Ambient care-interaction index

Designing caring relationships through ambient interfaces

Graduation Thesis

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Abstract

Design for product care focusses on stimulating users to prevent early obsolescence of products, which is particularly valuable for electronic household products. One product care strategy is to create attachment and therefore care motivation by strengthening the product-user relationship.

Currently, these strategies lack practicable design directions that designers can use easily, which is why little innovations occur. I propose to stimulate product care behaviour by improving the relationship between products and users through ambient interface implementation in design.

Ambient interfaces embrace communication with a playful, unobtrusive, intuitive character and gradual presentation. The goal of this project was to create a tool that summarises the characteristics of ambient interfaces. This became the 'Ambient Care-Interaction Index', an online tool that contains informative text and inspiring examples. It can be used to learn about ambient interfaces and inspire designers to use the qualities to (in)directly stimulate care.

Introduction

Apart from functions, designers also create the communication and character of a product. All of these things have impact on how the product is perceived in terms of understanding, appeal and attitude that people develop. People's perception of products again influences how people treat them. In the current linear economy, products are manufactured, sold new, used and replaced when their value decreases, or another product seems more appealing. When replaced, the old products are either stored for eternity or discarded, whereafter they are disposed to landfill or incinerated. In a circular economy, products are produced from recycled materials, sold (renewed) second-hand, used for as long as possible (/to its full capacity/capability) and repaired or repurposed when its value decreases. People might discover a more appealing product, but have the possibility to upgrade or re-sell their current product as opposed to discarding it. When discarded, products and parts are re-used, and materials are recycled as much as possible.

Prolonging product lifetime through product care

To work towards a circular economy, there are strategies for all of the above-mentioned aspects. One of them is prolonging the products' lifespan. Especially electronic household products have a relatively short lifespan (Wieser et al, 2015). Changes can be made in manufacturing, use and discarding. All of these features should be a part of the design process. Now, most focus is on manufacturing, more is forming around end of life, and slowly, sustainable use is starting to gain some attention as well. Webster (2017) stated "a circular economy is one that is restorative by design, and which aims to keep products, components and materials at their highest utility and value, at all times". Which implies that the most valuable product is a product that is used to its full potential. To accomplish this, use can be broken down into several parts; purchase, first use (learning), main use (including care) and eventually obsolescence. Looking specifically at providing care, this can also be split up in how you handle the product (careful/ correct use), small maintenance (proper cleaning), big maintenance (structurally checking and replacing parts), fault diagnosis and repair. **For this project I am mainly interested in stimulating careful use and small maintenance, since this can be influenced through day-to-day interactions.**

Product-user relationships

Interactions shape the relationship between products and their user. It can be strengthened through mutual care; noticing each others needs and providing support. To maintain a relationship, both entities need to adapt and communicate clearly. In nature, this happens simultaneously, as everything is connected. Yet, humans are detaching themselves from this symbiotic system by depleting resources and creating beyond the natural. Product design was once a way of utilising materials to create simple tools (as it is still for some other animals), but has become a very complex and polluting business. To change this attitude towards consumerism and the throw-away culture, care should be stimulated through design, treating the product-user relationship as a means as well as a goal.

Design for product care

According to Berger (2017), the circular economy is also a maintenance economy. Yet, design for product care is often overlooked, implemented at the last moment, or not taken into account from the start of the design process. When it is implemented, it is not done in very creative ways; generally companies tent to copy each other's solutions. It has a strong connection to financial value and increasing ease of care (through displays or automatic features). This way, the value of caring can get lost.

Relationship design

To extent product lifetime, by stimulating care and proper use, people should feel connected to their products. In the design field, there has been a shift from product, to user to experience design, which is now growing into system design. Yet, sustainability wise, this shift moves the value away from the user-product relationship, making the product a mere bearer of function instead of a product of its own. This is also part of the circular economy, since products can be shared to extend lifetime. Nevertheless, this approach removes the personal connection people can feel for their product, making it easier for consumers to replace a product once its function or capability is no longer desirable. To avoid this, my belief is that we should take a step back, and explore this relationship between product and user more, by re-introducing ambient interfaces to designers.

Ambient interfaces

Ambient interfaces were introduced in the late nineties, when offices started to get overloaded with stimuli from new innovations like computers (Weiser & Brown, 1996). This led to a need for less obtrusive interactions, creating a more calm, but also more efficient environment to work in. Ambient interfaces allow the user to act and understand 'by feeling', rather than 'by thinking'. Multi-sensory and experimental interactions can allow for more subtle

communication. This communication does not necessarily have to be functional from the start. Once people get used to their product's communication, it could be used to communicate care or additional functions/ options. By gradually learning how to use the product, a valuable two-sided relationship between user and product can be formed. Various terms describe ambient interfaces and similar interactions, therefore it can be hard to find a comprehensible explanation. Hence, the term, theory and its potential value are still quite unknown to designers.

Using ambient interfaces in relationship design

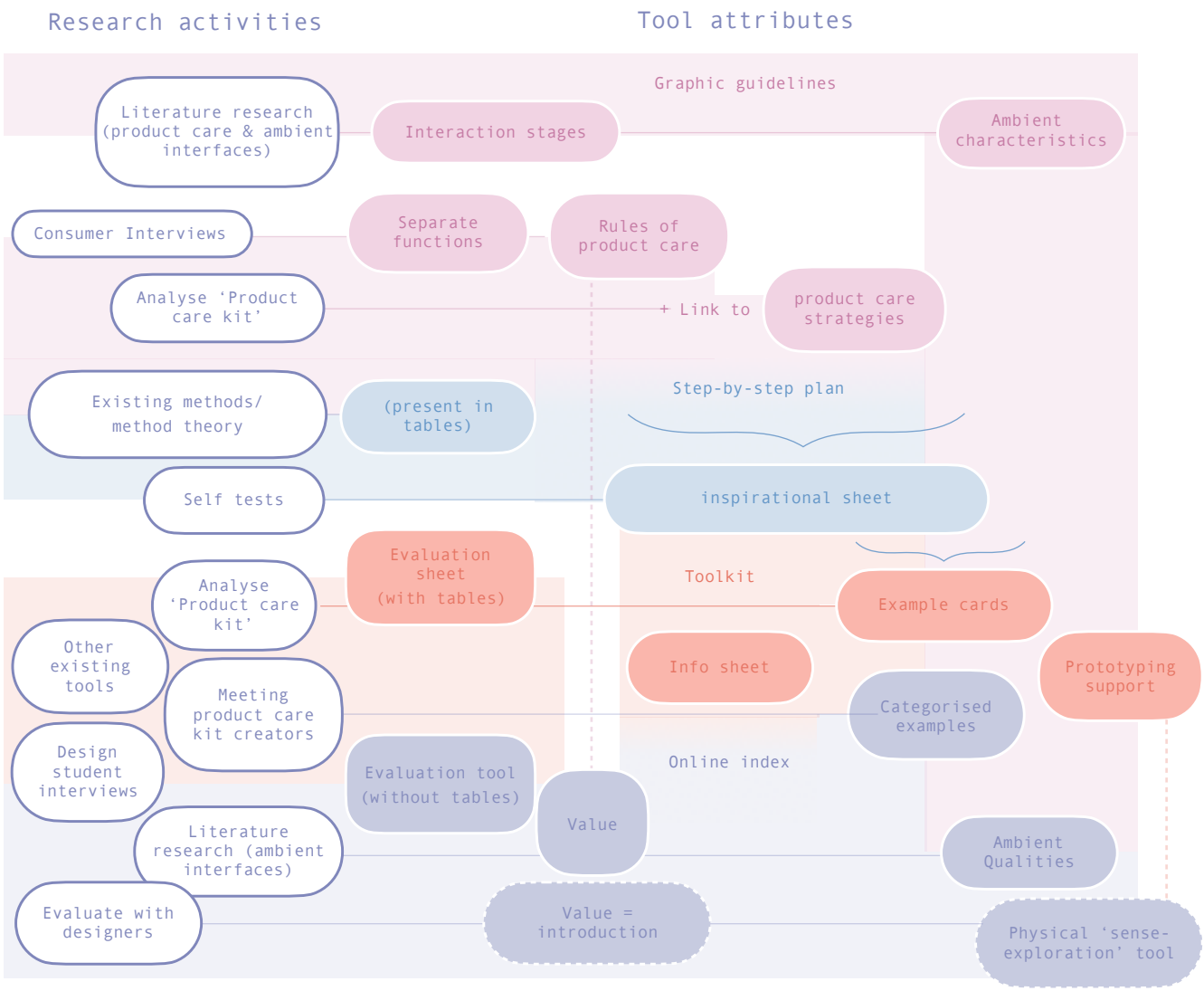
Relationship design is not a new term. It is proposed as a way to postpone replacement by designing for attachment (Mugge et al, 2005), which is part of design for product care. However, designers are not implementing these theories in mainstream design processes yet. According to Casais et al. (2015a), the amount of design directions on designing for meaningful relationships is very limited. When looking into the theory and strategies associated with relationship building through design, a set of principles was formed, yet no practicable design directions could be derived.

By using ambient interface theory as a strategy for relationship design, specific communicative qualities can be used to design interactions and product character. This relates to the relationship design strategies, but makes it more tangible.

Developing an index

I propose that product care behaviour can be stimulated by improving the relationship between products and their users through ambient interface implementation in design. Both ambient interfaces and product care are relatively unknown fields for most designers, yet they can strengthen each other. The theory on design for product care, relationship design and ambient interfaces share a lot of overlap. The difficulty lies in finding a way to introduce its value and content to designers.

Through ideation and testing (see simplified process below), I developed an online index to support designers in the creation of interactions and ideation on product characteristics. The Ambient Care-Interaction Index is a collection of examples to illustrate how the four main ambient qualities (as described in chapter 1.3) can be implemented in design, accompanied by text.



Design approach

The overview of my research activities on the previous page shows what activities led to certain attributes, and which were incorporated in each iteration. This process came forth from the following approach:

This project started out with the question 'Can increasing curiosity stimulate product care behaviour?'. Curiosity can be found in many things; learning skills, understanding art and discovering new places for example. My hypothesis is that allowing for curiosity in design could lead to a more meaningful and exciting relationship between products and their users, which could increase user's motivation and ability to care.

Research

To find (counter-)arguments for this hypothesis, I looked into three design fields;

Design for product care

Designing for care can be achieved through many strategies. I looked into the definition of product care and explored the various strategies that are recommended. To enhance my understanding of the user's care experience, I interviewed 7 consumers.

Relationship design

One proposed strategy in designing for product care is relationship design. It is not a new term, but it is not used often. It is very important in design for attachment and system design, but clear guidance on applying its aspects is still in development.

Ambient interfaces

To translate the previously mentioned curiosity into a design feature, I stumbled upon the field of 'Ambient interfaces'. It is a specific approach to designing interactions, allowing for more control in noticeability and perception, resulting in a more positive experience.

At the end of each chapter, the main conclusions were summarised as take-aways.

Design brief

In the Design brief, I compared and combined all take-aways. From this summary, the following design goal could be formulated: t**o create a tool that connects the characteristics of ambient interfaces through the full product experience, eventually improving communication and attachment to stimulate product care.** The design brief also provides context for the design goal, in terms of use (scenario's) and development (methods).

Design

Index development

The tool that was eventually developed is called the Ambient care-interaction index . In the development chapter, the most important iterations and decisions are presented and explained.

Index description

The final design is explained thoroughly in this descriptive chapter. It is a description of all features and their purpose. Since every feature contains various subjects, all links between features and subjects are also displayed in an overview.

Evaluation & recommendation

At the end of the project, a comparative study was done with 9 design students and designers, to evaluate the index. The results of this evaluation can be found in this final chapter. From the results, recommendations for alterations were proposed , as well as general suggestions for further research.

To conclude, a reflective chapter describes a discussion of the project's results compared to the initial hypothesis, and a conclusion of the research and its potential impact in the field of interaction design.

1.1 Design for product care

"Maintaining products is the most efficient way of retaining their desired level of performance and extending product lifetime. This is called Product care. Product care can be understood as any action that helps to prolong the lifetime of a product." (Tuimaka, 2019)

Product care can be provided in different levels, from responsive; cleaning when it is dirty, to preventive actions; checking for care and correctly using the product. For this project the focus lies on small and continuous care; caring behaviour towards the product and timely maintenance (inspection and execution). It includes daily interactions with the product, and needs both the product as well as the user to cooperate. The product needs to communicate the care that it needs in a comprehensive way, and the user has to be open to putting effort in protecting and listening to the product. Current research has already shown links to product attachment and behavioural psychology through the importance of motivation, ability and triggers. Ackermann et al. (2021) summarised current solutions for product care in the 'product care toolkit'. They recommend 8 design strategies to stimulate product care, which can be associated with Fogg's behaviour model. Other studies on behaviour refer to the self-determination theory to explain motivation. The problem is that currently, designers are not implementing these theories in mainstream design processes.

Through interviews with consumers, I will try to analyse options that designers have and what consumers are open to and prefer to encounter in new product designs.

Value

Extending a product's lifetime can be done through product care because it retains the products functional and aesthetic value. This way, products can be used for their maximal potential, which supports the Circular economy principle "to keep products, components and materials at the highest utility and value, at all times" (Geissdoerfer et al., 2017). The user can play a major part in this by providing care Stichting Repair Café International (2018) concluded.

Other strategies to decrease environmental impact of product design like recycling and use of 'biodegradable' materials can result in the opposite of what circular design wants to achieve; more waste. According to Chapman (2005), it can be used as greenwashing, since it advertises as 'sustainable', yet it can be used as an "excuse for more rapid discarding". Nevertheless, these strategies should not be discarded since they can be used in valuable ways as well.

*"The circular economy is innovational, but is also, at the same time, a maintenance economy. […] 'Maintenance', she [Mierle Laderman Ukeles] wrote, **'preserves the new, supports the change, protects the improvement, defends and prolongs the progress, renews the excitement,** repeats the flight'." (Berger, 2017)*

Strategies

Ackermann et al (2018) noticed three main influences in product care, derived from Fogg's behavioural model; **motivation, ability** and **triggers**. They describe how people need all three to perform care activity, but they do cover different aspects of design, like communication, character, material and functions.

In the Product Care Kit (Ackermann, 2021), 8 strategies were formed, all covering different aspects that influence care. Summarised, the categories are 'increasing value' (reflection, appropriation, social connection) and 'facilitating ability' (enabling, informing, awareness, emotional experience, control). The categories show how motivation, ability and triggers are intertwined and can be influenced through several methods. In each category, several researchers and theories will be discussed, the Product Care Kit will be indicated as PCK.

Increasing value

To increase product value, designers need to pay attention to the types of value that a product can have, and ways in which this value presents itself within a product. Van den Berge et al. (2021) outlined five types of values that influence people's incentive to care or replace. Casais et al. (2015a), developed design directions to design meaningful long-term relationships. The design directions that fit a value are added in **lilac**.

Emotional

Research about product attachment proves that emotional value is quite difficult to design for. Nevertheless, there are some strategies that could be applied through design. According to Mugge et al. (2008), an interaction which feels more personal to the user, can create attachment. This can be in the form of connection or personal growth. Additionally, PCK's appropriation is about personalising products.

> *"People tend to become more attached to products that symbolise a personal accomplishment and thereby express their self" - (Mugge et al, 2005)*

Emotional value can also be increased by creating memories, embracing traces of use and enhancing experiences (PCK's reflection). Moreover, my hypothesis is that constantly learning about the product will increase the memories with the product, and therefore attachment.

- **Keep track of progress:** provide visual feedback to personal progress

Epistemic

Epistemic value is about "arousing curiosity, providing novelty or the need for a change of pace" (Van den Berge et al., 2021). It is about designing products that are interesting, and that keep surprising users (Ludden et al., 2008). This can be done by allowing for upgradability (Van den Berge et al., 2021).

- **Design for mindfulness:** show how a product works

Functional

Functional value does not only rely on the amount of functions, but also on their usability and personal value to their user. Den Hollander (2018) summarises that the cause for early obsolescence is the loss of perceived value, which can be triggered by reduced functionality. Thus, increasing functional value can be very effective, yet the amount and complexity of functions can depend a lot on financial possibility as well.

- **Improve multi-sensorial communication:** improve communication by translating a message into a sensorial experience

Social

Products that make people feel like they belong have social value. These products are used by several people, or are used to enhance relations between people. To design for social value, a product could emphasise how it can be used together, or be linked to a platform (PCK's social connection). Interestingly, social value can also enhance the feeling of satiation, which in turn motivates product replacement (Van den Berge et al., 2021).

- **Support meaningful affiliations:** facilitating the practice of specific belongingness activities (guiding and/ or simplifying)

Conditional

Conditional value is very hard to design, since it is the value that a product has due to the circumstances that it is used or bought in.

- **Provide a meaningful context:** facilitate an interaction between product and context or props

Facilitating ability

For people to be able to perform care activities, they should be notified (triggers), feel informed (understanding the product) and supported (tools, communication & effort).

Triggers

Ackermann (2018) states: “in general, people are motivated to take care of their products, but still struggle to integrate these activities into their daily lives.” They present that what people lack most are triggers that notify about the care that’s needed.

My theory is that, to implement triggers in an effective way, they need to become recognisable and feel like a habit. **Habits do not require effort, but can be executed with ease.** Ease is defined by things that come naturally, one does not need to think about these things, we know what to do and when to do it. Habits feel easy, and can be formed. To care for products can be a habit that is stimulated by the product itself.

Habits are generally formed by rewards. A new reward based habit requires active consideration of the reward, later the brain only recognises the stimulus for the habit, which provides the feeling of the reward even without the reward being presented (Smith & Graybiel, 2016). The danger of reward based habits is explained in ‘Self determination theory’ (Ryan & Deci, 2000). They state that reward based habit forming is based on extrinsic motivation, which, according to Nicholson (2015), can be useful for short-term goals, but it can reduce intrinsic motivation. Intrinsic motivation is required for long-term goals. It is motivation that feels truly rewarding, as it provides purpose and feels valuable. Therefore, **for triggers to be effective over time, they should feel like reminders to intrinsically motivated habits**.

The PCK calls triggers ‘awareness’, which can be provided through push messages, appearance changes or changes in functionality.

Understanding the product

Regular channels like the product manual or online forums can help people understand their product. More interesting for the designer, people can also learn about their product through its appearance (material f.e.), feedback and affordances (PCK’s informing). PCK’s emotional experience (antecedents & consequences) is about anticipating the effects of activities and enhancing care result through design.

Tools, communication & effort

Users can be supported to provide care in three ways; enabling (PCK: providing the right tools), guiding through the process (communication) and reducing effort (PCK’s control: forcing/ automating care).

Even when people value their product, they often lack the confidence and knowledge to determine what is wrong or how that can be fixed. Therefore, proper use and maintenance should be communicated by the product. This should be done in a way that is not intrusive, but inviting, so the user becomes curious to understand what the product needs.

> *“Creating awareness through push messages was criticized by many participants, as these were perceived to be annoying. […]* ***Making the consumer aware through changing appearance or performance of the product was better accepted.”*** *-(Ackermann et al., 2021)*

Consumer Interviews

To understand how people experience care activities (in terms of usability, but also its value), I have interviewed seven consumers. The goal was to explore what people think of product care, how product communication and product value is perceived, whether people are conscious about product lifetime and the influence of specific interactions, and what their thoughts are on product personality and personalisation. The main questions were about current motivation and knowledge regarding product care, and to gain understanding of the learning process.

__Questions

The main topics of questions were usability, value, care activities, fun and personality. The full list of questions and sub-questions (in Dutch) can be found in appendix 2.2. The first question of the interview was to determine each participant's definition of product care, whereafter I explained my definition (including careful handling, proper use, cleaning and preventive checks).

Understanding products / learning process experience

To gain an understanding of different types of learning processes, I asked about products that took longer to understand, and products that were quickly understood. I also asked how they felt about this learning experience and important influential factors.

Value in long-term relationships

To determine the value of products, and what can influence this, I asked about the products that people had used for a very long time. Then I asked about their value, and if people owned any products with emotional value.

How do they care?

For two different household products (vacuum cleaners and coffee machines), I asked participants how they take care of their product. These products were chosen since they are available in a large range, made for different target groups. They are also very commonly used in most households. Furthermore, both require physical maintenance which allows for ambient interface application.

Fun and personal products

To explore the hypothesis that fun and engaging interactions can increase care interest, I asked what products people find fun to use and what makes them fun. I also asked what people would change if they could have more personalised products.

Personality (and value)

Participants were first asked how they define personality in products, and what their opinion about it is. Then I asked them about the Roomba robot vacuum cleaner, which every participant knew of. I asked whether it could be seen as a pet and why, and if they think it has value.

Setup

The interviews were conducted with seven consumers of different gender and age (table 1). All participants were dutch, hence the interviews were also held in dutch. Most interviews took place in the homes of participants, so they could explain by showing their products. One interview (with the 25 year old male) was held online, another (female, 23) was held in my apartment. The interviews were semi-structured; each topic was discussed, but the formulation of questions differed per participant. This made the conversations more natural and allowed me to anticipate on personal stories. The interviews were 30-60 minutes long.

V60 and M68 were a couple, of which V60 was interviewed alone, and M68 was interviewed while V60 added to questions, or they both discussed experiences. Before the interview, participants signed an informed consent form and possible questions were answered by the researcher. Each participant was asked to talk about the care they provide for either a coffee machine or a vacuum cleaner (see table 1). Additionally, the couple (V60 & M68) explained the descaling process of their steam generator, since they had never done this and were curious to figure it out on the spot. Based on the answers that people provided, I categorised participants based on their general care tendency, to be able to analyse connections in the analysis.

Gender	Age	Product	Careful
f	23	v	no
m	25	v	yes
f	46	v	no
f	47	c	yes
f	60	c	yes
m	65	c	semi
m	68	v	semi

*Table 1: Interview participants (gender (**f**emale/**m**ale), age, specific product (**v**acuum/**c**offee-machine), care tendency)*

Analysis

To analyse the interview answers, the interviews were transcribed (in Dutch). From the transcripts, conclusions were formulated (Appendix 2.3). The transcripts were then coded per participant, per question (Appendix 2.4). All codes were categorised, with font size indicating their quantity (Appendix 2.5). This overview formed the base for the final conclusions in five themes; Motivation Usability Value Understanding care Sustainability (Figure 1). I will elaborate on the conclusions in the next paragraph 'Results'.

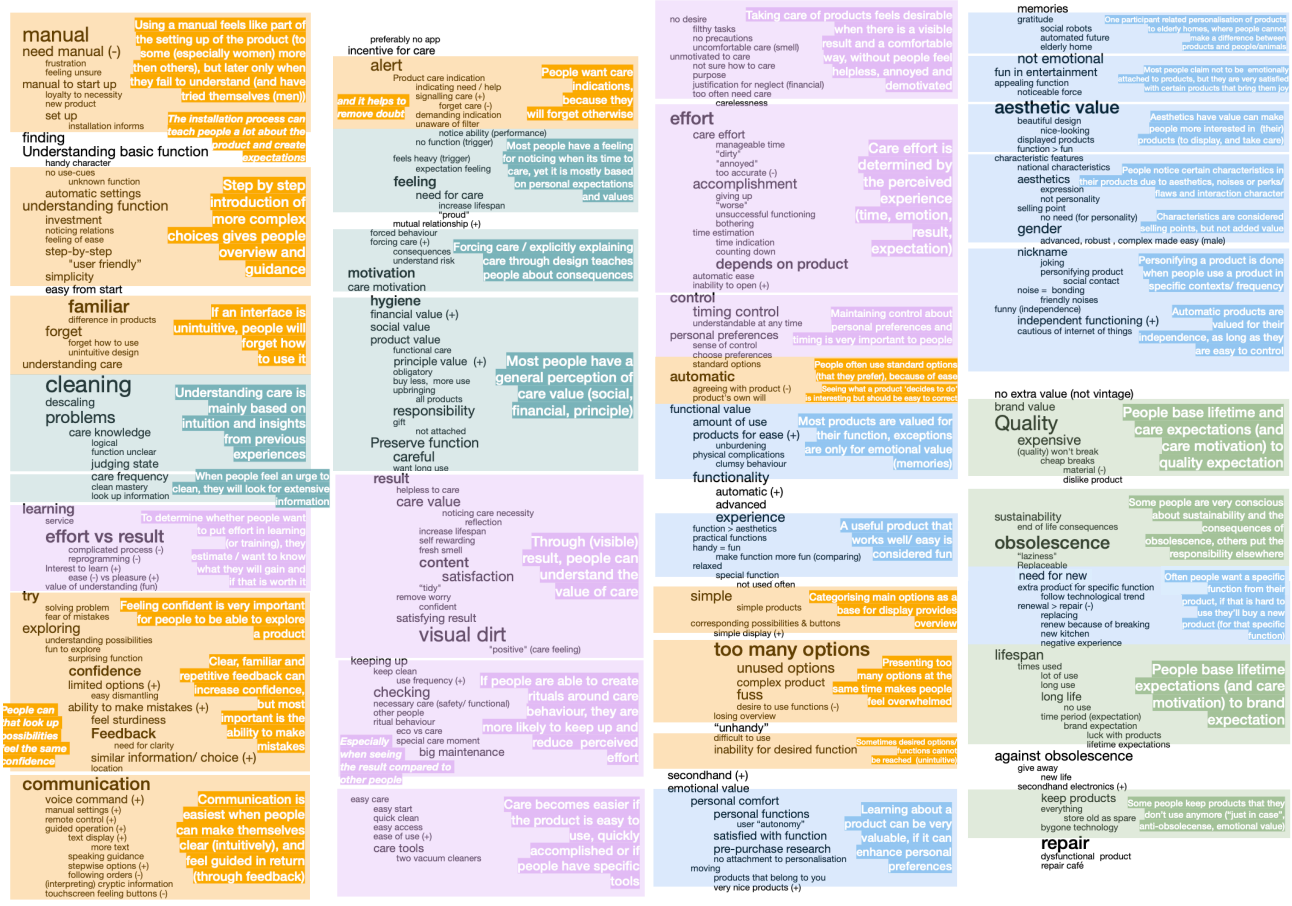


Figure 1: Codes (in black), arranged by category with the conclusions per theme (colours). Font size indicates amount of participants to which the codes belong (for example quality (7/7), too many options (5/7)). A bigger version of this visual can be found in Appendix 2.6.

Results

Confidence to explore

A positive learning experience can be supported by confidence. Confidence comes from familiarity and assurance. If people are able to recognise shapes or feedback, it is easier to distinguish progress to a next step. Additionally, learning about the possibilities of a product and exploring more complex functions becomes more appealing when people feel confident about using the product (quote, M25).

"Then you can also do more with the product than you initially think. First it's just 'let's cook', and eventually you can use it more easily because everything is set up in the same way." (M25)

When people are supported through the cleaning process, and they receive clear feedback, they feel confident performing maintenance tasks. Also, feeling positive about the usability of the product in general can increase expectations about ease of maintenance. Some participants did not agree to this statement, as they felt that care activities stood apart from the product's function.

Another common remark was that maintenance tasks that were performed regularly did not feel like maintenance anymore, but more like common things to do. **This shows that tasks that people feel comfortable and confident in, make the task feel more effortless, and more like habit.**

Control

People expressed very different opinions towards product care activities. The common denominator was the amount of control they felt over the activities. The problem with most activities is not the effort, but the timing. If people feel like cleaning, they will clean even if it takes a lot of time. They want to feel like it was their choice and desire to clean. Some participants mentioned that their product would just stop working, which was not appreciated. But when they initiated to clean, they could even feel excited about it (quote, F23). Other participants had very good experiences maintaining their product, when they were given a choice and proper guidance through the cleaning process.

"I cleaned the washing machine a while back, this was very satisfying .. Because it was really dirty .. I read about all kinds of things online, how to clean it, so I was like 'yeah, I'm really gonna do that' and that was really nice. It was fun." (F23)

Visibility as motivation

All participants mentioned that dirty looking/ sounding products provided more reason to clean them. This does rely a lot on the results as well. Some vacuum cleaners without a bag were reported to 'always feel dirty', which is why people did not clean them thoroughly anymore, even if they felt like they should. Therefore, visibility can act like a motivator (quote, F23), but if the product does not allow to be cleaned well, that can demotivate and provide negative feelings towards the product in general.

Quality expectations

Every participant mentioned the quality of products, and said something about related expectations. Products of higher quality are often related to higher financial value, and therefore deserve more care, since the product initial costs were high. Cheap products deserved less care, since people feel less responsible. If they notice that a product is build in a fragile way, they feel less prone to care since they feel like it would not be their fault if the product breaks.

Effort vs result

When asked about training a product (like a robot vacuum cleaner), 6/7 participants mentioned that the effort of training should be proportionate to the functional result. Most mentioned that the robot vacuum did/ would not quite fit their house, which undermines the product value. When an autonomous products adds variable tasks for the owner, this causes it to require more effort than manual products that require repetitive tasks. People saw value of training a product to fit personal needs, but not if this makes daily/ basic use more difficult.

Stepwise information

Most participants agree that products with too many options are difficult to use. Some people already mentioned this when asked about the definition of product care, relating it to people being unaware of what to clean or check (quote, M68).

> *"I just use that [black coffee option], and with many products that is the case I think, that people just, don't even know, all the things that a product can do. They have added too much. And people are only used to using 2 or three things." (M68)*

It seems that most people get **overwhelmed when many options are presented** all at once; they lose the overview of options and are unable to find an intuitive path to their goal. Categorising options is more desirable, since people are able to make connections between their goal and the product's functionality. A frequent example of this is the difference between a microwave and a washing machine. Microwaves were described as very unhandy, since they seem to present every option except for what people want. They lack manual adaptability, or present this in an unclear way, giving users the feeling that they cannot control functions. Washing machines on the other hand, explain manageable programs with clear numbers, which people can change and relate to. They show many options, but categorise them. This way, people see harmony in variety (being able to distinguish goals while noticing similarity in options).

Possibility to learn

When asked about their opinion of products that would suggest and explain how to use new functions, almost all (6/7) participants reacted in a positive way. They did have different views and fears on the matter. Some mentioned the hassle that understanding preferences could demand, although it could also be very useful. One participant commented that it would be 'real communication' if her products would indicate needs, to create a more two-sided relationship. Another spoke of being interested in a more guided experience. Two people referred to voice command as a favourable option to navigate products, especially since products can be very complicated if they contain many options. Overall, they agreed that learning more about the possibilities of a product could be beneficial if it would result in a more personal experience (M66, quote).

> *"I need to be able to make my own decisions. Not that I have to add the sauce […] That would deprive me of my **autonomy**. It could make **proposals**, […] but, it should not result in me needing to wait for 15 minutes, because it wants to propose all sorts of things to me, when I just want to warm up [my food]. Then I will **indicate** when I want proposals, then it could **provide feedback** […] But, I also think that **the fun or charm of it is that you can, experiment yourself** […] Everybody has their own preferences" (M66)*

Discussion

There were quite some similarities between existing research and the results of the interviews. The most interesting insights are elaborated on below.

Control

According to Mead & Baumeister (2021), people "seek objects which serve as symbolic 'helpers' rather than functional 'heroes'", especially when they feel low in control. They state that people want to feel like products can help them improve **alongside** their own efforts.

Previously I explained control in terms of motivation towards care activities. What Mead & Baumeister refer to is more about being supported by the product. As a result, users can feel more in control of the outcome of certain activities. This relates to what M66 said about the way in which learning possibilities should be presented. He thought he could value receiving suggestions from the product, but also expressed a need for autonomy.

Quality expectations

Van den Berge et al. (2021) addressed that some people deliberately show careless behaviour when they want to justify the replacement of a product. Both F23 and F47 admitted that there were certain products that they disliked to such extend, that they acted particularly careless towards these products. They did not want them to break, but they would not care if they would. This shows how important quality expectations can be.

Perhaps that a product that feels more automated could feel like it 'deserves' more care since it also tries to care itself, or at least tries to communicate. It seemed that most participants agreed that 'products that are designed well 'deserve' to be kept well'. Although this also related to financial value.

Possibility to learn

People expressed a positive attitude towards products that they could learn to use extra functions with. This resonates with what Van den Berge et al. (2021) state about evolvability. Evolvability/ upgradability is about considering all use phases and anticipating changing needs and possibilities.

DeKoven & Keyson (2000) recommended designers to look into the possibilities of automatically measuring physical factors not only to recommend, but also to learn about user preferences by focussing on goals through various approaches depending on the user/ goal. " The user can then react to the individual steps, or the whole plan, or particular parameters, without worrying about how the oven does it" (DeKoven & Keyson, 2000). This relates to how participant M66 described desired recommendations whilst keeping their autonomy.

Additionally, some people mentioned that they would replace certain products due to functional shortcomings, but if they were emotionally attached they would keep the product. This is also known as 'product hibernation', which is one of the down sides of emotional value (Van den Berge et al., 2021).

Conclusion & Take-aways

According to Fogg's behavioural model, to provide product care the user needs motivation, ability and triggers (Ackermann et al., 2018). The design of a product can influence each of these factors. It is common for current products to communicate with cryptic (blinking lights) or textual signals, or not at all. Signals can act as triggers, but without ability or motivation, people won't act. This results in users being unaware of incorrect use, and it can even result in a negative attitude toward the product (if it does not function as the user expects).

From seven interviews, it appears that consumers main concern is their autonomy, and their feeling of ease. Products should feel as something that serves them, yet there is room for a two-sided relationship. Some care is part of the charm of products (maintaining a motorcycle for example), where other care feels natural (cleaning the coffee machine after each use) or necessary (emptying the vacuum). How a care activity feels depends a lot on perceived effort and value. Reducing effort can be done by making the user feel able to perform a task, and break the task into small, fast tasks. Increasing the value can be done through product attachment strategies and informing the user through continuous communication.

The difficulty in designing for emotional and functional values is that they are complicated to implement, especially for cheap products. To implement strategies that improve these values, companies need to understand the possible impact, and strategies need to be developed which provide structure to design for these values.

Several strategies are proposed by researchers to implement product care in the design process, yet few are integrated naturally. To increase product care, designers should consider many facets of the design; to motivate and support the user in caring for their products. Eventually it comes down to **collaboration between the user and their product**; to care for a product is to understand when and how it needs care; users need prior knowledge & communication.

Learning

> Basic functions must be clear for people to feel **confident** to perform/ explore other tasks.
> **Categorising** options creates **overview** and allows people to make **connections** between their goal and the product's functionality.

Result

> People can **learn** about their product through its **appearance**, **feedback** and **affordances** (for example by enhancing care result).
> The effort of **training** should be proportionate to the functional result.

Care motivation

> (Perceived) care **results** can motivate or demotivate people.
> People won't act without **risk**.

> **Expected quality** relates to expected care **responsibility** (for financial and functional reasons).

> Tasks that people feel **comfortable** and **confident** in, make the task feel more **effortless**, and more like **habit**.
> **Habits** can be formed by **rewards**, but more valuable are habits which rely on '**intrinsic motivation**': motivation that feels truly rewarding, as it provides **purpose** and feels **valuable**.

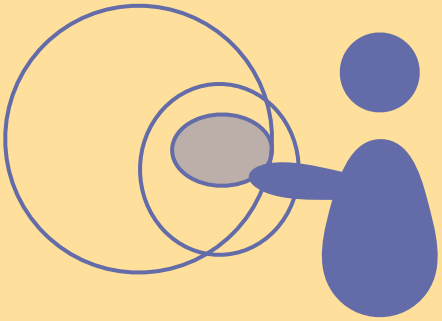
> Product care is valuable when it retains the products values:
- **Emotional**: create attachment through connection (personalising, memories) or personal growth (learning)
- **Functional**: increase usability (can be financially dependent)
- **Epistemic**: stimulate curiosity (surprise continuously)
- **Social**: emphasise social use, add comparison
- **Conditional**: context-related (very difficult to design)

Care ability

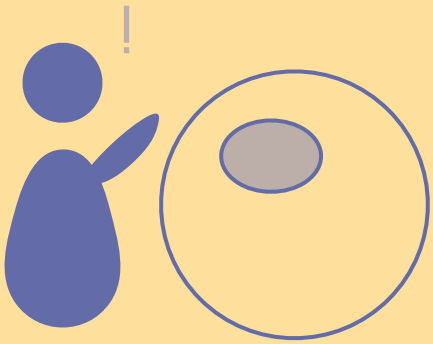
> What people lack most are triggers that **notify** about the care that's needed.
> Users value to be in **control**; the problem with most (care) activities is not the effort, but the **timing**.

> **Supporting care** can be done by providing tools, communication and automation.

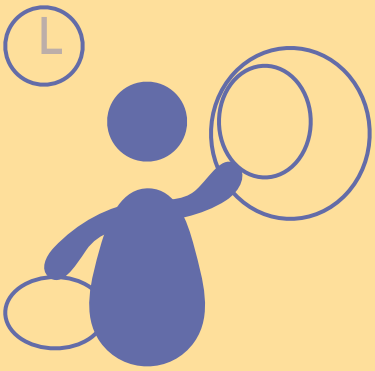
Mutual altruism



Participation



Control / mastery



Rituals / habits

"Building engaging, rewarding, active partnerships [..] by
- Ensuring **participation** through **creative** activities. This allows users to become producers, not observers of their interaction, which can also be achieved by letting the user **reconfigure** the product or **learn** a new skill or acquire knowledge through using it.
- Designing in mechanisms that **encourages users to care**, tend to and maintain the product, building a relationship of **mutual altruism**.
- Providing moments to **create a ritual or habit** with the product, forming a relationship of stability and reliability.
- Engendering a **feeling of control**, a sense of **mastery** through the object, either through intimate knowledge of the product and its inner workings or the ability to use it well."

Figure 2: Four strategies for relationship design (Haines-Gadd et al, 2018)

1.2 Relationship design

When a product is bought, it becomes a part of its user's life. The user will relate certain feelings to the product, its functions and its interactions. These feelings will most likely change over time, which forms the relationship between the user and their product. The term 'relationship design' follows along the line of 'experience design', but is more about the attachment and feelings towards the product over a longer period of time, instead of singular interactions. Even though the singular interactions eventually create the perception of the product, relationship design is more about the changes in needs and ability that might occur over time.

With more and more shared-ownership, a clear difference can be seen in relationships and therefore attitude towards products. With bicycles for example, people don't throw away a bike because they have a flat tire, yet the 'Swapfiets' company directly provides their customers with a new bike when something breaks. They do this so they can properly repair their bikes and therefore provide a valuable service to customers, by removing the effort of care. This is a circular business model, yet it creates a less valuable relationship between the bike and its owner.

Chapman (2005) related the concept to product attachment, as a way to increase product care and emotional durability. Different strategies for relationship design are animism, accommodating goals, communication, meaningful gamification and evolvability. These strategies focus on various aspects of design and characteristics which can overlap. Combining theory from different fields of research, relationship design has a lot of potential in improving the design of and attitude towards products.

Relationship design concept

In the design field, the focus has shifted from function, to experience and now system design. Experience design is about anticipating on emotion, focussing on individual interactions. System design combines various stakeholders, and is about designing the interactions between these stakeholders/ various products (Ceschin & Gaziulusoy, 2016). Therefore, in system design relationships are also very important. Nevertheless, in this context relationship is defined as the way in which the different stakeholders correspond to one another. The user is also a key stakeholder, but in terms of relationship might be seen as an initiator instead of a responder. In relationship design, the focus lies more on building this relationship over time, by both responding and commanding, and learning to work together. Most innovation today happens in the internet of things and artificial intelligence field. These fields are important and interesting, yet they cannot exist without their users. Teaching people how artificial intelligence works, and using it more frequently in household products is an important development which can increase relationship building and more informed decision making and interacting with products (Schwab, 2017).

__Theory

Relationship design is about anticipating change in the users' attitude towards the product and its values; a new product feels exciting, and it might disappoint or surprise later, depending on foregoing demands (Leube et al, 2016). One might strengthen/weaken values, or discover new values over time (Van den Berge et al, 2021). Mead & Baumeister (2021) argue that people use possessions to "develop, define, and communicate who they are", which relates to our attitude towards products and the value of relationships with products. The connection between users and products can increase if the product helps the user fulfil their goals.

Many researchers have proposed strategies to incorporate relationship building in the design process. Haines-Gadd et al (2018) incorporated it as one of their nine factors to extend product lifetime, proposing four strategies (figure 2). According to Leube et al (2016), relationships can improve by enabling both users and products to grow together. Furthermore, Karmann (according to Schwab, 2017) argues that relationships are about patience, and learning about each others behaviour (product and person). To conclude, **designing a sustainable relationship between users and their products is about anticipating and facilitating change in value.**

Figure 3: Overview of characteristics, strategies and directions on relationship building through design. The colours represent the credible researchers. Orange boxes/ fonts are used for 'other' strategies, credible by various researchers which are elaborated in the corresponding subheads. Specifically the theory of meaningful gamification is specifically set apart (in yellow) to portray its relation to the other strategies.

__Strategies

Attachment and emotional value have been researched before, yet Casais et al. (2015a) were one of the first to offer design strategies of how to implement it. They build upon the theory by Casais et al. (2015b) of how emotional durability can be shaped by implementing symbolic meaning in design. Casais et al. formulated sixteen design directions, all accompanying a short description and an example of an existing product. Chapman (2009) defined five characteristics that influence the strength of relationships to objects. Several researchers have looked into these different characteristics, proposing various strategies, which were summarized by Haines-Gadd et al (2018) (see figure 2). Figure 3 portrays an overview of relevant strategies (also discussed below), in relation to Chapman's characteristics and the sixteen design directions by Casais et al.

> *"The bond between people and things has always been filled with powerful and unspoken sentiments going well beyond functional expectations and including attachment, love, possessiveness, jealousy, pride, curiosity, anger, even friendship and partnership" (Antonelli, 2011)*

Animism

Antonelli (2011) wrote a book about the relationship between products and people. The history of artefacts shows that products have always meant a lot to people, but, like the theory of Animism (Leube et al., 2016) endorses, we have lost the natural connection with products. Based on Chapman's (2005) theory on emotional durability, Leube et al. (2016) defined seven characteristics to stimulate 'animism' through design: adaptability, energy, goal-oriented movement, memory, regeneration, sensation and communication. Because of these characteristics, people can unconsciously 'grant animacy' to products, which can trigger emotion. Throughout evolution, recognising objects could be alive has been beneficial to human survival. Nowadays, most of this can be found in religious instances, where objects have a spiritual soul, or are linked to a person. Leube et al. (2016) argue that products that act more as if they are alive will trigger more emotion from their owners, therefore enhancing its emotional value, resulting in motivation to care and preserve.

Communication

An important factor that influences the user-product relationship is communication. Watzlawick et al. (2017) presented 'Communication axioms', in which they stated "any communication implies a commitment and thereby defines the relationship". Antonelli (2011) also mentioned that "the nature of a relationship is dependent on the punctuation of the partners' communication procedures". According to Leube et al. (2016), communication is about listening and responding, which can also occur through pinching, tapping, touching, holding and talking to (and gesturing). The type of communication can be designed with the help of an 'interaction vision' (Pasman et al., 2011). In the interaction vision, the emotional outcome of the interaction is envisioned and anticipated through design. DeKoven & Keyson (2000) address that any communication is about dialogue, and that human-product interaction is about reaching a goal through dialogue. Some products gently help the user by providing feedback, where others might punish or alarm. The manner in which this is communicated affects whether the dialogue might feel collaborative, or judgemental.

> *"To achieve a more goal-directed level of interaction requires the ability to communicate at various levels, from product features to user goals. This dialogue is necessary in order to know what the user's goals are, and how best to achieve them according to the user's preferences and constraints. This requires two-way, give-and-take communication in order to reach a shared plan towards achieving the user's goal. In other words, this requires* ***user-product collaboration.***
> *– (DeKoven & Keyson, 2000)*

Accommodate goals

According to Mead & Baumeister (2021), products help people achieve needs, which forms the basis for the relationship between people and products. They state that, apart from the products function, people use products to achieve simple pleasures, or rather avoid small annoyances which positively affects their daily goal progress. Mead & Baumeister argue that this relationship should be regulated since it could lead to problematic outcomes when disregarded (in a form of product neglect or addiction). They link it to religious objects and self-regulation. In self-regulation, an end state is determined, then action is taken and **progress is monitored.** Especially the monitoring is important to be able to reflect to the goal and how it can be achieved, which can be very symbolic. By doing this, the product can be portrayed as a helper to achieve goals, rather than something that fulfils the goal. Hence, the user feels less dependent, and more supported. Additionally, Mugge et al. (2005) relates attachment to products that help people develop skills, where the user has an active role (f.e. carpenter tools).

Accommodating goals can also help the user form a more personal relationship with the product, if multiple ways of achieving a goal are available. **Allowing different people to find their way of reaching a goal can make people feel more confident in their own capabilities** (DeKoven & Keyson, 2000). If a product can be updated, new goals could be facilitated which would increase the functional value of the product. DeKoven & Keyson addressed that this personalisation does require a larger range of internal models (of tasks and user types), more complex dialogue rules and interaction capabilities (for preference and feedback), which might require new interaction metaphors.

Evolvability

Designing a relationship, all use phases should be considered. One strategy that relates to this is evolvability, also referred to as upgradeability. Van den Berge et al. (2021) explain that it is about "designing products that [illegible] and [illegible] to developing needs and/or technology with [illegible] and [illegible]". This could be done by adding parts, upgrading software, or hiding functions that can be discovered or revealed later. According to Van den Berge et al. (2021), evolvability is not applied at large scale, but product-service systems and modular (interchangeable) design could be fields where it can grow.

> *"the challenge is to keep the product developing and evolving side by side with its owner to preserve attachment and to reach a longer-lasting honeymoon period full of passion and desire". (Leube et al, 2016)*

Evolvability can also be facilitated through the **training of products.**

Bjørn Karmann (2016) developed a speculative product which enables people to teach common products personal gestures, to provide control and personal relationships (figure 4). Moreover, it can teach people about the functioning of artificial intelligence, to provide them with basic knowledge on how products can learn and give the user the authority of what and how the product can learn. Karmann did mention that you have to be very clear and precise in explaining interactions to an algorithm, since it can get confused. This can be annoying for people, but as Karmann states; "It's very much like a relationship as well. It's time based, you have to be patient. Those are the values I wanted to have in the product".

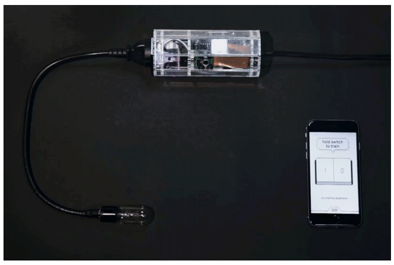


Figure 4: Objectifier; training device that can be plugged in to any product, guided by an app (Karmann, 2016)

Meaningful Gamification

Using game design elements to help build intrinsic motivation and, therefore, meaning in non-game settings is known as meaningful gamification. Nicholson (2015) proposes 6 design concepts that build upon intrinsic motivation (figure 5). This is based on the 'Self-Determination Theory' by Ryan and Deci (2000): **"rather than providing rewards for behavior, designers can create systems that help users find their own reasons for engaging with the behavior"** (Nicholson, 2015). It should provide a more positive experience and attitude towards the activity, which in term can result in long term loyalty and engagement in the company. Important to mention is that meaningful gamification is a means, not an end; it should evolve over time to prevent the user from getting uninterested.

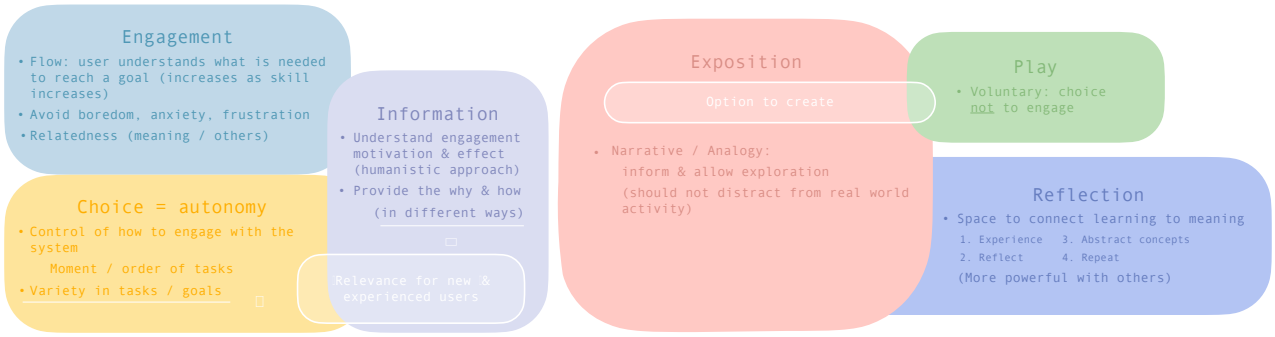


Figure 5: The six aspects of meaningful gamification (Nicholson, 2015)

Relationships to stimulate care

> *"Ultimately, **the ending of a product's life is a consumer decision.** The challenge resides, therefore, in designing products that support durable user-product relationships (van Nes, 2010) by focusing on durability of meaning and value (Chapman, 2005)." (Casais et al, 2015a)*

__Two-sided relationship building

Providing product care can become an important aspect in the relationship between users and their products. It is the part where users can show their side of the relationship, to make it more two-sided. To allow for this, products have to communicate and allow users to interfere. The interviews show that user-control plays a major part in this, and especially in the emotions related to the learning process. Rucker's (2021) research on object attachment describes a link with attitude and how attitude can be strengthened by emotion, depth of thought and level of certainty. Especially emotion and depth can be increased through relationship design. By focussing on creating habits from intrinsic motivation, users will understand the value of product care and feel confident providing it.

__Potential & limitations

According to Van Nes (2003), 78% of products still function at the time of replacement. This highlights the importance of the user's value of the product beyond its basic function, which can be strengthened through relationship design. Mugge et al. (2005) also calls this the psychological lifetime; "the time during which the product is perceived as valuable by the user". They state that it has an advantage as a circular strategy since it **does not rely on consumers' pro-environmental behaviour; it can benefit themselves.** Especially when combined with meaningful gamification, more value is added to keeping up with the care.

It is still unclear how the specific relationship design strategies influence product care and replacement, since they are not frequently implemented yet, and their effects and limitations have to prove themselves over time. Some strategies might also result in short-term relationships (Mugge et al., 2005). Nevertheless, strengthening the product-person relationship to prevent replacement is considered very important throughout literature (Van den Berge et al, 2021). Furthermore, Mugge et al. (2005) point out that incremental developments can have great impact, but designers should feel encouraged to explore radical innovations as well.

Conclusion & Take-aways

Relationship design is an overarching term that can be linked to various research fields. Casais et al. (2015) formulated sixteen design directions. To further enrich their theory, I would like to find out whether prolonging the learning process through ambient interfaces (by adding more dimension through various senses) can improve the product-user relationship. **My hypothesis is that through learning, users will create more positive memories (collaborating) with their products,** which will enhance their relationship. For this project, the main value lies in connecting the characteristics of ambient interfaces through the full product experience, eventually improving communication and attachment to stimulate product care.

For this theory to have impact, **the challenge lies in communicating its qualities to designers, providing support and guidelines to actually implement relationship design in the design process**. There is an opportunity in introducing lesser known research to designers, which could improve the meaning of their design actions. Especially since artificial intelligence is becoming more and more prominent, how interactions will change and feel will become more important as well. Thinking about the relationship should be a part of the design process from the start, when intentions about the character of the design are determined. If relationship design would become natural to designers, it could increase cooperation of different qualities within the design team, creating more flow in the product experience. Eventually increasing the attitude of users towards their products, improving general care and purchase behaviour.

> The main pillars of building engaging, rewarding, active relationships:
  - **Participation** through creative activities (letting the user reconfigure the product or learn a new skill or acquire knowledge through using it)
  - Mechanisms that encourage users to care, building a relationship of **mutual altruism**
  - Provide moments to **create ritual/ habit**; forming a relationship of stability and reliability
  - **Evolvability:** anticipating and facilitating change in value
  - **Animism:** adaptability, energy, goal-oriented movement, memory, regeneration, sensation and communication
  - **Communication** implies a commitment and thereby defines the relationship
  - **Accommodate goals:** user-product collaboration
    - Important that progress is monitored
    - Feedback character affects how the feedback is perceived
  - Engendering a feeling of **control**, a sense of **mastery** (through intimate knowledge of the product / its inner workings or the ability to use it well)

Strategies

> Allowing different people to **find their way** of reaching a goal can make people feel more **confident** in their own capabilities
  - To facilitate this, new interaction metaphors might be necessary

Mastery

> Incremental developments can have great impact, but designers should feel encouraged to explore **radical innovations** as well.

Radical innovations

> Increasing psychological lifetime has an advantage as a circular strategy since it does not rely on consumers' pro-environmental behaviour; it can benefit themselves
> **Teaching users about machine learning** can increase relationship building and more informed decision making in interacting with (household) products

Potential

Figure 6: Dangling String", by Natalie Jeremijenko, portrays moving data in an ambient way (Weiser & Brown, 1996)

1.3 Ambient interfaces in design

Since prehistoric times, humans have been 'designing'. Every object made by humans was essentially designed and through design we have been evolving into the humans that we are today. Products have become more advanced over time, and so has the design practice. We now assign specific people to design our lives, while at heart, every person is a designer. According to Leube et al (2016), interactions with products used to be natural in terms of use, became technological and complex over time, and with current technology are becoming more natural again, since we are able to improve communication between products and users. A specific strategy to implement natural communication is the concept of 'Ambient Interfaces'.

Ambient interfaces originated from a need for less obtrusive interactions to calm the environment (Weiser & Brown, 1996) (Wisneski et al., 1998) (Heiner et al., 1999) (Forlizzi et al., 2007). Their main focus was to help users prioritise information, by reducing the attention needed to notice interactions. It resulted in **playful explorations of interactions to communicate information streams.** More recently, ambient interfaces have been evolving to communicate more direct information, by increasing fluidity in design (Bielefeld University, 2022) (Austin & Wang, 2022). The focus is more on interactions feeling intuitive and seamless, by adding an element of adaptability (users and products learn from each other to improve communication and function). In this chapter I will explain the definition of ambient interfaces, explain how it can be used and its potential.

Defining ambient interfaces

When explaining ambient interfaces, I often refer to shifting gears in a car. You can look at the rev counter at read when you need to shift, but you can also feel and hear how the vehicle responds to your speed and then decide when to shift. The latter is an ambient interaction. It is **understanding subtle feedback** like you would in nature; often by using a **combination of your senses**. You have to gradually learn how to use it and by creating habits you allow yourself to listen more carefully and distinguish more detail. More scientifically, ambient interfaces is also defined as 'Peripheral displays' (Forlizzi et al., 2007) or 'Calm technology' (Weiser & Brown, 1996), which relates to the focus of the user's attention.

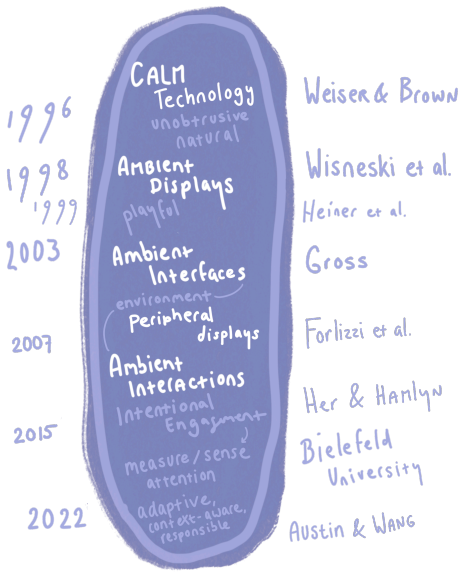
Calm technology

'Calm technology' was developed in the late nineties, when computers became more present in the office, and people started to become overloaded with feedback (Weiser & Brown, 1996). It was all on the same level; complex and attention-demanding. They argued for more hierarchy, and most of all, **more efficient and likeable interactions**. An example that they loved was the "Dangling String", an artwork by Natalie Jeremijenko (figure 6). It is a plastic string that is connected to the ethernet cable, moving as data is being transferred. According to Weiser & Brown "The long string is visible and audible from many offices without being obtrusive. It is fun and useful". It is efficient as it **uses minimal equipment to convey a simple message.**

Terminology

Several terms have been used to describe ambient interfaces (peripheral displays, calm technology, ambient interactions…). All terms have slightly different meanings, covering different parts. There is also a technological side to the term, since ambience is about using the environment.

For this project, **ambient interfaces** is described as an interaction vision with specific characteristics (unobtrusive, intuitive, playful, gradual) that can be used in product design. The term **ambient interactions** is used for interactions of an ambient interface.



Weiser & Brown explained that a calm technology is encalming because of its easy movement between the periphery and the centre of attention. This makes it easier to prioritise and focus, since the observer is in control. Besides, information that is noticeable from the periphery is informing without overburdening the mind. It is useful for daily interactions, which you don't want to be dominating (like you would with a movie or a video game for example). This is also something that can be trained; bringing more details into the periphery can 'enhance the peripheral reach', allowing for better focus. Comparing calm technology to the notion of affordances, they state: "for us the term "affordance" does not reach far enough into the periphery where a design must be attuned to but not attended to". Since an affordance is often about a specific shape or surface design that hints about possible intentions and capabilities.

To conclude, calm technology encalms as it empowers the periphery, by giving the observer control of their focus. As a result, the interaction can come to feel familiar, and give a sense of '**locatedness**': general awareness of what is happening in one's surroundings.

__Ambient displays

In 1998, Wisneski et al. coined the term Ambient display, to use in an architectural space to "present information within a space through **subtle changes** in light, sound, and movement, which **can be processed in the background of awareness"**. Heiner et al. (1999) used it to create a **playful** art piece that could convey information with bubbles in tubes filled with water. With their work they explored how ambient displays could provide background or context information, which an observer can attend to "only when appropriate and desirable." They also addressed how **ambient interfaces are very common in the natural world.** We are constantly exposed to small indications about the state of the weather, what mood people are in or how many people are around.

__Fluidity (Bielefeld University)

Bielefeld University (2022) has a research department specifically for ambient interfaces. They focus mainly on the control on attention, and try to make interactions more **seamless** and fluid. They also embrace the **playfulness** of ambient interfaces by, "if applicable, using artefacts that do not necessarily appear as controllers, such as tangible user interfaces, or by using gestures or physical contact". An example of this playfulness is displayed in the 'Power aware cord' (figure 7). It portrays how electricity flows through a cable, which can be perceived directly, but does not require the observers full attention.

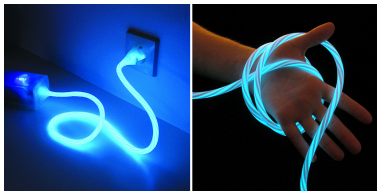


Figure 7: The Power Aware cord by Anton Gustafsson and Magnus Gyllenswärd (Helmke, 2013)

With fluid, they mean making interactions **adaptive** in a sense that **both the product and the user learn how to work with each other.** For example by increasing possibilities as users get more acquainted with the product. They use 'Cognitive Interaction Technology' to make this progress more natural to interact with.

__Mindful & adaptive (Austin & Wang)

According to Austin & Wang (2022), ambient interfaces can "better accommodate the humans who use these interfaces". Human-computer interaction researcher Yujie Wang collaborated with speculative designer Bram Fritz to research the implementation of ambient interfaces in the domestic context. They focussed on imagining a less demanding and intrusive user interface, that "would move beyond the screen". Wang described ambient interfaces (for the home) in five principles. They offer a mostly corresponding, but slightly different view on ambient interface qualities as described in the previous paragraphs. Table 2 cites Wang's principles, accompanied by the ambient qualities, which are explained in a more extensive way in the next 'Ambient spectrum' section.

Ambient Qualities	Principle	Description	Example technology
Unobtrusive	Mindful	• facilitate subconscious and intuitive interaction, rather than loudly announcing themselves	• wireless sensing and imperceptible computing, which would enable these interfaces to operate in the background rather than foreground, minimizing their presence
Playful, Intuitive	Sensorial	• interact with a wider range of human senses, particularly sound and touch, corresponding more fully to our actual experience of our environments	• Electronic textiles and auditory ambient feedback are just two promising avenues for engaging the senses of touch and hearing, respectively, encouraging more tactile and multi-sensorial interactions
Gradual	Adaptive	• adaptive and responsive to their users' ever-changing needs, preserving their valuable attention and cognitive bandwidth by anticipating those users' physical conditions and emotional states via sensory input, and tailoring their responses accordingly • respond with empathy	
Unobtrusive	Context-aware	• ambient interfaces would be aware of their physical context, gathering input from the home environment itself as well as from its inhabitants using device-free localization and context-aware computing • these qualities will further enable these interfaces to disappear into the background, freeing the home's occupants from the task of constantly attending to them, and achieving better alignment between humans and their domestic environment	
Relates to the qualities (especially gradual), but is more about trusting how data is used, which is not relevant for ambient interactions in general	Responsible	• must assume responsibility for the intimacy of their setting • privacy, of course, is of the utmost importance – this technology will adhere to privacy by design – as are reliability and inclusivity, which are supported by universal design principles • unlike analog objects in the home, connected devices introduce more complexity along with the risks that accompany that complexity • if a home's inhabitants cannot trust the digital tools they live with, no amount of utility will compensate for that	

Table 2: Ambient Interface principles for domestic interfaces, according to Yujie Wang (Cited from Austin & Wang (2022))

Implementing ambient interfaces

The concept of ambient interfaces relies on the implementations of various characteristics. The aforementioned researchers all present different views on these characteristics, which can be summarised in four ambient qualities. On the next pages each quality is explained through examples.

Applying the qualities does not automatically make an ambient interface effective. According to Gross (2003), interactions should also comply to a list of guidelines, which are described in the 'evaluation' section.

Ambient Spectrum

A spectrum might be the best way to present the qualities, because the amount and strength of each quality can vary per interaction and product. Most (unnatural) interactions are not totally ambient, but might possess some of the ambient qualities. Each quality is presented on a scale, accompanied by (hypothetical and existing) product and interaction examples. The range displays how some interactions portray different levels of each quality.

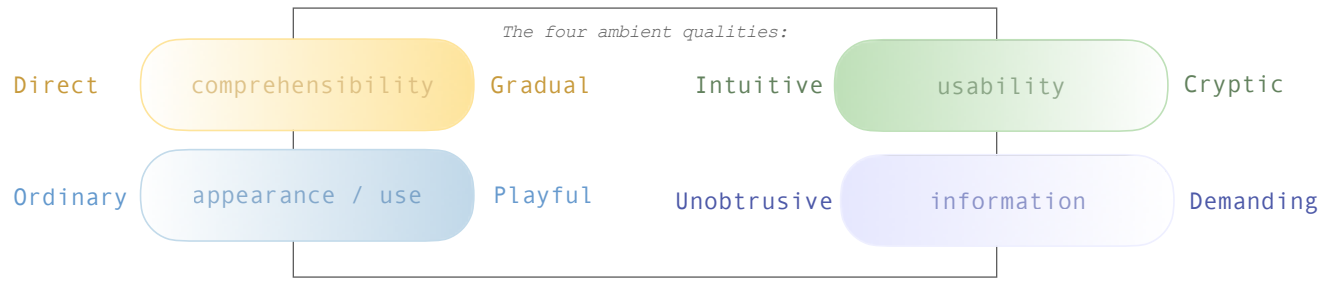


Figure 8: Examples of interactions: gradual (continuous communication, Subliminal Watch (Auger & Loizeau, 2004), sailing,) to direct (Sealock boat toilet)

Gradual learning

To adjust the sails when sailing, one has to pay attention to the direction of the wind, and feel the force on the sails. Both the visual cues of the direction of the wave and the curving of the sails, as well as the tactile cues of force and wind add to the ability to feel how to interact with the sails. To learn this ability takes time and practise, which is a gradual learning process which will **become easier and more efficient over time,** since small changes will become more obvious to notice. This principle is also used in the 'Subliminal Watch' (figure 8). Through electric pulses, it can teach people to subconsciously 'know' time. Another implementation of gradual learning could be continuous communication of mood and function. Designing a 'language' for a product might help people better understand their products functions and needs.

Reading precise numbers of a screen can be **distracting** to users (for example when shifting gears). Using multiple senses (audible feedback, feeling vibrations) can help users perceive the state of a machine and therefore handle it with more ease. Regardless, in some situations, it is more practical to receive direct feedback, or to combine clear, textual numbers and ambient feedback to be able to confirm doubts. For example, when it can be dangerous, like risk of overflow in a boat toilet (figure 8).

Intuitive

Removing a screen interface can make an interface feel more **natural** (Austin & Wang, 2022). Enhancing and anticipating on natural features of a product could increase usability, since there is a **direct link between function and feature**. Cars with lane assist magnify natural feedback, by slightly vibrating or correcting when people are not keeping to their lanes. It could also be utilised through other senses, for example by making a vacuum cleaner smell extra good when its bag has been replaced, or bad when it needs to be replaced. Moreover, Schifferstein & Desmet (2008) argue that the natural logic of a product depends on the use of all senses (**multi-sensory design**), therefore, designers should pay attention to familiar connections that people can make between perceived characteristics.

Intuitive associations can also make the use process more **efficient** by removing steps and/ or buttons. The difference between regular asthma treatment and 'Otto' (Sahin, 2020) demonstrates this efficiency (see figure 9). Generally, asthma patients have to go through multiple steps, using an inhaler, measuring peak flow and noting the measurements down to calculate the amount of medicine needed. With Otto, they just breathe out into the device, look at the lights and listen to audible feedback to determine when to stop, and then the device calculates the right amount of medicine, which they can breath in through the same device. Additionally, Otto requires the user to shake the device to 'wake it up', which is simultaneously a way to mix the medicine. More about Otto and its ambient qualities can be found in the 'Evaluation' section (page 35, figure 12).

Figure 9: Examples of interactions: intuitive (Otto inhale & shake function (Sahin 2020), vibration in steering wheel, vacuum cleaner smell) to cryptic (peak flow meter (HealthJade.net, 2019))

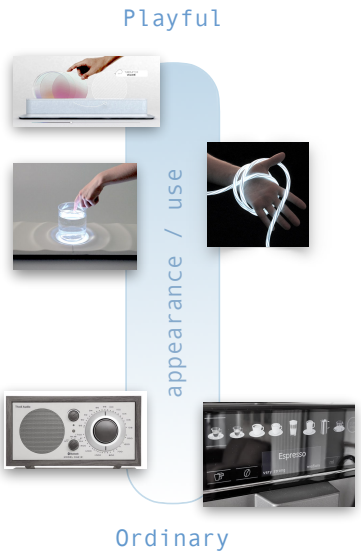


Figure 10: Examples of interactions: playful (Layered radio (Sheth, 2017), Water light (Turner, 2011), power-aware cord (Helmke, 2013)) to ordinary (radio (Han, 2015), coffee machine LCD screen (The Techregister UK, 2019))

Playful

Ambient interface theory encourages designers to explore experimental, playful ways to interact with products. According to Chapman (2005), most current interactions are meaningless. **Providing meaning through experimental interactions** could make these interactions more **distinctive**, **unique** and **interesting**. An example is the power-aware cord by Anton Gustafsson and Magnus Gyllenswärd, it displays the amount of electricity flowing to the device. Its function is to make users aware of their energy consumption, in a way that is interesting and **noticeable**. 'Water light' by Viktor Alexander Kölbig demonstrates playfulness by allowing the user to modify the colour and shape of light by 'playing' with actual water (moreover on page 38).

Ordinary interfaces often present data in a textual way (f.e. radio and coffee machine in figure 10). This provides the user control, but when too many options are presented, can also confuse them (see interview results, page 14-15). Designer 'X-Factor' translated the features of a radio to layered discs, which allow the user to control volume and bass (among other variables). Since this interaction is more physical and creative, it teaches its user to think about music in a different way and **personalise** its outcome.

Unobtrusive

Regular product communication can be rather obtrusive and **demanding**. Loud beeps communicating that the fridge door has been left open, or that particular passengers have not put their seatbelt on are very effective, but also annoying. They do not align with the 'calm technology' qualities and vision as described on page 28. The dangling string on the other hand, translates data in way that is noticeable, but also very **simple**. Subtle changes notify bystanders that something is going on, but allow them to decide how much attention they want to give it. The Condensation Cube by Hans Haacke (figure 11) is an example of an interaction that could provide the same possibilities. If applied in a coffee machine, for example, it could communicate that the water tank needs to be refilled, or that the machine should be descaled.

Obtrusiveness is not only present in notification, but also in **operation**. The LCD screen on a coffee machine for example, demands full attention to operate. It guides the user through multiple steps, to prepare the desired coffee. In an analogue espresso machine, these steps are **divided over separate features** (grinding coffee, measuring the amount, timing water volume). In a way this could feel like more effort to understand, yet it can also become more effortless over time. People can get used to the feeling of preparing coffee, by **using multiple senses** to understand the various components of the process. According to Ghosh (2018), this relates to the concept of '**transparent technology**', in which the tool is not the focus of attention in use, but rather a means to accomplish a goal with. Using a pen for example, the user 'sees through' the pen, and focusses on the writing, instead of holding the pen.

Figure 11: Examples of informative interactions: unobtrusive (Condensation Cube (MACBA, 2022), dangling string (see figure 6), analogue espresso machine (OPTION-O, 2021)) to demanding (fridge door, coffee machine LCD screen (The Techregister UK, 2019))

Evaluation

Gross (2003) defined a set of guidelines to evaluate ambient interfaces. Every ambient quality should comply with these guidelines, to contribute to an effective ambient interface.

Communication

- **Effective**, meaning that they should have limited goals to communicate qualitative information.
  - **Good utility,** "easy input for simple actions or for subtle presentation of simple information".
- **Visible functionality,** the interface should provide clear communication to which choices there are and what the system expects (recommended through physical affordances).
  - Easy to **learn** and **remember** using analogies could make this easier, but since unconventional interactions are recommended, the balance between fun and unclear can be difficult to keep.
  - **Adequate feedback**
  - **Consistent functionality,** use similar interactions for similar tasks

Goal

- **Efficient,** the interface should support the user in their tasks.
- **Context adequate,** the types of interactions should fit the target group/ context

Example product

A good example of a product that has an ambient interface is 'Otto' by Birnur Sahin. Otto is a device that helps asthmatics to measure, track and inhale medicine in the right way, by guiding the user with lights and sounds (figure 12). By using an unconventional interface without buttons or a screen, it makes the use of the device very **intuitive**. Users can activate the device by shaking it, thereby also mixing the medicine (**playful**). To measure how much medicine is needed, users can exhale into the device, with lights and sound providing feedback of a successful measure (**gradual**). When inhaling, the correct dose is provided, again guided by lights and a sound that counts down. When done, the device can be stored on a charger (so no reminders about charging are necessary; **unobtrusive**). To conclude, Otto is a very efficient, intuitive device that provides adequate feedback, simple steps and allows the user to understand what is happening by linking actions to functions (f.e. shake to mix & start).

Figure 12: 'Otto' by Birnur Sahin (2020); a device to measure, track and inhale asthmatic medicine in the right way, guided by lights and sounds.

Value and potential

Ambient interfaces, if designed correctly, could increase the **naturalness of our relationship with products.** Their unobtrusive output, intuitive technology and playful references can make regular interactions more positive, which could increase **compassion** towards products. Ambient interfaces are a natural phenomenon, which can be translated to our tech-filled life by incorporating the right qualities.

Especially in relation to product care, there is a lot of potential for the implementation of ambient interfaces. To change people's **attitude** towards product care, general **communication** through the product's design needs to change. Applying ambient interfaces provides a new way of interacting, which is especially promising when combined with a **gradual learning process** which can make product interactions more **timeless**.

The characteristic 'natural' is specifically interesting concerning product care. 'Natural' does not necessarily mean 'common', or 'like found in nature', but more 'intuitive', or 'related to its source/ goal'. One might use an unfamiliar, unique or experimental way to convey a message. According to Chapman (2005), too few designers dare to do this, which results in users that are unaware of the "banality" of objects, to which people mindlessly interact. Mugge et al. (2005) state that uniqueness and **irreplaceability** can be very influential to product attachment, ambient interfaces can be used in unique ways, and perhaps become personal if different paths are presented towards similar outcomes. Furthermore, Mugge et al. argue that implementing odours are very effective in arousing mood or feelings, which could **encourage the creation of memories** with products. Memories have a major impact on product attachment.

> *"Imaginative design will be a crucial factor in enacting sustainability in people's daily lives."*
> *– (Walker, 2011)*

For product care tasks, users can feel particularly bothered to take action since its value can be unclear directly (see chapter 1.1). Also, people tend to feel less motivated to take care of products that 'serve them' (that they bought for ease). If these products could **express themselves better**, users might feel more compassionate towards them. During the consumer interviews (chapter 1.1), it seemed that people's **perception of control** was one of the biggest motivators to care. If they felt like there was some risk, but that they could determine when they would perform care tasks, they were more okay with it. Since control is a major part of ambient interfaces, this could mean a lot for product care.

Conclusion & Take-aways

Ambient interactions feel intuitive, because of their adaptability and emphasis of natural feedback. They do not require full attention to be noticeable, therefore feeling unobtrusive to their observer. By using creative methods, designers can implement playful elements to communicate information in a more positive and simple way. Overall, this can leave the user feeling more compassionate towards their products, and enhance a two-sided relationship between user and product.

There is a lot of potential in implementing ambient interfaces in a broader design context, however, it is fairly unknown as a method. This might be because of its experimental character, or because no mainstream product manufacturer has explicitly used its qualities. Additionally, current applications of ambient interfaces are mainly about communicating information streams, instead of communicating needs or feedback. Recent research explores more direct communication by looking at adaptable technology that can notice the users attention, and personalise communication to make it feel seamless. Still, in the case of many ambient interfaces, it is about the attention that the product demands within its environment. This makes it hard for designers to determine the ambient qualities/ possibilities for a single product, without taking the surrounding products in account. Nevertheless, the impact on the relationship between user and individual product has barely been tested, which could be very valuable on its own. Hence, there is a lot to discover for designers in this area. Even taking the different characteristics of ambient interfaces apart could result in meaningful qualities that can elevate the product-user relationship.

Communication

> Main characteristics:
- **Unobtrusive**
  - calm: easy movement between the periphery and the centre of attention
    - makes it easier to prioritise and focus, since the **observer is in control**
    - a design must be attuned to but not attended to
  - natural: understandable by using multiple senses
  - **gradual:** learning over time, simple messages
    - can make product interactions more timeless
- Fluid
  - **playful**
  - seamless/ **intuitive**
  - Adaptable (learn together)

> Ambient interface evaluation:
- **Effectiveness**: limited goals, qualitative information
- **Utility**: easy input, simple actions, subtle presentation of information
- **Visible functionality**: clear communication, present choices and expectations
- **Learnability**: easy to learn & remember (f.e. analogies)
- **Adequate feedback**
- **Consistency**: similar interactions for similar tasks

Goals

- **Efficiency**, support the user in achieving goals
- **Context sufficiency**, fitting interactions for target group/ context

Potential

> Ambient interfaces can increase the **naturalness of our relationship** with products
> Through positive interactions ambient interactions can spark **compassion** towards products
> To change people's **attitude** towards product care, general **communication** through the product's design needs to change
> **Uniqueness** and **irreplaceability** can be very influential, ambient interfaces can be used in unique ways, and perhaps become **personal** if **different paths** are presented towards similar outcomes
  - Odours can increase memory creation, which can improve product attachment

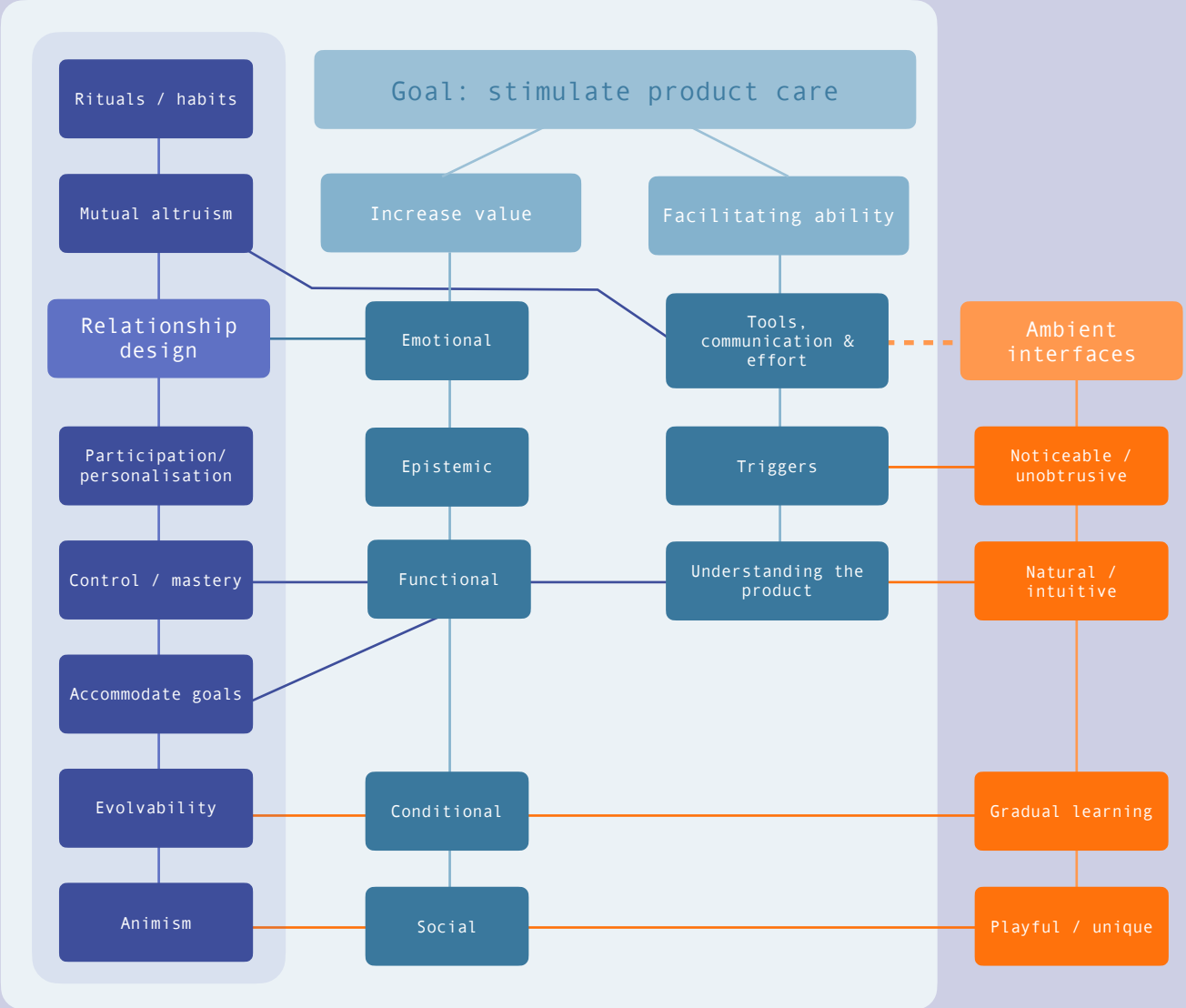


Figure 13: Overview of three main subjects (Relationship design, Stimulating product care & Ambient interfaces), and their aspects in relation to each other

2.1 Design brief

Looking at the research fields of product care, relationship design and ambient interfaces, there is a lot of overlap. An overview of the main insights (figure 13) summarises the connections between the fields. It shows how ambient interfaces fits both product care as a broader field, as well as the theory of relationship design within product care.

The connections between these fields are interesting, but only valuable when put into practice. From product care, relationship design and ambient interfaces, various researchers have proposed strategies to implement into the design process. For product care, some tangible tools have been developed (like the product care kit). Whereas for relationship design and ambient interfaces, only a few theoretical guidelines and some examples exist.

Therefore, the design goal of this project is **to create a tool that connects the characteristics of ambient interfaces through the full product experience, eventually improving communication and attachment to stimulate product care.**

Concluding Take-aways

Each research chapter (Design for product care (1.1), Relationship design (1.2) and Ambient interfaces in design (1.3), ended with a list of take-aways. Putting all of these take-aways together, they can be listed in 12 subcategories of similar insights (appendix 3), which can be combined into 9 categories for 4 themes (table 3). These themes serve the end goal 'to stimulate product care'. Figure 13 shows a schematic overview of the take-aways and their connections.

Themes	Categories	Subcategories (see appendix 3)
Personal capability	Feeling competent	Confidence to explore
		Enhancing care ability (tools, communication, automation)
	Unique Personalisation	Learn through appearance, feedback, affordances
		Radical innovations
Effort to achieve goals	Guiding goals	Overview connection between goals & options
	Intrinsic motivation & perceived effort	Effort vs result
		Comfort & confidence reduces effort (habit forming)
Motivation	Product (care) value	Increase Emotional value (motivation)
		Increase Functional value (motivation)
		Increase Conditional value (motivation)
	Feeling autonomous	Control = timing
Communicating	Needs & attitude	Communicating needs
	Responsibility	Quality & effort expectations
	Personality/ mood/ character	Increasing compassion

Table 3: Categories & themes from take-aways.

Connection between the research fields

Relationship design is part of design for product care, since it is a strategy to increase emotional value. To design for relationship building, many separate strategies can be applied. Some of these strategies relate to another aspect of design for product care; 'facilitating ability' (figure 13). Facilitating ability is mainly about product communication. This is where ambient interfaces could play a role. **Ambient interfaces provide qualities which can be valuable to stimulate product care through the communication of specific care activities, but also through the motivation that evolves from building a relationship of understanding and exploring.**

Relationship building through ambient interfaces

Austin & Wang (2022) argue that some domestic interfaces can feel very complicated, "serving the needs of the devices themselves more than the humans who use them". These devices are bought to fulfil a specific task, yet if their interfaces are too difficult to understand, it can feel like they complicate rather than support. According to Austin & Wang, implementing ambient interface principles can help users in understanding interfaces, by adapting and communicating in a mindful way (see table 2 for the full description of their principles).

Nicenboim (2014) explains that ambient qualities like unobtrusiveness and gradual learning can train people to notice subtle changes. She compares this to the relationship that people build with animals, where they get familiar with character traits which allow them to understand what animals want and need. The better the user knows the product, the closer their relationship can grow. This is also affirmed by Watzlawick et al. (2017), who stated that communication forms the basis of a relationship.

An example where ambient interfaces are used to strengthen product-user relationships, are three interactive light objects by Viktor Alexander Kölbig (figure 14).

"Air Light- this lamp is developed to give the user the ability to adjusting the light without touching it. Just the presence of the hand inside the ring is enough to turn it on. A magic color change is triggered when the user simply turns their hand!"

"Seide- this lamp develops its fascination the moment you touch the soft, smooth textile interface. Depending on how far it is pushed inside, the user can brighten and dim or turn it off by petting it gently."

"Water Light- fascinated by moving water and the reflections of light on the surface, this lamp consists of a light source and container holding water. The water not only spreads the light, but also acts as the interface for adjusting brightness and color. The amount of water added or taken away adjusts the amount of light, and stirring the water with your finger changes the color of the light- just like mixing water colors."

Figure 14: Air light, Seide and Water Light; three interactive lamps that strengthen the relationship between product and user through ambient interfaces (Turner, 2011).

Context

The design process generally starts with a problem definition or an innovative possibility. Either way, a concept is developed around a new solution. At some point (which can also be the start of the project), the character of the product is determined. It can be initiated by the company (to support a specific brand-image for example), or by the design team. Often, a mood board and/or mind map is created which forms the basis for ideation and prototyping of shapes, materials and interactions.

The main themes of this project's research regard communication, usability (capability & effort) and motivation. These themes are intertwined in the interactions of the product, and can be translated to a product character. This is where using the insights regarding relationship design and ambient interface implementation can have most impact, **when designers are relatively free to come up with radical solutions, but the main functionality and needs of the products are determined already.**

__Target group: electronic household product designers

Electronic household products have substantially small lifetimes, compared to other (big/ analogue) household appliances (Wieser et al., 2015). Furthermore, Stichting Repair Café International (2018) concluded that 70% of all their repairs were electronic household products, of which many were caused by poor maintenance. Additionally, Kim & Christiaans (2016) concluded that of product returns (in the US), 68% were due to 'soft problems'; non-technical problems, mostly related to perception of quality. This shows that **the problem of returns is inherently one concerning communication, of care needs and guidance, but also of usability in general.**

*"It turned out that all [soft] problems expressed by users were related to their perception of the product's 'instrumental quality', i.e. the extent to which the device contributes to the performance of users or to the **promotion of their goals**" – (Kim & Christiaans, 2016)*

Therefore, the target group to support with new information and inspiration on interactions are electronic household product designers, especially in large corporations that can have big impact on general consumer attitude.

Methods

From the start of the project, the goal has been to have stimulate care for all electronic household products, and develop a general tool that can be used for many designs. Focussing on improving a single product would not show the versatility of the various theories and strategies that are possible within product care and ambient interface design.

Hence, a set of guidelines has been iterated on through the project, tested and modified into various formats, with different focuses.

__Benchmarking

Changing the format, I looked for inspiration on method writing by analysing design methods (f.e. Roozenburg & Eekels, the Delft design guide) and reading Method content theory (Daalhuizen & Cash, 2021). Furthermore, I explored existing design tools by interviewing the creators of the product care kit (Ackermann et al., 2019). Additionally, I looked into various prototyping tools like 'Little bits', and explored physical and online tool(kit)s.

__Interviewing designers

To gather more information on the needs of designers regarding interaction design and prototyping tools/ inspiration, I interviewed 6 Industrial Design bachelor students that were participating in the course 'Digital interfaces' in Delft. To compare, a master student of Integrated Product Design was also interviewed.

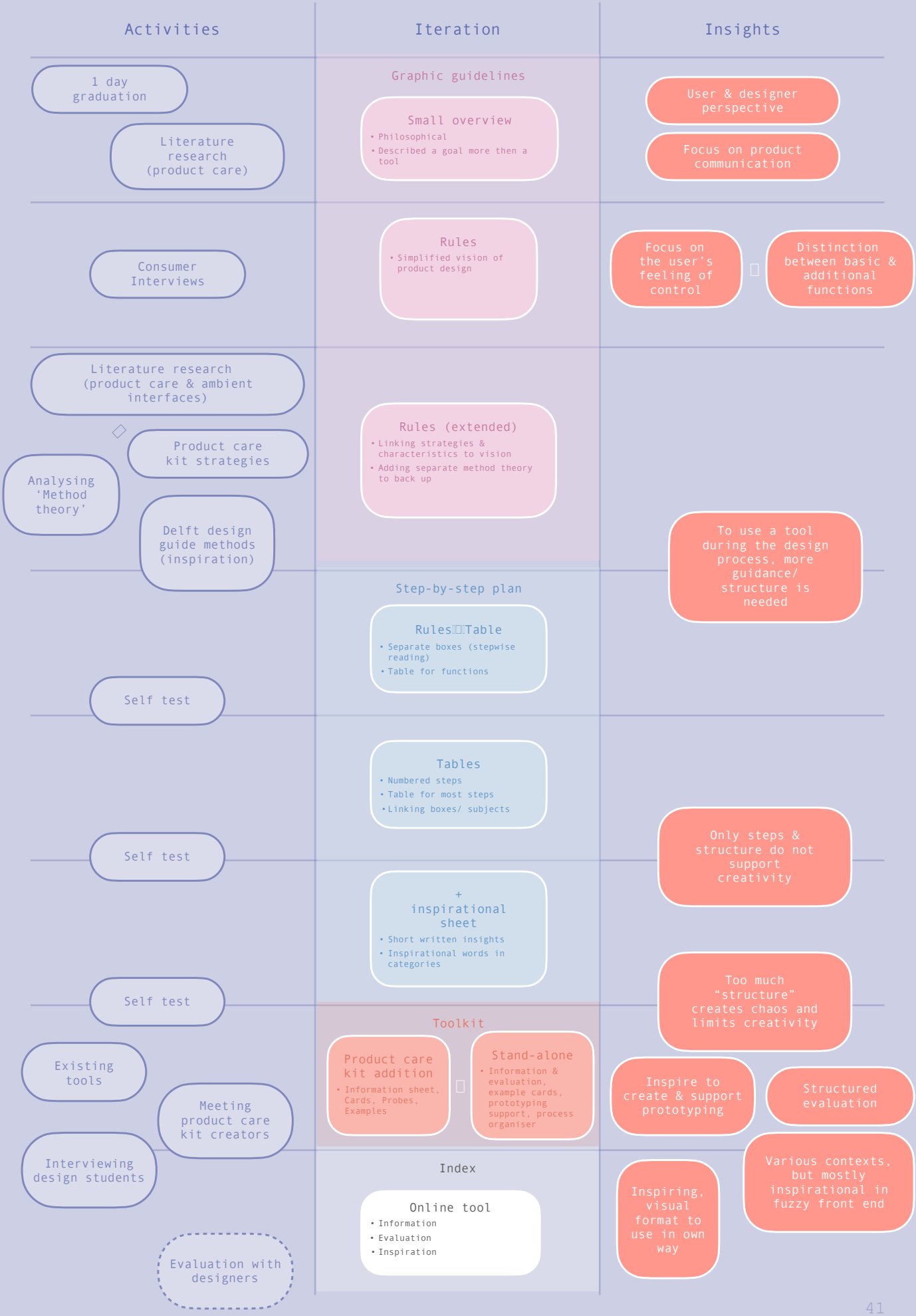


Table 4: simplified overview of index development with activities, iterations and insights gained

2.2 Index development

From the start of the project, I wanted to create a tool to support designers in designing for product care by informing them about the use of ambient interfaces. At first this was proposed through **graphic guidelines**, which became more of a **step-by-step plan** with tables, then a **toolkit** and eventually the online **index**. The amount of information and focus of the tool changed with every activity that took place during the project. From every iteration, I gained insights, which eventually came together in the final concept (for every iteration, the main aspects are accentuated in bold text). A simplified representation of this progress can be found in table 4. Major changes are explained below, accompanied by some of the iteration visuals. A more elaborate journey, including all iterations can be found in appendix 4.

Graphic guidelines

At first, the guidelines were a mere theory, which was translated to a vision about how ambient interfaces could be integrated in design (figure 15). The format was chosen to provide an **overview of the steps** where ambient interfaces could fit, and what rules would make the interactions effective. It was very philosophical, and felt more like a design goal than an actual tool. It was not tested, since I first wanted to conduct consumer interviews to improve my knowledge of how users perceive their products in relation to care (see page 12-16).

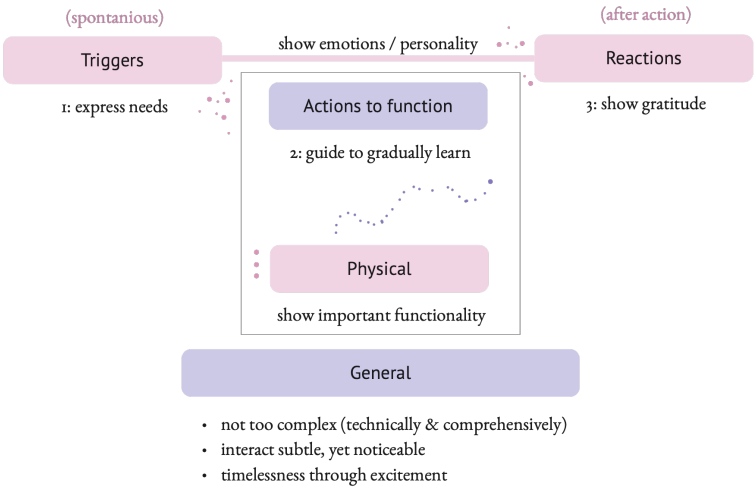
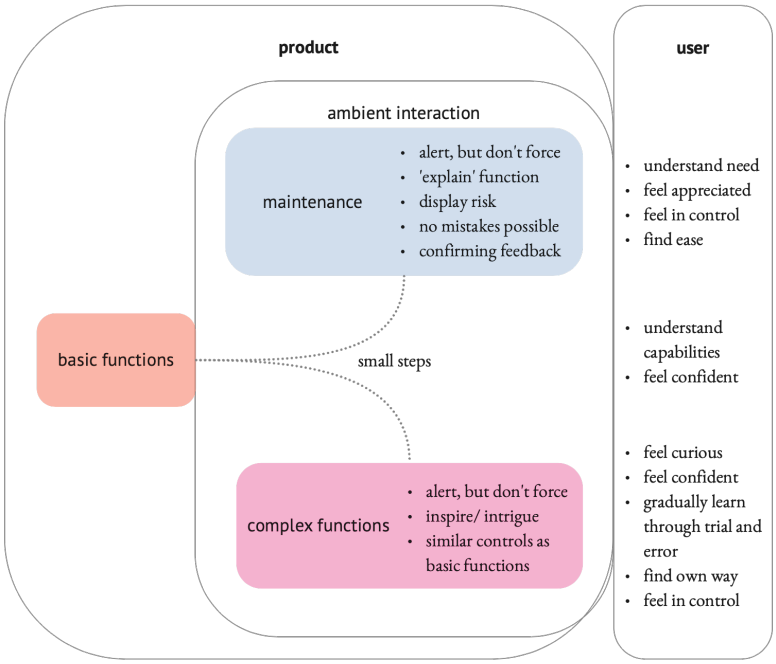


Figure 15: First draft of the guidelines; a graphic overview of how the product could communicate in an ambient way in three steps, and general rules.



After the interviews, I added more detailed descriptions of specific 'rules' that either related to maintenance activities or complex functions (figure 16). Also, I made a **distinction between what the product should evoke and how the user should perceive that.**

Most interview participants stated that an ambient interaction (that a user would need to learn to understand), would not be appreciated at any given moment, especially when they desired to use a basic function. Therefore, I decided to **exclude basic functions from the ambient interaction design.**

Figure 16: Guidelines iteration after the interviews, showing a distinction between what the product should evoke and how the user should perceive that

Step-by-step plan

I analysed 'Method content theory' by Daalhuizen & Cash (2021). By answering and applying the different parts of this theory, I aspired to add more profoundness to the guidelines. The theory did not directly come back in the guidelines, but it did form a basis which I kept in mind (figure 17).

Figure 17: The five aspects of method content theory (Daalhuizen & Cash, 2021) in orange, with descriptions for the guidelines in purple.

An important part of the theory's aspects was to **guide the user towards a goal**. Keeping this in mind, and taking inspiration from the methods in the 'Delft design guide', I tried to present the guidelines in a more **stepwise** way (figure 18). I tried to formulate a test with the guidelines, but I thought that the steps would not be clear enough. Therefore, I **added tables to increase overview.**

When testing the guidelines myself (appendix 5), I felt like I needed even more tables to make the steps easier to understand. I also added an '**inspiration section**' underneath, which includes the main principles of ambient interfaces and the product care strategy take aways (figure 19). This inspiration was to help provide more information about **what an ambient interaction could look and feel like**, since I got stuck while trying to come up with creative interactions.

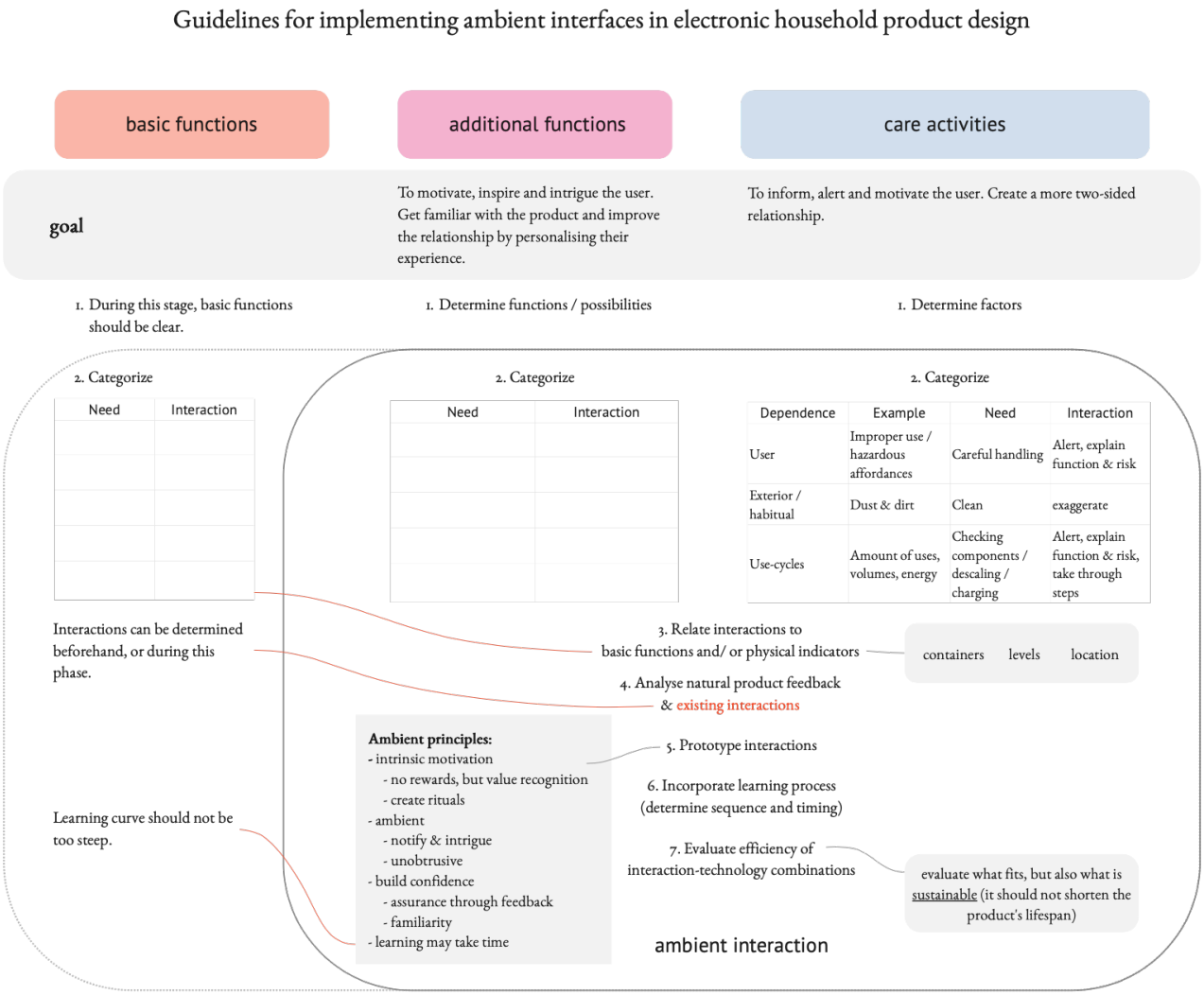


Figure 18: The guidelines with a specific goal mentioned on top and numbered steps accompanied by tables.

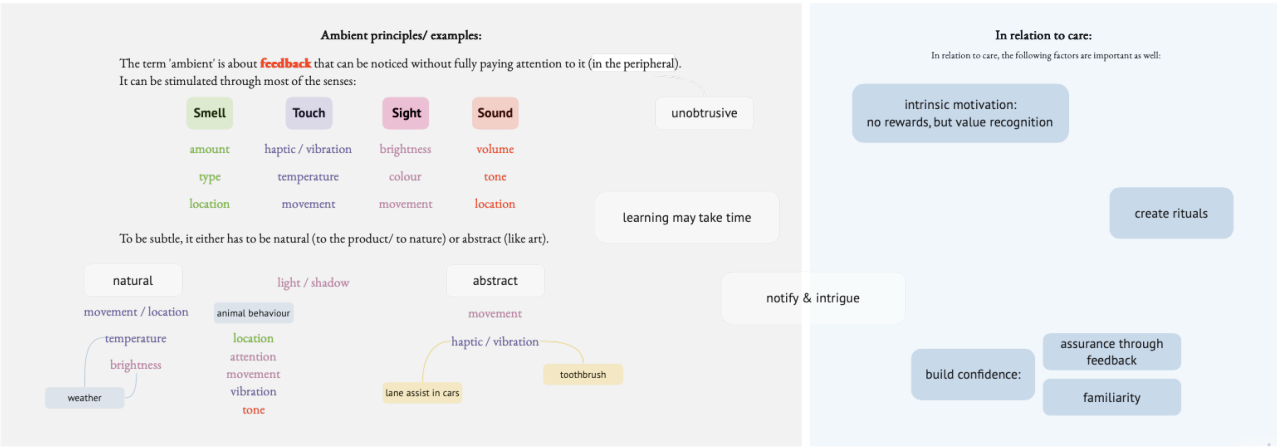


Figure 19: Inspiration section, explaining how ambient interfaces stimulate the use of all senses, a few examples of where they are used (animal behaviour for example), general characteristics and tips for product care implementation

Toolkit

When finishing the self-test, the **tables became very overwhelming** to work with. Especially during the most important part; designing interactions, **the table format seemed to reduce creativity**. Therefore, I explored various ways of presenting the guidelines, focussing on the goal '**to inspire and inform**'.

Looking back at existing methods, I returned to the product care kit, which I analysed before to learn about strategies in designing for product care (see chapter 1.1). The product care kit consists of magnetic cards that can be used during an ideation session, with product examples and an information sheet (figure 20). The various strategies proposed by the care kit share a lot of similarities with the information that I want to elucidate with my tool. Yet, the care kit lacks practical inspiration on interactions.

At first, I wanted to make a tool that could be added to the kit, in the same format. This was supposed to make the link from ambient interfaces to care easier to understand, but also to separate the two theories more. Extending the Product care kit with 'ambient additions', could provide more focus on the development of specific interactions with ambient characteristics.

I added an evaluation form, to **help designers decide which interactions would fit best** (to the ambient qualities). **To stimulate creativity and prototyping, I also wanted to add a set of probes.** In the paper about the product care kit, they state that "a fun, visual and easy to use design tool is more likely to inspire and enthuse people about product care than a piece of text can" (Ackermann et al, 2021).

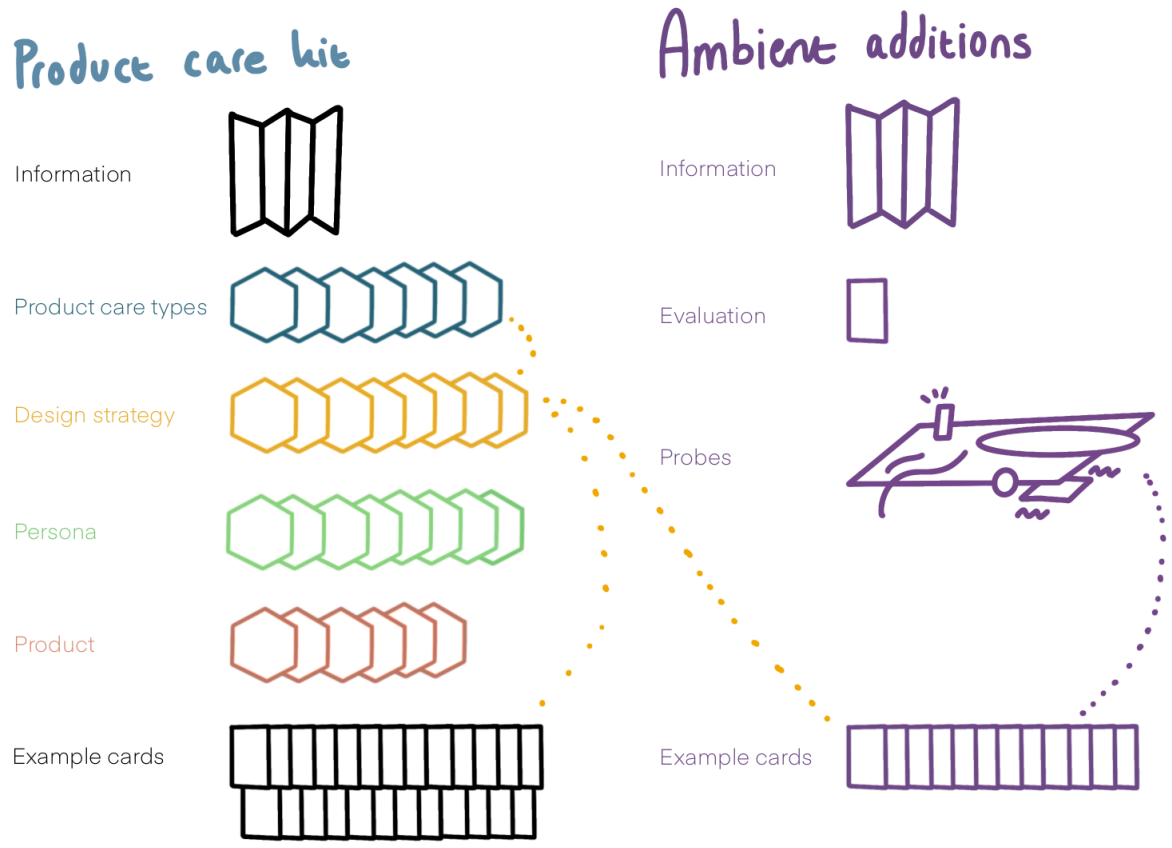


Figure 20: The product care kit elements (hexagons are magnetic) and the 'ambient additions', an additional toolkit to use ambient qualities in product care design.

Ambient qualities are not only beneficial to use to stimulate product care, but are essentially implemented to make interfaces more mindful to use. Additionally, I figured that the toolkit should be **accessible** to use with any preferred method or tool. Therefore, I decided that the 'ambient additions' kit should not just be an addition for the product care kit, but should also **work on its own,** or in combination with other tools or methods**.** This is what led to the basis for the 'Ambient interaction kit' (figure 21).

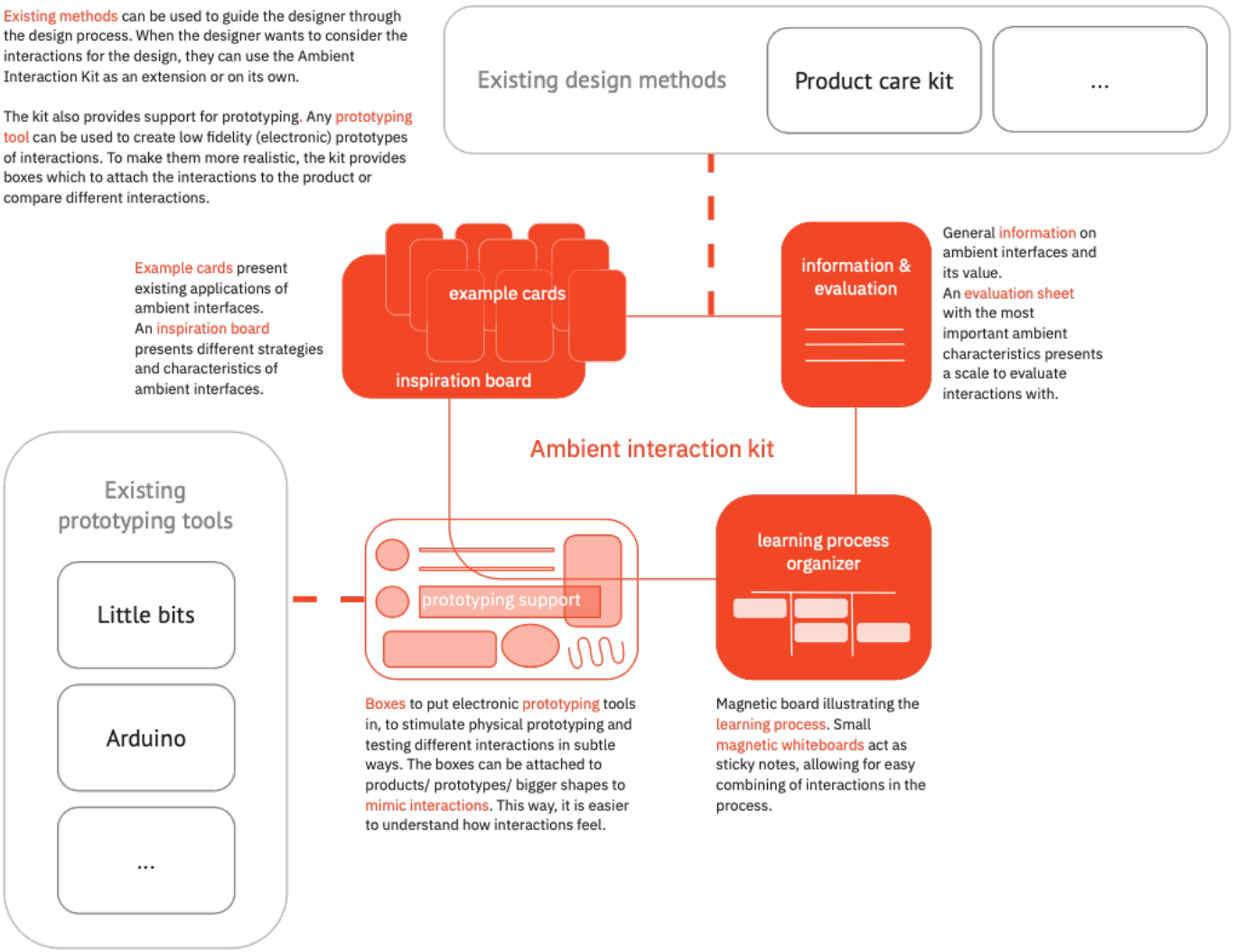


Figure 21: Ambient interaction kit, which can be used together with existing design methods & prototyping tools. It includes example cards, an inspiration board, prototyping support, general information and evaluation aid, and a 'learning process organizer'.

Index

I discussed the idea of the stand-alone kit with Laura Ackermann and Mahana Tuimaka (who designed the product care kit). Additionally, I talked to 6 bachelor students and an IPD student about how they were designing interactions now (what tools and methods they used). A summary of the discussions can be found in appendix 4.4.

The conclusions from these conversations, and the take-aways that I derived from these conclusions can be found in table 5. These take-aways, together with the insights gained from the other iterations (figure 22) led to the design of the 'Ambient care-interaction index' (chapter 2.3).

Conclusions from discussions	Take-aways for the index
People have difficulties understanding how a tool can be used; provide a simple introduction or let the tool speak for itself through design	The tool should not restrict by forcing specific use, but support several goals
Different contexts require different tools; a physical tool can be more stimulating in a group session, an online tool is more useful when working individually and for getting familiar with a topic	An online tool is more informing for individual use; which could be valuable for discovering information & inspiration
Inspiration is often found online, when looking for specific themes for example, or scrolling through visual websites (Pinterest for example)	(Quick) inspiration is looked for online
Example cards are not helpful if there are too many	People should be able to find examples that fit their interest easily, and then find examples/ information that relates to that to discover more
The value of a method (and if that is applicable to a specific design assignment) should be clear for people to use it	Make information on why and when the tool can be used clear
It can be difficult to learn when a tool/method can be used	The tool should be applicable to various parts of the design process and for various purposes to reach a large audience and feel valuable
People look online (also at non-design related fields) for inspiration	The tool should also include art and research that can inspire interaction design
In rapid prototyping, the hardest part is covering the electronics to make it seem realistic	If 'prototyping support' is offered, it should include general parts to cover up electronics, which can be attached & detached easily

Table 5: Conclusions from the discussions with product care kit experts and design students on design methods and ambient interface possibilities (left). On the right, take-aways derived from the conclusions.

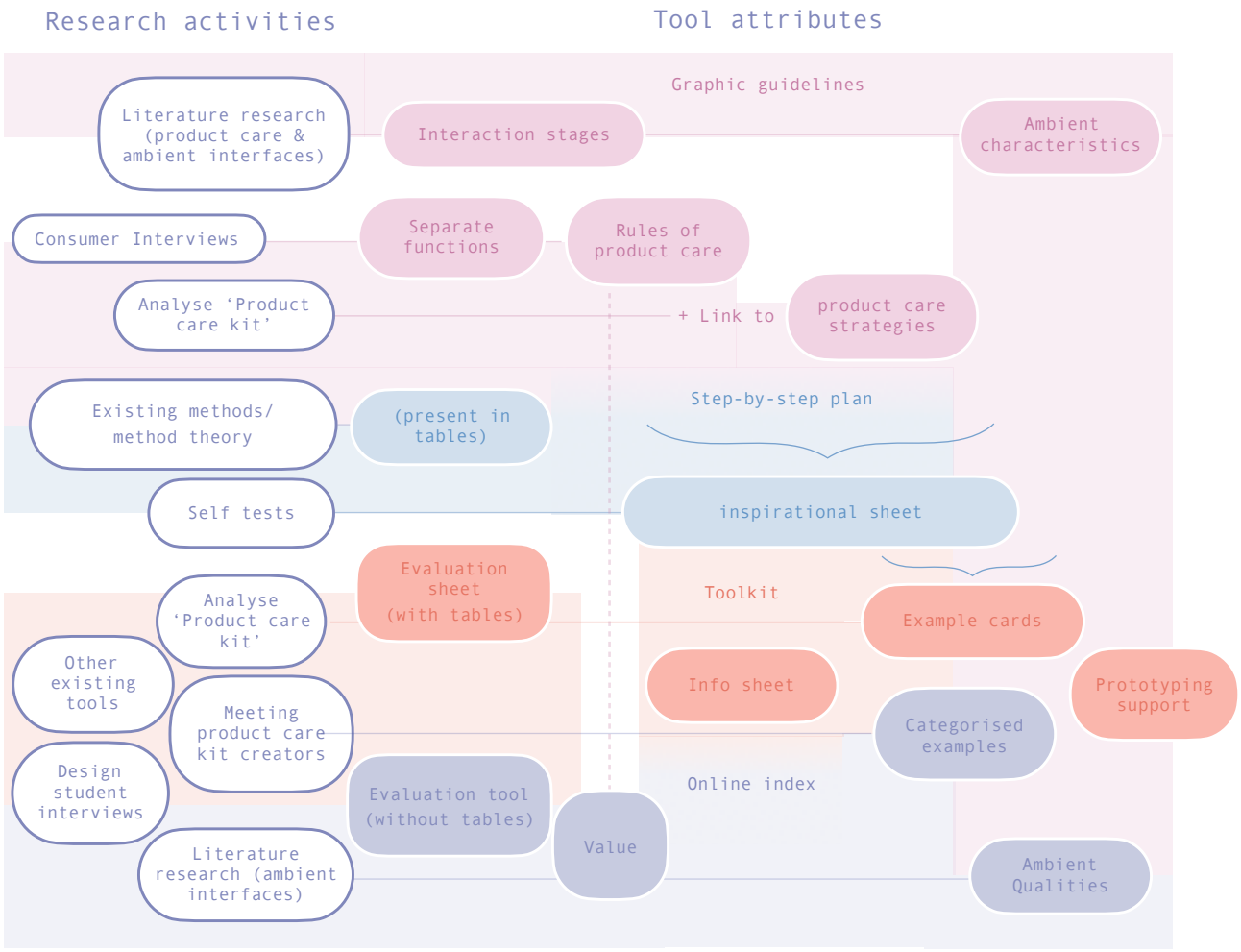
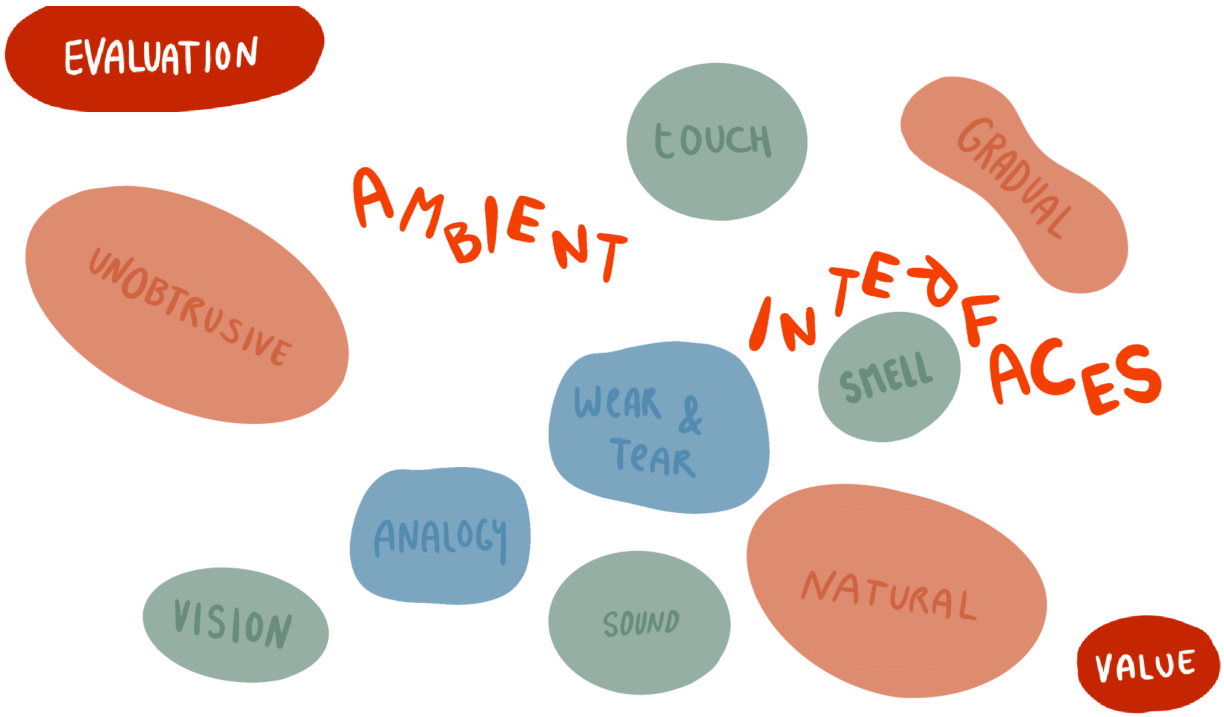


Figure 22: Overview of tool attributes, in relation to research activities: some attributes were discontinued (white space), others changed (or were combined) into different attributes (colour transition)


EVALUATION
TOUCH
GRADUAL
AMBIENT
UNOBTRUSIVE
INTERFACES
SMELL
WEAR & TEAR
ANALOGY
NATURAL
VISION
SOUND
VALUE

2.3 Ambient care-interaction index

Increasing the product-user relationship through design means that the designer should pay attention to the product's expression and character, from the start of the design process. Different characteristics and ways of expressing through interaction can be hard to come up with and validate.

Looking at designer's needs and ways to communicate the value of such tool, various concepts eventually led to the creation of an index. It consists of clusters of information that can be explored and provides structure to support designers in creating meaningful products. Through a comparative test the tool was evaluated (see chapter 2.4).

Goal & context

__Design goal

The goal of the tool is to support designers in designing relationships between the product and its user, by informing about ambient interface implementation in an inspirational way. As a result, product care activities can be stimulated through communication and motivation.

__Interaction vision

Designers should feel like they have an overview of the characteristics of ambient interfaces, and the ability to explore what these characteristics mean in forms of design examples, but also value.

The information should feel inspiring and informative, but not overwhelming.

__Target group

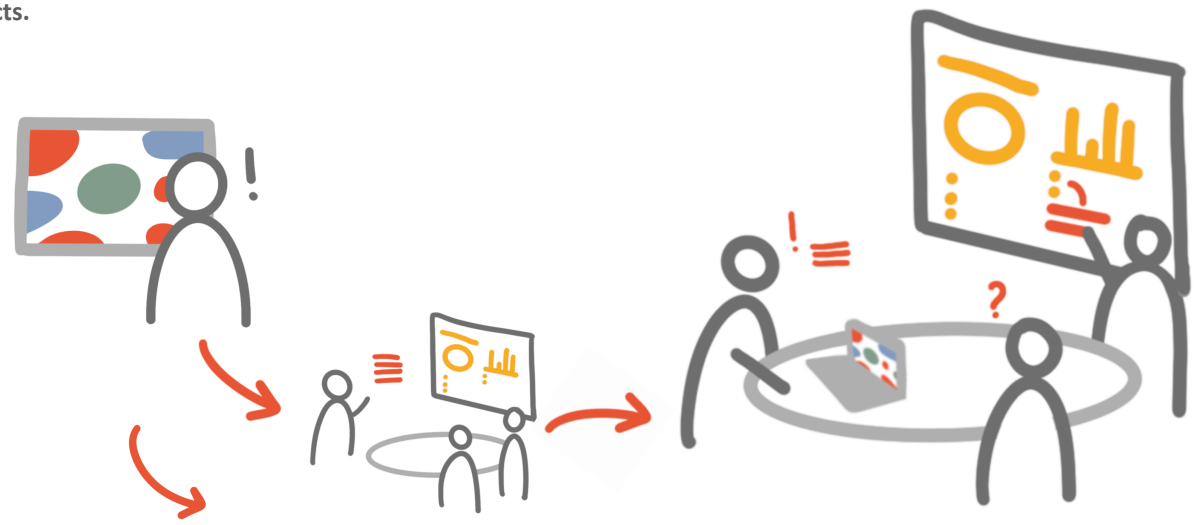
The index is meant to provide support in designing out-of-the-box, meaningful interactions through ambient interfaces. Its main purpose is to stimulate product care, either through directly using the interactions to communicate a need for care or by increasing motivation to care by building a caring relationship.

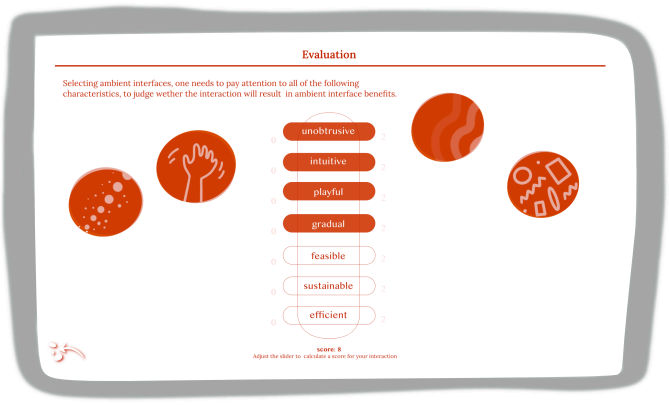
Therefore, **would probably suit a company that already understands the value of designing long-lasting products.**

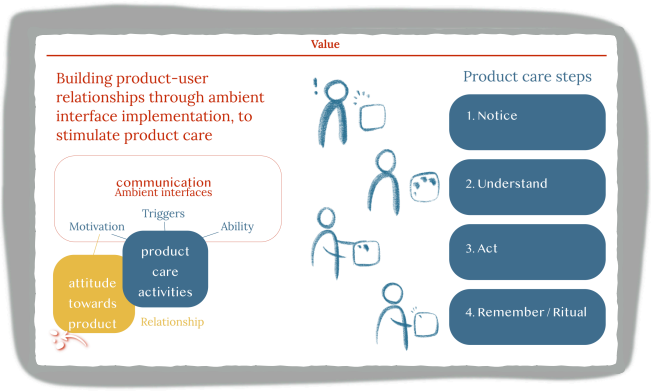
__Context

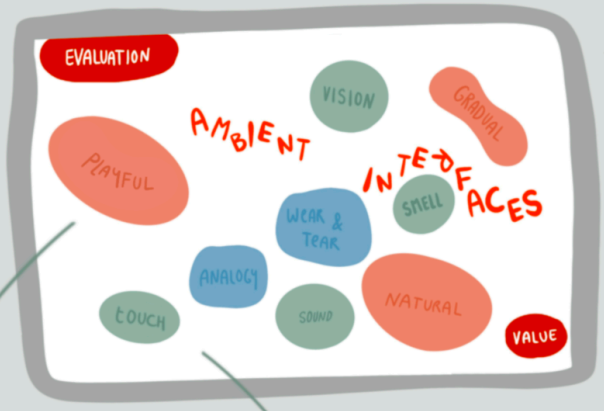
The tool is made for product designers that design electronic household products. It is meant to support them in the fuzzy front end of the design process, where the function of the design is clear, but its character is yet to be determined.

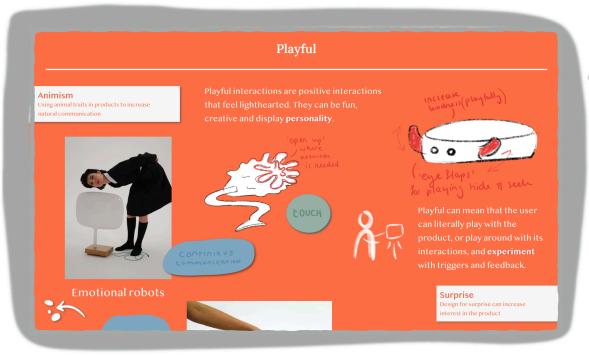
It is an online tool, which could be used in a group setting, first to be explored individually or to get a general impression through a presentation perhaps. This is especially relevant for understanding the value of the method. When brainstorming, one team member could validate choices or inform colleagues about possibilities. When a specific aspect suits the product, the group could explore the topic together and discuss what more they can find. After designing several interactions or relationship designs, the tool offers guidance on evaluating concepts.

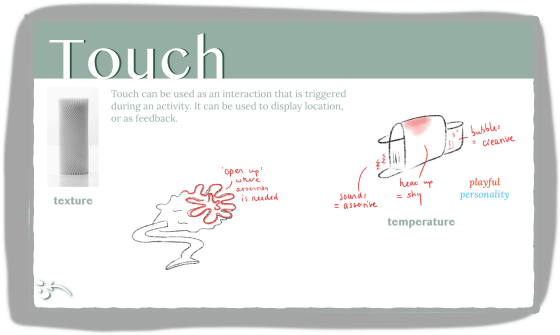



Evaluation
Selecting ambient interfaces, one needs to pay attention to all of the following characteristics, to judge wether the interaction will result in ambient interface benefits.
unobtrusive
intuitive
playful
gradual
feasible
sustainable
efficient
score: 8
Adjust the slider to calculate a score for your interaction

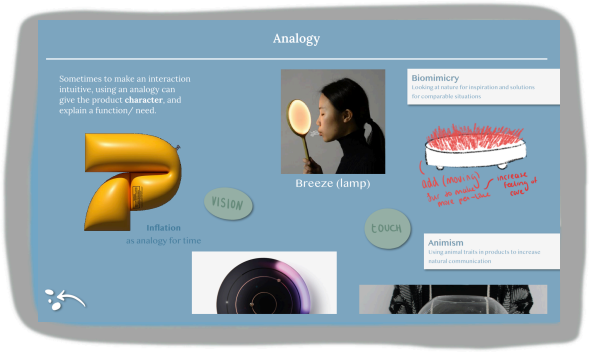

Value
Building product-user relationships through ambient interface implementation, to stimulate product care
communication
Ambient interfaces
Triggers
Motivation
Ability
product care activities
attitude towards product
Relationship
Product care steps
1. Notice
2. Understand
3. Act
4. Remember / Ritual


EVALUATION
AMBIENT INTERFACES
VISION
GRADUAL
PLAYFUL
WEAR & TEAR
SMELL
ANALOGY
NATURAL
TOUCH
SOUND
VALUE


Playful
Animism
Using animal traits in products to increase natural communication
Playful interactions are positive interactions that feel lighthearted. They can be fun, creative and display personality.
TOUCH
Playful can mean that the user can literally play with the product, or play around with its interactions, and experiment with triggers and feedback.
Surprise
Design for surprise can increase interest in the product
Emotional robots


Touch
Touch can be used as an interaction that is triggered during an activity. It can be used to display location, or as feedback.
texture
'open up' where someone is needed
temperature
bubbles = creative
keep up = shy
sounds = assertive
playful personality


Animism
"The attachment people experience towards products has been the topic of many studies but very little has been written on animism and product attachment. Here it is argued that in order to grant a product animated qualities, the user actually requires animistic thinking and it is necessary to translate perceivable characteristics of animacy into product language." (Leube et al., 2016)
"Animism can make valuable contributions within ubiquitous computing contexts, where objects with designed behaviors tend to evoke a perception that they have autonomy, intention, personality and an inner life." (Van Allen et al., 2013)
"In order to produce an emotionally charged interface between subject and object, the designer must cater to the animist tendencies of the user, who then grants objects animacy. [...] these processes are likely unconscious." (Leube et al., 2016)
Recommendations
"The easiest way to encourage the perception of life in products likely is through a product's appearance and behavior since some crucial criteria for life – such as DNA – cannot be observed. In biological language, we work on the phenotype and not the genotype of an object. In order to focus more on animacy, we defined seven characteristics based on Koshland (2002), Bell (2012a, 2012b) and Moskowitz (2012): adaptability, energy, goal-oriented movement, memory, regeneration, sensation and communication" : (Leube et al., 2016)
Adaptability
The ability to adapt to its environment, and/or its user by itself. It shows that the product can improvise and learn from past experiences.
Energy
Life as we know it involves movement. It must be an open and metabolizing system.
Goal-oriented movement
Memory


Analogy
Sometimes to make an interaction intuitive, using an analogy can give the product character, and explain a function/ need.
Inflation
as analogy for time
VISION
Breeze (lamp)
Biomimicry
Looking at nature for inspiration and solutions for comparable situations
TOUCH
Animism
Using animal traits in products to increase natural communication

Description

The Ambient care-interaction index is an online tool, that consist of three elements; static elements (value and evaluation), dynamic elements (characteristics, strategies and senses) and additional pages (providing in-depth information on specific topics). Static elements can be found on the home page, where the dynamic elements move as one scrolls the page. Both can open pages that include further information on a new page. Additional pages can only be opened through dynamic elements. All pages can be found in appendix 6.

Elements

The image on the previous page shows the various elements of the index. Below, each element is described.

Evaluation

To support designers in deciding which interactions or concepts best fit the vision of building caring relationships through ambient interfaces, important characteristics/criteria are highlighted. The criteria are described in a concise way, emphasising their desired result. Additionally, sliders per criterion allow users to rate concepts with a score (appendix 6.1).

Qualities

The four ambient characteristics are presented in red. Small text boxes elaborate on the value and description of the quality. Examples (speculative and existing) accompany the text, illustrating how the qualities can manifest in design. Existing examples can be explored by clicking though (their web page will open). Relevant strategy and sense pages are displayed as well, which also open when clicked. Additionally, research links are included, to introduce designers to new theory and help them substantiate their choices (appendix 6.2).

Research summary

The qualities and strategies originate from various theories. Theories are summarised on yellow pages, which can be reached through white boxes on relevant quality and strategy pages.

Value

The value page provides a general description of ambient interfaces, an introduction to relationship design through ambient interfaces, and its link to product care (appendix 6.1).

Home page

From the home page, all dynamic elements are presented in text. The colours depict the type of information (ambient qualities, (relationship, product care & ambient) strategies and senses).

Senses

Ambient interfaces endorse the use of multi-sensory interactions. To inspire designers to explore the different senses, there is a page for each sense. They are mainly inspirational, but also provide relevant research on feedback and possibilities (appendix 6.4).

Strategies

Several strategies related to ambient interface theory, are displayed in blue. They are common design strategies (like using an analogy) or more ambient (continuous communication). Again, information is presented in small amounts of text, accompanied by inspirational examples and relevant links to characteristics, senses and research (appendix 6.3).

__Navigation

The index can be navigated through by clicking on elements. All qualities, strategies and senses can be found on the home page, and are repeated in relevant pages. This allows users to click through pages (figure 23). Every page has an option to return to the previous page (bottom left), and the home page (bottom right).

__Format

The index is online because it should enhance creativity by presenting links and references, but allowing the user to choose a starting point. Compared to a physical format, it can be more informative since one can find specific information quickly. Additionally, links to external pages (of research and examples) can directly provide the user with sources and complete information.

Presenting an overview of (new) information can be overwhelming, which is why the elements are presented in short sentences or words, and colour coded. This way, they are recognisable, but also present little information first hand. By exploring several elements, users can get a feeling for various topics and their relations. These relations allow users to find topics that fit their interest without needing to study all topics.

Responsibility

The index would probably have the most influence it it were represented by a design agency. They could use it to design with, but also maintain the website (continue adding examples, and updating research) and distribute the knowledge and usage of the index. The access to the index could be sold (through a membership for example) and by providing (creative) workshops on its content.

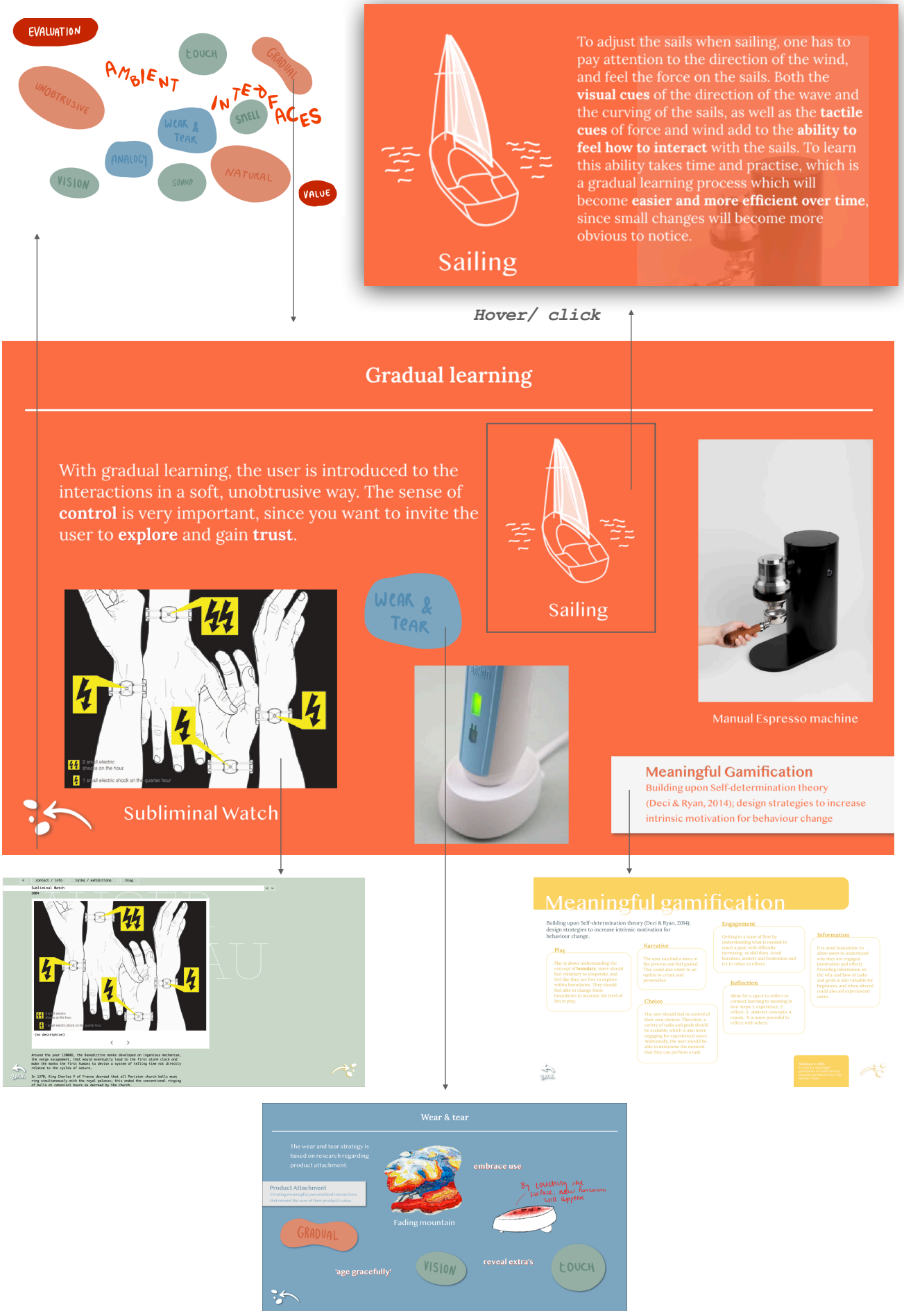


Figure 23: Navigation through the index (homepage → gradual (& hover), gradual → wear & tear strategy, gradual → research summary, gradual → product example, gradual → homepage).

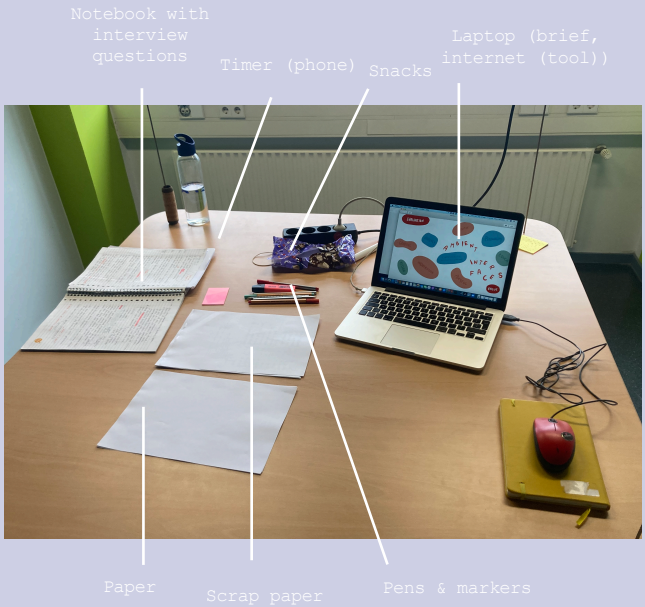


Figure 24: Set-up in Studio Talk, participant's view

2.4 Index evaluation

To evaluate wether the index is a valuable tool for designers, I constructed a test. In the test, I asked nine (graduate) design students to design a vacuum cleaner that stimulates product care through design. Half of the group could use the Ambient Care-Interaction Index, the other could not. Interestingly, of the participants that did not use the index, most still came up with an ambient interaction. Yet, they doubted if it would be as effective as the non-ambient, more conventional interaction. Therefore, **the main conclusion is that the index gives designers confidence that ambient interfaces can be effective.**

Method

The goal of the test was to evaluate the value of the index, in designing for product care. Therefore, I asked participants to design a vacuum cleaner that stimulates product care. By observing and discussing their process and results, I could analyse participants' reasoning and thought process to derive conclusions about the added value of the index and its content. All tests and conversations are summarised in appendix 7.3 and 7.4.

Half of the participants were asked to explore the Ambient Care-Interaction Index and use it when they felt that it could help, the others were not. This way, the influence and value of the index could be evaluated. Furthermore, I asked the participants about their knowledge of and view on product care design, and their general design process.

The tests took about one hour each, of which they had 30 minutes to design. Some tests took a little longer since some participants wanted to learn more about the index (especially the participants that did not use it during the test) and discuss. All participants verbally consented that I recorded their sessions. I recorded the audio and screen (two sessions were held online, therefore also their faces were recorded). The recordings were used to analyse the test results.

__Process

At the start of the test, I asked participants a few questions about their design experience and education, also regarding designing for product care. Then I introduced the task through a design brief pdf (appendix 7.1). The goal was to 'design a vacuum cleaner, which stimulates product care through design'. I added a small definition of product care, and a list of care activities for vacuum cleaners. Additionally, a list of vacuum cleaner functions was provided. The brief also stated that the participants were free to use any shape, brand, target group or character that they would like for their design, as long as they focussed on product care.

Each participant was asked to come up with (at least) 2 concepts (which they could sketch or explain to me), and then choose one final concept which they though would be most effective at stimulating product care. They could pick one or multiple care activities to focus on per concept.

During the test, participants drew mind-maps and concepts. I observed their process (and index use) and asked them to think out loud and explain their steps.

After 20 minutes, I asked the participants to finish their two concepts and start to choose one. Some participants already started explaining their choice process right at that moment, others took more time to choose or combine features in a final concept. Afterwards, they discussed their concepts, process and the index by answering questions on feasibility, desirability and structure. Additionally we discussed the value of product care.

The reasoning behind the tasks and questions can be found in appendix 7.2.

__Set-up

Most tests (5/9) took place in Studio Talk (a small room at the faculty of Industrial Design & Engineering). Two tests took place online, and the other two at the participants houses. All participants were provided with paper, pens, markers, sticky notes and a laptop (except for the online tests). They were told that they could use any books or look up things online. In the tests with the index, participants could find the index on the laptop as well. Figure 24 shows the set-up in Studio Talk.

Participants

The participants were all design students who studied in Delft, of which five were already graduated from their masters. Participant 6 (table 6) only graduated from the Industrial Design Engineering bachelor, and was now studying Industrial Ecology. The complete information about the participants can be found in the answer summary in appendix 7.3. Five of the nine participants were friends of mine.

#	Relation	Index	Gender	Age	Study	Grad.
1	stranger	no	m	30	IPD	yes
2	stranger	no	f	25	DFI	no
3	stranger	yes	m	26	IPD/DFI	no
4	friend	no	f	24	DFI	yes
5	stranger	yes	f	24	IPD	no
6	friend	yes	f	24	Bachelor	no
7	friend	no	m	24	SPD	yes
8	friend	yes	f	23	IPD	no
9	friend	yes	m	24	SPD	yes

*Table 6: Test participants (relation to me, index use, gender (**f**emale/**m**ale), age, design study, whether they have graduated their masters*

Results

The test was set up to test multiple parameters; whether using the index would improve designs, influence the design process and decision making and provide value to designers, and if the interface and structure of the index would be understandable. Furthermore, the designers were asked about their experience with, and thoughts on design for product care and its value.

To analyse the results, the participants' answers, design processes and concepts are documented in appendix 7.4.

Final designs

Overall, the participants all came up with several ideas, from which they chose one final concept. Table 7 shows these final concepts. Participant 3 (P3) was asked to explore the index, which he did at the start of his design process, yet when he started sketching and ideating, he forgot to use the index. After 20 minutes, I asked him to choose one design (he chose the 'Dyson dust scraper, see table 7), and then come up with one more concept by explicitly using the index. Afterwards, he was asked to compare this concept (noise alterations), to the other concepts, and pick a final design.

An unexpected result was that, apart from P1 and 8, all participants mentioned transparency as a solution. P4 stated that it could be used to communicate honesty, and increase motivation, but that it could also demotivate because it might never really look clean. Only P2, 5 and 7 chose to use transparency in their final design.

Design process

The participants were asked to come up with a minimum of two concepts, so they could eventually decide on a final concept. Five out of the nine participants came up with separate ideas for various care activities (P1, P3, P4, P5, P9). P4, 5 and 9 picked several ideas to combine into one final concept. P2, 6 and 8 focussed on one care activity. P7 designed two complete products (including all care activities and basic functions), but he quickly came up with the interactions (without really ideating), and re-used or slightly altered them In both concepts. The concepts varied most in shape, and the way that 'remove dirt' was incorporated. Eventually P7 chose his final concept based primarily on this difference in removing dirt. Table 7 shows the final concepts per participant, with a short explanation of the problem(s) that the participants focussed on and their design solution(s).

Most participants followed a fairly similar design process, in which they first explored the brief (and index), then some (P1, P2, P9) made mind maps regarding care activities and motivation. They picked a problem to focus on, and then either ideated or talked while sketching their first idea. The amount of ideas that participants came up with, and of questions that participants asked themselves differed a lot. There was no clear distinction in this process between participants that did and did not use the index (the complete processes per participant can be found in appendix 7.4). Participants that used the index did mention that the index 'immediately' provided them with inspiration (P6) and a certain direction (P8), where most (3/4) participants that did not use the index felt like they lacked background information (P2) to help them steer and decide (P1, P7).

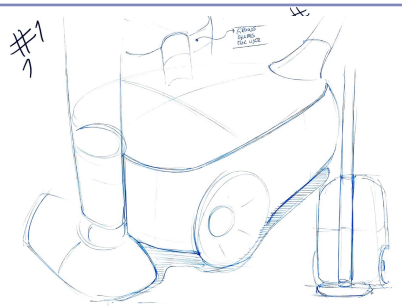
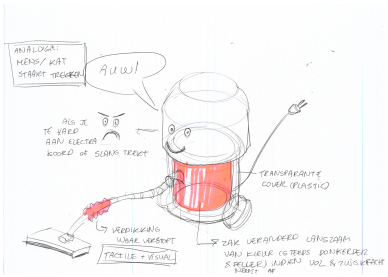
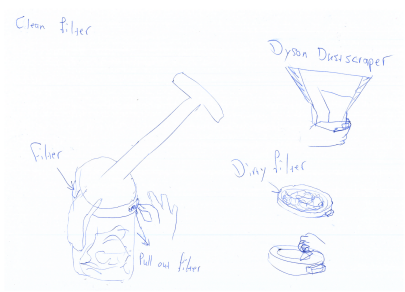
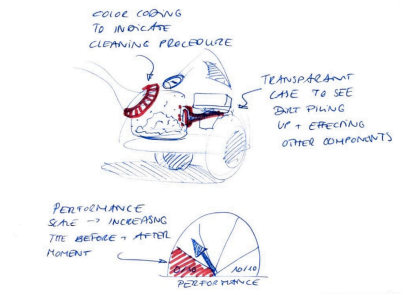
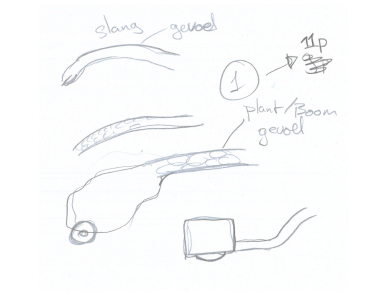
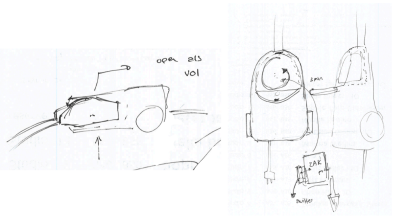
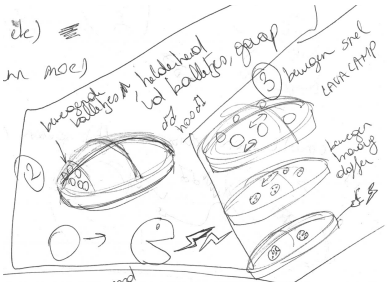
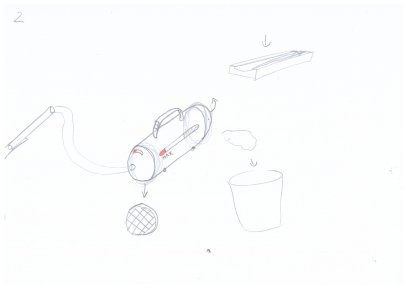
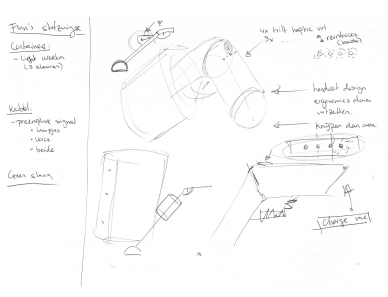
Without index		With index	
Magnetic indention to place tube (Prevent 'tube-hook' from breaking)		'Henry' vacuum cleaner with transparent case to show bag with colour indicator to display fullness of bag, face that changes from happy to sad + noise (ow!) when cord is pulled (Prevent pulling) Tube thickens to display blockage	
Participant 1			Participant 5
Dyson Dust-scraper': extensible scraper to clean filter (Clean filter)		"Dyson noise 'decreases' when the container gets fuller" (Empty on time)	
Participant 3			
"Transparent case displays dirt piling up + effecting other components" and color coding to indicate performance scale (Empty on time)		Tube has 'scales' that show that the tube gets more fragile when pulling it too hard (Prevent pulling)	
Participant 2			Participant 6
Bag container opens up (and vacuum stops working) when bag is full (Empty on time) Provide special cloths with new bags (Stimulate (internal) cleaning)		Display portraying energy levels through moving balls (Charge on time)	
Participant 4			Participant 8
Effortless hand held vacuum which opens on the rear (no bag) & fullness indicator; transparent bar with color indicator (Empty on time) Extensible filter + indicator in numbers; 30 is red (Clean filter) Wireless charger with indent to store vacuum cleaner (Charge on time) Snap to colour when blocked		Audible 'charge me' when turning the vacuum off (Charge on time) Lights and indicating battery level Vibration in handle indicating container fullness (Empty on time)	
Participant 7			Participant 9

Table 7: The chosen concepts of all participants, divided in two columns: those who could use the index (right) and those who could/ did not (left). Left of each drawing, the concepts and the problem(s) that they are meant to solve are explained.

Decision making

When deciding on a final concept, participant focussed on various qualities. Each participant's reasoning is summarised in table 8. It appears that without the use of the index, participants focussed on convenience, faith due to own experience or preference and feasibility. Participants that used the index expressed more value for aesthetics, noticeability, clearness, personal preference and improving how the interaction feels. P6 was the only one that actually used the evaluation tool from the index.

Without index		With Index	
1	Implementation, desirability, viability	3	Enthusiasm that it creates for the company (how well it fits the brand), how much nicer the care task becomes
2	Faith in design based on own experience with similar qualities/ interactions	5	she wanted to make it friendly, and make sense (not too aggressive, not too dirty looking)
4	If people are forced they will act, and it should make the cleaning easier	6	Evaluation tool in index: - Unobtrusiveness: type of colour, how alarming the interaction is; "Bit more in the background" - Playfulness: colour use, character - Gradual learning: change during use - Feasibility: costs, materials, mechanisms - Sustainability: materials, durability - Efficiency: energy & effectiveness
7	- Convenience - Personal preference	8	First think about what she would want at home, then think about aesthetics, but would want to iterate to make more effective (by combing multiple cues (several visual/ visual + audible)
		9	- how noticeable (in a feasible way) the interactions were - "More direct, instead of that you first have to look.. you know the only vibration happens when the container is full, that is clear"

Table 8: Decision qualities (with & without index)

Value for designers

Inspiration and information

Participants said that the index had most value in providing inspiration when they felt that they were stuck. They liked the combination of theoretical knowledge (references to research and explanations) and examples. P5 stated that the index is inspiring but also informing:

> *"It is first of all a way to learn and inform about ambient interfaces, and after that an inspirational source because of the examples of existing products" – P5*

P6 said she used the index "to gain inspiration at the start and then design, and then when you get stuck you can fall back on this [index]", especially since she had not worked with ambient interfaces before. She expected that if you would work with it more often, that it could be "a good extra tool to use during the ideation, during the brainstorming".

The participants seemed to value how the index provided original directions to look into:

> *"The tool stimulated me to use sound, because normally I would not think of that quickly, I would rather think of mechanical solutions" – P3*

According to P9, looking at the examples helped with brainstorming, especially since they were from a different product category; "you can learn a lot from that".

Additionally, P9 said that the examples helped to make adaptations to his ideas. He appreciated that the examples added to the textual information. P5 and 8 confirm this, but think the text is necessary as well: "I thought the tool actually was really nice, because it provides inspiration and the text is nice because only with the visual aspect you don't really know what's going on" (P8).

> *"If you don't know anything about ambient interfaces, is it a good tool to acquire knowledge on the matter, and it is fun that you combined theoretical knowledge but in a very approachable way because it looks nice, there are pictures so you don't have to read a boring paper, and examples of real products so you understand 'oh this is what is meant by the theory' in how you can really apply it" – P5*

Ambient qualities

Even without the index, some designers came up with creative, sometimes even ambient solutions. P2's transparent body with 'performance meter' for example, could be considered ambient since the actual communication (gradually brighter colours) fits the ambient quality 'gradual learning', and the location of which parts need attention is quite 'intuitive'. She also stated that unique design can be a selling point, which relates to the 'playful' quality. The bright colour on P7's cord-end could be considered 'unobtrusive' and 'intuitive' since it is a small, yet noticeable feature that can be easily understood.

Furthermore, P4 made two comments that relate to the 'gradual learning' quality. When we discussed the effectiveness of her concepts, she said that products probably should not demand users to pay attention to all care activities at once. Instead notification for one activity should gradually reduce, so users can learn about new activities over time. She also made a connection to routine behaviour (see quote).

"Many household products are part of routine behaviour, if these nudges are designed well the care can become part of the routine, and when that happens, something new can be introduced to the routine" – P4

The designers that did not use the index did have more doubts about the ambient qualities of their interactions. P4 for example, was afraid that if something would too subtle, people would not be forced and therefore would not act. P1 and 2 thought that their second concepts, which responded onto the user's emotion, would be undesirable (to buy and/or to use). Additionally, P8, who did use the index also worried that her final concept "could be cute, could be annoying after a few times". However, P1 did mention that his concept could be more desirable if the 'disturbing' interaction would be more subtle, which fits the ambient quality 'unobtrusiveness'.

"Maybe it should be more collaborative with the user .. not like the product disturbs you to do something, but instead motivates you" – P1

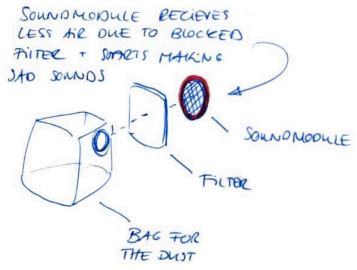


Figure 25: P2, second concept

In her second concept, P2, wanted to use the filter of the vacuum cleaner to influence the noise that came out, therefore teaching the user to listen to understand how dirty the filter was (figure 25). If it was too dirty, it would sound as if the vacuum was sad. This usage of the vacuum's 'natural' features is not only efficient but could also be very 'intuitive' and 'gradual'. P3 used the index to come up with a similar interaction (using the sound of the vacuum to communicate performance). He also mentioned that the sound is probably already artificially produced, and the device currently also measures when the airflow is blocked. Therefore, it would be possible to use those sensors to change the feedback gradually.

P3 was quite enthusiastic about ambient interfaces in general, he said: "I like that ambient interfaces are very elegant, very gradual." Moreover, he talked about how using the senses can be very useful in designing notifications:

*"I can imagine touch, smell, sound, things like this are appreciated a lot, if you were to play around with things like this, you notice that .. especially in the sense of 'I clean my vacuum cleaner, so it sounds nice again', that results more in such a **product relationship**" – P3*

P6 was a bit uncertain about the theory on relationship building. She said it related to the 'playful' quality, but thought 'intuitive' and 'unobtrusive' opposed the theory a bit: "Unobtrusive is that is does not make you conscious of your behaviour, whereas when you really build a relationship, well maybe, building a relationship does not have to be conscious, it can happen unconsciously." When P3 chose his final concept, he said one of his reasons was that it seemed more in line with the theory of ambient interfaces and the relation between users and their product. He was quite content with this concept: "it is actually a very simple solution, but much more product care."

Link to product care

According to P9, the index helped him understand “what kind of things I can look at” when designing for product care. He perceived the examples as “ways to inform the user that something is wrong with the product and that that needs to be changed to prolong the lifetime”. He did note that ambient interfaces could also be used for other purposes, so designers do have to make the link to product care themselves, “but that is in design anyway”. Moreover, P3, 5 & 8 found that the index was missing the link to product care. P5 said that she expected a list of design for sustainability-basics (like allow for disassembly and that kind of ‘rules’). She thought that would be nice because according to her, many people don’t know about that. P8 stated: “I did not know it was a tool for product care, otherwise I might have looked at ‘evaluation’.”

Two participants (5&6) specifically mentioned that implementing ambient interfaces could be beneficial in stimulating product care. P6 argued that the interactions could make a difference by changing “how people see their product”. P5 said: **“product care now is not sexy, it is not fun, it really something that you ‘have to’, this can make it fun. Instead of a mom that says ‘don’t pull the vacuum cleaner’; it can make it more attractive in an intuitive way.”**

(Future) context

When asked whether they could see a possibility to use it in their future design practices, most reacted in a positive way. They did sketch various use scenarios. P6 considered it as an inspirational tool which could be used individually, or in a brainstorm session with multiple people. In a group, it could be: “a central place where the basic values are that you want to have in the product ... that that would result in more unity, that you understand each other, so you could say ‘I have applied this and you can see that here [in the index]’.

*“To look more into the subject, I think that it can be useful. The advantage is that you don’t have to look it all up yourself but that it is already in one place, that **saves time.**” – P5*

P1 did not use the index, but when I explained and showed it, he thought it could be valuable for a household manufacturer such as Philips, but that a design agency like Van Berlo (where he did an internship) could use it as well. He said that Van Berlo already tries to incorporate sustainability in their work, and also use and sell tools that support product repair. He thought it was nice to inspire people to use “wild creativity to get to positive ideas”.

P7, who also did not use the index during the test, thought his designs would have improved by using the theory: “I think if I would have used this I would have created a better design, but not a more innovative design, because I would still have made these designs but based on what is presented here [in the index] instead of from my own experience, because of the time limit.” He thought it consisted of good “inspiration material”, which he could use when designing, but he would not pay for it.

“You can design without methods but sometimes you just miss something .. if I would design something for user experience I could use the tool” – P7

P8 just started her graduation project on sustainable consumer behaviour, she said she wanted to use it for her project because of the inspiration it provides.

P3 thinks that, “in its current state maybe once” he could use it as a “stepping stone”, since it would be nicer than reading a paper or watching a lecture on the subject. In a corporate setting he was concerned that it would be hard to “validate to your CTO, because it can get really expensive”, and that most companies won’t allow designers to add sensors if it is not to improve the product’s function.

__Interface structure

I introduced the index as a tool that is about ambient interfaces, which are specific interactions that can help in designing for product care. With that information, the main goal was quite clear to participants. Even after showing it quickly to P7 (who did not use it during the test), he said “you explain and provide examples to inspire designers to apply this”. Despite that, most participants (4/5 that tested with the index) said the index lacked structure, or at least some sort of introduction.

*“Now it is very open, which is nice on the one hand because you **explore more**, but you don’t really know what you are exploring” – P3*

Introduction

Many participants thought the tool lacked a clear introduction to the index, but mostly to its content and why that could be valuable. This could engage people to use the index (P7, P9). The value page could act as this introduction, as "it contains why, what and how" (P7). It could act as a pop-up (P3) or walk-through, yet it should be quick so people won't skip it (P8). Also, the link to product care was not clear enough (P3, P5, P8). P5 thought an overview of basic rules for sustainable use (also including repair f.e.) would be useful since many designers are unaware.

'Value' and 'Evaluation'

Only one P6 used the index as I had intended; she started with value, then checked evaluation, went through all the different bubbles and used evaluation to choose a final idea. That the others did not is not necessarily bad, since the index is meant to be used freely (without a forced approach).

*"It is **nice to have some decision support**, because otherwise, it is always difficult to decide out of nowhere" - P6*

However, 'value' and 'evaluation' were barely used. According to P5, P7 & P9, this was unfortunate since they thought evaluation felt like a summary of the index's content. P1 also thought 'evaluation' was valuable as it could help users narrow down their ideas to more feasible ones, since the tool encourages people to "use wild creativity", but "if you want to make impact it cannot be too abstract".

When asked, 3 participants explained that it was unclear what 'value' and 'evaluation' stood for, and since they had a limited amount of time, it did not feel valuable to look at (P5 & P8). P8 said she would have used 'evaluation' if she knew it related to product care.

P8 thought 'value' might need a different title, as she thought is was about user value (so did P4) instead of index value. Both did not explore the feature. After exploring, P8 thought the top of the page required more overview (more white space and hierarchy), since it was unclear how it should be read, though the content was interesting.

P7 argued that the components should switch place, because people generally approach an interface from top to bottom, left to right. P3's behaviour confirms this as he immediately clicked on 'evaluation'. Moreover, P5 thought both components were less important than the others, due to their location on the edge of the screen. As a solution, all participants agreed that a general introduction would make their purpose more clear. Additionally, adding evaluation to the introduction "shows the criteria which you design for" (P7).

"Evaluation, I would have want to start with this, because these are the important parts, and you do see them all come back, but that could guide them [users] through it a bit more" - P9

Layout

Observing participants' behaviour in navigating the pages of the index I noticed that people appreciate the white space between the images, so they can calmly hover their mouse without getting a reaction. P5 said about the general layout: "It is playful, but also confusing", because she forgot what she did and did not view already.

None of the participants understood that they could scroll without being told otherwise (on the home page, but also on the other pages). P3 thought it would not work since it was a prototype. P7 suggested placing an arrow on the home page to encourage scrolling. After demonstrating the home page scroll, P4 said "it is funky, I like it, it has personality".

Sometimes it was unclear that components could be clicked; P4 & P8 did not understand this on the home page. P6 had no idea that the research titles linked to more information, although she did think it could be valuable: "because sometimes it is nice to get some distance from the design and dive into a subject and be able to read more" "Because now I used it mainly through short definitions of the terms and then with the examples but sometimes you want more background, so I think that is interesting".

P6 did understand that she could click trough pages, which she appreciated. P5 also liked that she could click through, yet always had the option to go back with the bottom-left arrow.

Physical addition

P3 raised the topic of a physical prototyping tool to enhance understanding and feeling of the various senses. He thought that could add to the index, which he felt acted more as an introduction: "As it is, I think it is a bit to empty to use during the process, it is like reading a paper, and then you have many ideas to start with".

*"The tool gives information, but it does not **help me to communicate my idea**, it is more of an educational tool, it does not help with the practical activities, with shaping, it is more inspiration and information" - P3*

__View on product care

Overall each participant recognised the value of designing for product care; P1 thought it was important to avoid creating waste and feeling responsible for purchased products. P3 talked about his experience at the company that he works for, and how since it is not considered at the start of the design process, designers miss a lot of details: "after-purchase maintenance is the last thing on my list, the focus is on interactions and cool technology".

P4 hopes that companies already consider care activities in their design. However, P1 argued that "not all companies take this [product care] in consideration", because they [illegible]: "sustainability is becoming a hot topic in the industry, because a leading company starts something, and then you don't wanna fall back and then you just say something about it, but it is sad that it is not a sincere act, and of course you are copying others, and the impact that you can make is just so weak".

He thinks even if designers are aware of the value of and methods for implementing product care, companies and agencies won't care. Then awareness needs to be created first, or a leading company should come up with an example that they can copy.

P4 thinks companies will find it desirable to consider product care if it proves to prolong the product's lifetime. Yet, it can be difficult since companies always have to deal with costs. Additionally, she said she would probably try to always keep it in mind because of its value and importance, but: "if you are the only one in a team that thinks about it, you might forget to consider it".

> *"I generally believe that products can **shape behaviour** and I think sustainability, which I think this ultimately leads to, is a great goal" – P2*

> *"it is very **underrated**" – P3*

> *"I think it should always be implemented, especially looking at the state that the world is in now" – P8*

> *"It is a very important possibility to **prolong the lifetime**, and that is very useful for the sustainability of the product" – P6*

> *"I think that it is astounding how many things people throw away, out of **lack of understanding or laziness**" – P7*

> *"With product care you can anticipate to people's wish to be 'better' for the environment, but also take into account people's nature of doing as little as possible .. not all people, but **product care could create a better balance**" – P4*

Care qualities

Table 9 presents the qualities that participants came up to stimulate care. These qualities were explicitly mentioned in their concepts (see appendix 7.3 and 7.4). There is no clear distinction between participants that did or did not use the tool. The only notable difference is that using multiple cues was only recognised as a quality by participants that used the index: P5 & P6. P3 & 6 (with index) as well as P2 & P4 (without) recognised that gradual learning could be beneficial.

> *"Product care is just, definitely sustainability-wise it **largely depends on the user**, which is very **underexposed** […] we tend to forget the interaction with people" – P9*

> *"..ignorance, as in **knowledge** as well as in the fact that there is no **feedback** about it" – P4*

> *"If we design products that people **understand** well, they will also understand what is wrong with the product more easily and it therefore maintain more often and don't throw it away" – P7*

> *"If it **feels vulnerable**, I think people will handle it better" – P6*

> *"Making the interaction as **human as possible**, because I think that people **feel responsible** when something is human" – P4*

> *"People will **get to know the feeling** and understand how handy it can be, and then hope that it will catch on" – P4*

Quality	Without index				With Index				
	1	2	4	7	3	5	6	8	9
Notify	Through disturbance	Gradually	Force to act		Gradually	Using multiple cues	Increasing visibility	Using multiple cues	
Make the task easier	Results in more careful handling			+ more comfortable	+ nicer (more smooth/ satisfying)		Require less energy		
Help people understand how, where and when to clean				+ understand the product in general					
Emotional value/ pressure							making the product more alive/ vulnerable	as human as possible	
Positive emotion			"you want to stay in people's 'good graces'"			"Make it friendly, and make sense"			
Provides a satisfying before and after									
Allow for more thorough cleaning									
"know the feeling and understand how handy it can be"									
Introduce new activities over time									

Table 9: Care qualities (with & without index)

Discussion (Index evaluation)

The greatest value that the index seemed to provide is encouragement to **come up with out-of-the-box ideas,** P1 mentioned this, and it can also be seen when comparing the concepts of both groups (table 7). Looking at their process (appendix 8.3 and 8.4), participants that did not use the index still came up with creative ideas, yet it was never their first idea that was already quite unconventional. Also, they seemed less confident about their unconventional designs. The designers that used the index still based their designs mainly on problems that they recognised from their own experience, but their solutions were more unconventional than those that did not use the index. They relied a lot on what they had seen before or on mechanical solutions. The reason for this might be that participants that used the index did not only copy from designs that they had seen before, but also from designs that were new and less typical.

The comments on companies copying others (P1, P3) could be a way in which ambient interfaces can be most valuable: **providing a new, more emotion-based way to stimulate product care (directly or though motivation). If this is picked up by a leader in the household industry, it could become an example for others to follow.**

> *"**Product care now is not sexy**, it is not fun, it really something that you 'have to', this [ambient interfaces] can make it fun. Instead of a mom that says 'don't pull the vacuum cleaner'; it can make it more attractive in an intuitive way" – P5*

Participants 3 & 4 were concerned that companies would not allow designers to add sensors if it "is not necessary for use" (P4), since they care most about costs. This seems to be a general problem with product care design; companies don't see the value it can bring. Ironically, P3 said companies would only allow sensors if it would "improve the product's function", which is part of what product care can do; prolong the functionality of the product.

Many participants that did not use the index felt that they needed more background information on the scope (P1, P2, P7). P8 also said she would normally like to do more research beforehand, but that the index now replaced that and made the process easier and quicker since she did not have to look things up. Therefore, **the index is not a complete stand-alone tool (which it also is not supposed to be), but it can provide support and guidance for designers to pick a direction.** Other participants (P5, P6, P9) seemed to appreciate the quick access to inspiration as well.

One goal of the index was to not only stimulate care through communication but also through motivation. The value of motivation was mentioned by three participants that did not use the index, as well as three who did. Out of the three who did use the index, two saw the value in emotional motivation, which may have been because of the index.

Comparing concepts

To compare the final designs on effectiveness is quite difficult, since the designs differ a lot per participant. Based on the decision qualities that the participants came up with (table 8), the noise adaptation concept of P3 could be considered **most effective** in stimulating care because it is gradual, noticeable yet subtle, quite desirable and reasonably easy to implement. My evaluation of the concepts can be found in appendix 7.5.

Care Strategies

The most surprising element of the test to me was that participants came up with a lot of creative, and seemingly effective concepts with and without the use of the index. Looking at the qualities that people came up with, there is a lot of overlap with strategies that current research on product care design suggests. **It shows that designers struggle most with giving importance to product care** (in means of purposefully designing for it and being allowed to design for it).

Limitations

Many participants stated that the **time limit** restrained them from coming up with better ideas. P4 explained: “you get to a reflective stage pretty quickly which is not bad necessarily, but can also hold you back”. She thought more time to think about the reasoning for care (neglect) and the experience of vacuuming would have been valuable. P5 thought this also affected how well the tool could be tested, since she did not have time to read everything (the research summaries for example). Perhaps I should have given participants time to let their ideas sink by asking them to start designing for some time and then iterate at home, explaining their final design a week later (P6). However, it would have been more difficult to observe their process.

It was sometimes difficult not to interfere in the ideation and argumentation of the participants because I got enthusiastic about their ideas. I tried to reduce the influence/ impact of my interference by asking questions, but I know that even asking questions can steer people in certain directions.

I did not do a pilot test, therefore P1 was the first designer that I tested with without using the index, and P3 was the first designer that I tested with with the index. After testing with P3, I asked participants to use the tool when they felt like using it, and to explore it beforehand, which they did. If I would have done a pilot test (with the index), I possibly could have expressed myself differently to P3.

Some participants (7&9) asked which care activities were most impactful, and I answered them by saying that blockage of the motor could possibly overheat the motor, but that all activities could be explored since I did not have explicit data. This influenced their final design choice, but it did not seem to influence the amount of ideas that they came up with during ideation.

The participants were asked to design ‘a’ vacuum cleaner, and focus on ‘any’ care activity. Some participants mentioned that they would have liked a smaller scope. I chose this broad scope to allow participants to use their own experience, and not be limited to design for something that they would have little knowledge on. This was also the reason why a vacuum cleaner was chosen; so every participant could relate. It remains uncertain if the index would also be valuable to use for other products.

Conclusion (Index evaluation)

The general design goal of this project was '**to create a tool that connects the characteristics of ambient interfaces through the full product experience, eventually improving communication and attachment to stimulate product care**'. Specifically, the index was supposed to provide information on ambient interfaces and inspiration to implement at the start of the design process. It should encourage designers to think about the relationship between the user and the product through the ambient qualities. Furthermore, the structure of the index should feel inspiring and informative, but not overwhelming, by providing overview and the ability to explore. Finally, the index could help designers in choosing a final concept. After testing these various aspects, it can be concluded that the content of the tool was proven to be valuable, but the structure should be improved.

The goal of the index is to **inform and inspire** designers at the **start of their design process,** to **implement ambient interfaces** in the design of their product, and to [illegible] between the user and their product. Two participants (who designed with the index) mentioned specifically how their concepts could influence the relationship, and one more argued that her design should be 'friendly'. In the test, participants quickly moved through the research phase, focussed most on ideation, and went through a quick conceptualisation to make their final decision. They said the index best fits brainstorming (in the ideation phase).

The database was supposed to provide an **overview of information** in an **inspiring way,** by presenting the main characteristics of ambient interfaces with examples, relevant research and strategies. Participants appreciated the combination of examples and short sections of information. The additional elaborative summaries of the theory were not used by any participant. The index had most value in providing inspiration when participants felt that they were stuck. They liked the combination of theoretical knowledge (references to research and explanations) and examples. One Participant specifically stated that the index is inspiring but also informing.

The **structure of the index did have some flaws.** Many participants thought the index lacked an introduction to its value. One participant said it felt like there was a lot of information in the index, which could feel overwhelming. The playful way in which the information was structured forced people to 'just start somewhere', which was explorative, but also confusing. Two participants said they sometimes forgot what they had viewed before.

In terms of **impact on the concepts** that participants came up with, **the tool was meant to support designers in creating more effective designs using ambient interface theory** Participants seemed to create concepts which focussed more on the emotional than practical response when using the index. **It provided support and inspiration to choose a more unconventional direction.** This was mainly because of the examples.

When **choosing a final concept,** participants who did not use the index focussed on convenience, faith due to own experience or preference and feasibility. Participants that used the index expressed more value for aesthetics, noticeability, clearness, personal preference and improving how the interaction feels. Only one participant used the evaluation tool in the index.

Reflection

Discussion

In this project, I connected the research fields of product care, relationship design and ambient interfaces. I proposed that the three fields could add to each other, and that ambient interfaces could be a new way to stimulate product care. Through analysing existing literature, interviewing consumers and eventually the development and evaluation of an index, my theory was validated. It shows potential, but some questions remain. The interpretations of the index evaluation results can be found in the discussion section of chapter 2.4, some related insights will be outlined (again) here.

__Content validation

The index displays information that is proven individually through research. Nevertheless, the combination of product care and ambient interfaces has not been tested, to my knowledge. In theory, there is a lot of common ground, as presented in chapter 2.1 (Figure 13, p.36) and table 10 (p.69). During the evaluation, both groups of participants (with and without index) came up with ambient interactions. Especially 'gradual learning' and 'using multiple senses' were valued. This shows that designers (unconsciously) connect the fields of ambient interfaces and product care as well.

__Concerns

Van Nes & Cramer (2005) said that product attachment should not be desired in every product: "what would happen if we had a bonding with many of our products? It would be a real burden to care for all these objects." The strategy to enhance product attachment should be well considered and applied delicately. The same may apply for ambient interfaces. Participant 8 doubted her interaction would be too much, and that it could also be nice "if a vacuum is just a vacuum".

When deciding on a final concept, some participants combined their ideas to form a single concept. By doing this, they needed to consider how the separate interactions could differentiate from each other, and how it would fit the general character of the product. They did not seem to have any specific problems with this, but they did have to adapt some interactions. Since their concepts were not tested, it is unclear if the functions of each interaction would be clear. I wonder if it will be feasible for designers to combine multiple ambient interactions without it being too much for users, or that prioritising some interactions would be enough. Another option would be to introduce new interactions over time, as participant 4 proposed. Multiple interactions could occur simultaneously in a subtle manner, since users learned to understand the interactions in a more prominent manner before.

__Potential additions/ alterations

The ambient quality 'gradual learning' is about the user continuously improving their ability to understand communication. It allows for better cooperation with the product, and can also mean that the product adapts to better fit its user's abilities and needs. Giaccardi et al. (2022) refer to this as "the co-performance of humans and nonhumans". They argue that "computational things today connect and learn, and thus actively participate in design in ways that previous industrially produced objects could not".

The Objectifier by Karmann (presented in chapter 1.2, p. 23) is a device with which anyone can train their products to learn to interpret certain interactions and translate them into actions. Karmann created it to provide people with the "ability to customise the home environment and give people more control over their devices" (Schwab, 2017). It is an interesting combination of using personalisation and bonding with a product (Mugge et al, 2005), providing control to the user (interview results) and allowing the user to find their own effective way of communicating with the product (Nicholson, 2015). On the other hand, it goes against the general design principle that users often don't understand their own desires. Nevertheless, it is an interesting opportunity for companies to add some sort of training element to products. It could also allow for ambient interfaces to be implemented, if they were used as an inspiration for example.

Eckler (2020) considered ambient interfaces as a way to use personal data "(ex: emotion, gesture, location, voice analysis and heart rhythm) […] to deliver more personalised, predictive experiences". With the rise of artificial intelligence, products might become more able to fulfil personal needs. Using it in combination with ambient interfaces and relationship design, it could enhance positive user experiences.

__Value for companies

Ambient interfaces are supposed to be a means of communication that improves users' attitudes towards products and provide motivation to care for these products because of their playful, unobtrusive and intuitive character and

gradual presentation. Currently, product care, if applied at al, is communicated in a practical manner (providing tools, paying attention to (dis)assembly..). Companies are copying each other's approaches to get to similar solutions. The drive behind their actions is based on monetary value. Walker (2011) argued that maybe companies should become more interested in creation and creativity, in order to develop meaningful products. Moreover, Bocken & Konietzko (2022) argue that: "to innovate their business models, companies need to build the capability to experiment, test and commercialize radical ideas across research and development, manufacturing and marketing departments". They conducted interviews with innovators in frontrunner multinationals (H&M, IKEA and Philips), and concluded that these companies show a sincere interest in becoming circular, yet they do not know what strategies they can implement to get there. Since ambient interfaces can be applied in a subtle, feasible manner, they could epitomise a change for product care interaction design.

Considering the monetary value of ambient interfaces, the benefits of relationship design could be relevant. Mugge et al. (2005) argued: "a stronger person- product relationship and an extended product lifetime can increase consumers' loyalty to the brand." It influences reputation of good quality and provides an opportunity to create a service- or update-based profit model. This can benefit both companies and the environment impact of products since people will see more value in delaying product replacement.

__Limitations

In the test, participants were asked to design for product care. If people are designing in general, product care is often overlooked. The index does not directly remind designers to keep product care in mind. I hope that it will stimulate motivation through the character of the interactions, but this cannot be guaranteed unless the index is tested without mentioning product care.

There is a lot of research that relates to ambient interfaces in terms of behavioural science and human-computer-interaction. I have touched upon the themes that seemed most relevant to me, but many more can be considered relevant for the index as well as general reasoning.

Conclusion

__The problem

For the sake of the planet's, and therefore people's well-being, research advocates for a more circular economy (Webster, 2017). One aspect of the circular economy, is using products to their full potential by increasing their lifespan. This is relevant for small household products, since they make up for 32% of electronic waste (Forti et al. 2020), and have relatively short lifespans (Wieser et al, 2015).

Current solutions often concern manufacturing and material use, but sustainable use is starting to gain some attention as well. Sustainable use is about (energy) efficiency, product care and repair. Especially product care is often overlooked, implemented at the last moment, or not taken into account from the start of the design process. Still, there are a few researchers who consider product care to be very important, and who have developed strategies to stimulate it. The key thing with product care is that it often needs to be provided by the user, where manufacturing and repair are mainly the company's responsibility. Companies tend to disregard care in the design because they benefit of product replacement, especially if they can blame the customer for neglecting what they suggested in the user manual. Luckily, there is a growing preference towards companies that take responsibility by developing products that last longer. Especially with the increasing pressure that is put on companies to become more sustainable (by consumers as well as governance), there is an opportunity in attending to product care. There is a lot to gain, since 78% of products still function at the time of replacement (Van Nes, 2003). In addition, it has an advantage as a circular strategy, because it does not rely on consumers' pro-environmental behaviour; it can benefit users as well.

__Proposed solution

To improve product care, companies should incorporate the three facets of stimulating behaviour: motivation, ability and triggers (Ackermann et al., 2018). Regarding motivation, relationship design has been proposed as a way to postpone replacement by designing for attachment (Mugge et al, 2010). Nevertheless, designers are not implementing these theories in mainstream design processes yet. Casais et al. (2015a) blame this due to the limited amount of practicable design directions on designing for meaningful relationships.

In this project, I propose that 'ambient interfaces' can become the foundation for these practicable design directions, as a means of (product care) communication and to improve the relationship between products and their users. To communicate this to designers, I developed the 'Ambient Care-Interaction Index'; an online tool to explain ambient interfaces through inspiring examples and information.

Ambient interfaces

Ambient interfaces allow the user to act and understand 'by feeling', rather than 'by thinking'. Multi-sensory and experimental interactions can allow for more subtle communication. This communication does not necessarily have to be functional, but once people get used to their product's communication, it can be used to communicate care or additional functions/ options. By gradually learning how to use the product, a valuable two-sided relationship between user and product can be formed. The aspects of ambient interfaces can be summarised in four 'ambient qualities': gradual (learning), intuitive, playful and unobtrusive.

Various terms describe ambient interfaces and similar interactions, therefore it can be hard to find a comprehensible explanation. Hence, the term, theory and its potential value are still quite unknown to designers.

Combining research fields

Combining the fields of product care and relationship design with the theory of ambient interfaces presents an opportunity for new innovations in all fields. Table 10 displays the overlap between the three fields.

Design for product care	Relationship design	Ambient interfaces
Control	Engendering a feeling of control, a sense of mastery	Unobtrusive: the observer is in control
	Allow users to find their way of reaching a goal	Gradual learning: adaptive
Possibility to learn	Participation through creative activities (reconfiguring & learning skills/ knowledge)	
	Evolvability / training of products	
Effort vs result	Reaching a goal through dialogue; user-product collaboration	Intuitive: understanding subtle feedback like you would in nature
	Intrinsic motivation	
Confidence (& habit forming)	Create a ritual or habit with the product; forming a relationship of stability and reliability	
Quality expectations (feeling responsible)	Natural connection with products (animism)	Playful: adding personality to a product
	Attitude	Playful/ intuitive: more efficient and likeable interactions
		Unobtrusive: informing without overburdening the mind, can be processed in the background of awareness
Visibility as motivation		Intuitive: uses minimal equipment to convey a simple message
Stepwise information		
General purpose is to maintain function	Building a relationship of mutual altruism	

Table 10: Overlap between the research fields of product care design, relationship design and ambient interfaces

Another similarity between these fields is that their value is relatively unknown to designers, but most of all to companies that produce household products.

Familiarity with strategies

Product care is often overlooked, implemented at the last moment, or deliberately not taken into account at all. When it is implemented, it is not done in very creative ways; generally companies tent to copy each other's solutions. It has a strong connection to financial value and increasing ease of care (through displays or automatic features). This way, the value of caring can get lost. Furthermore, emotional and functional values can be complicated to implement for designers, especially for cheap products. To apply strategies that improve these values, companies need to understand the possible impact, and strategies need to be developed which provide structure to design for these values. The strategies that researchers currently propose, are hardly used in regular design processes. To increase product care,

designers should consider many facets of the design; to motivate as well as support the user in caring for their products. Eventually it comes down to collaboration between the user and their product.

As for relationship design, even though theory exists, it is rarely (consciously) implemented in mainstream design processes. According to Casais et al. (2015a), this is because the amount of design directions on designing for meaningful relationships is very limited.

The qualities of ambient interfaces are occasionally used in designs, but the term remains quite unknown. Two of the design students that participated in the evaluation of the index had heard of the term (or something similar) before, but they did not exactly know what it entailed. Ambient interfaces appear to be unknown to most designers. This is possibly due to the many definitions, its experimental character, or because no mainstream product manufacturer has explicitly used its qualities yet.

Ambient Care-Interaction Index

Concluding from research on relationship building and ambient interfaces, communication throughout the product's lifetime could be a novel solution to stimulating care. Communication is a broad term, which includes motivating the user by embodying value, gaining mutual trust and respect through the nature and character of interactions and teaching about the functions of the product, thereby facilitating the ability to express the need for care.

Translating these pillars to an index that provides structured information, the Ambient care-interaction index provides support by being an informational tool which allows designers to explore freely. The online tool contains informative text and inspiring examples. It can be used to learn about ambient interfaces and inspire designers to use the ambient qualities in their designs. It is not bound to be followed in any way, but it does provide enough information to support and provide structure. Fitting the context of designing in the 'Fuzzy front end', where the product's 'personality' is shaped, designers can be inspired to follow strategies that could fit their design goal, and refer to related research to support their choices.

The index was developed through iteration, after obtaining information from literature studies, interviews, self-tests and conversations with experts. Eventually, the index was evaluated by comparing the design process and concepts of 9 design students and designers (of which 5 designed with, and 4 without the index). The index was received well, participants liked the core idea of being presented with examples of interactions that they were not very familiar with, which focussed on the more emotional side of design. The actual interface received some critique, mainly concerning its lack of an introduction. They also argued that this introduction could emphasise the link to product care more. That said, participants recognised the value it could bring; supporting and guiding designers in designing more unconventional interactions to stimulate product care.

__Future potential

After testing, I discussed the general value of product care with each participant. All of them recognised the importance of designing for product care, but they were also quite pessimistic about the possibilities in applying it when designing within a company. The two participants with the most experience (one worked for a household appliance manufacturer, the other for a sleeping device company), both said it would be very difficult to implement care attributes since companies are often not aware of its value. They said companies copy others, hence they would need a market leader to present an inspiring innovation before they would dare follow.

This means that implementing ambient interfaces to stimulate care will be difficult. But, if applied well, they have the potential to become the innovation that inspires companies to change their product care communication. For this to happen, designers and companies need to become aware of the value of ambient interfaces, and how they can be implemented. If the index could be used by a design agency to teach with and implement in designs, the theory could reach a broader audience. It could be presented in an educational but also a corporate setting.

To conclude, the Ambient Care-Interaction Index adds to the field of product design by linking multiple disciplines together in an overview of possibilities that can steer designers in a more user-centred direction.

Eventually, the goal of the index is to empower and inspire designers to use ambient interfaces to create products that are meaningful to their users, in terms of function and character. They should incorporate factors that stimulate a two-sided relationship in which both product and user are valued and mutually supported. The product through receiving proper care and an extended lifetime, the user through improved functionality and understanding of the product. If every product would be designed with a certain relationship in mind, people's attitude could change as it feels more natural to care for products, or discard them in the right way.

Recommendations

By evaluating and discussing the tool with design students and designers, a lot of recommendations appeared. Most emerged from the comments that participants made on the index, others are impressions that I came up with from observing and analysing the evaluation and general notes on the project.

Actual website

First of all, it needs to be stated that the index in its current shape was build as a prototype in Flinto. If it were to be used by companies, it should be programmed as an actual website (to be used legally, but also to function properly). This would also allow for an option to add examples, information and links to relevant websites. This way it could be updated by its owner (whether this would be a design agency or a company). Moreover, the copyright of examples and research that was used needs to be figured out.

Index Introduction

The main missing feature appeared to be an □□□□□□□□□□□. Participants said it could be valuable to explain why people should use the index in general, what ambient interfaces are in general and how the index can be used. One participant noted that this particular 'why', ‘what’, ‘how’ sequence would be important.

The participants had several ideas on how the introduction should look, but they all agreed that the ‘□□□□’ page could be a good start. The value page already starts with an explanation of the connection between ambient interfaces, relationship design and product care (why) and a brief list of steps that should be considered when designing for product care (what/how), followed by a more elaborate description of ambient interfaces and the qualities (what) and ending with a descriptive image of the index (how).

Some participants added that the top of the value page should be calmer, leaving more room for the individual segments and creating a more logical order of reading. The page could then shortly explain product care (show the main steps and refer to other elements), and slightly next to it present the summary of ambient interfaces. Scrolling further, this summary could turn into a ‘walk through’ of the index, first showing that the page that people are looking at is ‘value’ and that ‘evaluation’ portrays a quick overview of the ambient qualities as well. This should inform users that ‘value’ is about the value of the index, and not ‘user value’ or something similar. The other segments (qualities, strategies and senses) can be clickable, first showing a small text explaining their objective, then the ability to visit the page.

The introduction/ value page could pop up when the index is opened for the first time. After that, it could open on the home page again or on the ‘value’ page with a clear ‘back' arrow. To avoid people skipping the introduction, a small overview of the content or clear subtitles (and a table of contents) could be added. Small tests would have to show which attributes and approach would be most effective and pleasant.

Search/ suggestion option

Two participants thought some sort of ‘quiz' would be useful in the index to help people understand what value it could bring to them. If people could search for or select a specific type of product (that provides emotional value or a ritual for example), context, target group or even an interaction vision, relevant topics could be suggested. It would make the tool more interesting, but it could also reduce the free exploration which is currently forced upon users. In addition, it would make the index more complex by adding a database of links between variables, examples and pages.

Some participants expected the tool to provide specific information on cleaning filters and other care activities. This approach to suggesting relevant information is also interesting to consider, although participant 9 also explicitly appreciated that the tool provided examples of other product categories. It allowed him to interpret the examples in his own way and come up with original ideas. It might be nice to link to the biomimicry website (AskNature.org), where users can look up specific problems or topics to see how nature solves complex problems. However, this would move away from the focus on ambient interactions and more to a general inspiration database, which is not its main function.

Small changes

The **location of ‘value’ and ‘evaluation’** should be switched, together with the new introduction, this should make their purpose recognisable. Two participants did not know they could **click the segments** on the homepage, another did not know the ‘research titles’ contained more information. It could help to add shade to both. Additionally, a **visible scroll** bar (which would already be present on an actual website) and an arrow on the home page should be added to emphasise the possibility to scroll.

Further research

To test the effectiveness of both the theory and the tool, the concepts that participants came up with during the evaluation should be tested by consumers, and compared to regular vacuum cleaners. The concepts were only reflected upon by me and the participants that created them. For now it remains unclear if the functions of each interaction would be clear and effective.

In this project, the focus was on electronic household products, since they present a large part of the global electronic waste, and require care that the user can provide. Therefore, it it would be valuable to repeat the evaluation test for another household product to see if the index and theory is still valuable, or if there would be any complications. Furthermore, it could be interesting to see if it would also be applicable for other product categories, like automotive design for example.

The online format of the index was chosen because it would be an easy format to quickly have access to when in need of inspiration. If the index would be used in a group setting, or as a workshop, it might be beneficial to expand it or replace it with a physical card deck and physical prototyping inspiration or support. This direction has not been thoroughly explored in this project.

It was quite challenging to find research that relates to ambient interfaces since there are many definitions of the same topic. It is definitely possible to find more information that could add to the theory and the index.

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