# AESTHETIC DURABILITY

# & REPAIR

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Master thesis
Integrated Product Design
2023 - 2024

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# PREFACE

If you've come across this report, chances are you have a fondness design, and maybe particularly in product design. I also assume that, aside from your love for beautiful, functional things, you're conscious of their impact on our natural world. It's hard not to be aware of this given the times we live in. If you're a product designer, you likely understand the challenge of balancing your love for creating things within this context. I don't want overwhelm you with numbers that warn you of the gravity of the situation, giving you the feeling you have to take immediate action. Instead, I'd like to slow things down.

This project began with a desire I have felt for a while to explore and articulate what it is that makes a product truly sustainable, or better said, durable, with a vision for the long term. What our role as creators of objects can be, and having a better understanding of what we place in this world. This seems like quite a big undertaking, and I'm aware of only having scratched the surface of just a tiny part of this immensely broad subject. Nevertheless, it's been an opportunity to experiment, read, learn from others, and to try to build solutions. Thoughts that attempt to consider many years to come, and we hopefully can use to continue the conversation, and perhaps more importantly, building solutions, together.

# ACKNOWLEDGEMENT

First of all, I want to express my gratitude to my chair and mentor, Bas and Maurizio, for their dedication and enthusiasm, our lively conversations and thoughts that helped shape the project, and for bringing the expertise of their two backgrounds. An extra thank you to Bas for pushing and enabling me to exhibit at Dutch Design Week, and to Maurizio for the wonderful references and ideas that enriched this project.

I would also like to thank some people from the Industrial Design Engineering faculty. Wing, for the opportunity to exhibit at the Dutch Design Week and the budget that enabled me to create so much. I appreciate the faith when selecting my project, even when the prototypes did not yet exist. And most importantly, everyone at the PMB, especially Carlo, for all the prototyping assistance and good company.

Lastly, I am of course very grateful for all my lovely friends and family that were there during this project. To Mats, for our late-night conversations (on design), the things we love (and hate) and all the references and books which made their way to me and this project, and for together with Loek, from whom I received so much love, support and meals, being a home. Hans, for your support and sharing this experience together, not without a day of laughter. To Han, for our endless and beautiful conversations. To Selma, for always being there, and your patience with me finishing this thesis. Tom, for your unmatchable critical views and having opened up a new way of thinking for me through your own work years ago. I will always follow my big brother, of course. To Bibi, Haak and Opa for all the love and many forms of support. But above all, Joost, for being there in every way. From (very meticulously) building objects to put on top of cars to cooking meals, from proofreading to emotional support, always with love, enthusiasm, and a smile.

# ABSTRACT


Each year, over 50 million tonnes of electronic waste is generated globally, with the Netherlands averaging more than 20 kg per capita (Compendium voor de Leefomgeving, 2023). The shift from a linear to a circular economy is crucial in addressing this issue, emphasizing the importance of durability and repairability in product design. Additionally, the forthcoming legislation from the European Commission (2023) regarding the "right to repair" highlights the need for designers to create products that are both durable and repairable.

This project delves into a product's durability, considering not only its physical repairability, but also how it can retain aesthetic value over time. Central to this exploration is the question: "*How can appliances be re-designed for retainment, considering repairability and aesthetic durability?*" Drawing upon literature research, a design space is formulated, guiding the several re-designs of the same appliance, in this case a sandwich maker, with each re-design focusing on a specific aspects of repairability and aesthetic durability theory. Evaluation of these re-designs by visitors at Dutch Design Week informed challenges, guiding the further development of one of the re-designs into a functional prototype.

The literature review addresses repairability through the challenge of fault diagnosis, particularly as products are often perceived as 'black boxes'. Practical design implications for improving ease of disassembly and part replacement, alongside the value of awareness of components in having a product repaired, are discussed. Aesthetic durability is explored from the perspectives of 'living with things' and the 'life of things'. The former examines aesthetic pleasure from a multisensory point of view, and the role of familiarity and novelty in design. The latter discusses the dimension of temporality in product design throughout a product's lifetime, and the concept of products becoming 'things' when they break down.

The construction of a design space with three axes based on this theory—'the possibility to repair', 'our pleasure as users', and 'the life of the thing itself'—provides a framework for creating eight diverse prototypes reflecting various perspectives from the theory. Evaluation by 3010 Dutch Design Week visitors identifies one prototype, featuring an 'oven mitt'-like top, as standing out for its emotional qualities such as 'connection' and 'beauty.' This re-design is selected for further development into a functional prototype, highlighting repairability improvements and offering the opportunity for ergonomic testing.


*Figure 1. An overview of the results: the re-designs, their position in the design space and the functional 'Oven mitt' prototype*

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# INTRODUCTION

The shift toward a circular economy is a large operation, involving many stakeholders such as policymakers, material suppliers, manufacturers, business owners, and waste operators (European Recycling Platform, 2017). Collaborations among all stakeholders are crucial, as various factors are interconnected, such as economic, environmental, and regulatory considerations. The role of a designer is significant, yet a small part of this large whole.

The transition from a linear to a circular economy centres on closing loops within the stages of the product's lifecycle, ensuring that materials or the product itself never come to waste. Figure 3 shows how the linear lifecyle becomes a circular one, by closing loops within each step (Ellen MacArthur Foundation, 2022). After use, the product can either be reused through distribution, refurbished or remanufactured, or recycled into new raw material. Typically, larger loops require more time and energy. This means that in the most inner loops, by keeping the product whole as much as possible, most value can be captured.

The smallest loop concerns maintaining and prolonging the life of products, meaning that it is retained by the user. This asks for products that are durable and can be easily repaired rather than being discarded when they break or become outdated. This is exactly what the European Commission's (2023) proposal for the "right to repair" is about. Both inside and outside the legal warranty period, repairs of goods should become easier and cheaper. Appliances especially are a category of household goods that pose challenges regarding repairability. Annually, over 50 million tonnes of electronic waste is generated, and in the Netherlands alone this is an average of more than 20 kg per capita (Compendium voor de Leefomgeving, 2023).

This shows that incorporating repairability into appliance design is crucial, yet does present challenges for designers. Because what makes an appliance repairable? And in what ways can its repairability be considered from the start of the design process? Determining the factors that contribute to a product's repairability are inherently specific to each product. Fortunately, there are tools available to assess existing products, and guidelines to improve them.

However, designing for the retention of products is not only a practical matter. Research shows that important reasons for product disposal include a lack of attachment to a product, or desire for new alternatives (Reynolds et al., 2024). Thus, in addition to enabling the retention of functional value over time through repairability, how can appliances be designed in such a way that someone would want to retain them as well? This question will be explored in this project by delving into the essence of the product itself, investigating the role of aesthetics in durability—a concept that will be referred to as "aesthetic durability," meaning a product's ability to maintain its aesthetic value over time.

This project aims to explore perspectives on designing long-lasting appliances, through the introduced topics. This exploration centres around the question:

*"How can appliances be re-designed for retainment, considering repairability and aesthetic durability?"*

The research delves into the factors contributing to a product's repairability and aesthetic durability, investigating how both functional and aesthetic value can endure over time. Building upon the insights from literature research, these aspects are translated into a design space for re-designing appliances. Through a case study with an emphasis on prototyping, it is explored how repairability and aesthetic durability can intersect in practice in the design of appliances.

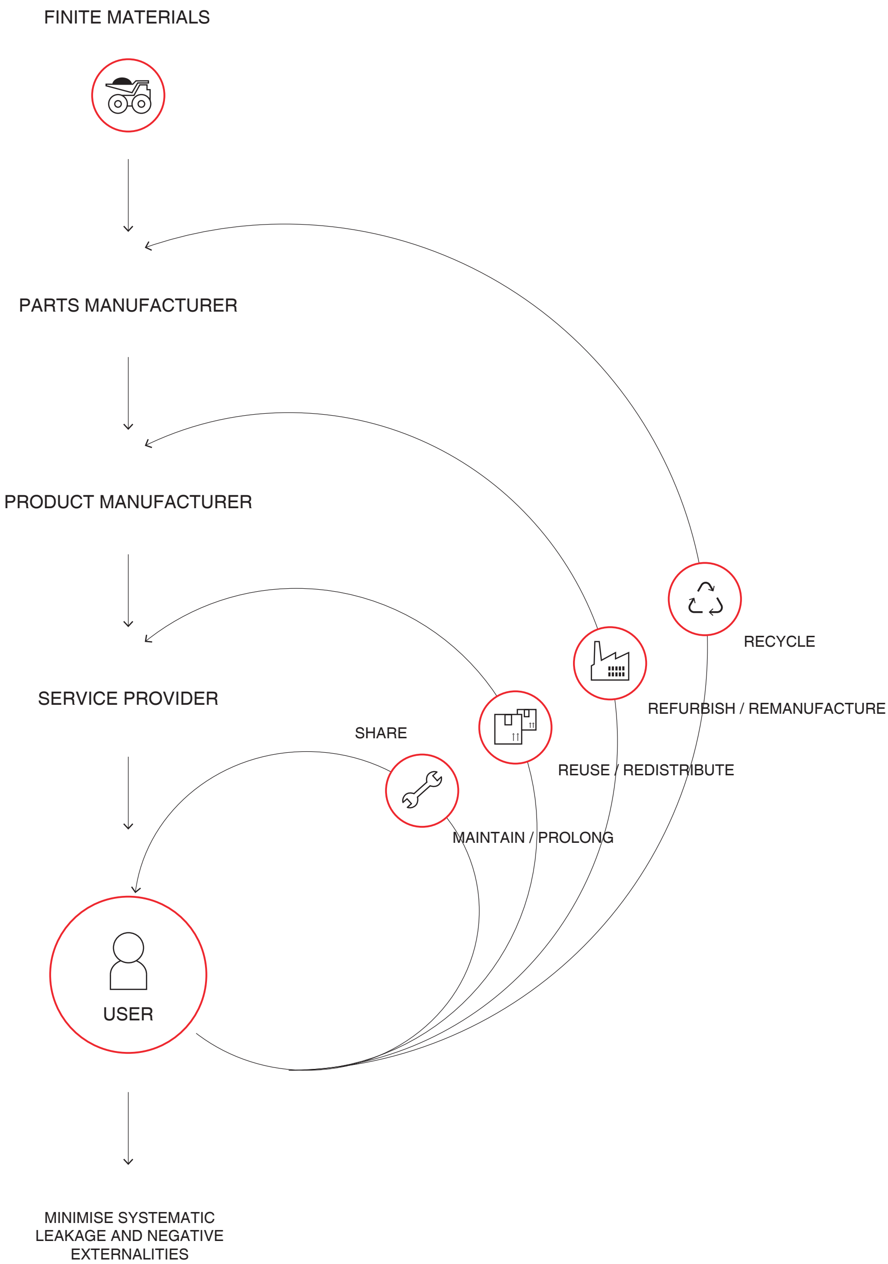


*Figure 2. The technical cycle of the circular economy butterfly diagram*

# APPROACH

*"Re-design refers to the redoing of the design of ordinary objects. You could call it an experiment, an attempt to look at familiar things as if it were our very first encounter with them. Re-design is a means by which to correct and renew our feelings about the essence of design, hidden within the fascinating environment of an object that is so overly familiar to us that we can no longer see it. Producing something new from scratch is creative, but making the known unknown is also an act of creation."*

- Kenya Hara (2007)

Re-design has the ability to shine new light on the things we think we know well. Changes to familiar objects suddenly become more apparent. It is exactly this potential that underpins why this approach is taken to convey the theory on repairability and aesthetic durability into tangible outcomes. Hopefully we can learn from this case study, and this research can help in applying the theory to the re-design of other objects. This chapter delves into the re-design approach, through its process, methods and attitude.

## PROCESS

Figure 3 provides an overview of the process that was followed.

From a selection of household appliances, a case study was chosen based on various criteria, which will be further elaborated on in the following chapter 'Case study.'

Drawing from existing research on repairability and aesthetic durability (see chapters 'Repairability and 'Aesthetic durability'), a conceptual design space was formed (see section 'Aesthetic durability & Repair').

The chosen appliance for the case study was dissected and analysed (see chapter 'Dissection'). Each re-design differed from the original appliance by changing only the aspect taken from the theory (see chapter 'Re-designs'). In this way, each re-design positions themselves differently in the design space (see section 'The relation of the re-designs to the research').

Subsequently, the redesigns were evaluated (see chapter 'Evaluation'). In this instance, a small research was carried out in a test setup at the Dutch Design Week. The goal of this research was to find out what people find important in the things they own, and how they relate the re-designs to these valued qualities. The outcomes were used in the selection and further development of one prototype.

Finally, one re-design was selected for further elaboration and made into a functional prototype (see chapter 'A step further'). This prototype serves multiple purposes: bridging the gap between theory and reality, providing a basis for experiential and ergonomic testing, and serving as a starting point for potential future detailing.

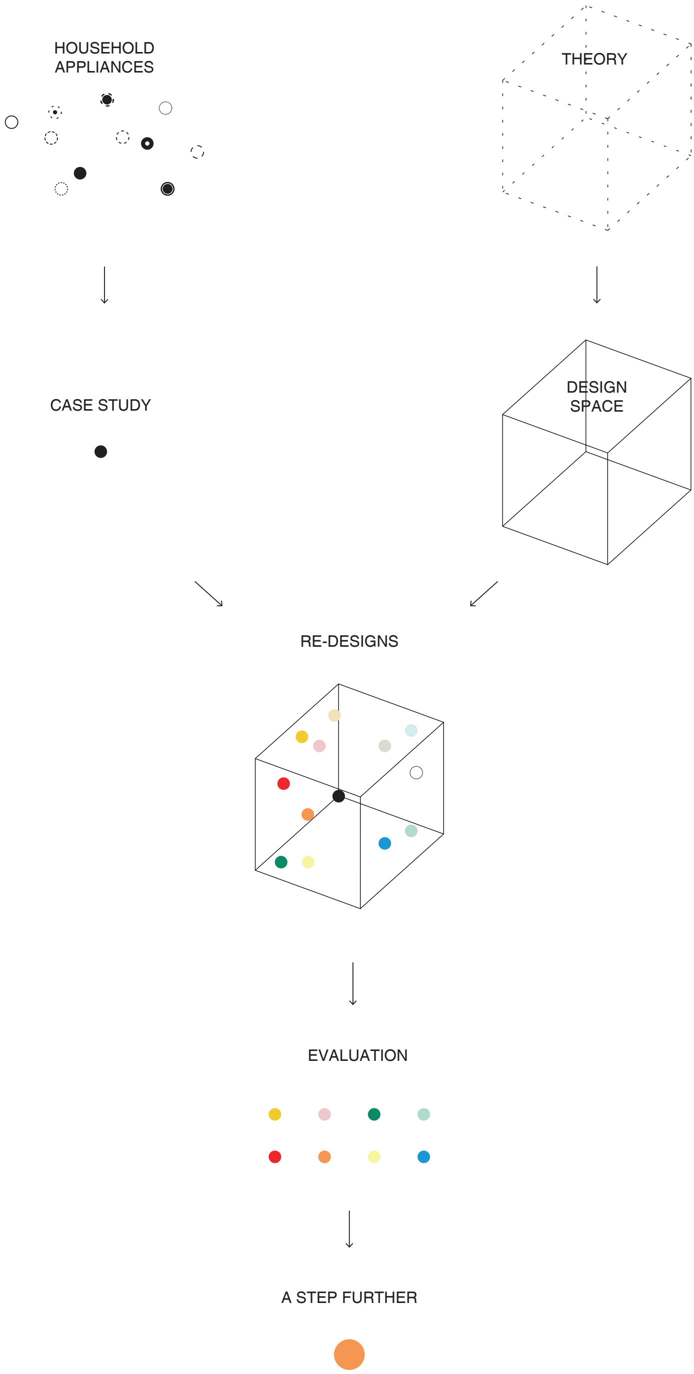


*Figure 3. Schematic of the design process*

## METHODS

### DESIGN SPACE

The design space that was used, is formed using a mix of existing scientific research, writings by designers or thinkers, references of theory in practice and personal experience. It is shaped through reading, connecting, translating and writing. The framework this creates gives several options of starting points for each re-design.

### PROTOTYPING

From early on in the process, prototyping plays an important role to generate ideas, and make the theory and these ideas come to life. It forces us to design objects that are physically realistic and serves as a way to develop new ideas.

### HOTSPOT MAPPING & DISASSEMBLY MAPPING

The case study is analysed through 'hotspot mapping' and 'disassembly mapping' (see chapters 'Repairability' and 'Dissection'). With a "hotspot map", the product's architecture is evaluated by identifying the priority parts, which are parts that either require high maintenance, have a high failure rate or are important for the primary functionality of the product (Flipsen, 2023), and their accessibility. This method involves dismantling the product, recording all the steps and documenting the general properties, the activities involved in disconnecting parts and the difficulty of these activities. The "disassembly map" visually represents the location of these parts in the product architecture by illustrating the relationships between parts, and the number of steps needed to free them (De Fazio et al., 2021).

## *ATTITUDE*

*Building the design space felt like laying a foundation of strong reasoning. It involved reading, engaging, bringing together, writing and finding the right tone to convey the thoughts.*

*On the other hand, prototyping offered a way to be free. To experiment, wander and create. However, without a strong foundation, there would be a risk of wandering off too far.*

*As these two different approaches both required immersion, they were never done at the same time. Throughout this project, I constantly shifted between both, allowing each to inform and enhance the other.*

# CASE STUDY

As mentioned in 'Introduction' and 'Approach', a case study on an appliance, an often disposed category of consumer products, is used to convey and explore the theory on repairability and aesthetic durability in practice. The first step in the design process is to select an appliance that could serve as a proper case study, serving as a carrier for the theory (see Appendix 2 for full overview of case study considerations).

## RELATABILITY

To ensure visible changes in a familiar object, I prefer the case study to be an everyday product that is relatable in the Dutch cultural context. Appliances that are less common in Dutch households, such as handheld vacuum cleaners or mixers, are therefore excluded from consideration.

## COMPLEXITY

To explore both fields of theory, the appliance preferably has a level of technical complexity that presents opportunities for improvement in repairability. However, it should still be possible to dissect and re-design within the project's timeframe of 100 days. Large appliances, such as ovens, washing machines and even vacuum cleaners are therefore excluded from consideration.

## COST INDEPENDENT PERFORMANCE

For this project, I aim to focus on the theoretical aspects of the re-design, rather than paying attention to improving the product's performance. Therefore, the selected appliance category should have minimal price related performance variations. For instance, the hair dryer segment has a large diversity of different technologies and price ranges.

## ORIGINALITY

To be able to bring a fresh perspective to the project, I avoid commonly studied products and focus on an object that is less often explored. For instance, the toaster, a subject of study by various designers, is deemed less suitable.

The decision-making process involved rating a selection of appliances based on these four preferences. Each factor was assigned a weight (100, 80, 50, and 50, respectively), and the final scores were calculated. The highest-scoring appliances were then considered for further evaluation, all deemed suitable for the project. The sandwich maker ended up as the chosen case study. Widely recognised, commonly found in Dutch households and inexpensive, this appliance offers opportunities for exploring repairability, especially concerning the heating elements often becoming stuck in the grill plates. Distinguished from contact grills or panini presses, the sandwich maker features a hinge, requires to be closed shut, and has grill plates with triangular forms (Figure 4).

*Figure 4. The sandwich maker case study*


*Figure 5. The initial pool of household appliances*

Designers can design for physical product durability by for example selecting robust materials, using high-quality components, and over-specifying dimensions (PROMPT, 2022). However, despite these efforts, products can malfunction at some point. Through repair, the faulty product can be restored to a condition where it can fulfil its intended purpose again (NEN, 2020).

Currently, the primary focus of product design often centres on minimizing production costs, leading to a high repairability not being taken into account (Leiden-Delft-Erasmus Centre for Sustainability, 2023). Fortunately, there's a growing recognition of the importance of product repairability, evident in the EU's introduction of regulations known as the "right to repair." This initiative aims to make the repair of goods easier and cheaper, both within and outside the legal warranty period (European Commission, 2023).

Yet, what exactly makes a product repairable? And how can designers integrate repairability into their product designs? This section explores these questions, emphasizing repairability as an integral part of the design process from the beginning, rather than an afterthought. Guided by principles from NEN (2020) and PROMPT (2022), various stages are covered—from diagnosis to disassembly to replacement—highlighting perspectives to improve repairability. The examples demonstrate that designing for repairability can often be accomplished through existing, and fairly simple, and practical solutions.

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These refer to the page numbers of a re-design that is connected to a specific part of the theory. Jumping to these pages in between reading may help both the theory and re-design come to life.

## DIAGNOSING A BLACK BOX

The moment a product malfunctions, the first step is to identify the underlying issue. However, a challenge arises for those that are not familiar with repairing products. Most products conceal their components, leaving people unaware of what they might encounter when opening them up. This phenomenon is commonly referred to as a 'black box', meaning objects that have their internal complexity hidden away, leading to users only focussing on its inputs and outputs (Figure 6 and 7).

Sociologist Bruno Latour notes that over time, scientific and technical work has been made invisible by its own success. The more science and technology succeed, the more opaque and obscure they become (Latour, 1999). This trend is particularly evident in the digitization of products, where visible mechanical components that directly demonstrate functionality are replaced by digital counterparts. For instance, some modern microwaves open with a digital button instead of a direct, physical one and opening the hood of a tesla reveals more storage space. Of how many of the products that surround you right now do you know what is going on inside? Improving the visibility and understanding of a product could narrow the gap between the user and the product. Highlighting the composition and functionality of a product in its design can be helpful in the initial step of diagnosing malfunction. This may lower the threshold of repairing, as you already are already familiar with the product's components.

Some products with a higher complexity already have a way to guide users in diagnosing repairs, as they self-indicate their malfunctions, such as certain printer interfaces communicating its malfunction and how to solve the issue. In cases where the product itself doesn't offer such indicators, ideally, repair guidance is available through manuals.

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## EASE OF DISASSEMBLY

To identify the issue, the black box has to be opened. Key to repair is the possibility to disassemble, whereby the product is taken apart in such a way that it could subsequently be reassembled and made operational again (NEN, 2020). Every product can be opened somehow, but the challenge is to make this an easy process and not permanently damage parts in doing so.

### ACCESSIBILITY

It is essential for the part or connector to be accessible or reachable by hand or a tool. This means that ideally fasteners are visible and not hidden away or even obstructed for tools, which can sometimes be the case with concealed screws.

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### USER-FRIENDLINESS

Several factors impact the user-friendliness of the repair process. The size and weight of a product influence how easy it is to handle during examination. For instance, a washing machine might pose more challenges compared to a toaster, which can be easily picked up and inspected.

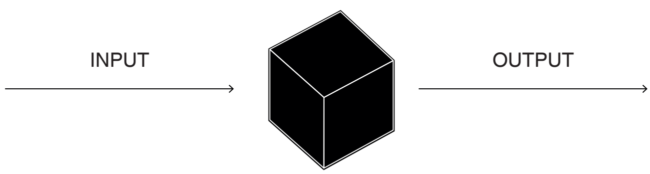


*Figure 6. Schematic of the black box principle*


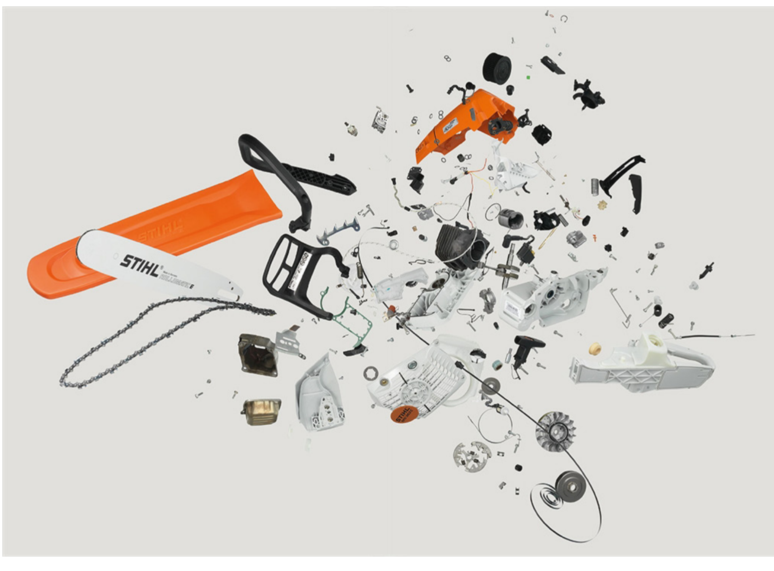


*Figure 7. A very 'exploded view' of a chainsaw (McLellan, 2019)*

Moreover, it may be difficult to retrace each step of the disassembly process if a manual is absent, potentially hindering the reassembly of the product. This issue can sometimes be addressed by incorporating 'keyed' slots that allow parts to fit in only one way. This aligns with the principle of poka-yoke, a concept defined by industrial designer Shigeo Shingo and introduced in the Toyota production system. It involves designing devices that serve to prevent unintentional mistakes that anyone can make (Shingo, 2021). Examples include microwaves that won't turn on when the door is open, and the chipped of corner of a SIM card edge to ensure it is inserted it correctly.

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## TOOLS

Ideally, from a repairability perspective, no tools or only basic tools are necessary to detach fasteners in a product (Figure 8). Moreover, minimizing the variety of tools needed not only reduces the level of skill required, but also saves time. Nevertheless, it's important to acknowledge that in some instances, specific tools—demanding more skill or knowledge than basic tools, such as a soldering iron—may be unavoidable.

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## DURABILITY

Durability is not exactly a repair consideration but more of an overarching objective in this research, but still worth mentioning in this context. During use and disassembly, we want to make sure that components don't break, meaning parts should be robust. Some factors that contribute to this are material and component selection, over-specifying the load on the parts or making sure parts cannot easily be dropped. An example of this is "The Optimist" toaster by the Agency of Design (n.d.) (Figure 9). This toaster is made from a robust piece of cast aluminium with few parts to break. Additionally, the number of slices of bread that have been toasted are displayed on the side.

Furthermore, the incorporation

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of reusable connectors increases the ease of disassembly. This means that permanent connections like glue are discouraged. For wiring, connections that are soldered or crimped can complicate replacement, demanding more specific tools and skills. Prioritizing reusable and easily detachable connectors adds to the overall ease of disassembly.

## NUMBER OF STEPS

To assess the effort that is required to access and replace the most important parts, the number of steps that are required is fundamental. These important parts are called priority parts, which are parts that either require high maintenance, have a high failure rate or are important for the primary functionality of the product (Flipsen, 2023). With a "hotspot map", the product's architecture is evaluated by identifying these priority parts and the ease of reaching them. This method involves dismantling the product, recording all the steps, documenting the general properties, the activities involved in disconnecting parts and the difficulty of these activities. A more detailed analysis of this approach, applied to the sandwich maker, is covered in the 'Dissection' chapter.

Ensuring that priority parts are easily accessible is essential for increasing product repairability. The "disassembly map" visually represents the location of these parts in the product architecture by illustrating the relationships between parts, and the number of steps needed to free them (De Fazio et al., 2021). The map's orientation, whether vertical or horizontal, signifies the complexity of the disassembly process. A vertical map suggests more sequential steps, while a horizontal one implies parallel steps, making it easier for repairs.

There are several design strategies to reduce the number of necessary steps to reach priority parts (Flipsen, 2023). Firstly, 'surfacing' involves relocating the critical part to the top of the disassembly map so that it becomes more accessible.

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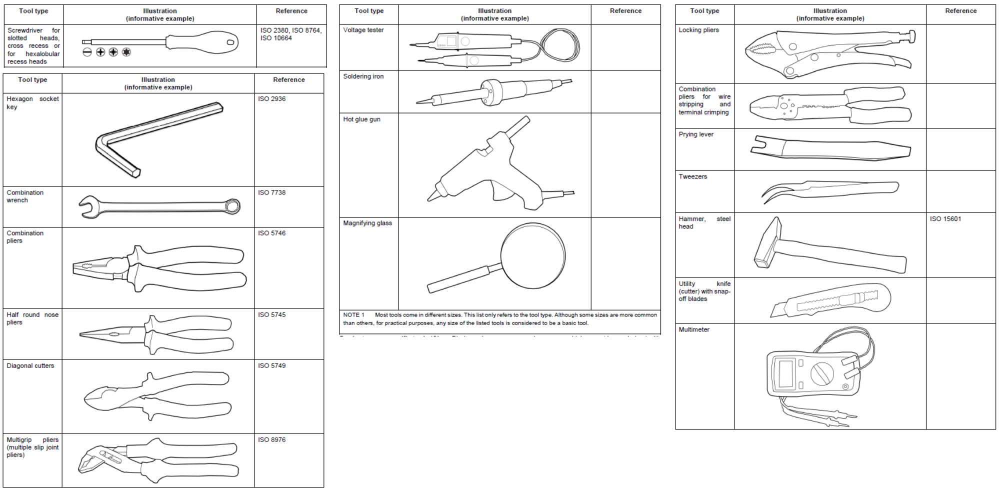

| Tool type | Illustration (informative example) | Reference |
|---|---|---|
| Screwdriver for slotted heads, cross recess or for hexalobular recess heads | | ISO 2380, ISO 8764, ISO 10664 |
| Hexagon socket key | | ISO 2936 |
| Combination wrench | | ISO 7738 |
| Combination pliers | | ISO 5746 |
| Half round nose pliers | | ISO 5745 |
| Diagonal cutters | | ISO 5749 |
| Multigrip pliers (multiple slip joint pliers) | | ISO 8976 |
| Voltage tester | | |
| Soldering iron | | |
| Hot glue gun | | |
| Magnifying glass | | |

NOTE 1 Most tools come in different sizes. This list only refers to the tool type. Although some sizes are more common than others, for practical purposes, any size of the listed tools is considered to be a basic tool.

| Tool type | Illustration (informative example) | Reference |
|---|---|---|
| Locking pliers | | |
| Combination pliers for wire stripping and terminal crimping | | |
| Prying lever | | |
| Tweezers | | |
| Hammer, steel head | | ISO 15601 |
| Utility knife (cutter) with snap-off blades | | |
| Multimeter | | |

*Figure 8. Basic tools and their reference standards (NEN, 2020)*


*Figure 9. 'The Optimist' toaster, designed to last for generations*


*Figure 10. A disassembled Fairphone, showcasing its modular design (Wiens, 2024)*

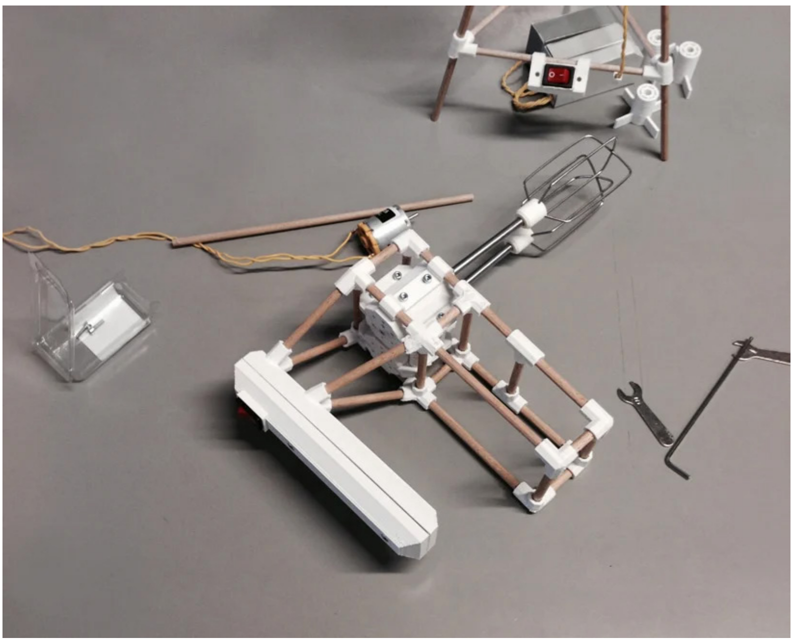

*Figure 11. The 'Hacking households' system offers users the ability to assemble, customise, repair and repurpose existing products*

Another technique is clumping, where parts are grouped into a subassembly which is easy to take out before reaching a critical part. Another way to call this is modularity, where modules form semi-autonomous chunks. A well-known example is the Fairphone (Figure 10), a modular phone designed to be easily opened and have components replaced by the user, with just the use of a Phillips #00 screwdriver (Fairphone, 2022). While modules may decrease disassembly time, it is important to note that they often increase the prices of spare parts. Lastly, there is the option of 'trimming,' which aims to reduce the number of activities and time needed to reach critical parts by rethinking the use of fasteners. As mentioned earlier, this technique focuses on the use of reversible fasteners and common tools. Another strategy in line with this thought is to minimize the overall number of parts.

### REPLACING

Finally, when the broken part is found and freed, it is time to replace it. It is often dependent on the manufacturer if spare parts are available. A way to approach this issue during the design process is to use standardised components that are readily available, to the extent the product allows it. This not only ensures easier access to spare parts, but also contributes to cost reduction, time needed for tooling and reduces the complexity of identifying the components. A conceptual example of this principle is the "Hacking Households" project by Jesse Howard (Figure 11), which is a system building upon a basic structure using standard components, offering users the ability to assemble, customize, repair and repurpose existing products, as seen in Figure 11 (Designboom, 2014).

Another strategy to address this could be to design products that have the capability to adapt by allowing for component upgrades. This is already common in digital products that enable software updates, yet could also be applied in modular designs that permits users to upgrade certain components can enhance the product's longevity and adaptability.

### AWARENESS

Lastly, it is important to recognize that not everyone is suitable for or interested in repairing their products themselves. Nevertheless, it is important that in that case users have their products repaired by someone else. This could mean that some parts of the product are relatively easy to access for diagnosis or small repairs through the use of basic tools, and some parts are only reachable at an expert level. For instance, the Fairphone's modules are replaceable with a common Phillips screwdriver, yet accessing the internal components of these modules requires a Torx screwdriver, which you may consider as a more 'advanced' tool. However, awareness of the product's functioning and internal components might already contribute to the willingness to have it repaired, as the product would no longer be a 'black box'.

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# AESTHETIC DURABILITY

The various discussed approaches to enhancing repairability show perspectives into improving the functional durability of a product, and the physical possibility of its retention. However, the question remains, how can designers ensure that users not only have the possibility to retain their products, but also the desire to do so?

Research suggests that the strengthening of the emotional bond between consumers and their products will lead to them holding on to the products they own. Two determinants positively contribute to this degree of emotional attachment between people and their products: memories and enjoyment (Schifferstein et al., 2008). This means that products that are enjoyable and/or carry memories of specific events, people, or places in users' lives, are more likely to evoke emotional attachment.

Yet, to design for this emotional response in people is not straightforward. Designers have control over the product itself, and all they can hope is for their design to be a fertile soil for emotional connections to grow. Closer to the essence of the product itself, and more directly influenced by designers, are its aesthetics. The aesthetic experience of an object can elicit emotional responses (Desmet et al., 2007), thus contributing to emotional attachment. Hence, the term used is aesthetic durability, which is the ability of an object to retain its aesthetic value over time.

This section on aesthetic durability is approached from two perspectives: that of the user (living with things), and that of the object (the life of things). The former delves into a detailed understanding of aesthetic pleasure, exploring principles discussed in things that are familiar and unfamiliar to us. In the latter perspective, the dimension of time in product design is discussed, considering how temporality influences the life of products.

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These refer to the page numbers of a re-design that is connected to a specific part of the theory. Jumping to these pages in between reading may help both the theory and re-design come to life.

## *LIVING WITH THINGS*

We are surrounded by things that are made by us, for our convenience and pleasure. They exist to serve us, seamlessly fitting into our lives, giving us new capabilities, and functioning as extensions of ourselves. They should be easy to use and cater to our life and needs, or excite us. In this section, we examine these objects from our perspective as users.


*Figure 12. A Makita drill granting new capabilities*

## A SENSE OF AESTHETIC PLEASURE

When discussing the 'aesthetics' of things, the conversation mostly revolves around visual characteristics. Vision is by far the most prominent sense in research on human perception, logically, as it is for most of us our most important sense to experience and move through the world around us (Hekkert, 2006). Design, too, places most emphasis on visual aspects. It was the Finnish architect Juhani Pallasmaa (2012) who pointed out that "modernist design has housed the intellectual and the eye, but has left the body and the other senses homeless".

Yet, the definition of aesthetic pleasure doesn't limit itself to sight. It is defined as the pleasure attained from sensory perception, the degree to which all of our senses are gratified (Hekkert et al., 2008). Designing for these other senses is challenging, especially when we have the habit to focus on visual aspects. Kenya Hara's "Haptics" exhibition exemplifies an alternative approach (Figure 13). In this exhibition, he invited designers from different disciplines to redesign an object starting from the senses, in an attempt to make the other senses "drool". No sketching was allowed, intentionally avoiding a visual focus (Hara, 2007).

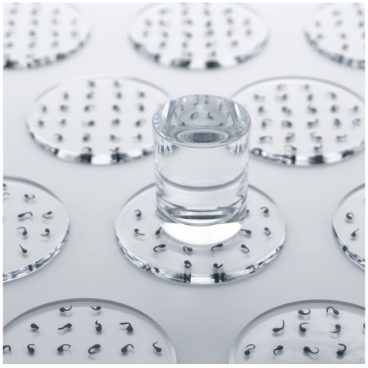
In personal experiences, I have often overlooked the consideration of the other senses. In a project involving an appliance design, I was so focused on integrating function and form, that I only started to consider the other senses afterwards. The realisation that the product also moved, made sounds and would be touched, were an afterthought. Not knowing what to do, I did a meagre attempt of changing the design by looking at the other senses one by one. In retrospect, I can see I made a mistake at that time. Our vision, hearing, touch, smell and taste are never isolated. Within each sense and in the interplay between them, there is a plethora of experiences, and these experiences are limited by their current definitions. Brushing softly against something with the fingers is completely different than grasping a doorknob with the whole hand (Hara, 2007). Hara continues to say that to label both as "touch". oversimplifies the experience and misses important nuances. A "sense of pressure" would be a better description for the latter. From this perspective, the senses would number at least a hundred, and not five.

Designing for a hundred senses doesn't really seem to be easier than for five. A design strategy for this would be to evaluate the signals emitted by a product first, and the corresponding sensations perceived by the sensory systems secondly (Schifferstein et al., 2008). So, this means we turn the reasoning around. Instead of focusing on each sense individually, we examine the stimulus that excites our senses. Each of our sensory nerves give a specific sensation when excited by a certain stimulus. The same external stimulus can thus evoke different sensations across our various senses. Consider sunlight, for instance – what we see as light is simultaneously sensed by our skin as warmth through infrared radiation. As these two sensations are so different from each other, physicists once believed to have separate existences (Von Helmholtz, 1971). However, we now know that this light and heat are both from the same radiation, yet of different wavelengths. In Hara's terms, we could call this sensation the "sense of sunlight", referring to its whole aesthetic experience.

# P. 79

## FAMILIARITY

Aesthetic pleasure can come in different forms. A common distinction of factors that influence the aesthetic appeal, are of things that are typical or familiar, and novel or unfamiliar. On the one hand, people appreciate it when sensory messages are consistent and appropriate to the product conveying them (Schifferstein et al., 2008). We prefer things that are familiar to us and we have been exposed to repeatedly. This inclination is rooted in us, as this preference for the familiar is adaptive, since it will lead to safe choices instead of risking the unknown (Hekkert, 2006). Another reason for this preference is that repetition or familiarity make cognitive processing easier and more fluent, and this fluency is intrinsically more pleasant (Hekkert et al., 2008). This means that the aesthetic response is not only based directly on the stimulus, but also on the pleasure of the process of fluently perceiving things. This process and confirmation of receiving what we expect, 1.



2.

3.

4.

*Figure 13. Designs from Hara's HAPTICS exhibition. (1) Tadpole coasters by Shin Sobue (2) Juice skin by Naoto Fukasawa (3) Cabbage bowls by Yasuhiro Suzuki (4) Floating compass by Shunji Yamanaka*

*Figure 14. 1144 Handle by Jasper Morrison for FSB. Otl Aicher's 'Four-Point Guide to Good Grip' states that every door handle should have a 'thumb rest', a 'forefinger furrow', a substance that guides the hand and a form of support for the ball of the hand (FSB, n.d.). "I had come to believe that it was not the designer's job to invent form, just to apply it in the right places at the right time and for good enough reasons" (Morrison, 2006)*

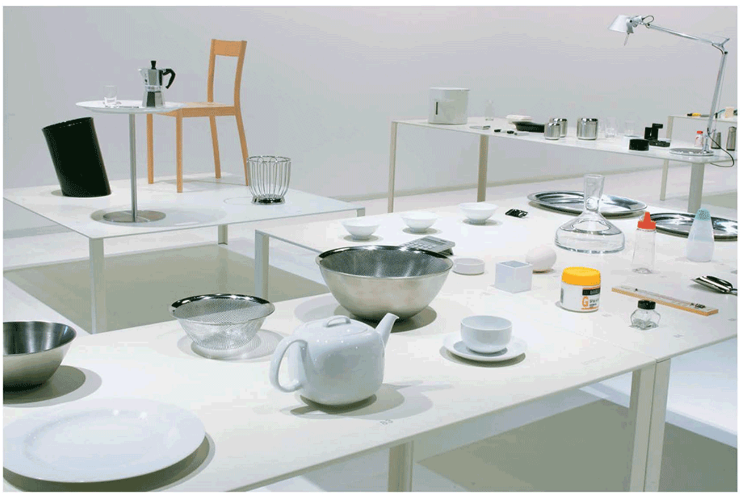


*Figure 15. The Super Normal exhibition, 'the beginning of an understanding of a tricky subject'*

gives us an immediate feeling of comfort (Harper, 2017).

Even if an object is unfamiliar to us, we have a deep familiarity with many different materials and their sensory experience. Without actually touching an object, we usually have a clear idea of what it would feel like to reach out and handle it (Fleming, 2014). If you imagine a steel sheet, you can imagine the cold (or if the sun has been shining on it in summer, burning hot) sensation of touching it, and imagining the weight when trying to lift it. We can imagine what our hands smell like afterwards, what it would sound like if we dropped it and we can even imagine the taste we would have on our tongues if we were to lick it (Hara, 2007).

# P. 75

Even though we live in a world filled with different kinds of objects, we still know how to manage and interact with them quite well. According to Don Norman (1988), the relationship between the properties of a physical object and the capabilities of a person that determine how the object could possibly be used, is called an 'affordance'. This refers to the potential of actions that are possible with an object, based on its properties and on the capabilities of the user. For example, door knobs afford turning, pushing or pulling, light switches afford flipping and steering wheels afford turning. The cues or indicators that communicate the affordances are called signifiers, which help the user understand how certain actions should be performed. This can be in an explicit manner, such as with labelled buttons, or implicit, such as the shape of a handle indicating how to grasp it (Figure 14). Products are often designed to be an extension of ourselves, granting us new capabilities, preferably in a seamless manner. Our familiarity with certain affordances and their possible signifiers make it easier to understand products that are novel to us yet have characteristics we are used to. This allows us to intuitively recognize how to interact with new objects based on our prior experiences with similar objects.

# P. 71

In order to recognize things, we tend to classify them into groups of objects which have shared properties. Through experience, we create so-called prototypes of things in our minds, which are typical representations of an object in a category (Hekkert et al,. 2008). Some of these objects come close to being one of these prototypes, being so recognisable that it is the most normal and effortlessly familiar example of a particular type of object. Designers Jasper Morrison and Naoto Fukasawa (2007) call these objects 'Super Normal', which are often discrete, anonymously designed objects that they say outperform their counterparts with ease when it comes to long-term everyday use (Figure 15). They are highly recognisable and their use is often instinctive or even subconscious, and we take them completely for granted yet would be at loss without them in our everyday existence. For something to become super normal takes time, as familiarity grows over time, and is dependent on culture, generation, and the environment we grew up in. Perhaps these objects without ego are the ones that survive the longest.

## UNFAMILIARITY

Familiar things may give us pleasure that never tires us, yet sometimes there is a risk of saturation and boredom (Hekkert et al., 2008). People are besides the comfort of familiar things also attracted by new, unfamiliar and original things and want to avoid stagnation. We like things that excite and even sometimes challenge us. Whereas familiarity relates to a comfort in being able to interact more passively, pleasure that comes from unfamiliarity asks for an active attitude towards objects as we have put effort in understanding what is in front of us (Harper, 2017).

You can wonder if prototypical objects have become the way they are because it was the most logical and perhaps inevitable form, or it would have been possible to have ended up with another standard. Many designed objects are taken for granted in the way they are: chairs have four legs, the hands of a clock go clockwise, cups feel smooth against the lips (Harper, 2017). However, the moment we are confronted with an object that challenges these conventional expectations, we are forced to stop and reflect on what is going on.

Nonetheless, novel or innovative products are often not liked immediately, and it takes time for appreciation to come. According to Raymond Loewy, a user's desire for novelty only goes so far, as they are not ready to accept solutions if they derive too much from their norms (Loewy, 1951). He calls it a tug of war between attraction to the new and fear of the unfamiliar. He coined the sweet spot for the degree of novelty of a product 'Most Advanced Yet Acceptable', which is a term that has been thoroughly researched for its validity, of which the outcomes show that people prefer novel designs as long as it does not affect typicality, or prefer typicality as long as it is not to the detriment of novelty (Hekkert, 2006). Moreover, novelty is fleeting, and this immediate excitement of something new will give way to normalcy as soon as the 'honeymoon period' is over (Chapman, 2015).

When revisiting the designs from Hara's Haptics exhibition, we can see that they balance both unfamiliar and familiar aspects. Attention is drawn through novelty, yet there are enough recognizable elements to hold on to, or, two familiar things are combined into something unfamiliar.

## *THE LIFE OF THINGS*

Even though the products around us are made by us and for us, they have an existence of their own. They have their own characteristics, live their own lives, they change over time. Some of these changes are caused by us, and some aren't. They exist when they are not in use, or do not have an owner. Their lives can go on beyond us, without us. Besides making sure our products serve and please us, we could have a deeper understanding of their lives, how they are made, and how they work. Now, we take a look from the perspective of the thing itself, through the different stages of their lifetime.

*Figure 16. A free standing toaster from 'the free Kitchen' by Sam Chermayeff Office (2015)*

*Figure 17. Stills from the bell casting scene in Andrei Rublev*

Designers often use digital renders of 3D models to communicate information about a product's form, materiality, and, if context is provided, its dimensions, as well as the ways and places it could be used. These visual representations enable us to relate it to ourselves and imagine it existing somewhere (Vooren, 2020). Yet, these images can be misleading. They often show a snapshot of perfection, a polished representation that is an idealized version of a product. I feel these computer-generated images often lack life. They do not exist in the real world, and if they do, they rarely maintain this flawless state for long. Everything in the world is subject to time. Products have a life they go through and age, discolour, damage, change, get dirty, crack, move, scratch, decay, malfunction, break and are repaired. Some of these changes happen because of us, and some are out of our control. Whether desirable or not, the passage of time is another dimension to (product) design that is not caught in slick renderings, yet an inherent part of all physical things. Many of these changes are typically unwelcomed and attempted to be avoided or hidden. However, there lies an opportunity to embrace these changes, integrate them in the design process and create added value through them.

## ASSUMING FORM

In the final chapter of Andrei Tarkovsky's film 'Andrei Rublev', set against the backdrop of 15th-century Russia, a young boy takes on the important task of casting an immense bell. It is an undertaking commissioned by a prince, with life-or-death consequences, all depending on the quality of the chime of the bell.

While the emotional and symbolic meaning of this chapter within the movie is powerful, I was mostly mesmerized by the casting process of this bell. The process starts with a long search for the perfect clay in the pouring rain, its selection relying on only the boy's instinct. A massive operation of digging a large pit and forming the mould follows, in which dozens of men are involved. The whole pit is set on fire to bake the mould, and the furnaces built especially for this project melt kilos of silverware, to together be reborn as this giant bell. As soon as the gates open, a stream of liquid metal is released, quickly flowing down with sparks flying, filling the mould. The energy of this material, together with the labour of all men serving this object, are frozen into its final form. The mould cools down. With great anticipation it is broken open, and the bell emerges (Figure 17).

In the transition from material to a finished object, there is a degree of force and velocity (Harper, 2017) which is very prominent in the case of this example. Throughout the model-making process for this project (which was a lot less impressive than the bell, I must admit), I was always fascinated by this in-between state. Each process has its own specific energy, until it was frozen into its final form. Some of these processes were slow, like the gradual emergence of a shape during the CNC milling of foam, and others took only a matter of seconds, like vacuum forming - transforming a hot, plastic sheet swiftly into an object. Whether witnessing human hands shaping a vase at the pottery wheel, or large machines forming sheet metal into a car door, there is this same mesmerizing effect of seeing objects emerge from material.

However, the traces of a product's creation process are a dimension that is often erased in post-processing. Parts get sanded, coated, cut, trimmed. In appliances, many of these traces are hidden inside. If you were to open them up, you'd encounter signs of their production process. These traces may be unfamiliar to many due to lack of knowledge, yet will never become familiar if always hidden away. But beyond that, a closer inspection might give you an understanding of the reasons behind their design, their components and why the product functions the way it does. What's usually a black box that performs a specific task becomes transparent, and offers us the opportunity to get a deeper understanding of the product itself.

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We gave the products we created a purpose they will have to fulfil for us. We designed them to constantly go through the same cycle of actions, making them confined by what we gave them the capability to do. During their lifetime, they are subjected to our use or environmental factors. By allowing these changes to become part of their aesthetics, the object is in a way 'set free' (Harper, 2017), as there is room for letting it live its own life and having it become part of its aesthetic that we interact with.

# P. 87

It makes sense that the objects that age beautifully are durable in an aesthetic sense. The products capable of accommodating changes, are also the products that can carry the memories formed during use. As mentioned in the introduction of this chapter, the recollection of memories significantly influences the degree of attachment between people and the products they own (Schifferstein et al., 2008). Products that can carry these changes well, can become containers of time, containing stories of interactions between people, places and events. The stainless steel water bottle I use every day got damaged only 5 minutes after I purchased it on holiday – I directly filled it with sparkling water, which made the cap blow off and fly 4 metres into the air. I always get reminded of that moment I experienced together with my friends, walking down the streets of Milan on a very hot summer day. Although a silly example, I think many of us can think of an example of these kinds of traces on the things they own.

## WHEN THE DRILL BREAKS

At some point, many products face the inevitable fate of life: they come to the end of their existence. The moment they break down or malfunction, they turn into 'things', according to German philosopher Martin Heidegger (1968). Borrowing from Heidegger's definition, Bill Brown (2004) extends this notion in his essay on 'thing theory':

*"We begin to confront the thingness of objects when they stop working for us: when the drill breaks, when the car stalls, when the window gets filthy [...] The story of objects asserting themselves as things, then, is the story of a changed relationship to the human subject and thus the story of how the thing really names less an object than a particular subject-object relation."*

When using a drill, it dutifully serves its intended purpose. It functions as an extension of our arm, granting us new capabilities and meeting our needs and expectations. The drill appears passive, existing to serve us. However, the moment the drill breaks down, this self-evident relationship is disrupted. Suddenly, we are confronted with the fact that the drill stands apart from us – an independent entity with its own being, existence, properties. The broken drill demands our attention, urging us to understand why it failed and how to fix it. We are required to understand the drill and its essence.

Not only when something breaks down, but also when it experiences a temporary malfunction, we may encounter the 'thingness' of an object. A phone with a dead battery can turn from being your most frequently used and perhaps most valuable possession into resembling nothing more than a useless block. At times, we may even choose to live with objects that have turned into 'things'. In our home, there's a loose doorknob on the toilet. My roommates and I have adjusted our way of grabbing this doorknob, to the point that it has become an automatic step that made us forget it has ever been loose. Until a guest comes along, and I hear a loud, dramatic thud in the hallway. Suddenly, this doorknob has again 'asserted its thingness', as if asking for attention in the most stubborn manner. Although I understand the inconvenience of this, and we could put in the effort to repair it, I noticed that I also like our doorknob's personality (Figure 18). I think we all have examples of how we have adjusted ourselves to our belongings. Lending your old bike to a friend can suddenly make you very conscious of how you have been using it, as you have to explain all its peculiarities. Perhaps it can make our daily lives more interesting to have

*Figure 18. The fallen doorknob*

some objects around us that behave unpredictably, or aren't perfectly tailored to our needs.

Sometimes things can become unusable or obsolete, and they can't really find a place to exist anymore. Claes Oldenburg's 'Typewriter Eraser, Scale X' is an enlarged sculpture of such an object (Brown, 2004) (Figure 19). Though it is very recognizable as a functional object, those from my generation encountering it will probably be wondering, "what is this thing"?

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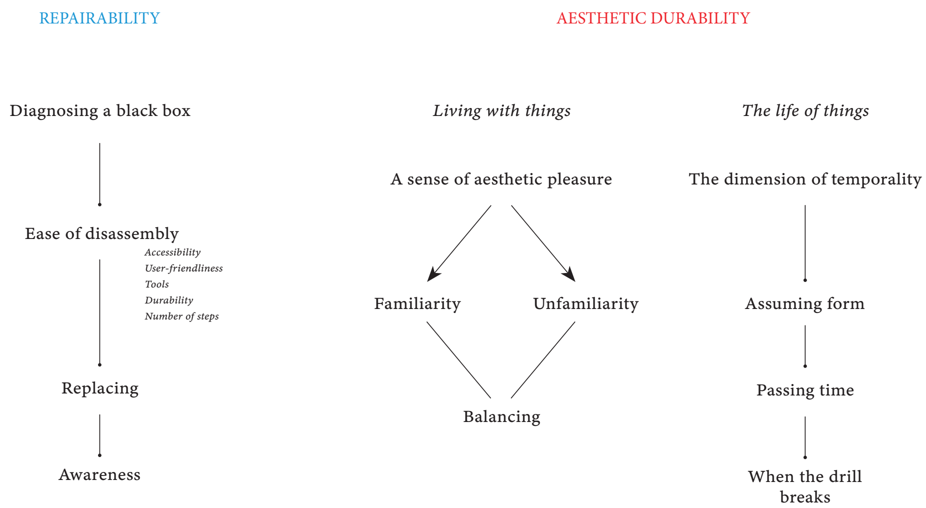
*Figure 19. Claes Oldenburg's 'Typewriter Eraser, Scale X*




'When the drill breaks' marks the moment we shift our perspective and engage with the product differently. It turns from just one part into many parts, urging us to look at these components typically unnoticed, and putting time into understanding it through repair. This is a process where we systematically take the object apart, try to figure out what is broken and why, how the product works, actually fix or replace the broken part, and reassemble it correctly – or at least have it repaired.

Throughout reading the theory on repairability and aesthetic durability, you may have noticed that awareness of the product itself is a recurring theme. It comes forward in attempting to avoid the 'black box', awareness of a product's components and functionality, appreciation for its production process, 'setting the object free' and its 'thingness'. All these notions share a certain degree of respect for the thing itself, going beyond the convenience they offer us.

The sentiment underlines the reason the theory focuses on 'aesthetic' rather than 'emotional' durability. While emotional attachment is effective in prolonging a product's lifespan, the emphasis of aesthetic durability lies in acknowledging and respecting the intrinsic value of objects beyond our individual attachments. It is not an egocentric relationship but a symbiotic one, where our pleasure is intertwined with respect for the space thingness takes. Emotional attachment can be a consequence, but is not the main objective.

Based on the theory, we could roughly distinguish between three dimensions that would create the design space for re-design (Figure 20): the possibility to repair, our pleasure as users and the life of the thing itself. These axes represent the theory, and where the emphasis of each re-design would lie.

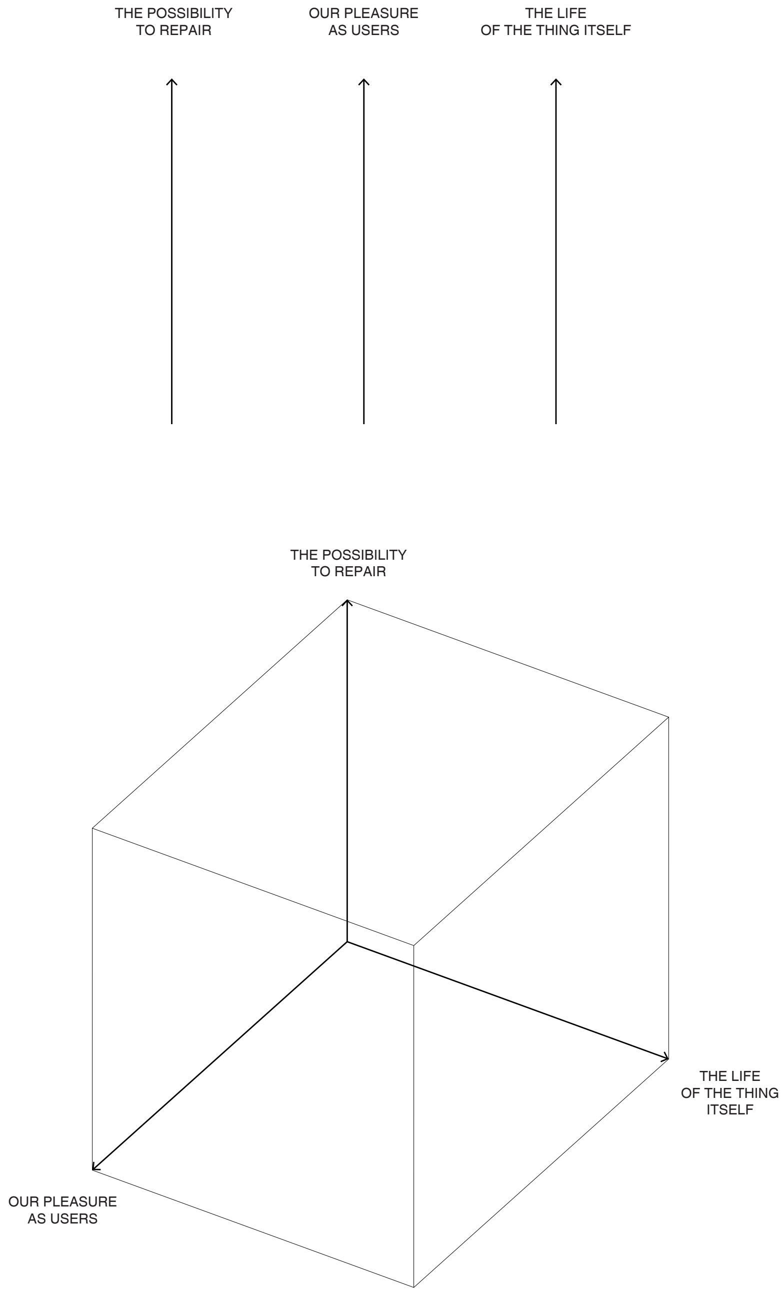



*Figure 20. Three axes based on the theory forming the design space*

# DISSECTION

Before applying the discussed theory on repairability and aesthetic durability in the redesign of the sandwich maker, it is essential to gain an understanding of the product and find out what aspects of the product can be improved. This chapter delves into the functionality of the product, its parts and materials, and its ease of repair, through disassembly.

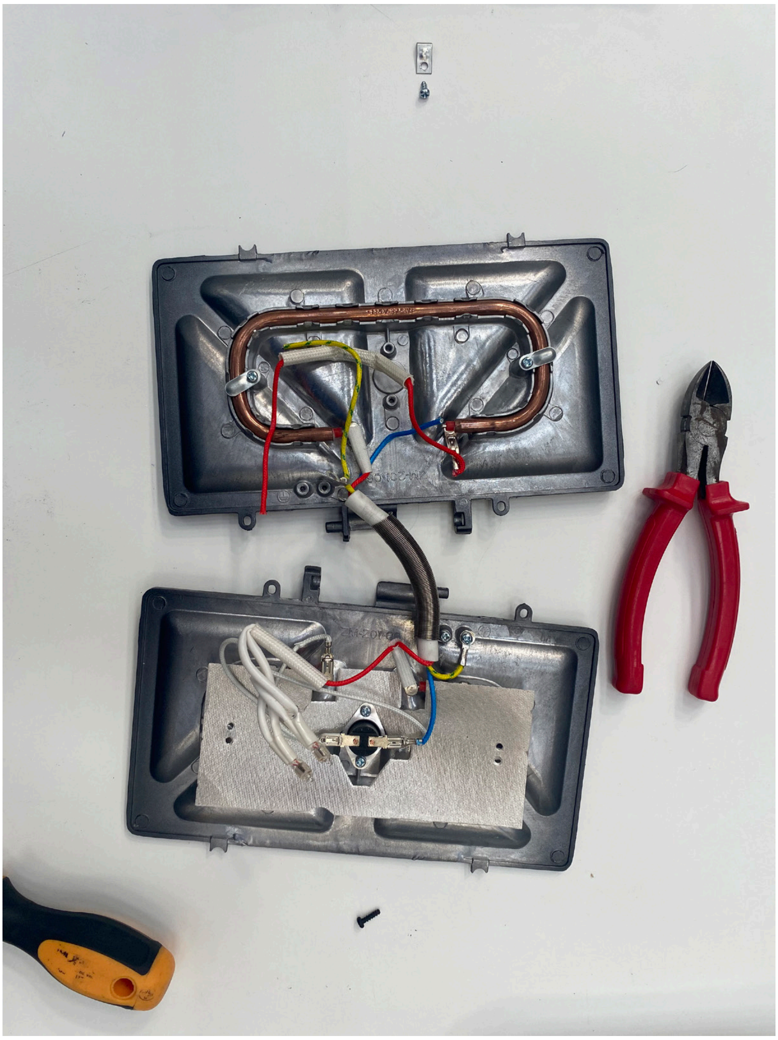


*Figure 21. Disassembled grill plates from a sandwich maker*

## FUNCTIONALITY

When plugged in, the red light turns on and the heating elements start warming up. Once the appliance reaches its maximum temperature, indicated by the green light turning on, it's ready to use. Simultaneously, the heating element turns off, allowing the appliance to gradually cool down. When the temperature drops to the minimum temperature, the green light turns off again, and the heating elements switch back on. This cycle of turning on and off continues, until the appliance is unplugged. The state machine diagram in Figure 22 gives a visual representation of this sequence.

## CIRCUIT

Figure 23 illustrates the electrical circuit diagram of the sandwich maker, explaining its previously described functionality. When the product is turned on, and current begins to flow, it follows the path of least resistance through the thermostatic switch (normally closed), the low-resistance red light, and the heating elements. At a temperature of 250 degrees Celsius, the thermostatic switch's contacts open, making the current flow through the green light which is now in series with the heating elements, reducing their current and thus their heating wattage.

The red light is positioned between the two grill plates instead of between the live and neutral path, reducing the voltage on it. This placement makes sure that if an element breaks, the red light also turns off, preventing it from erroneously indicating the product is still functioning.

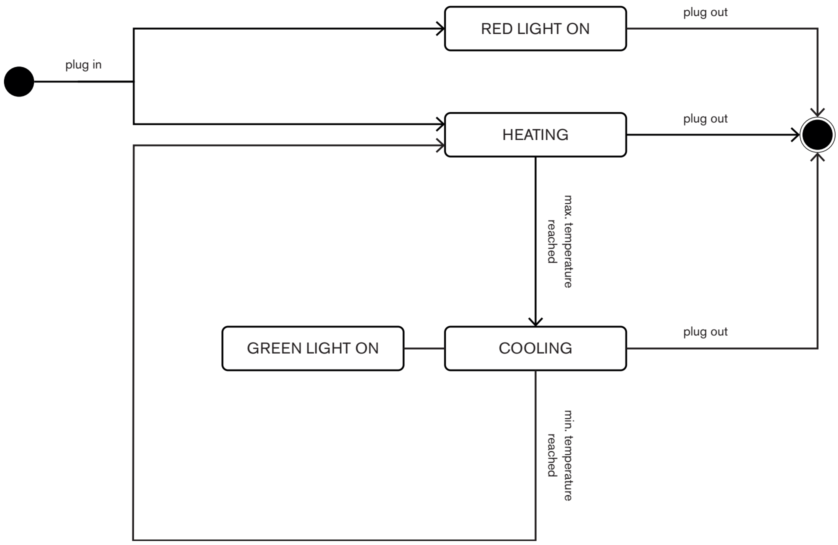



*Figure 22. State machine diagram*

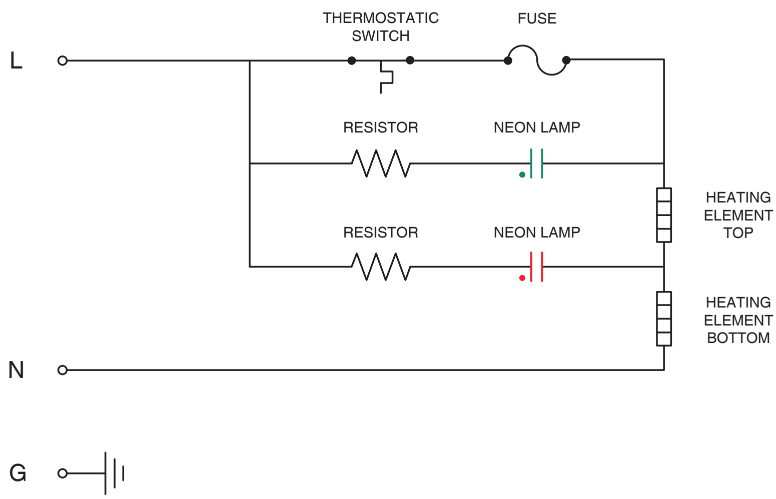



*Figure 23. Circuit diagram*

## PARTS

Figure 28 shows all the parts of a disassembled sandwich maker, of which some are also discussed in this section. Some of these parts are considered 'priority parts', which are the parts that should be easy to access and disassemble, because they are either important for the functionality of the product, have a high probable failure rate, or require maintenance over time. An overview of the 'hotspot map' that was used to indicate these critical parts and the ease of reaching them can be found in Appendix 3.

### CASING

The casing is crucial in housing and protecting internal components and the users. Moreover, it serves as a structural basis to which parts can be attached. In the first electrical household appliances, the first fully synthetic plastic Bakelite was often used (Meikle, 1997). It was suitable as it could be moulded, is unaffected by most chemicals, an excellent insulator for heat and electricity and scratch-resistant. These properties are important in the sandwich maker – at least the grip of the appliance should be possible to touch for users without burning their hands, and heat should not be lost to the casing. The disadvantage of this material is its brittleness. Newer plastics that were easier and more affordable to produce, and still possessed these qualities, superseded Bakelite. For instance, the casing of the Home Essentials sandwich maker* is made of PBT, which is a thermoplastic polymer.

### CLOSING LID

The closing lid clamps the appliance through a snap fit connection. Often the closures are quite small and fragile, which leads to having to put quite some pressure in your fingertips to open or close them and making it a part that can break.

### THERMOSTATIC SWITCH

An essential component in the functioning of the sandwich maker is the thermostatic switch. This part initiates the sequence of states that the product undergoes, as explained in the state machine diagram, regulating the heating process. The thermostatic switch is a standardized part, available for different temperatures, equipped with two connector pins and a mounting holder. Within the casing, there is a bimetallic strip. This strip is made of two metals bonded together, each with different coefficients of expansion (Figure 24). When it is normally closed, the strip closes the electrical circuit by touching an electrical contact. As the temperature rises, the metals expand, leading to a change in length between the strips. This discrepancy in length causes the entire strip to bend, breaking the circuit by disconnecting it from the electrical connection. Consequently, the heating turns off. As the strip cools down, it returns to its original form, closing the circuit once again. This is a component that can fail when operated for a long time (Terzioğlu, 2013).

### HEATING ELEMENTS

The heating elements are connected to the grill plates and serve to convert electric energy into heat using Joule heating, a phenomenon where a conductor generates heat due to the flow of electric current (IQS Directory, n.d.). It consists of a coil (often made of a nickel-chromium alloy), functioning as the resistance wire, and is enclosed by an electrical insulator, typically compacted magnesium oxide. Surrounding the heating element is a sheath made of copper or steel alloy (Figure 25). To prevent moisture from entering the insulator, the ends are shielded with insulating materials such as ceramics or silicone rubber. These tubular heating elements can be bent into various forms to accommodate the heat distribution necessary for the application.

### THERMAL FUSE

This component adds an additional safety layer. In the event of a temperature control failure causing the product to overheat, the thermal fuse breaks down, disrupting the electrical circuit. In cheaper models this component is not always present.

**the home essentials sandwich maker is at €9,95 one of the cheapest sandwich makers on the Dutch market, which I often used for prototyping purposes*

GRILL PLATES

The grill plates are made of aluminium and will heat up to around 170 degrees. Aluminium has a high thermal conductivity compared to many other metals (The Engineering Toolbox, 2005), and it cools down rapidly. It is also cost-effective, can be easily moulded into desired shapes and is lightweight. However, to prevent bread from sticking to the grill plates, a non-stick coating like Teflon is applied. Teflon has gained a bad reputation due to the presence of Pfas and the fact that it can wear off with incorrect use. Some alternatives, such as ceramic grill plates, exist on the market.

NEON LIGHTS

The two lights are neon lamps, which are miniature gas-discharge lamps (Figure 26). It is a glass envelope that contains two or more electrodes and is filled with a mixture of neon and other gasses. With sufficient voltage applied between the electrodes, the lamp produces an orange glow (Miller, 1969).

WIRING

The electrical wiring facilitates the flow of electrical current between the components. These wires are covered with cloth for heat resistance and are color-coded for identification.

MICA

Some sandwich makers also include a sheet of mica between the heating element and the casing. In more expensive models, it tends to be a larger sheet, while in cheaper ones, it might just cover the light mount, preventing more heat to escape (Figure 27). This mica sheet might look like a shiny piece of cardboard at first glance, but its sound upon dropping is more like that of metal. Mica is a group of minerals and a naturally occurring sheet material known for its excellent thermal and electrical insulation properties (Thwaites, 2012).

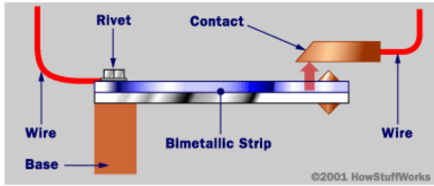



*Figure 24. Functioning of thermostatic switch*

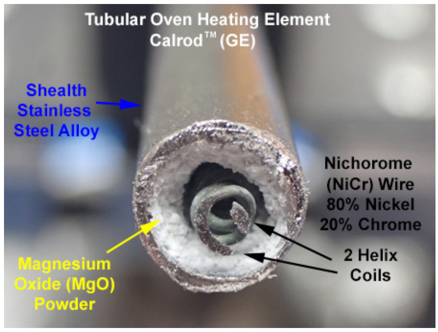



*Figure 25. Inside of a tubular heating element*

*Figure 26. Miniature neon lamp*

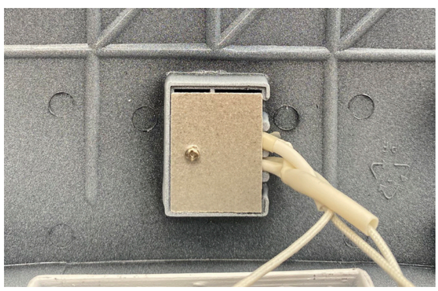


*Figure 27. Mica sheet covering the lights*

The disassembly map of the 'Home Essentials' sandwich maker on the next page shows the interrelationship of its parts. The priority parts as discussed in the previous section are indicated under target components, either giving a failure, environmental or economic indicator.

Most parts are accessible in 1 to 5 steps, with the use of hands or common tools such as a Phillips head screwdriver and wire cutters. However, one part requires the use of an uncommon tool, which is a Tri-wing screwdriver (Figure 31). This tool is necessary to access the connection to the power cable. Moreover, the connections to the heating elements on the bottom grill plate are not reachable unless the power cable is detached, requiring cutting (Figure 30). Additionally, freeing the lights and resistors results in permanent damage to the connections, as they have to be cut (Figure 32). Lastly, the heating elements are firmly stuck in the grill plates and cannot be freed (Figure 29).

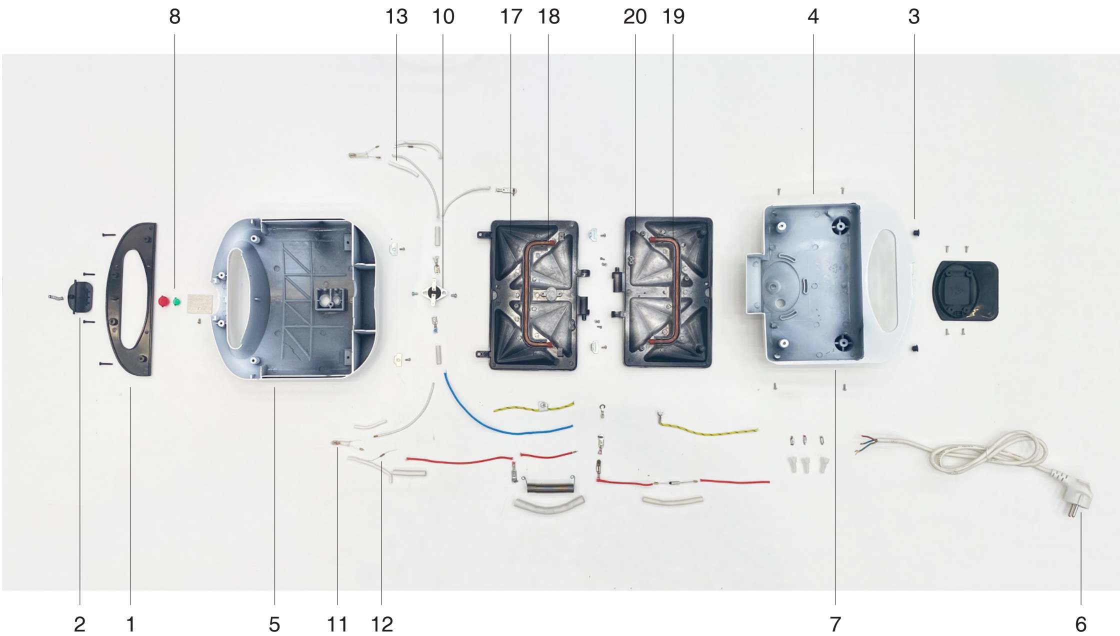
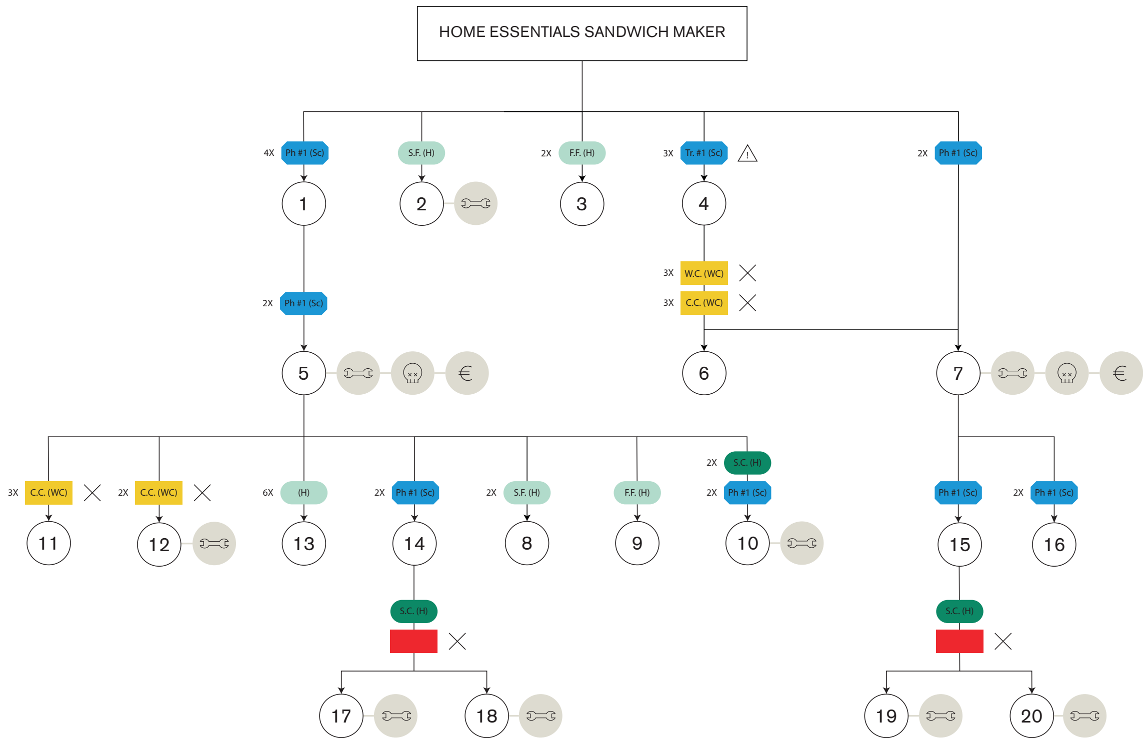



*Figure 28. Disassembly of the sandwich maker*




## COMPONENTS

1. Connection cover
2. Closing lid
3. Rubber leg covers
4. Bottom cover
5. Top casing
6. Power cable
7. Bottom casing
8. Light covers
9. Light stop
10. Thermostatic switch
11. Neon lights
12. Resistors
13. Shrink tubes
14. Heating element lids top
15. Cable holder lid
16. Heating element lids bottom
17. Grill plate top
18. Heating element top
19. Grill plate bottom
20. Heating element bottom

## CONNECTORS

S.f. = Snap Fit
F.f. = Friction Fit
W.c. = Wire Cap
C.c. = Crimp Connector
S.c. = Spade Connector
Ph. #1 = Phillips 1 Screw
Tr. #1 = Tri-Wing 1 Screw

## TYPE OF TOOL

(H) = Hand
(Sc) = Screwdriver
(Wc) = Wire cutter

## PENALTIES

Uncommon tool

Non-reusable connector

Low visibility

Product Manipulation

## MOTION TYPE & FORCE INTENSITY

Low Mid High

Hand

Single motion tool

Multiple motion tool

## TARGET COMPONENTS

Failure indicator

Environmental indicator

Economic indicator

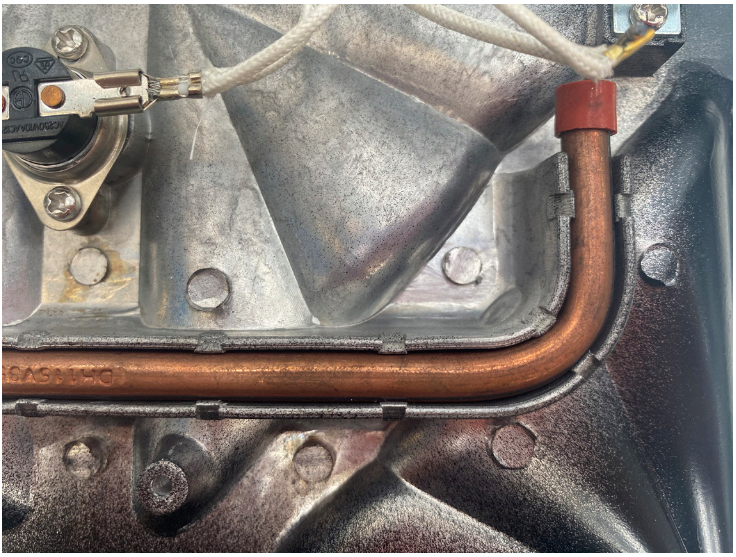


*Figure 29. Stuck heating element*

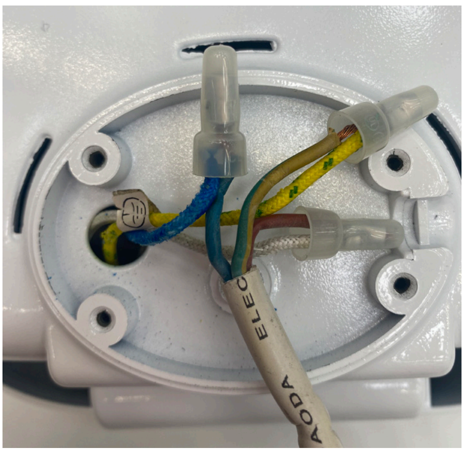


*Figure 30. Power cable connection*


*Figure 31. Tri-wing screw*

*Figure 33. Fragile closing lid*

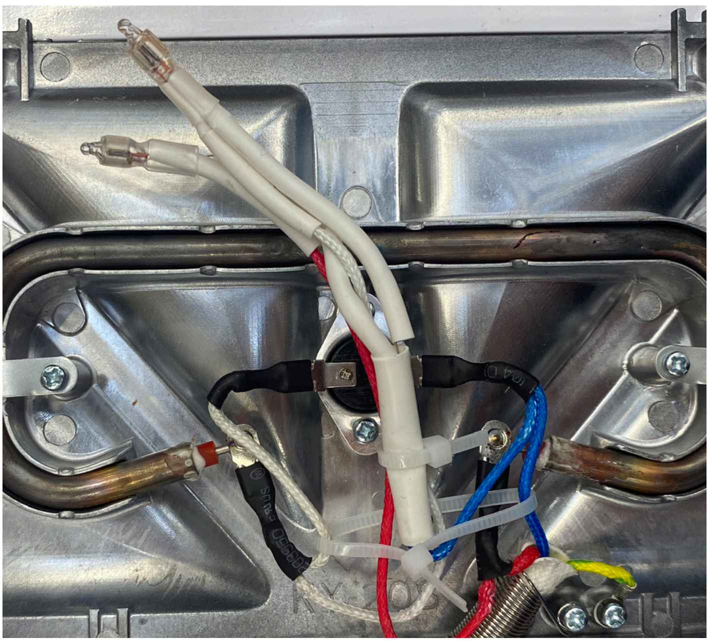


*Figure 32. Lights and resistors*

The explored theory on repairability and aesthetic durability have formed the design space. After dissecting and analysing the sandwich maker, areas for improvement have been identified. Now, the original appliance will be placed at the base of the design space. Following the three different axes, the re-designs will diverge from the original appliance and position themselves within the space (Figure 34).

The re-design process starts with very simple sketches, of which some are quickly translated into prototyping experiments (see Appendix 4 for insights in the process). The choice of prototyping technique always followed the idea, aiming for the most direct and effective ways to communicate the idea, deciding which aspects have to be designed for and which not. Additionally, the possible feasibility of further designing the prototype into a functional product was always considered.

This chapter presents eight re-designs, discussing their repairability and aesthetic durability. Furthermore, references are provided to show the ideas' inspirations.

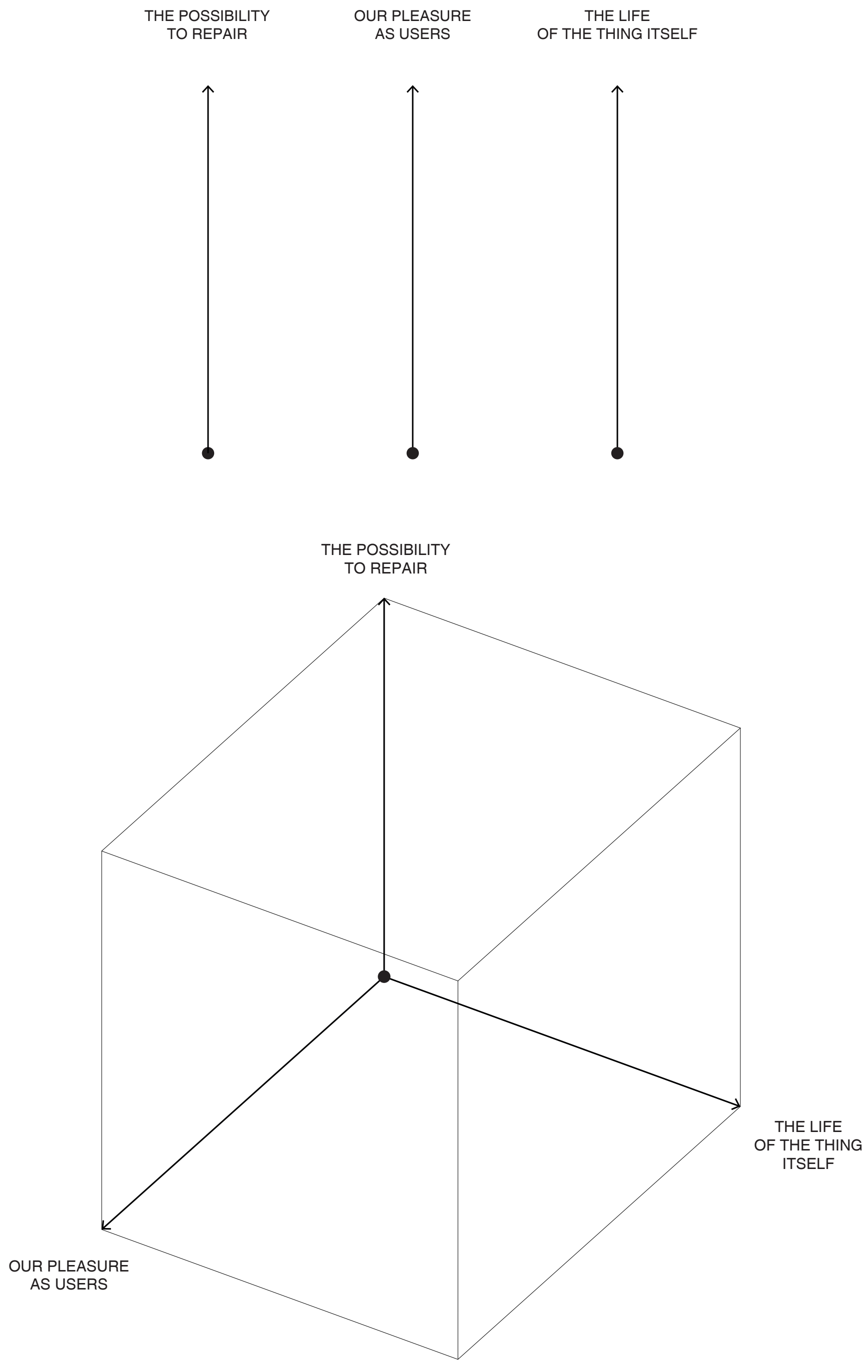



*Figure 34. The original sandwich maker at the base of the design space*

## REPAIRABILITY

The 'black box' principle is quite literally avoided by making the 'box' transparent. This not only allows for a clear view of any malfunctions without the need to take the entire product apart, but also assists in the repair process through the colour coding on the outside. Other than that, while waiting for your sandwich, you might inspect the product to pass time. After a few of these instances, the components that first seemed unfamiliar will become familiar to you. Maybe you will develop a deeper understanding, which lowers the threshold for repairing as the distance between you and the product has become smaller. It actually also makes sense to get a view of the inner components before purchasing. Wouldn't we be able to make a more informed decision? "This one doesn't have a fuse for extra safety" or "this connection seems too fragile" could suddenly become considerations in choosing what products you will own. The self-repair manifesto states "if you can't fix it, you don't own it" (iFixit, n.d.) but maybe what should precede that is something along the lines of "if you don't know what is inside, you can't really choose for it".

## AESTHETIC DURABILITY

By turning the casing transparent there is no attempt to create an aesthetic to please ourselves, but its aesthetic flows out of its functionality. It refuses to conceal any aspect which makes it more earnest. Unfamiliar parts become familiar to us and we can see how the product functions and changes. For instance, with varying temperatures, the copper plated heating element changes into many different colours.

For those who grew up in the 80s or 90s, there might be a sense of nostalgia with this casing, reminiscent of the transparent casings that were popular for electronics like Game Boys, iMacs, and telephones. This aesthetic could be dismissed as just a passing trend, but perhaps this transparency also gave us a sense of control over the electronics that were suddenly becoming a big part of our lives. Being able to see what we were buying maybe gave us a sense of trust in the products, or at least eased the transition from an analogue to digital lifestyle. I wonder if this 'transparency' disappeared due to a preference for more minimalist aesthetics or if a certain distance between product and consumer is something that was desired by manufacturers.

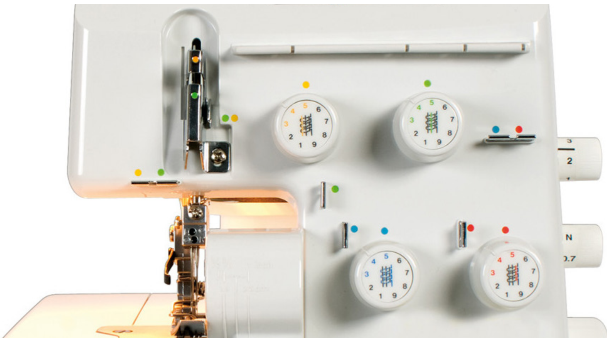


*Figure 35. Colour guidance on a lock machine could also be applied for a product's wiring*

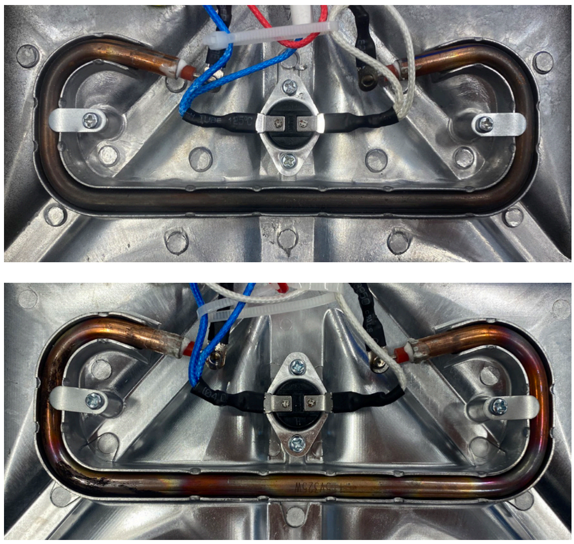


*Figure 36. Colour changes during use*

*Figure 37. Products with transparent casing or not new*


KY 20S


KY 20S

REPAIRABILITY

Here, the casing of the product has been turned inside out, revealing the structural implications of the design that are usually inside. Now the connections between the casing and the inner components are visible and reachable from the outside. The polished, clear inside gives a clear overview for repair purposes, serving as a blank background for the internal components. It is okay to be looking at the inside, while it usually can feel like a place where you are not supposed to be.

The process of turning an existing casing inside out also served as a good way to understand what technical design steps were made and why, as if retracing the path of the original designer.

AESTHETIC DURABILITY

As a consequence of creating a polished exterior, the necessary structural ribs are visible on the outside, as are the traces of the production process. The injector pins of the injection moulding process have left their marks and a misty overspray of paint is revealed. You're now immediately confronted with a crucial part of the product's essence, of how it is made, and the consequences of why it is made this way. Perhaps it will also increase curiosity of other products' internals.

*Figure 38. Several people mentioned the resemblance to the principle of centre pompidou by Renzo Piano and Richard Rogers*

*Figure 39. A crate with structural ribs on its exterior to protect its contents*

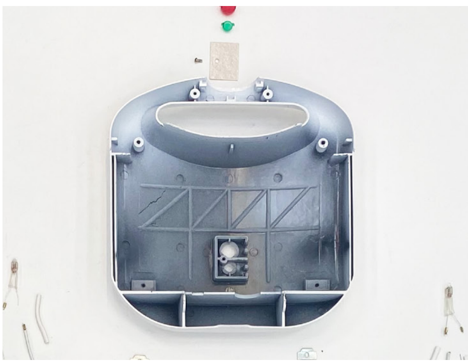


*Figure 40. The interior of this sandwich maker casing is used as inspiration*

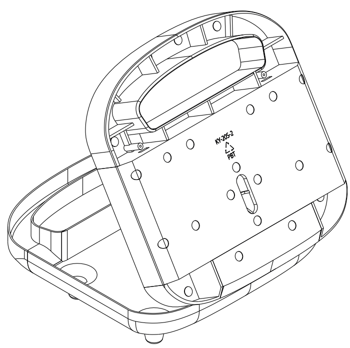


*Figure 41. Prototype line drawing, from a 3D model used for 3D printing*


bottom
bottom
grill plate

## REPAIRABILITY

This redesign came from my personal experience of taking this product apart for the first time, without the use of things that helped me organise, such as small trays for the screws. I just stored them between the already existing ribs, and simply added a sticker to help categorise them and help me remember which ones go where. To create a better overview during my repair job, I added a rod similar to that of a car hood, and used another sticker that maps out the wiring. To make the handling of the product even easier, a suction cup that keeps it steadily in place is added.

## AESTHETIC DURABILITY

If you are not familiar with opening up products, the interior may be a discouraging sight, revealing all these components you are not used to seeing. The added supports guide you in the process of shifting from unfamiliarity to familiarity in the act of learning to repair. The car hood is a support which enables us to take a look at what is going on inside and to fix it. Why would only the outside be designed to have a pleasant interaction, and not the inside?

Figure 42. *A car hood opened by a rod*

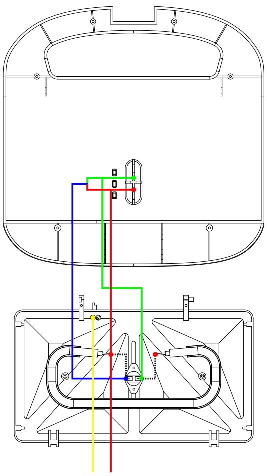


*Figure 43. The sticker used on the inside*

*Figure 44. An organized box*

Screws

## REPAIRABILITY

The large screws emphasise the object's repairability, inviting you to open it up. All that is needed is a standard tool; a large Phillips head screwdriver that doesn't require a lot of precision. This may even give novice repairers the confidence to disassemble the product.

## AESTHETIC DURABILITY

The screw is one of the most universally recognized components. They are applied in countless different materials and products, machines, constructions and more. Many people are familiar with the use of a screwdriver, and there is even a chance you own at least one yourself. This model is an appreciation of the functionality of the modest screw. These small yet vital parts keep the entire product together. Here, they are enlarged to highlight their familiar functionality.

*During this redesign, I was in a phase where I was saturated with designing. I felt we already have enough things and should just appreciate the inventions that already exist. I didn't really use references. So, I will keep this space empty.*

## REPAIRABILITY

The number of parts is reduced, the grill plates can be slid in and out, a fragile closing lid is avoided: the sandwich maker is simply made of two robust ceramic blocks. Ceramics have a high hardness, resistance to scratching, and endurance against chemical erosion. However, they have low resistance to impact and are prone to breaking if dropped. This design emphasises the need for careful handling, ensuring longevity and durability if used correctly and handled with care.

## AESTHETIC DURABILITY

This brick-like redesign is of a (still unbaked) ceramic model that makes use of its material properties. It challenges the classic, white, shiny, plastic look of most kitchen appliances and might remind you more of handmade pottery. Due to its electrical non-conductivity and durability it could be a suitable material for household appliances. As you put the top on, its weight clamps the bread and the appliance turns on, making you aware of the force applied to your sandwich. Perhaps this closure is inconvenient as it requires more effort, but the comfort of the direct use of this material would be a big enough benefit in this interaction.

*Figure 45. Two halves of a plaster mould, to cast a cup, the ball connectors served as inspiration*

*Figure 46. Big brick*

*Figure 47. Failed experiments*

## REPAIRABILITY

By replacing the hard, outer shell of the sandwich maker with a soft, fabric one, the casing (which are priority parts) is less prone to breaking, and the temperature can be gauged by hand. This makes the use of lights unnecessary, which means the amount of parts and thus the complexity of the product is reduced. Moreover, the aluminium grill plates could become a free-standing part, as the casing is no longer structural. The fabric would be a layer that can be peeled off easily, quickly accessing the internals of the product without the use of tools. This is a process that would have to happen once in a while, as the fabric would need occasional washing. This leads to the user being confronted with the internals of the product once in a while.

## AESTHETIC DURABILITY

Just like other appliances that heat up, such as ovens and water kettles, the sandwich maker gives us indications of its temperature. When it is turned on and the right temperature is reached, you hear the soft click of the thermostatic switch. Lights turn on and off, the expanding aluminium gives a crackling sound and you may catch a whiff of melted cheese. Touching the appliance in the wrong spots might even result in an unwelcome burn. Pleasurable or not, the aesthetic experience of this product gives us a "sense of temperature". This sense is usually designed for through lights. This re-design purposefully communicates through another sense than vision through an oven mitt-like top. Touching is not something that should be avoided, but is necessary in the use of the product. You could imagine slightly pressing down the top with your entire hand to feel the temperature and indicate if it is ready to use. Over time you hopefully become more accustomed to its use, as your hands get to know the product better.

*Figure 48. An old fashioned sandwich iron to use on the stovetop was the initial inspiration, how would this translate to an appliance?*

*Figure 49. A completely metal sandwich maker could only be used with something like an oven mitt*

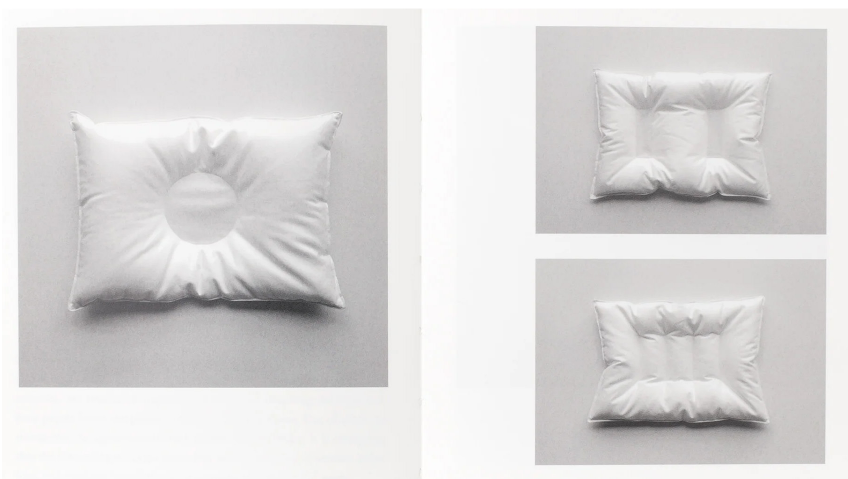


*Figure 50. Pillow tensions by Yuko Sato (Hara, 2015)*

## REPAIRABILITY & AESTHETIC DURABILITY

Perhaps, we don't need a precise knowledge of the internals, but simply be more aware of the essential parts that make a product function. With this casing, it seems as if a cloth has been stretched over the internal components. Instead of revealing every detail, it acknowledges the silent presence of these components. Hopefully, this raises our curiosity without demanding a full understanding. Maybe not everyone needs in-depth knowledge on repairing their products, but heightened awareness may be enough to take the step to entrust them to an expert.

*Figure 51. Wrap sealed boats I passed every morning when cycling from Rotterdam to Delft*

*Figure 52. Wrap sealed boat in the water*

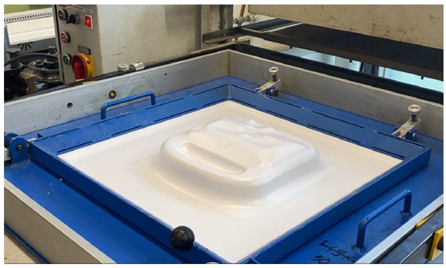


*Figure 53. The vacuum forming process*

*Figure 54. Left: the unappreciated intended. Right: the appreciated unintended, which led to finding an in-between*

## REPAIRABILITY

Just as with the 'stretched' prototype, maybe a silent presence of the components will create more awareness of the functioning, leading to a deeper understanding and having products repaired sooner. This layer of thermochromic paint replaces the lights, reducing the amount of parts and thus the complexity of the product. Moreover, it informs us directly if the product is not functioning, as it remains black.

## AESTHETIC DURABILITY

The sandwich maker has a repetitive heating and cooling cycle. The moment it is turned on it starts to heat up, when the right temperature is reached it turns off and cools down, and when it starts to cool down it turns on again. If you have patience while watching this prototype, you can see the colour of the casing gradually change to white when the appliance is heating up, showing the life and breath of this product. This colour change starts in a very specific shape: that of the heating element. Not only does this clearly communicate what the effect of this process is on the material of the casing, we also get a glimpse of a component inside the appliance. Moreover, the thermochromic paint replaces heat indication by lights and shows you where not to touch it, and when the product is in use.

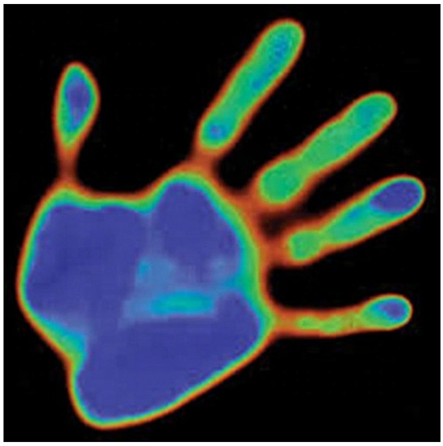


*Figure 55. Handprint on thermochromic film*

*Figure 56. Visible heating filament in a toaster*


*Figure 57. Old lettering revealed*

Each redesign diverged from the original appliance along the three theoretical axes. Informed by the outcomes of the product dissection, they prioritize various aspects: potential repair improvements, the degree of pleasure it gives, and considerations of life of the thing itself. The re-designs are placed along each axis (Figure 58), illustrating their relationship within the design space (Figure 59).

This conceptual framework offers an overview of how the re-designs align with the research. It also suggests potential areas for new re-design positions, where gaps in the design space remain. For instance, a re-design could centre around the pleasure that could come from the repair process and its interactions, explore ways to enhance the aesthetic aging of a product, or aim to use everyday components to create a re-design with increased thingness and familiarity simultaneously.


*Figure 58. The prototypes placed on the axes*

The positioning of the designs within this space reflects my intended interpretation as the designer. However, others may choose to place them differently, and alternative perspectives may give other positions for re-designs. Nonetheless, the aim is to conceptually convey the variety of options there are for applying the theory.

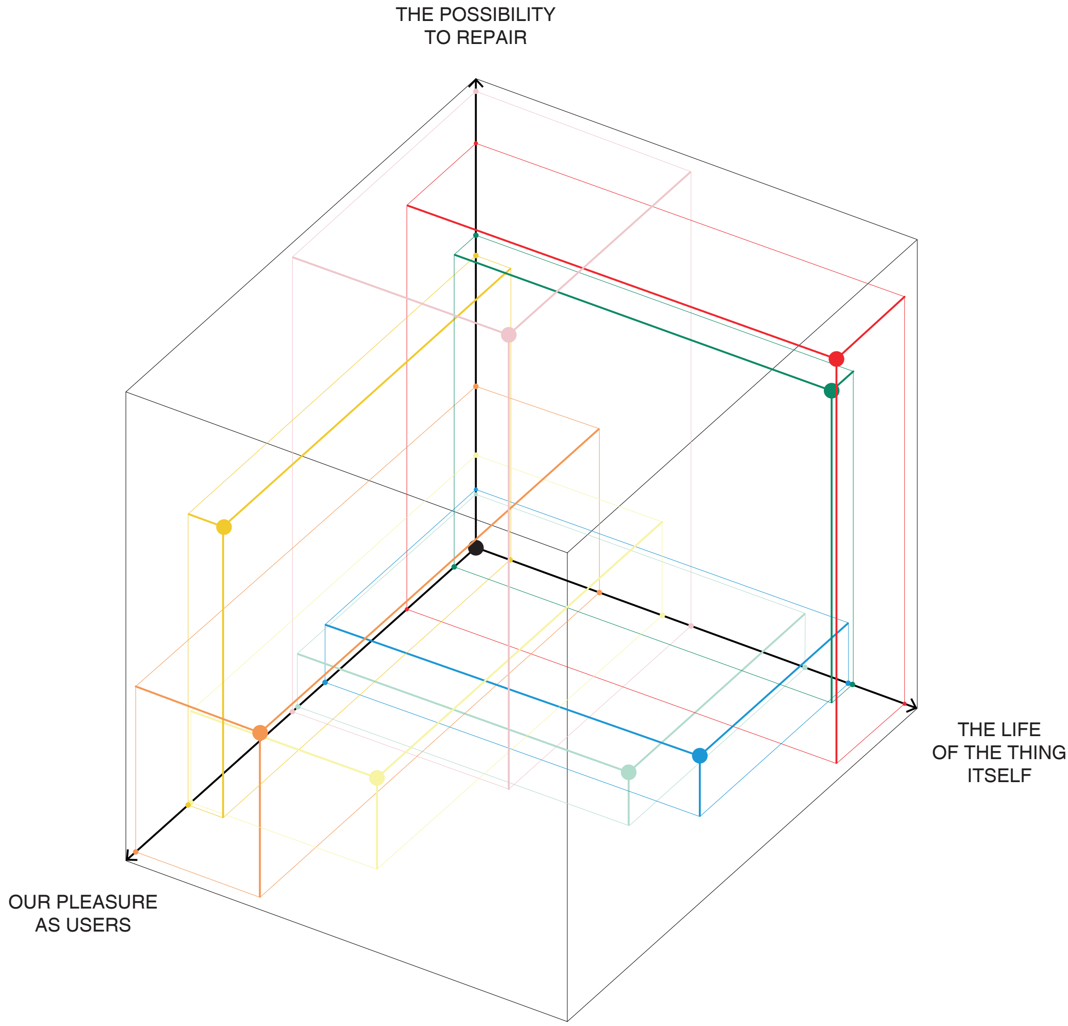



*Figure 59. The prototypes placed in the design space*

## INTRODUCTION

The exploration of this graduation project centres in the broadest sense around the question: *How can appliances be re-designed for retainment, considering both repairability and aesthetic durability?* Product longevity was researched through translating theory on repairability and aesthetic durability into eight physical, conceptual prototypes. Even though these prototypes are conceptual, they are designed with the physical possibility to produce them in mind, to bridge the gap between theory and reality. This quantitative sub-research aims to be an objective 'anchor' in the subjective process of translating theory into practice. It does so by researching which needs participants value the most in the objects they own, and how the eight prototypes would meet these needs in their perception. The insights can be used to decide on what the detailing challenges are per prototype, and which prototype to continue with to take a step further.

### FUNDAMENTAL NEEDS

The research aims to identify the most important qualities for users in their objects and the reasons behind these preferences. The product qualities used in the research are based on the fundamental needs as described by Desmet and Fokkinga (2021). Beneath the apparent differences we as people have on the surface, we universally share the same fundamental needs that shape our goals and desires. Regardless of culture, age, or lifestyle, everyone shares a common set of 13 fundamental needs that are crucial for well-being and development. Each of them is broad and overarching, consisting of many sub-needs. Needs are the basic requirements for our functioning and the nutriments for our well-being and advancement.

### RESEARCH QUESTION

"What qualities do people prioritise in their possessions, and how do these preferences align with the re-designs?"

1. Which qualities do participants consider most important in the objects they own, and why?

2. Do these reasons align with the fundamental needs they were based on?

3. How do participants associate the identified qualities and the re-designs?

## METHOD

### RESPONDENTS

Seven prototypes, each accompanied by brief explanatory texts, were showcased at TU Delft's Industrial Design Engineering first ever solo exhibition at the Dutch Design Week in Eindhoven. Unfortunately, one prototype requiring to be turned on for the experience was excluded due to safety concerns. The exhibition drew 15,000 visitors over a nine-day period, with a total of 3010 attendees participating in the voting process.

### EXPERIENTIAL QUALITIES

From a selection of fundamental needs, 11 experiential qualities were defined. This translation is important because experiential qualities are more specified, focusing on how a product is perceived. Opposingly, fundamental needs are broader and rooted in the underlying motivations of people. For instance, a familiar product (experiential) can fulfil the fundamental need for relatedness, while a convenient product (experiential) can cater to the fundamental need for comfort.

Out of the 13 fundamental needs, only those aligning with the scope of this graduation research, centred on repairability and aesthetic durability of appliances, were considered. For instance, the fundamental need for fitness (having a healthy and strong body) could give insights that are interesting for appliances related to food, but was excluded as it diverges from the overarching research focus. A comprehensive list of the fundamental needs and associated experiential qualities that were considered can be found in Appendix 5.

### SETUP AND PROCEDURE

The seven prototypes were showcased in a booth, as depicted in figure on the following pages. Visitors were initially provided with a brief project overview. The process was guided by numbered signs, leading them through the steps. Firstly, visitors were asked to select a quality they highly value in the products they own, choosing from the 12 options on removable notes (Figure 60). Subsequently, they were asked to elaborate on why the selected quality is important to them by writing on the back of the paper. Finally, visitors were asked to attach their chosen quality to the corresponding prototype using the provided receipt holder. After the event, the votes for each prototype were counted, and the written responses were systematically coded using 'Atlas.ti'.

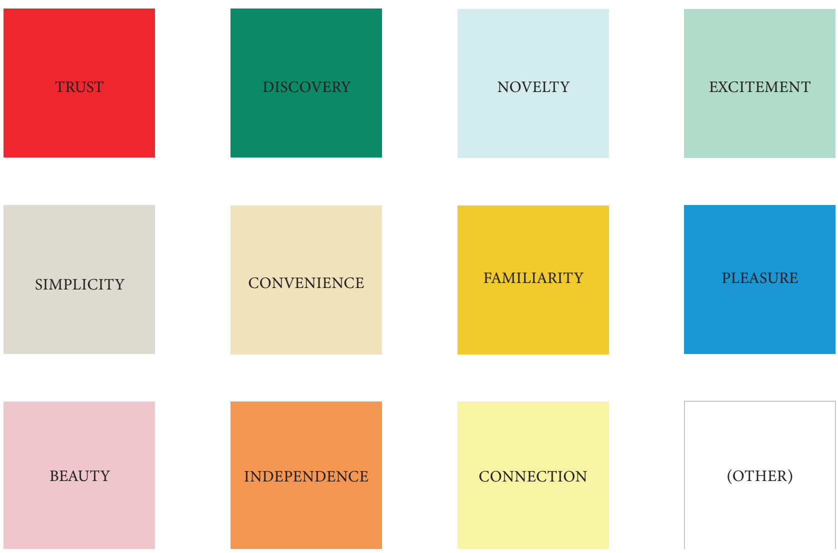
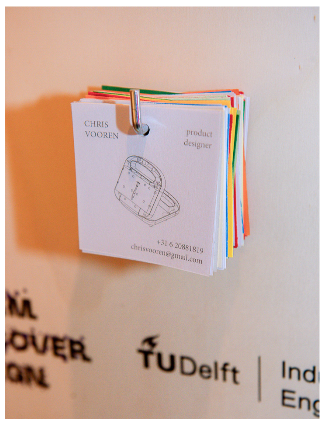



*Figure 60. The experiential qualities used in the research*


1. Please pick one quality you value a lot
in the objects you own
Kies één kwaliteit die je belangrijk vindt in de objecten die je bezit


EXCITEMENT


DON'T TOUCH


CHRIS
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TUDelft

*1. Which qualities do users consider most important in the objects they own, and why?*

Over a span of nine days, a total of 3010 visitors voted. 749 of the 3010 visitors also wrote down the reason of their vote (see Appendix 5), which is nearly a quarter of the respondents. Figure 61 shows the popularity of each quality relative to each other. Simplicity is deemed important by most people, followed by trust and convenience, together making up for 47,8% of the votes. Analysis of the provided reasons reveals an emphasis on practical considerations. Visitors expressed a desire for products that last a long time, are easy to understand and use, and improve efficiency in their lives.

These qualities are followed by beauty, excitement, connection and pleasure, together collecting 31,1% of the votes. Visitors that voted for these qualities mostly have emotional motivations, seeking for products that contribute to their happiness, beautify their homes and evoke personal memories of people, places or events. Noteworthy mentions from the blank and connection notes are memory, nostalgia, and history, which visitors linked to emotional attachment. Out of 93 reasons for connection, 23 were related to memories, history, or nostalgia. Additionally, 10 respondents mentioned these qualities on the blank notes.

Subsequently, familiarity and discovery represent a combined 9%. Familiarity is associated with comfort in the known, reflecting personal identity, and intuitive interaction with products. Conversely, discovery involves the joy of gaining new insights, learning, and the excitement that comes from such exploration.

Finally, novelty and independence, with a combined representation of 5.1%, are the least frequently chosen qualities. Independence revolves around users' ability to accomplish tasks autonomously, with products functioning seamlessly without any user intervention. Novelty is linked to innovation, uniqueness, and the thrill of exploration.

*2. Do these reasons align with the fundamental needs they were based on?*

Most of the responses corresponded to the overarching fundamental needs the qualities were based on, yet there were some exceptions.

While "trust" is mostly interpreted by visitors as relying on a product to function as expected and sometimes as establishing a connection with a product, the fundamental need of "security" is rooted in being safe from harm and threat. In a human connection context, trust and security may be closely linked, as trusting and feeling secure with someone gives a sense of safety and reliance. However, in a product context, these terms might differ. While some respondents did mention safety, particularly in the context of a product like a sandwich maker, dangerous situations are not very common. It's possible that the choice of words complicates the linkage, and choosing 'safety' as a quality might have been a better link to the fundamental need of security.

The quality of "familiarity" does not directly align with the fundamental need "relatedness" based on people's reasoning. Relatedness is about cultivating warm, mutual, and trusting relationships with those you care about, whereas visitors explained familiarity mostly as finding comfort in understanding how things work intuitively, which may also be a quality that is related to the fundamental need of competence. However, this comfort in intuition with a product can be a consequence to trusting and warm relationship.

For "excitement", there isn't a direct connection with the need of "competence". Excitement to the participants is centred around bringing joy and avoiding boredom, while competence revolves around having control over one's environment and exercising skills to master challenges. Nevertheless, a connection can be found, as excitement can be seen as a consequence of competence. Similar to trust, this may be a result of the choice in words that was influenced by making it appropriate in the context of products.

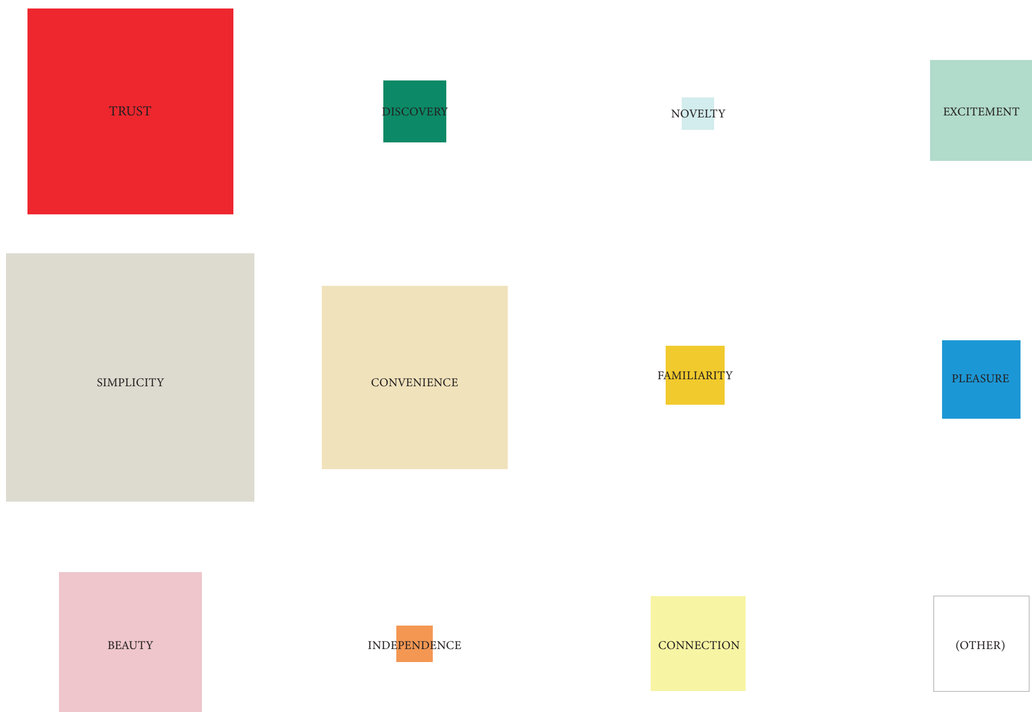



*Figure 61. The voting results show the popularity of each quality relative to each other*

NUMBER OF VOTES →

↓ NUMBER OF VOTES

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SIMPLICITY | 152 | 19 | 115 | 140 | 43 | 51 | 38 | **558** |
| TRUST | 82 | 56 | 63 | 72 | 85 | 74 | 31 | **463** |
| CONVENIENCE | 101 | 33 | 77 | 30 | 59 | 75 | 43 | **418** |
| BEAUTY | 64 | 76 | 63 | 43 | 45 | 18 | 12 | **321** |
| EXCITEMENT | 22 | 64 | 20 | 32 | 53 | 19 | 16 | **226** |
| CONNECTION | 22 | 75 | 34 | 29 | 26 | 23 | 4 | **213** |
| PLEASURE | 22 | 55 | 27 | 25 | 21 | 14 | 12 | **176** |
| DISCOVERY | 6 | 19 | 15 | 13 | 52 | 27 | 7 | **139** |
| FAMILIARITY | 33 | 22 | 26 | 7 | 12 | 16 | 16 | **132** |
| INDEPENDENCE | 10 | 11 | 10 | 16 | 13 | 16 | 5 | **81** |
| NOVELTY | 7 | 20 | 4 | 19 | 11 | 5 | 7 | **73** |
| | **521** | **454** | **450** | **426** | **420** | **338** | **191** | |

*Figure 62. Heatmap giving an overview of what experiential qualities were linked to the prototypes*

*3. How do users associate the identified qualities and the re-designs?*

The heatmap in Figure 62, with prototypes and qualities ranked by popularity, illustrates the total number of votes of each quality in relation to the prototypes.

## DISCUSSION

### FUNCTION FIRST

Functional aspects, such as reliable performance and ease of use for more convenience in people's lives, received the most votes. This preference is quite understandable since products are created for practical use, and their reliability is fundamental to their purpose. Shifting the focus towards these functional aspects in the next phase is important. However, many visitors did value more emotional or personal qualities. Beauty, happiness, or feeling a connection to a product were seen as the prerequisites for ownership for them, and not its functionality.

### MEMORIES, NOSTALGIA AND STORIES

The results show that 33 of the 749 written responses concerning connection mentioned memories, history, or nostalgia. The literature research in the chapter on aesthetic durability highlighted the influence memories on the emotional connection between people and their products.

### FURTHER PROTOTYPE DEVELOPMENT

In order of popularity, the implications of the results for further development of each prototype is discussed on the following pages.

**Screws**

*Highest valuation on simplicity and convenience, and a high valuation on trust and beauty.*

It is unclear whether the screws, or the high resemblance of this prototype to a familiar sandwich maker have contributed to its high valuation on practical qualities. Nevertheless, in detailing it would be the challenge to reach the same effect and make the screws stand out in a similar way. Moreover, the consequences of this concept for the exterior have to be designed for.

**Stretch**

*Overall valued above average for most qualities. High valuation on simplicity, convenience and beauty.*

Functional development would be most important for this prototype, with a focus on the integration of lights and a closing lid. Exploring whether an awareness of parts encourages repairs by the user can be further investigated through testing and interviews.

**Oven mitt**

*Highest valuation on beauty, excitement, connection and pleasure. Lowest valuation on simplicity, and a low score on convenience.*

This prototype receives the highest valuation for emotional feelings of connection and happiness. Memories are mentioned as crucial for emotional attachment, aligning theoretical research. Further development should prioritize function and ease of use.

**Brick**

*High valuation on simplicity, but lowest on convenience.*

While perceived as straightforward and lacking unnecessary functions or parts, this prototype is not deemed convenient to use and scores low on emotional qualities. Future development should focus on enhancing user-friendliness, diving into ceramic making, and addressing the challenge of making the product functional.

**White box**

*Highest valuation on trust and discovery. High valuation on excitement. Low valuation on simplicity.*

The transparency of the casing led visitors to trust in its functionality and durability, and not perceive it as fragile, which could have been the consequence of the visibility of its components. Further development could detail the casing for functional purposes, or explore achieving a similar effect in a more balanced, simple design.

**Inside out**

*Lowest overall valuation. Lowest valuation on trust.*

This prototype would be most challenging to develop as it is valued low on almost all qualities, practical and emotional. Exploring subtler ways to show the interior, and seeking a more universally appealing design that is more accessible for people not familiar with the injection moulding process may be ways for improvement.

**Repair shop**

*High valuation on trust and convenience.*

Although valued for practical qualities, this prototype scores low on emotional valuation. Future development could target high self-repairability as the main objective, considering interior implications for the exterior and usage. User testing can help optimize ease of repair.

**Diversity of sample**
Several factors may have influenced decision-making. The Dutch Design Week caters to a specific audience, primarily consisting of people working in or at least with an interest in the design field. This means that the results do not represent the preferences of an average or diverse sample. It might be possible that a broader population does not prioritize certain qualities to the same extent.

**Unintended characteristics influencing decision-making**
Many participants did not read the explanations, relying mostly on visual appearance for their decisions. However, some visual characteristics were secondary consequences that were not fully designed. Many details were not considered during prototyping, as the primary focus was on conveying the idea rather than intricate detailing. So, people did assess the prototypes based on these unintended characteristics too. For instance, a visitor mentioned voting for the 'stretch' prototype because of their preference of round shapes.

**Imagination instead of actual use**
Some conversations with visitors revealed that they voted for the appliance that resembled a sandwich maker as they know them the most, particularly the visitors prioritizing practical qualities such as convenience. These visitors interpreted the prototypes more literally, envisioning them directly within their conventional context rather than considering their conceptual representation through imagination of use scenarios. Thus, evaluation by visitors had to be done through visual aspects, or the imagination of use or interaction instead of actual use.

**Engagement to the content**
As expected at an exhibition, some visitors engaged more to the work than others. It is possible that not everyone fully understood the voting system, or simply did not take the time to attach their quality to the appropriate model, opting for a random or conveniently positioned one. It may have been beneficial to rearrange the prototypes each day to prevent this.

**Influence of voting stacks**
As the amount of votes were visible for each visitor, they may have influenced their voting behaviour. It is not expected that the colours to have influenced the voting of the specific qualities, as their popularity was difficult to distinguish between different stacks.

**Experiential qualities**
As indicated in the results section, it is mentioned that three experiential qualities (trust, familiarity, and excitement) may have deviated from their intended overarching fundamental need. In a next study this could be prevented by reconsidering words more closely aligned with the fundamental need.

**Non-product specific answers**
The research could be improved by delving into the reason of participants for associating specific qualities with the prototypes. The current approach considers the consequences for further development based on the votes per experiential quality, meaning it relies on interpretation of these results. A more targeted follow-up study could provide deeper insights into the specific areas that the prototypes need to address for improvement.

The study's limitations somewhat reduce the specificity of the consequences for further development, but do offer a more general indication of their strengths and weaknesses. Given that the prototypes are still in a conceptual phase without functionality, this is acceptable as it provides a broad sense of direction to continue with. However, for the next phase, involving the development of functioning prototypes, a more focused study is recommended. This study could delve deeper into a specific prototype, with a targeted approach for improving overall usability and refinement.

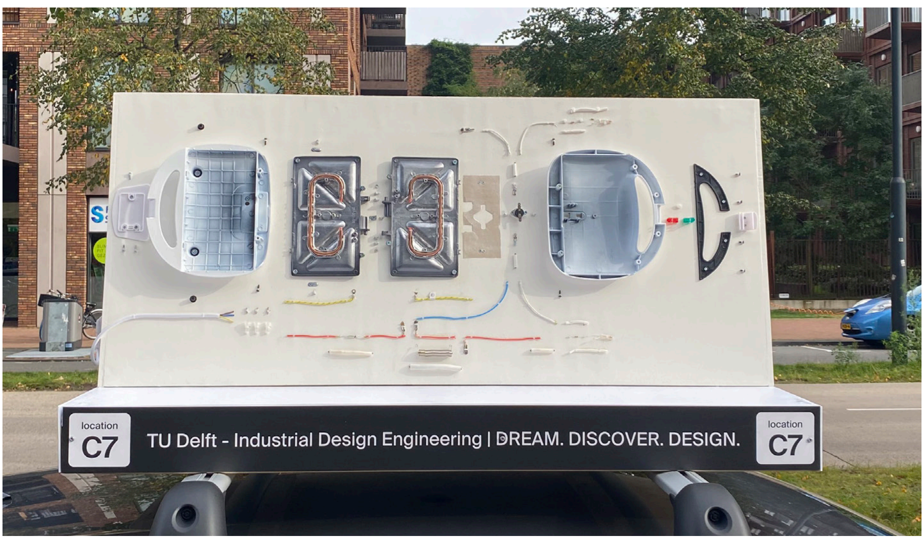
The goal of this research was to identify what qualities participants prioritise in their possessions, and how these preferences align with the re-designs. By doing this, the prototypes that were designed based on research were evaluated by participants, and the outcomes are used to choose a prototype and develop the prototype further into a functional, usable product.

The findings revealed an emphasis on functional aspects such as reliability, simplicity, and convenience, reflecting participants' preference for practical considerations in their product choices. However, many visitors did value more emotional or personal qualities. Beauty, happiness, or feeling a connection to a product were seen as the prerequisites for ownership for them, and not its functionality.

Furthermore, the analysis of users' associations between the experiential qualities and the re-designs shaped the implications for further development. For instance, prototypes receiving high valuations for emotional qualities, such as beauty and connection, may benefit from further development prioritizing function and ease of use. A list with design implications for each prototype was formed based on this research.


*Figure 63. The object on top of the Dutch Design Ride I designed as promotion for the TU Delft's exhibition, built by Joost van Baar*


M. DISCOVER. DESIGN.
location
C7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TU Delft - Industrial Design Engineering | DREAM. DISCOVER. DESIGN.
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# A STEP FURTHER

The purpose of taking one prototype a step further is to develop a functional and operational model that showcases multiple repairability solutions, communicates the product's usage, and facilitates ergonomic evaluation for testing (Evans et al., 2010). This would serve as an initial step in transitioning from conceptualization to embodiment design.

Within this project, I want to demonstrate that all the re-designs that are made reflect valid thoughts. They do not attempt to present a single right answer, but rather present diverse positions within the design space. Therefore, the selection of which prototype to further develop is not a matter of right or wrong; each has its own set of challenges.

In the evaluation phase, the prototypes were all valued differently, resulting in distinct challenges per prototype, as presented in the previous chapter. Among the prototypes, one stands out when looking at the outcomes. The oven mitt prototype excels in beauty, excitement, connection, and pleasure—qualities that go beyond mere functionality and are related more closely to the theory on aesthetic durability. It evoked a strong response in these aspects compared to the others, yet presents challenges regarding functionality. I was drawn to this challenge: how could this product actually be made functional?

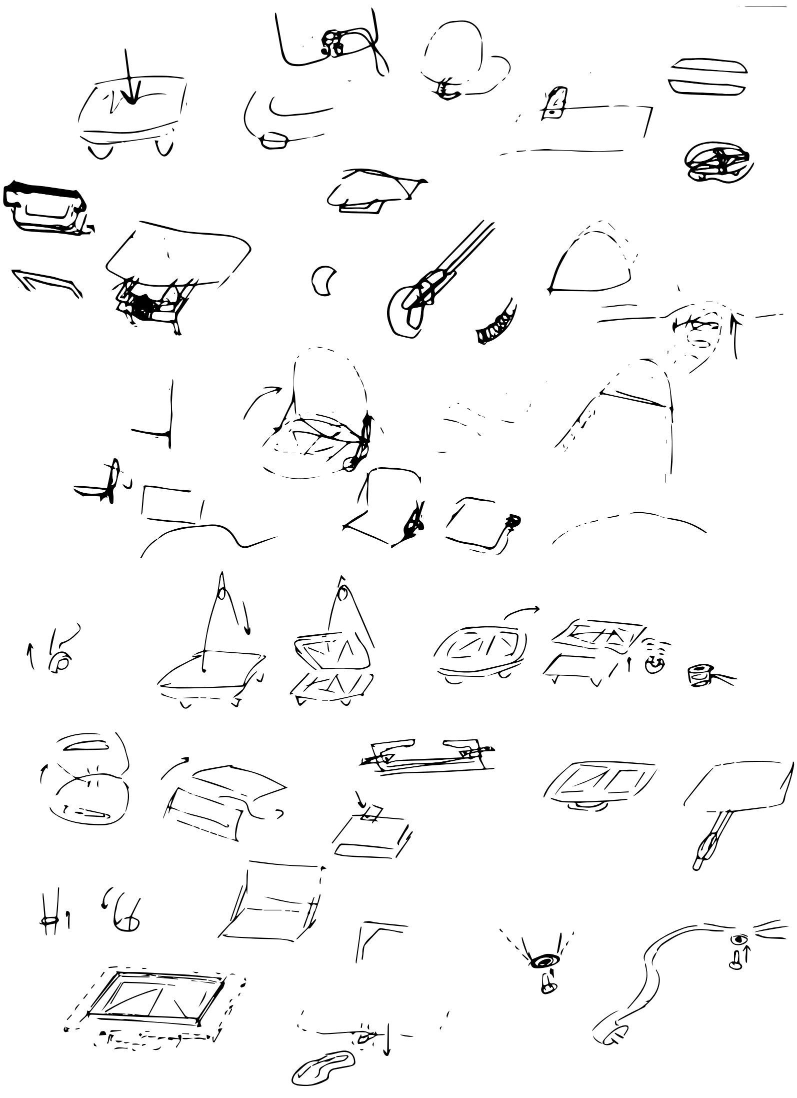


*Figure 64. The process began, just as with the first re-designs, with very simple sketches intended to address the challenges. For additional details regarding the design process, please refer to Appendix 6.*

INTERACTION

With this cover, similar to that of an oven mitt, touching is not something that should be avoided, but is necessary in the use of the product. Instead of a hard, outer shell that should be avoided to touch during use, resting your hands on top of the appliance gives you an indication of when it is ready to use, and literally makes the distance between you and your product smaller. Over time you will hopefully get to know the functionality of the product better.

The warm feeling is very pleasant, and I could imagine warming my hands on it while waiting for my sandwich to be ready, similar to sitting with a hot cup of tea. Instead of walking away and distancing myself, I might stay for this pleasant feeling.


unplug before removing covers

## CARE

As the casing is made of white cotton, it will become dirty over time. Periodic washing is thus important, and it can be thrown in the washer together with all other kitchen textiles such as tea towels and pot holders. After simply removing the magnet-connected covers, all that is left is a bare aluminium appliance, a moment where you get confronted with the product's internal components. Over time in this care process, these will not be so unfamiliar anymore.

This washing approach necessitates time, care, and attention, which can be viewed as an inconvenience. As the product demands attention from time to time, requiring effort, its thingness comes to the forefront. Yet, caring for this product can also be seen as caring for oneself for a moment. While its convenience and efficiency in use are not necessarily improved compared to the original design, one may question if these are the qualities that should be most important.

An example of a similar train of thought is that of signage for a clinic for obstetrics and paediatrics designed by, again, Kenya Hara (2007) (Figure 65). These soft, white cotton cloths are easily soiled, yet also easily removable, like socks. On the one hand, this approach of creating soft signage is taken from the perspective of the needs of mothers relaxing before and after childbirth. On the other hand, the clinic constantly maintaining cleanliness shows their dedication to hygiene for patients and visitors.


*Figure 65. Cotton hospital signage*

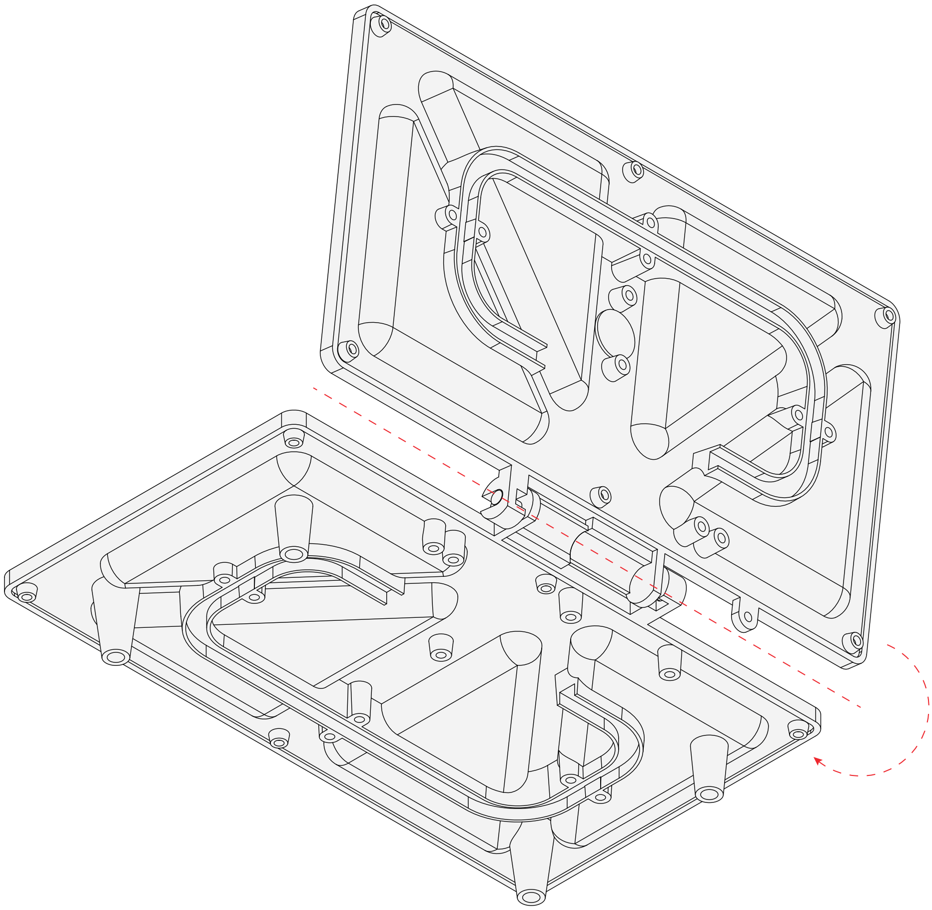


*Figure 66. The bare aluminum plates and the way to detach them from each other*

## ASSEMBLY

All components are attached to the two cast aluminium grill plates, which form a self-standing assembly as the bottom part integrates four legs (Figure 66). To detach these plates, they must be rotated beyond 180 degrees.

Figure 67 illustrates the attachment of all components to the grill plates. Ferrite pot magnets (1) with threaded pins are used, as they retain magnetism even at high temperatures above 250 degrees Celsius. Heating elements are now secured to the grill plates by three screwed-in clamps (2). A hook (3) prevents the plates from falling backward when opened; to fully disassemble the product, this hook must be unscrewed first. Silicone rubber feet (4) stabilize the appliance; this material can withstand high temperatures up to 230 degrees Celsius. Lastly, aluminium clamps (5) secure internal cabling and the power plug, preventing damage if the plug is pulled. Figure 68 illustrates how the components are wired.

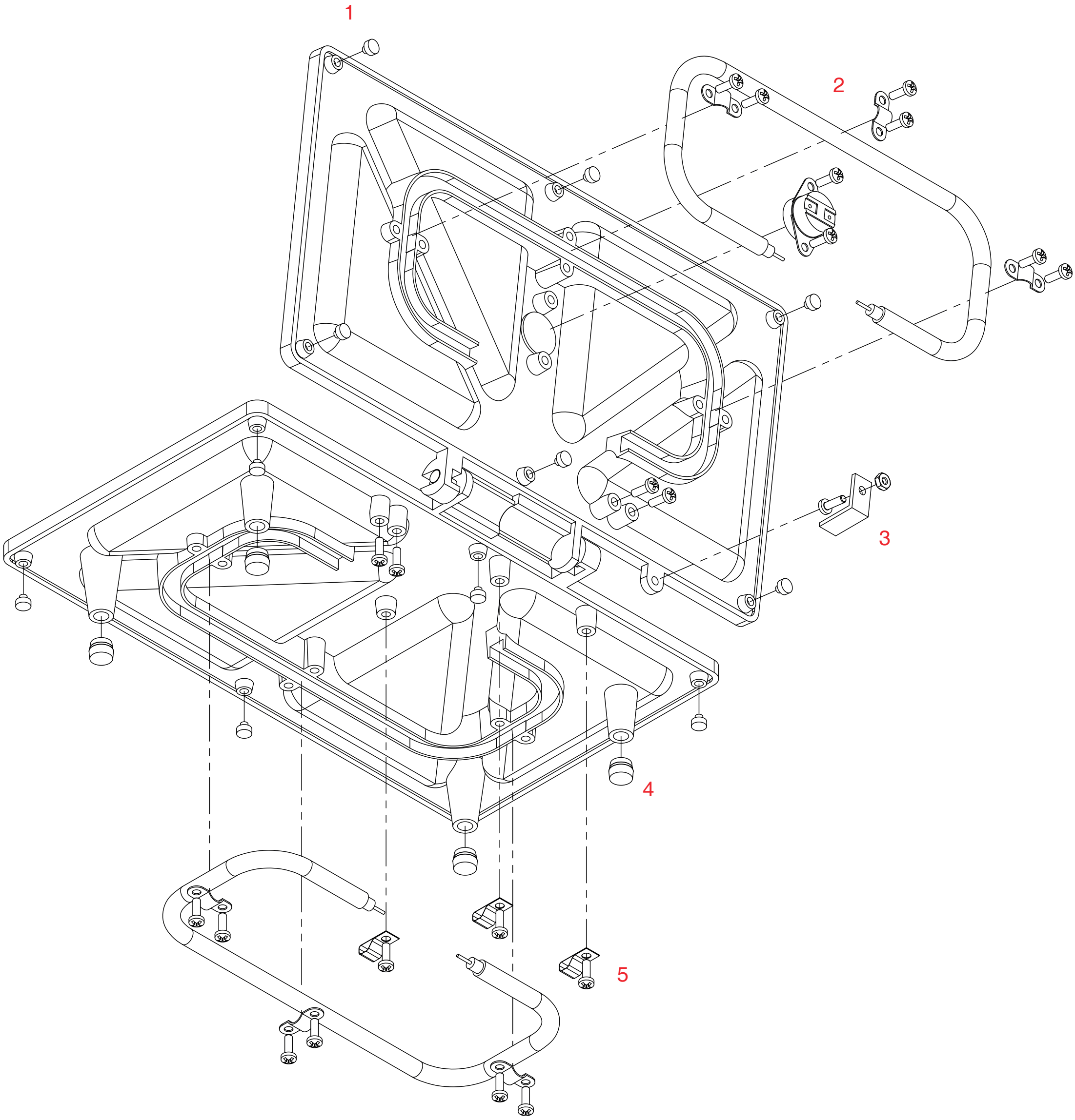
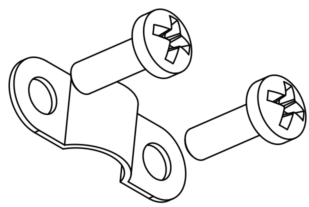



*Figure 67. Exploded view of components*

1

2



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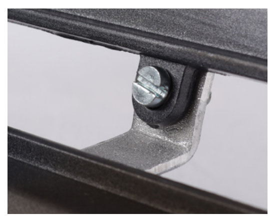

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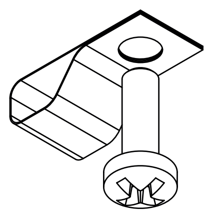


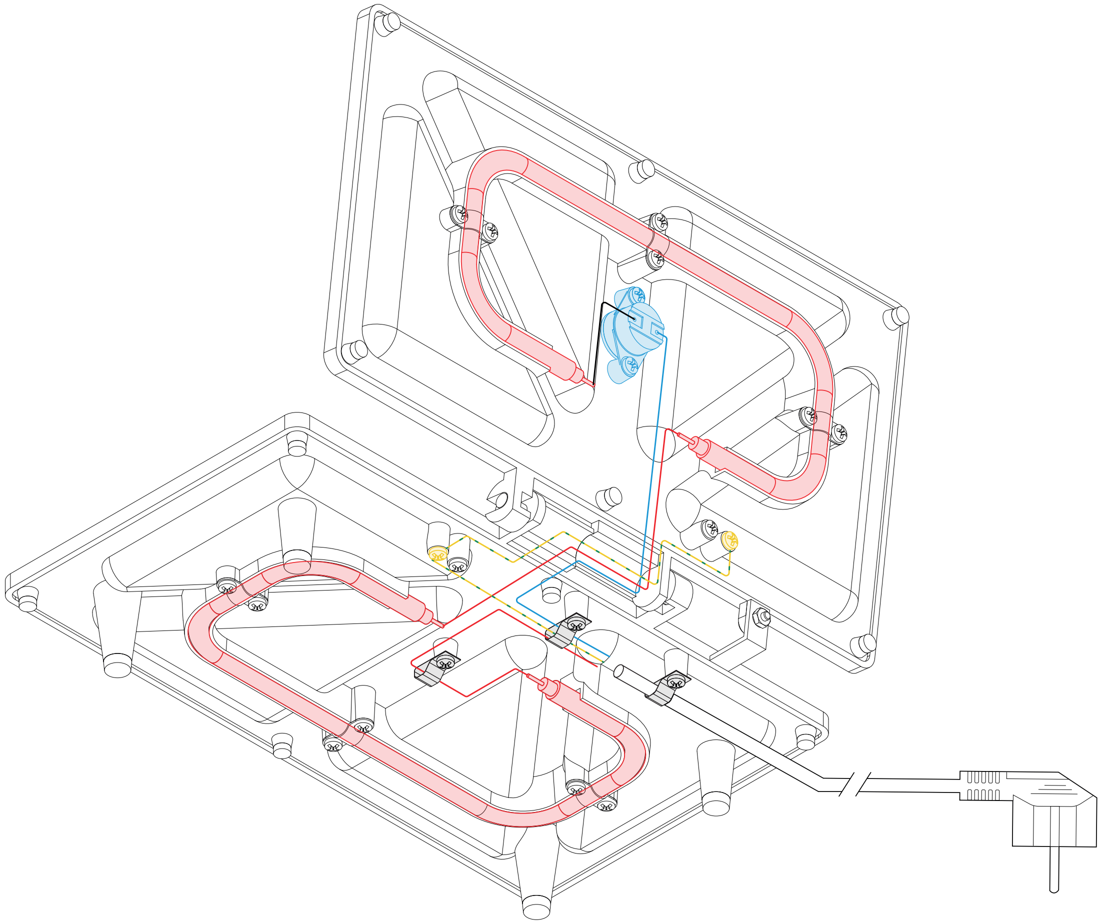
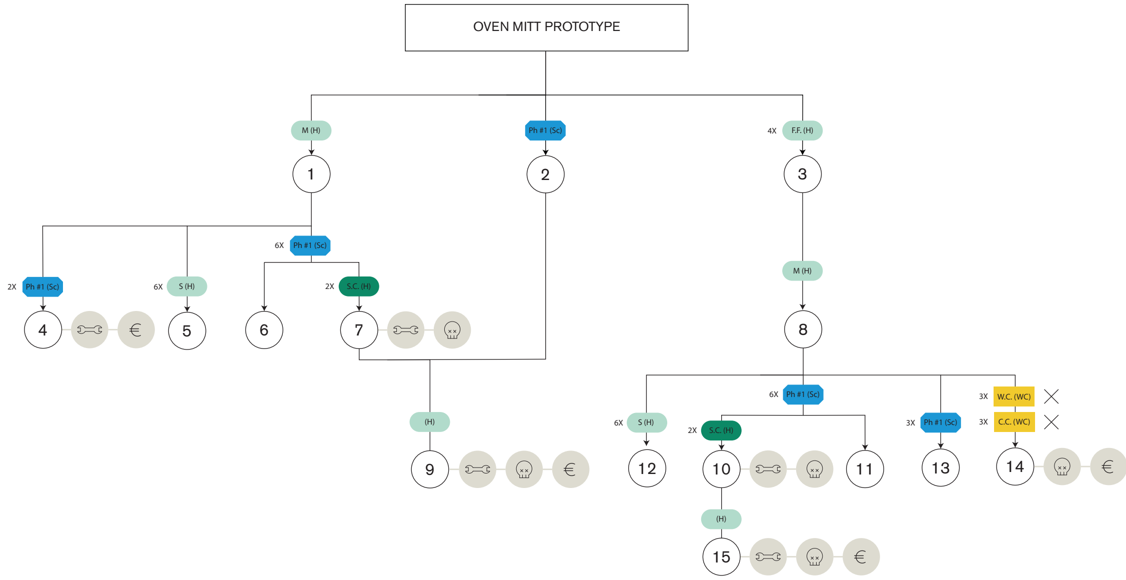


*Figure 68. Wiring of components*

The updated disassembly map on the right indicates a reduction in parts from 20 to 15. Neon lights, their covers, resistors, the closing lid, connection cover, and bottom cover are now unnecessary. A Phillips head 1 screwdriver is the only tool required, along with a wire cutter for the power plug. The heating elements ar no longer stuck in the grill plates and the bottom grill plate is reachable without having to cut the power cable or the use of an uncommon tool. The remaining components can easily be removed by hand.




## COMPONENTS

1. Top cover
2. Stop
3. Rubber feet
4. Thermostatic switch
5. Magnets top
6. Heating element lids top
7. Heating element top
8. Bottom cover
9. Grill plate top
10. Heating element bottom
11. Heating element lids bottom
12. Magnets bottom
13. Cable clamps
14. Power cable
15. Grill plate bottom

## CONNECTORS

M = Magnet
S = Screwed
F.f. = Friction Fit
W.c. = Wire Cap
C.c. = Crimp Connector
S.c. = Spade Connector
Ph. #1 = Phillips 1 Screw

## TYPE OF TOOL

(H) = Hand
(Sc) = Screwdriver
(Wc) = Wire cutter

## PENALTIES

Uncommon tool

Non-reusable connector

Low visibility

Product Manipulation

## MOTION TYPE & FORCE INTENSITY

Low Mid High

Hand

Single motion tool

Multiple motion tool

## TARGET COMPONENTS

Failure indicator

Environmental indicator

Economic indicator

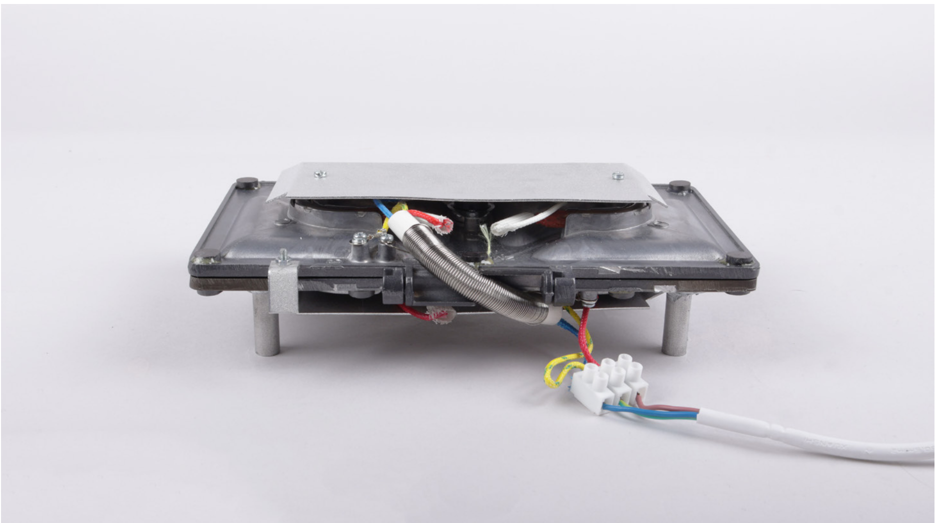


*Figure 69. The covered and bare prototype*

*Given that the heating elements reach temperatures of 250 degrees Celsius and the aluminium grill plates reach 170 degrees Celsius, Kevlar fabric is used to protect the cotton and filling, as it can withstand temperatures up to 300 degrees Celsius. In this prototype, the legs are hard soldered, magnets are glued and stitched on, the heating element is safeguarded by an aluminium cap, and the power cable is connected with a screw terminal.*

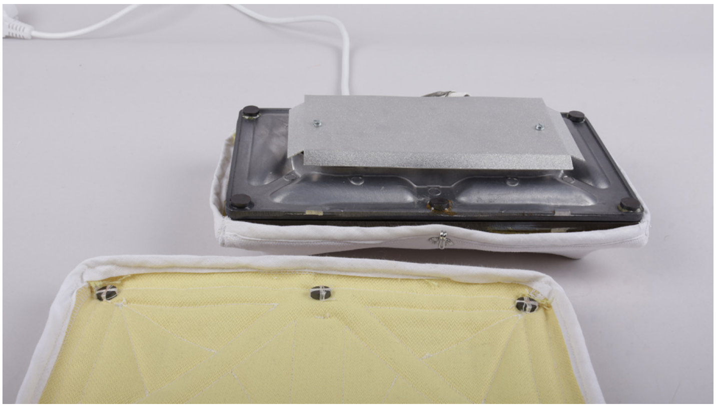


*Figure 70. The aluminium cap and Kevlar-lined cover*

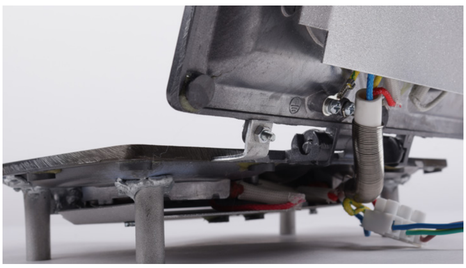


*Figure 71. Back of the prototype*

*Figure 72. Prototype in its natural habitat*

# DISCUSSION

This project centred around the question,

*"How can appliances be re-designed for retainment, considering repairability and aesthetic durability?".*

The research results show an exploration of the approach, theoretical considerations regarding repairability and aesthetic durability, and nine prototypes reflecting these principles. Each of these aspects will be discussed here separately, including recommendations.

## THE APPROACH

### RE-DESIGNING

*The re-design approach aimed to highlight the impact of the changes based on the theory on a familiar object.*

The noticeable divergence of the re-designs from the original appliance confirmed the intended effect. However, this approach also presented limitations. Building upon existing products can be constraining to design freedom, as you are confined to the not so empty 'canvas' of your case study. Moreover, I sometimes wondered during the process how necessary it is to change and create new things, and if there is not already enough at hand. Maybe the solution for this pile of e-waste lies more in behavioural changes. Perhaps we don't need a specific product like a sandwich maker, and a simple pan would suffice.

### DESIGN SPACE

*The intention of creating a design space along three axes—'the possibility to repair,' 'our pleasure as users,' and 'the life of the thing itself'—was to offer a wide variety of options for applying the theoretical principles to the re-designs.*

From my personal perspective, this approach provided a broad yet grounded framework for experimentation. It resulted in a diverse range of prototypes, reflecting various aspects of the theory. Visitors at the Dutch Design Week recognized the diversity among the prototypes as was seen in the results of the research. Moreover, it felt like there was still enough potential for more redesigns, especially if the theoretical framework were expanded.

To assess if this approach truly serves as an effective design method, evaluating it with other designers would be ideal. An option would be to further elaborate into this method around the discussed theory, for instance by applying it to other appliances. Would there be a large variety of options? Or would the solutions become repetitive? And if so, would that be a bad thing or not? Would this give more directed conclusions or guidelines to design for?

During this project, the intention was to explore how the theory can be applied to real products, yet what would be the next step? Is this approach mostly suitable in a conceptual stage? Could it also be used to detail products that will actually be made and sold? Or would it, which would be unfortunate in my personal view, remain mostly a carrier of thoughts?

To follow this path of perfecting this 'method' could easily fill another year, yet starting off with organising a workshop, such as a one-day pressure cooker involving multiple designers and other appliances could be a great starting point for a quick evaluation of the current approach. In this elaboration, I would like to develop the approach to go beyond a conceptual stage.

### EVALUATION

*The evaluation at the Dutch Design Week aimed to bridge the gap between theory and reality by receiving feedback on the prototypes.*

It could be argued that the setup of the study was too broad to have a focused further development of the prototypes. However, the prototypes were not yet in a stage where interaction could be tested, making it challenging to evaluate a directed product-user experience. Moreover, as the product was chosen for its relatability there was the assumption that visitors would be able to imagine interaction with it. This was however not confirmed in the research, which is a point of improvement.

## THE THEORY

*The theory is divided into two parts: one focusing on the factors contributing to product repairability, and the other on the factors contributing to aesthetic durability. Moreover, it was explored where these subjects intersect.*

The discussed theory has only scratched the surface, but is grounded in scientific findings, providing a solid starting point. While repairability was primarily based on concrete design implications, the theory on aesthetic durability operated on a more conceptual level. However, both overlapped in an attitude of shared respect for the object itself, going beyond our role as users.

The two factors contributing to emotional attachment, pleasure and memories, functioned as a starting point to move the focus from the user to the object itself, and explore other related theory and examples from design practice. This shift from emotional attachment to aesthetic durability was important. Though not thoroughly discussed, endlessly holding on to your things is not intended as the main goal. It is rather an awareness of the value of our things, and part of that is recognizing when it is time for an object to move into the next loop of the circular economy. This is not addressed in the current research as it falls out of scope, as it could as well be a whole research on its own.

Lastly, in translating theory into practice, interpretation is inevitable. Another designer, using the same starting point, may construct a different design space. They may have been influenced by different literature, papers, inspirations, and personal experiences. For instance, other designers might emphasise product care or the experience of the act of repairing, which would both be relevant directions to take within this project. This degree of subjectivity is important to acknowledge in this translation, and part of the reason why the project result does not consist of straightforward guidelines to design for aesthetic durability and repair.

## THE RE-DESIGNS

*The objective of the re-designs was to demonstrate the application of theory and propose solutions for designing products that are repairable, and aesthetically pleasing.*

Assessing whether the re-designs are more 'long-lasting' than the originals in terms of repairability and aesthetic durability is challenging. They remain at a conceptual and somewhat experimental stage, and lack evaluation from others based on the underlying theory. A more focused evaluation could give an indication of the extent to which the prototypes successfully embody the theory, confirming the intended outcomes. A theory related questionnaire, similar to the scale to measure consumer-product attachment by Schifferstein et al. (2008) could serve as inspiration.

### THE BRIDGE FROM THEORY TO PRACTICE?

As previously mentioned, the prototypes remain largely experimental. Furthermore, most changes are concentrated on the casing, which was experienced as the component with the most potential for alteration, and serving as the connection between the product's function and the user.

Most of the re-designs show quite radical changes to the original appliance. During a short design cycle of elaboration on several prototypes, I had the initial intention to translate these radical thoughts into more subtle changes, to find a solution that would be closer to an acceptable reality. However, it felt impossible to tone the designs down. The gap felt too large to bridge. It may have been a time constraint, but it may also be possible that this approach is not suitable for subtlety, which also maybe shouldn't be desirable, as the theory could get lost. This aspect could be further explored in a pressure cooker workshop aimed at refining the approach, to explore to what extent this approach is suitable to create everyday products that will be used by people.

The 'Oven mitt' prototype has been taken one step further, into a functioning prototype, made for evaluation on repairability and aesthetic durability to give insights for further design elaborations.

In terms of repairability, a disassembly map highlights repair improvements, yet the actual repair interaction could be tested. For instance, removal of the covers has become a simple task, as is reaching the power plug. However, how would users experience this, and wouldn't the threshold now be too low, leading to unsafe situations?

To assess the prototype's aesthetic durability, its general experience and the interaction with the temperature of the appliance can be directly tested as the prototype is functional. Moreover, its closing mechanism could also be evaluated by users, just like the ritual of removing and washing the covers.

Several areas for improvement for a next iteration on the design have already been identified for the current prototype. Further testing and iterations will likely reveal additional points for enhancement. Currently, the following insights were found:

*The current magnets have insufficient strength, causing covers to detach when the sandwich maker is opened.*

*An improved interaction to ensure that users remove the plug when detaching covers may be desired, for instance using the power plug's pins as a sort of key to remove the cover.*

*To prevent the fabric from burning, a Kevlar layer is used that is supposed to withstand 300 degrees Celsius. The heating element only reaches 250 degrees, but still burns the cover. In the prototype this is resolved through an extra aluminium cap, yet in a final design it is preferred to limit the amount of extra parts. In a next design iteration, either a different material that can really withstand the temperature, or an easily detachable cap similar to the one in the prototype is required.*

*The weight distribution of the grill plates made the product tip over, which is why extra weight was added to the front in the prototype. In a further design this extra weight could be integrated in the mould.*

*Exploring alternative cable connection methods, like crimping and protecting with plastic caps.*

*Assessing practicality and maintenance with washing covers, considering offering replacements of varied designs.*

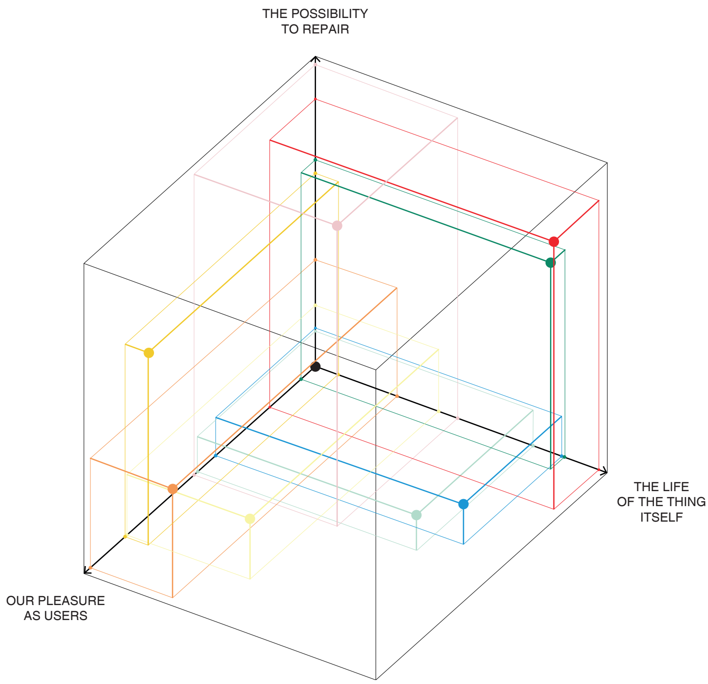
# CONCLUSION

The project delved into re-designing appliances for retainment, considering repairability and aesthetic durability, to align with the shift towards a circular economy and anticipated repair legislation. A re-design approach was developed, drawing from theory on repairability and aesthetic durability. This formed the basis for constructing a design space with three axes ('the possibility to repair,' 'our pleasure as users,' and 'the life of the thing itself'), within which nine prototypes of sandwich makers were developed, one of which was further elaborated into a functional model. Through theoretical exploration and prototyping, the aim was to bridge the gap between theory and practice.

Research on repairability and aesthetic durability emphasized the importance of ease of disassembly and aesthetic pleasure for users, alongside the awareness and respect of the 'thingness' of objects. This perspective came forward in several prototypes to varying degrees, as is apparent by their positions within the design space. Moreover, their various placements in the space highlighted the range of options available for designing for repairability and aesthetic durability, with some prototypes exhibiting more overlap between the two subjects than others. This diversity showcased there is no singular solution, but rather a variety of possibilities to take into consideration during re-design.

While both the theory and re-designs could be expanded and mostly remained at an experimental level, they did serve as a foundation for future exploration of the approach and the implications of the theory on actual use. This actual use in a real-world setting was attempted to be bridged through the evaluation at the Dutch Design Week, where the input 3010 visitors helped establish challenges for further development of each prototype. The development of the 'Oven mitt' prototype for potential user testing is a step forward in this direction, offering an opportunity to gather feedback from user testing.

Future elaboration on the project could also focus on further development of the design approach itself. This could involve evaluating the approach with the help of other designers, potentially through a one-day workshop where they apply the theory to different appliances. Insights from this session could offer starting points for further refinement and exploration of the design approach.


THE POSSIBILITY
TO REPAIR
THE LIFE
OF THE THING
ITSELF
OUR PLEASURE
AS USERS







# AFTERWORD

During this graduation project, I have felt most at peace during all these years of studying.

This may sound unusual, considering this period is often regarded as one of the most stressful, bringing over five (and often even more) years of studying to a close into one big, individual design project. However, my first years of studying were the ones I struggled most. After finishing my bachelor's degree, I swore to never return to this faculty. I felt suffocated, sitting in a room without any views to the outside world, behind a laptop, always working in a group project, day in day out. I didn't understand this was what design was supposed to be like, and I still don't. I noticed how actually creating, building things, slowly started to move further away from me. The threshold became higher and higher, and I saw it happening with my peers too. We all seemed trapped, clinging to our computers.

This period was marked by restlessness and uncertainty. I explored many paths in search of a sense of direction. From considering a switch to architecture to a disappointing semester at art academy, I felt like I explored all the possible options. Yet, amid this uncertainty, I felt a determination to return to pursue product design – but on my own terms.

I am glad that I did. The advanced embodiment design course made it click; it was what I always had envisioned studying industrial design engineering would be like. I improved my prototyping skills, and felt I was finally growing as an engineer. I discovered the freedom to follow my own path the faculty offered (and the appreciation that came with it), and the possibility to make anything in our amazing workshop. Finally, in this graduation project, it felt like so much came together. I was able to prototype from early on, to explore theory and draw inspiration from other designers, delving into subject close to my heart. The fact that I ended up creating a fabric prototype felt like coming full circle – clothes, and sewing, have for my whole life been a creative outlet that is so intuitively, without this threshold I did experience in other forms of creating. I am glad of having turned years of restlessness and negativity about this faculty into something positive.

Don't get me wrong, the graduation process hasn't been without any struggle. Transitioning from the world I had created for my prototypes, to conducting research at Dutch Design Week was a difficult adjustment for me. I needed to adopt a scientific approach and take a certain distance from what I had created. The process of setting up this research and writing about it was not the smoothest phase of the project, and definitely something I could, and should, grow in.

Moreover, I think I anticipated, or desired, a more subtle application of the theory in the latest prototype. Sometimes, I would pause and think of how ridiculous it was that I was making a sandwich maker with fabric covers for my master's graduation. There is a strong desire in me to move beyond conceptual exploration and create tangible, everyday solutions. I think this desire also came from wanting to unite these two sides I experienced inside me, one that is automatically more attracted to conceptual thoughts and aesthetics, and one that wanted to grow as an engineer. Perhaps this was not a reasonable, or suitable goal within this project. Luckily new things will come, and I can pursue to grow as an engineer, realist and maker.

Ultimately, this is just another project. It makes me happy to think it reflects what I was occupied with in this period of my life. Which designers I loved, which movies I watched, which conversations I've had with the people that surrounded me, which books I've read; the things that crossed my path that helped shape this project to what it is. I finalise this thesis with the start of spring and the sun shining. Time for something new.

*“[...] ‘In mijn leven als consument,’ zei hij, ‘heb ik al met al drie perfecte producten gekend: Paraboot Marche-schoenen, de Canon Libris-notebook met ingebouwde printer, en de Camel Legend-parka. Van die producten hield ik, zielsveel, ik had ze mijn leven lang bij me willen hebben door regelmatig, in het ritme van de natuurlijke slijtage, identieke producten aan te schaffen. Er was een volmaakte, trouwe relatie ontstaan, die van mij een gelukkige consument maakte. Ik was in het leven niet in alle opzichten helemaal gelukkig, maar dat had ik dan toch maar mooi: ik kon op gezette tijden een paar van mijn lievelingsschoenen kopen. Het is weinig maar het is veel, vooral als je een tamelijk karig privéleven hebt. Maar dat genoegen, dat eenvoudige genoegen, heb ik niet mogen behouden. Na een paar jaar zijn mijn lievelingsproducten uit de schappen verdwenen, de productie ervan is botweg stopgezet – en in het geval van mijn arme Camel Legend-parka, ongetwijfeld de mooiste parka ooit gemaakt, heeft de productie maar één seizoen geduurd...’ Hij begon te huilen, langzaam en met dikke tranen, en schonk weer een glas wijn in. ‘Het is hard, weet u, het is vreselijk hard. Terwijl de meeste onbetekenende diersoorten er duizenden, soms miljoenen jaren over doen om te verdwijnen, worden fabricaten binnen enkele dagen van de aardbol weggevaagd, ze krijgen nooit een tweede kans, ze kunnen enkel machteloos het onverantwoordelijke, fascistische dictaat van de verantwoordelijken voor de productlijnen ondergaan, die natuurlijk beter dan wie ook weten wat de consument wil, die bij de consument een vernieuwingswens pretenderen waar de nemen, maar zijn leven in werkelijkheid alleen maar transformeren in een uitputtende, wanhopige zoektocht, een eindeloos ronddolen tussen telkens veranderende schappen.“*

From ‘The Map and the Territory’
by Michel Houellebecq


Toasters

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