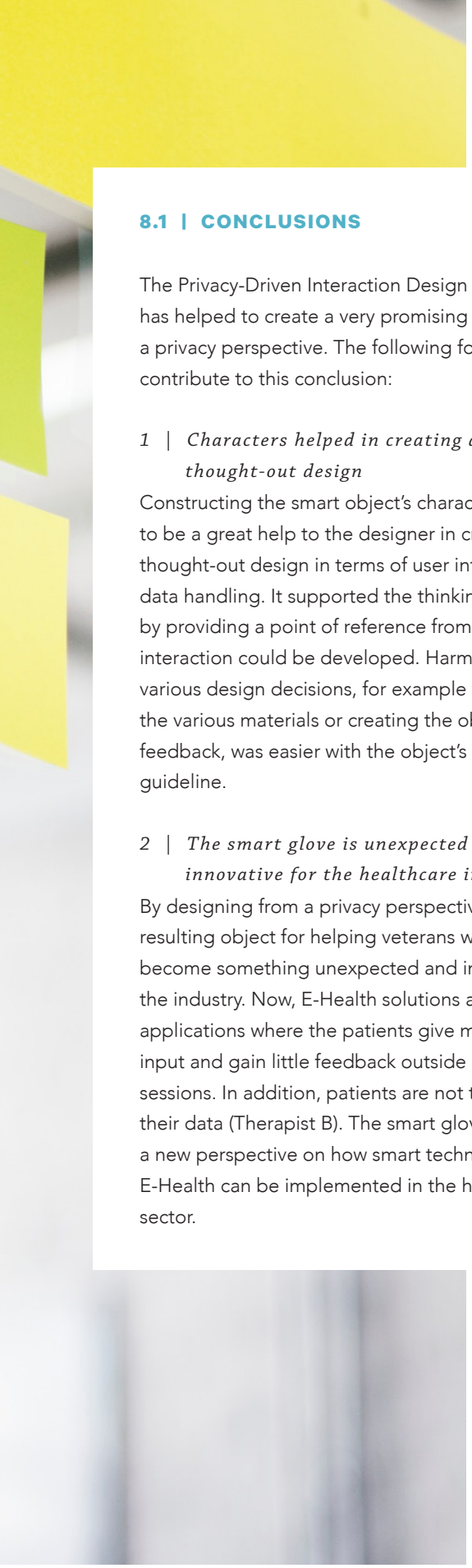
DESIGN CHOICES DESIGN CHOICES

8

CONCLUSIONS & DISCUSSION

*This chapter will present the main conclusions that are drawn from performing a design process with the **Privacy-Driven Interaction Design** (**PDID**) approach and explain why the writer sees potential in this approach. It will also discuss the limitations of this project and give recommendations on how further research and design can help improve the PDID approach.*

A separate subsection will discuss the recommendations for the case study specifically. Since the case study was subordinate to the development of the PDID approach and it served as a context within which the design strategies from the PDID approach could be tested and evaluated, the main discussion will focus on the development of this approach. However, since the smart glove was designed for an existing case and could still be of use on other projects, this chapter will still give recommendations on future development of the product.



8.1 | CONCLUSIONS

The Privacy-Driven Interaction Design approach has helped to create a very promising design from a privacy perspective. The following four reasons contribute to this conclusion:

1 | *Characters helped in creating a thought-out design*

Constructing the smart object's character proved to be a great help to the designer in creating a thought-out design in terms of user interaction and data handling. It supported the thinking process by providing a point of reference from which the interaction could be developed. Harmonizing the various design decisions, for example when choosing the various materials or creating the object's feedback, was easier with the object's character as a guideline.

2 | *The smart glove is unexpected and innovative for the healthcare industry*

By designing from a privacy perspective, the resulting object for helping veterans with PTSD has become something unexpected and innovative for the industry. Now, E-Health solutions are often (web) applications where the patients give mostly textual input and gain little feedback outside of the therapy sessions. In addition, patients are not the owners of their data (Therapist B). The smart gloves provide a new perspective on how smart technologies and E-Health can be implemented in the healthcare sector.

3 | *The PDID approach guided the design process*

During the design process, the PDID approach acted as a valuable compass when the designer got stuck. By coming back to the design questions and design strategies of the PDID approach, the process could be steered in the right direction again.

4 | *The smart gloves show the approach's impact on the design process*

The outcome of the design process are two smart objects which would not have been created without using the PDID approach during the design process. This shows clearly that this approach has an impact on the design process. This makes a strong case for the usefulness of the design approach. If the outcome would have been a product which felt arbitrary, then implementing this approach in the design process would not have any value. The impact of the various elements of the PDID approach, like for example the object's character and the user's control over their data, show that it has value.

8.2 | DISCUSSION

8.2.1 | Discussion on the PDID approach

The project chose consciously to begin by developing the Privacy-Driven Interaction Design approach with a conceptual framework based on current developments in the HCI community. This was followed by a more practical approach with a case study to further improve the design strategies, as proposed in the conceptual framework. During this process, it was evaluated how the design strategies performed in a design process, based on a relevant scenario. This helped to expand the set of design questions and design strategies that formed the guide, as presented in Chapter 8.

The scope of this project has not allowed for extensive user testing of the proposed design strategies. This project has intentionally focused on the conceptual approach within the timeframe that was available. The practical approach with the case study for veterans, although valuable to the development of the conceptual framework, was limited to one design project. This means that more testing is required to validate the practical use of the proposed PDID approach in a wider variety of design projects.

It is recommended to carry out user research on the PDID approach consisting of three components. The first component is to develop an extensive set of templates and tools as a toolkit for designers to use in the design process. This project has started this process by creating a checklist of important questions to ask during a design process. However, this template has not yet been tested with designers during design projects. It is important to evaluate this with designers to validate if it is widely accepted as a useful tool. Designers should give feedback on the clarity of the questions and the guidance during the design process.

The second component is to evaluate the long-term impact of the proposed design approach by researching the user experience of products that were created using the PDID approach. This project's creation of the smart glove for veterans served as a valuable design demonstrator for a vivid illustration of what is possible with this design approach. A user experience evaluation would bring further insights in the effectiveness of the design approach, which was prohibited by the time limit of this project.

The third component is to research user's perception of characters in products. The experience of characters could vary among users as characters are sensitive to prejudices. Users base their impression of characters on prior experiences with those characters. Varying prior experiences will therefore lead to different experiences of the smart object's character. However, further research should show how impactful these different experiences can be on the user experience of the object. This project recommended to use characters that are generic and have some general norm to them which is commonly accepted, or which can be easily understood by a user. If this is enough to minimize the impact of the user's prior experiences should be evaluated in this third component of future user research.

8.2.2 | Discussion on the Case Study

During the case study, this project made use of a combination of research that was done prior to the project (*Li et al., 2018*), which included valuable insights on veterans as a target group for the smart object, and research done during the project (*Interviews with Therapist A and B*), which provided understanding of the treatment of PTSD from the perspective of a therapist. However, the developed concepts of the two smart gloves have not been user tested with veterans to evaluate their impact in real-life scenarios. It is therefore recommended to perform more extensive user research and user testing with veterans if the smart glove concepts are to be further developed and implemented in the treatment of PTSD.

In addition, this project recommends developing the implementation of the smart glove together with therapists. Now that there is a visual demonstrator of what can be done with a PDID approach, therapists can give feedback on how new smart technologies can be incorporated in the treatment of PTSD.

REFERENCES

Apple. (n.d.). Researchkit and carekit. Retrieved from: https://www.apple.com/researchkit/ [Accessed: December 15, 2018]

Biocheck. (n.d.). Zo werkt het. Retrieved from: https://biocheck.nl/zo-werkt-het/ [Accessed: December 3, 2018]

Cbinsights. (2017, September). Apple is going after the health care industry, starting with personal data. Retrieved from: https://www.cbinsights.com/research/apple-health-care-strategy-apps-expert-research/ [Accessed: December 15, 2018]

Cila, N., Smit, I., Giaccardi, E., & Kröse, B. (2017, May). Products as agents: Metaphors for designing the products of the IoT age. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (pp. 448-459). ACM.

Custers, B. (eindred.), Dechesne, F., Georgieva, I., Hof, S. van der, Sears, A.M., Tani, T. (2017). De bescherming van persoonsgegevens: Achte Europese landen vergeleken. Universiteit Leiden - Elaw, Center for Law and Digital Technologies, WODC.

European Commission. (n.d.). Protection of personal data. Retrieved from: https://ec.europa.eu/info/aid-development-cooperation-fundamental-rights/your-rights-eu/know-your-rights/freedoms/protection-personal-data_en [Accessed: December 13, 2018]

European Union. (2010). Charter of Fundamental Rights of the European Union. Official Journal of the European union C83 (Vol. 53.) Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:12012P/TXT

Farooq, U., & Grudin, J. (2016, October). Human-computer integration. interactions 23, 6 (October 2016), 26-32. DOI: https://doi.org/10.1145/3001896

General Data Protection Regulation. (2016, April). Official Journal of the European Union. Vol L119 (4 May 2016). 1-88.

Gezondheidsplein. (2018, November). Posttraumatische stressstoornis. Retrieved from: https://www.gezondheidsplein.nl/aandoeningen/posttraumatische-stressstoornis/item34107 [Accessed: December 3, 2018]

Holmquist, L. E. (2017, June). Intelligence on tap: artificial intelligence as a new design material. Interactions 24, 4 (June 2017), 28-33. DOI: https://doi.org/10.1145/3085571
Janlert, L. E., & Stolterman, E. (1997). The character of things. Design Studies, 18(3), 297-314.

Kuutti, K., & Bannon, L. J. (2014, April). The turn to practice in HCI: towards a research agenda. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems (pp. 3543-3552). ACM.

Laschke, M., Diefenbach, S., & Hassenzahl, M. (2015). Annoying, but in a nice way": An inquiry into the experience of frictional feedback. International Journal of Design, 9(2), 129-140.

Li, X., Rozendaal, M. C., Jansen, K., Jonkers, C., Vermetten, E. (2018). Things that help out: Designing Smart wearables as Partners in Stress Management. In AI & Society.

Mathiasen, N. R., & Bødker, S. (2011, May). Experiencing security in interaction design. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2325-2334). ACM.

Motti, V. G., & Caine, K. (2015, January). Users' privacy concerns about wearables. In International Conference on Financial Cryptography and Data Security (pp. 231-244). Springer, Berlin, Heidelberg.

National Public Media. (2018, August). New data: smart speakers hitting the mainstream. Retrieved from: https://www.nationalpublicmedia.com/news/draft-new-data-smart-speakers-expand-beyond-first-adopters/ [Accessed: December 13, 2018]

NOS. (2018, March). Eindstand referendum: meer kiezers tegen inlichtingenwet dan voor. Retrieved from: https://nos.nl/artikel/2223978-eindstand-referendum-meer-kiezers-tegen-inlichtingenwet-dan-voor.html [Accessed: December 13, 2018]

Oxford Dictionaries. (n.d.). Definition of privacy in English. Retrieved from: https://en.oxforddictionaries.com/definition/privacy [Accessed: November 26, 2018]

Rijksoverheid. (n.d.). Stimuleren gebruik e-health. Retrieved from: https://www.rijksoverheid.nl/onderwerpen/e-health/overheid-stimuleert-e-health [Accessed: December 3, 2018].

Rozendaal, M.C., (2016). Objects with intent: a new paradigm for interaction design. Interactions 23(3):62–65

Rozendaal, M. C., Ghajargar, M., Pasman, G., & Wiberg, M. (2018). Giving Form to Smart Objects: Exploring Intelligence as an Interaction Design Material. In New Directions in Third Wave Human-Computer Interaction: Volume 1-Technologies (pp. 25-42). Springer, Cham.

Scott & Cerulus. (2018, January). Europe's new data protection rules export privacy standards worldwide. Politico. Retrieved from: https://www.politico.eu/article/europe-data-protection-privacy-standards-gdpr-general-protection-data-regulation/ [Accessed: December 13, 2018]

Search Encrypt. (2017, November). 7 principles of privacy by design. Medium. Retrieved from: https://medium.com/searchencrypt/7-principles-of-privacy-by-design-8a0f16d1f9ce [Accessed: December 15, 2018]

Sentient. (2018, September). Understanding the 'black box' of artificial intelligence. Retrieved from: https://www.sentient.ai/blog/understanding-black-box-artificial-intelligence/ [Accessed: December 15, 2018]

Stichting Centrum '45. (n.d.). Veteranen. Retrieved from: https://www.centrum45.nl/nl/voor-wie/veteranen [Accessed: December 3, 2018]

Stichting Centrum '45. (2018, Oktober). Traumabehandeling veteranen. Retrieved from: https://www.centrum45.nl/sites/default/files/domain-6/documents/2018-10-10_veteranenfolder_nieuw.webversie-6-1539250910204563706 3.pdf [Accessed: December 3, 2018]

Thuisarts. (2016, Juni). Ik heb een posttraumatische stressstoornis. Retrieved from: https://www.thuisarts.nl/posttraumatische-stress-stoornis/ik-heb-posttraumatische-stress-stoornis [Accessed: December 3, 2018]

TU Delft. (n.d.). TECARE: a smart wearable system for sensing stress of veterans with PTSD. Retrieved from: https://www.tudelft.nl/en/ide/research/research-labs/emerging-materials-lab/smart-textiles/tecare-a-smart-wearable-system-for-sensing-stress-of-veterans-with-ptsd/ [Accessed: December 3, 2018]

Versluis. (2015). 'Als behandelaar word je een coach die over technische hulpmiddelen beschikt om iemand weer grip te geven op het dagelijks leven'. Cogiscope. ISSN 1871-1065. P 43-44.

Wikipedia. (n.d.). Privacy. Retrieved from: https://en.wikipedia.org/wiki/Privacy

Wooldridge, M., & Jennings, N. R. (1995). Intelligent agents: Theory and practice. The knowledge engineering review, 10(2), 115-152.

Zhao. (2018, January). 'Black Mirror' in China? 1.4 billion citizens to be monitored through social credit system. (December 14, 2018). Newsweek. Retrieved from: https://www.newsweek.com/china-social-credit-system-906865