Make it last

Development of a design intervention to improve consumers' expectations of the lifetime of electronic products

Mark Verhoef | 4569369

MSc thesis - Strategic Product Design
Industrial Design Engineering
Delft University of Technology

23 January, 2025

Chair: Prof. Dr. Ir. Ruth Mugge
Mentor: Jelle T. E. Westervaarder, MSc.

"Our excesses are the best clue we have to our own poverty, and our best way of concealing it from ourselves"

- Adam Philips

Make it last - Development of a design intervention to improve consumers' expectations of the lifetime of electronic products.

Author
Mark Verhoef | 4569369

Master's thesis
Strategic Product Design
Faculty of Industrial Design Engineering
Delft University of Technology

Supervisory Team
Chair: Prof. Dr. Ir. Ruth Mugge
Mentor: Jelle T. E. Westervaarder, MSc.

23 January, 2025

A little thank you

I would like to thank my supervisor Ruth and my mentor Jelle for all their helpful advice and feedback throughout this project. I couldn't have wished for better collaboration and supervision.

I would also like to thank my family, friends and coworkers for supporting me along the way, letting me share my thoughts, ideating with me, and answering all those hard survey questions.

And I would like to thank Katrina Heijne and her students, for their efforts to tackle the problem with me.

Abstract

This graduation thesis aimed to explore how product design can improve consumers' lifetime expectations for electronic devices, with prevention of premature replacement of these products as the eventual desired outcome. Prior research has identified the damaging effects of mass consumption on the environment, due to the continuous demand for new materials and the rising deposition of toxic waste. This thesis proposed a theoretical model that related consumers' predicted and intended lifetime (two types of lifetime expectations) of a product to its mental book value. It then explored potential strategies to influence these factors of replacement behaviour in order to reduce the eventual desire to (prematurey) replace a product. These strategies were supplemented by examples from practice, and used as inspiration in a creative process to develop a design intervention for smartphones and headphones. This intervention should stimulate consumers' lifetime expectations for these devices.

The design intervention consisted of a ring of twelve LED segments implemented on the exterior of the smartphone or headphones, as well as an additional widget for more information. Each LED segment represents half a year of ownership for the smartphone, and one full year for the headphones. The main purpose of this ring is to stimulate consumers to complete the ring at least once, and thus, to use it for longer than the average lifespans of these types of products. The total number of segments should also give them an indication of its potential physical lifetime. The widget was developed to complement the message of the ring through more detailed information on the current status of factors related to the device's life.

An experiment with 2 (device: smartphone/headphones) x 2 (with/without intervention), between-subjects design was conducted to test whether the intervention would be effective in increasing consumers' lifetime expectations and mental book value for an electronic product, and in decreasing their intention to replace it. Division of the participants among the two device groups was based on their experience with either of the devices. The data analysis showed a significant decrease in the depreciation of the mental book value of smartphones, and an increase of the total predicted lifetime (in years) of headphones, among the treatment groups. This suggests that the design intervention of this thesis may successfully affect these factors of consumers' replacement behaviour. The intended lifetime and replacement intention, as well as the remaining measures for the predicted lifetime and mental book value, were not affected by the intervention during the experiment. This could partially be explained by participants' difficulty with the subject, the experiment's design, and certain variables that acted as covariates.

Follow-up research could, for example, address the less represented factors from the theoretical model, other strategies from practice, or the discontinued concepts from the design phase. The intervention may also be tested on other devices, or with a physical model within a more realistic use context instead of an online experimental setting. Further exploration of the intervention's business implications and its potential decreasing effect on sales, is also advised.

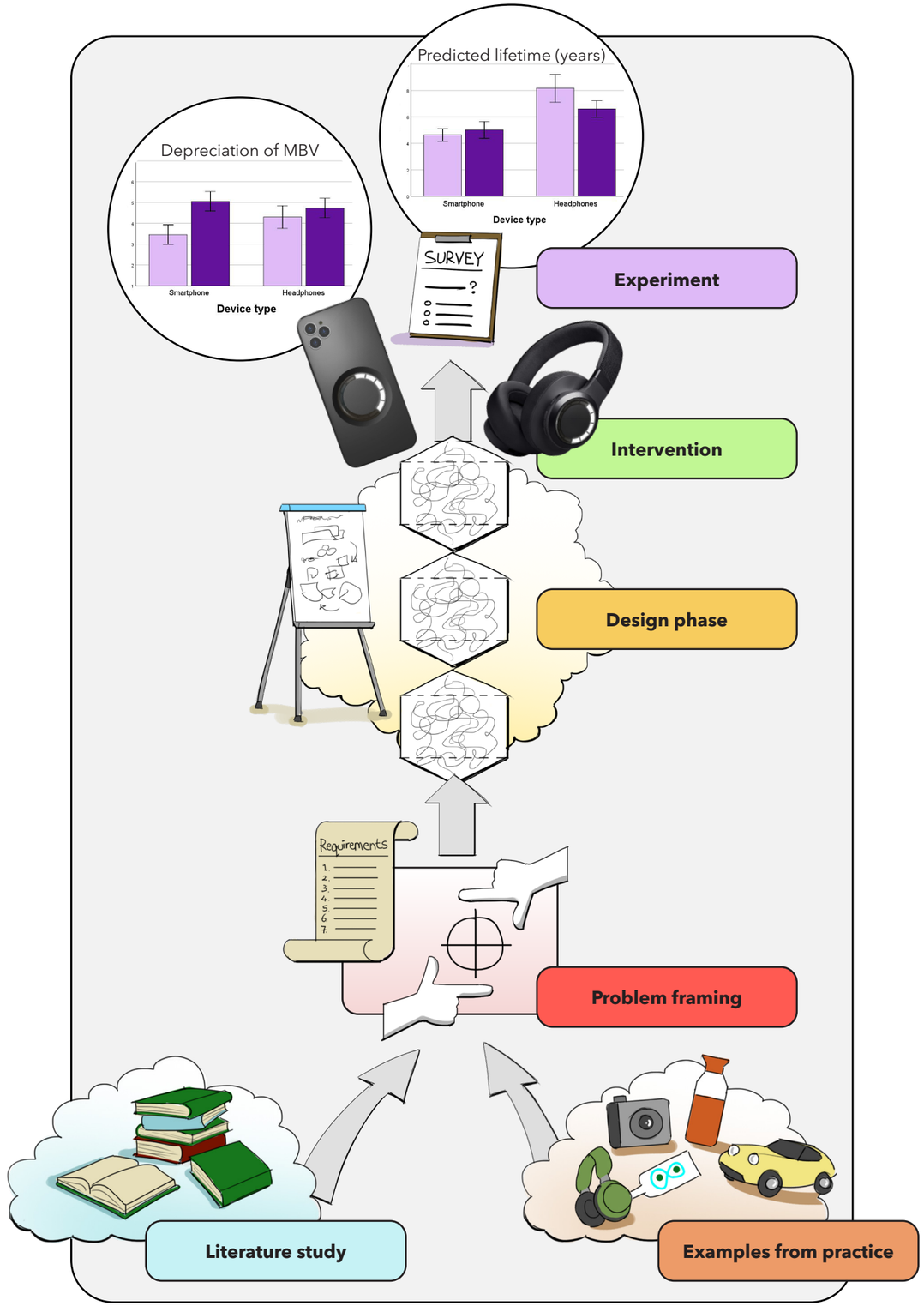


Figure 0.1. Overview of the different phases of the graduation project, with the start at the bottom and the end results at the top.

Table of contents

Click any of the chapters to jump to the corresponding page.

1. Introduction

Since the beginning of the age of industrialization, our modern (western) society has been developed based on the concept of economic growth. Essential to this process is for companies to increase their profit. However, our desire for perpetual growth and ever-rising sales for the sake of welfare and development has been causing severe damage to the natural environment, due to the establishment of a throwaway society. This development has led to an increasing demand of material inflow and growing waste stream, which puts the natural environment under considerable stress. A much-researched aspect of this problem is the share of electronic waste, also referred to as 'e-waste', 'waste electric and electronic equipment' or WEEE. A study from 2023 shows that the global generation of e-waste has been steadily growing by about 2 megatons per year since 2014, reaching an amount of 53,6 Mt (or 7,3 kg per capita) in 2019 (Liu et al., 2023). It is predicted that by 2050, global e-waste generation will cross the 100 Mt, amounting to 10,5 kg per capita (Vishwakarma, Kanaujia & Hait, 2023). These predictions can be seen in figure 1.1.

The main reason for this type of waste being so damaging for the environment, is the fact that electronic products contain a high concentration of harmful chemical materials, such as heavy metals, polymers and artificial chemical compounds. The balance of ecosystems is not only put under stress by the eventual deposition of these chemicals, but also by their excavation at the start of an electronic product's life. Out of all materials required for manufacturing mobile phones, metals such as gold, palladium, silver and copper, as well as plastics, have the most energy-consuming mining processes (Yu, Williams & Ju, 2010). Over the past decade, smartphones have been sold in increasing numbers by companies and purchased more often by consumers (see figure 1.2). Brands make elaborate efforts to convince consumers to buy more of their products in order to secure their competitive position on the market, the rise of their profits and the expectedly resulting growth of their company.

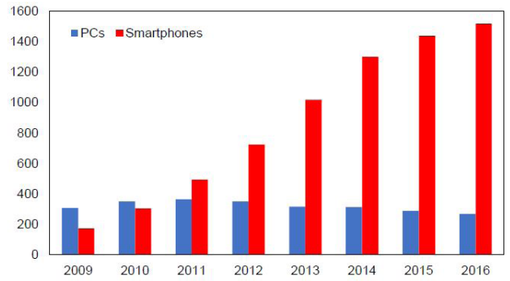


Figure 1.2. Worldwide sales of PCs and smartphones, expressed in millions of units. Image from Carton, Mongardini & Li, 2018).

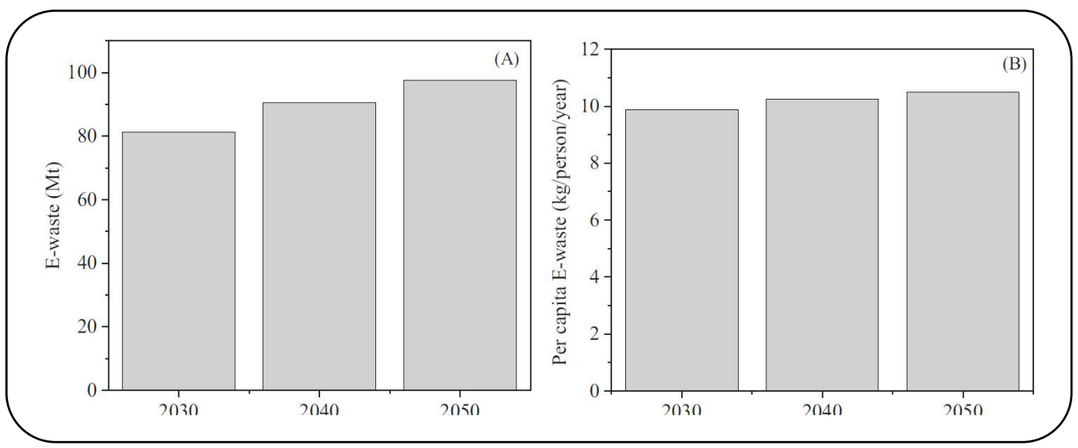


Figure 1.1. Projections of e-waste generation for the years 2030, 2040 and 2050, in total amounts of Mt (A) and per capita (B). Image from Vishwakarma, Kanaujia & Hait, 2023.

Raworth (2017) defined her model of Doughnut Economics as an important solution to secure the future of the planet and humanity on it, and many initiatives have been taken to reach the goals of this Doughnut model (see figure 1.3). A circular economy designed to be regenerative and distributive plays a central role in her vision, as it has been posed by many others before her. Interestingly, an important characteristic for a circular economy to support sustainable development, is to not just close the loop of material flow, but also to slow it down, as mentioned by Cooper (2020), who argued that product replacement cycles should be slowed down in order to move away from the throwaway society.

Regarding the first characteristic, i.e. to close the circle, many efforts have already been taken, for instance in redistribution of products (Sarigöllü, Hou & Ertz, 2010; Thukral, Shree & Singhal, 2022) and recycling of materials (Liu et al., 2023). Slowing down the cycle, on the other hand, has more recently come to attention in studies, and is found to require more empirical research (Van den Berge, Magnier & Mugge, 2023A). The challenges for legislation, industry and consumer behaviour that must be tackled in order to achieve slower product replacement cycles, are also considered much bigger (Cooper, 2020). In general, there would be a lack of concern about the environmental consequences of short product lifetimes (Cox et al., 2013).

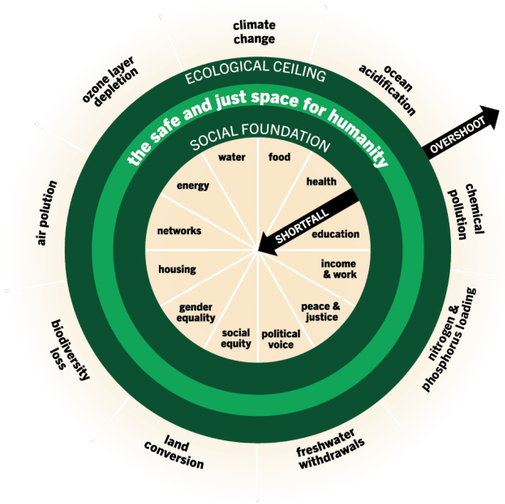


Figure 1.3. Raworth's model of the Doughnut Economy, which defines the boundaries of the 'safe and just space for humanity'. Image from University of Leeds, 2025).

This graduation thesis contributes to knowledge on product lifetime prolongation, and used a consumer behaviour approach to explore how a product's first life can be extended. The project thus exclusively focused on the period in which a first consumer purchases and disposes of it. The process of disposition, e.g. passing along, reselling, hoarding, or throwing away (Sarigöllü, Hou & Ertz, 2010), and the additional product lives are not considered in this project. Chapter 2 of this report entails a literature study on consumer product replacement behaviour, mental accounting and product lifetime expectations. This chapter ends with a model of the relations between these theoretical factors, and suggests potential design strategies to manipulate them. In chapter 3, design examples from practice are analysed that stimulate consumers' lifetime expectations and mental book value. Chapter 4 then synthesizes the information from those two analyses to clearly frame the design problem and define objectives and requirements to guide the design process. Chapter 5 then reports this design process, which was aimed at finding meaningful concept interventions intended to increase consumers' expectations of product lifetimes. Chapter 6 discusses the eventual design and intended effect of the intervention. After that, chapter 7 reports the design and results of an experiment, to test whether the intervention actually establishes that intended effect. The report than closes in the last three chapters, in which the results of the experiment are discussed, the project is concluded and reflected upon.

2. Literature study

The first step of this thesis was to study the present scientific literature that concerns consumer behaviour and decision-making. The aim of this study was to understand how and why consumers decide to discard and/or replace their currently owned products, and why this happens not just with products that have functionally or aesthetically deteriorated, but also with those that still function well. The so-called mental book value that a consumer attributes to the product in the mental accounting process, as well as the expectations that they have regarding its potential lifetime, are key concepts in this explorative phase. They play a central role in the eventual theoretical model that is presented at the end of this chapter. Based on this model, several implications were defined for what a product's design could do to influence the mental accounting process of consumers, and stimulate their lifetime expectations. In the end, this was intended to lead to more responsible consumer behaviour compared to the current situation.

The structure of this chapter is as follows. First, general replacement behaviour of consumers will be explored, after which the concept of psychological obsolescence will be addressed to understand premature replacement of products. Subsequently, mental accounting and the associated depreciating effect of satiation on mental book value will be discussed. This concept of satiation will then be related to psychological obsolescence, followed by an addition of psychological costs of scrapping to the established theory. After that, a relation between mental accounting and product lifetime expectations (specifically, the predicted and intended lifetime) will be theorized. From the resulting main theoretical model of this project, potential implications for product design will be derived, which formed a basis for the rest of the project.

2.1 Replacement behaviour of consumers

Consumers' attitudes towards product lifetime play an important role in their replacement behaviour. Magnier and Mugge found that consumers are becoming accustomed to shorter lifetimes, and that participants mentioned that "it is just time for a new one" as the main reason for replacement of smartphones, vacuum cleaners and TVs (Magnier & Mugge, 2022).

Consumers have various reasons for deciding whether to replace their currently owned product. As found by Van Nes and Cramer, their motivations for replacement include wear and tear, improved utility, improved expression and new desires (Van Nes & Cramer, 2005). Interestingly, when new desires arise in the consumer's mind, their current product may still be in perfect condition, only it does not sufficiently serve their needs and wants anymore. The perceived value of the current product has then dropped to a level where it is no longer relevant for the consumer. A promising contextualization for this phenomenon was created by Cox et al., who defined the 'nature' and the 'nurture' of a product (Cox et al., 2013). Nature refers to the functional durability of a product, based on its physical characteristics such as quality of materials, components and assembly methods, and the moment of breakdown due to degradation. Nurture, on the other hand, refers to the willingness of the consumer to keep the product before they decide to dispose of it, which is based on their perception of value of the product; figure 2.1 shows the factors that play a role in product nature and nurture, as suggested by Cox et al. (2013). Related to this, Oguchi et al. (2016) divided consumers' expectations of product lifetime into three types: predicted lifetime, intended lifetime and ideal lifetime. Predicted lifetime again refers to how long the product functions before it breaks down, though in this case as it is estimated by the consumer. Intended lifetime refers to how long the consumer expects to use the product before they will desire a replacement and dispose of the old one. And ideal lifetime refers to how long the consumer would actually want the product to last.

Nature and nurture can be considered to be related to predicted and intended lifetime, respectively. It should be noted that, when the nature of a product lasts longer than the consumer's nurture, the consumer may decide to replace the product when it still functions perfectly well; i.e., when it shows little to no signs of loss in performance. As an example of this case, the consumer may say something like: "I expect this product to last five years before it actually breaks down, but I expect to be bored with having it after three years, so I will probably discard and replace it by then." Considering the environmental consequences, this particular behaviour of consumers is very problematic, as it implies that more products (and thus, more raw materials and energy) are required to meet their demands. There is much potential in preventing replacement of products that still function as they should (Magnier & Mugge, 2022). Hence, this project will focus exclusively on finding solutions to prolong the lifetime of products that are in that particular condition.

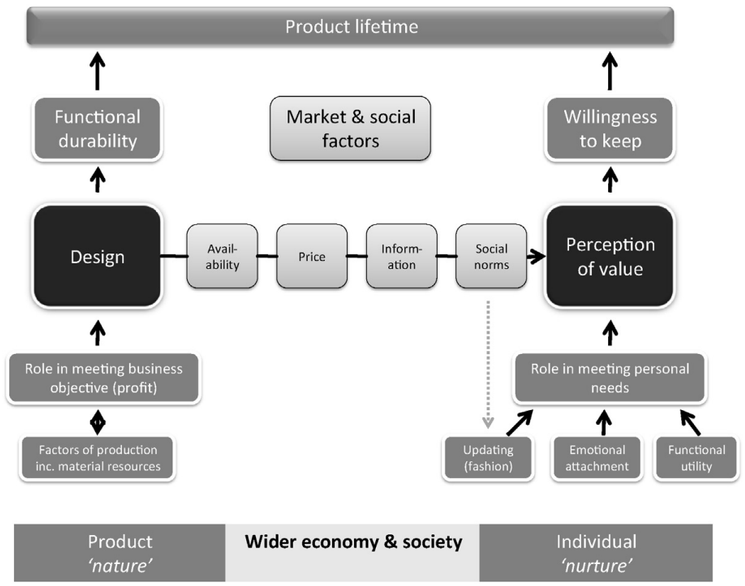


Figure 2.1. Product nature and nurture, and the relevant factors that play a role in the definition of these concepts (image from Cox et al., 2013).

2.2 Psychological obsolescence

A possible explanation for consumers to lose interest in their still well-functioning products can be found in a study by Spinney et al., who addressed the phenomenon of *psychological obsolescence* (Spinney et al., 2012). With their study, they argued that the destabilizing effect of technological development and the accompanying prospect of new functions and better performance of laptops was experienced by consumers as a reason to devaluate their currently owned laptops. Namely, being aware of new technological improvements was found to induce a feeling of frustration with the consumer's current laptop model, as its lacking performance and appearance would become more noticeable. Spinney et al. suggested that the activities of businesses to support the instable nature of product qualities can be seen as an important driver for psychological obsolescence.

The factors that stimulate psychological obsolescence were expanded by Park (2009), who defined both 'absolute' obsolescence as well as 'relative' obsolescence. Absolute obsolescence refers to when the product no longer physically functions as it should, e.g. due to wear and tear and material degradation. On the other hand, rapid technological developments and consumers' accordingly changing desires can be categorized as factors that contribute to the 'relative' obsolescence of the product. Socio-psychological factors such as status, self-identity and fashion would also contribute to relative obsolescence. Figure 2.2 captures the relations between the discussed factors, and how they together may define psychological obsolescence.

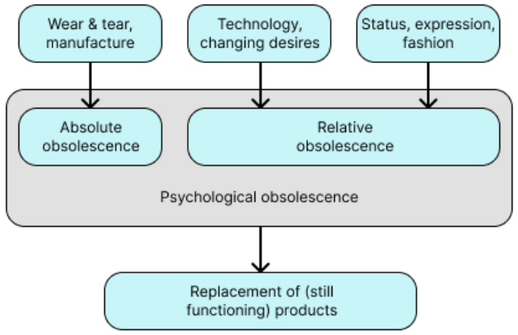


Figure 2.2. Factors that may contribute to psychological obsolescence of products, as suggested by Park (2009), which eventually leads to replacement of products (that may still function well). The role of technological development as discussed by Spinney et al. (2012) can be attributed to the relative obsolescence.

Online retailers such as Bol.com, Coolblue and Amazon play very well into psychological obsolescence and consumers' desires to replace their reusables, by emphasizing the frustration of outdated models and/or the convenience of ordering a new one (see figure 2.3). Additionally, clever advertising strategies for products in other industries are suggested to stimulate psychological obsolescence by highlighting the beauty of brand-new models (Bridgens et al., 2019). The desire generated by these aesthetics would be an important driver for premature replacement of the consumers' current product.

Figure 2.3. Advertisements of online retailers often emphasize the frustration of malfunctioning products (Coolblue), and how quickly their products are delivered (Bol.com) . They play well into consumers' desires to renew their owned reusables.

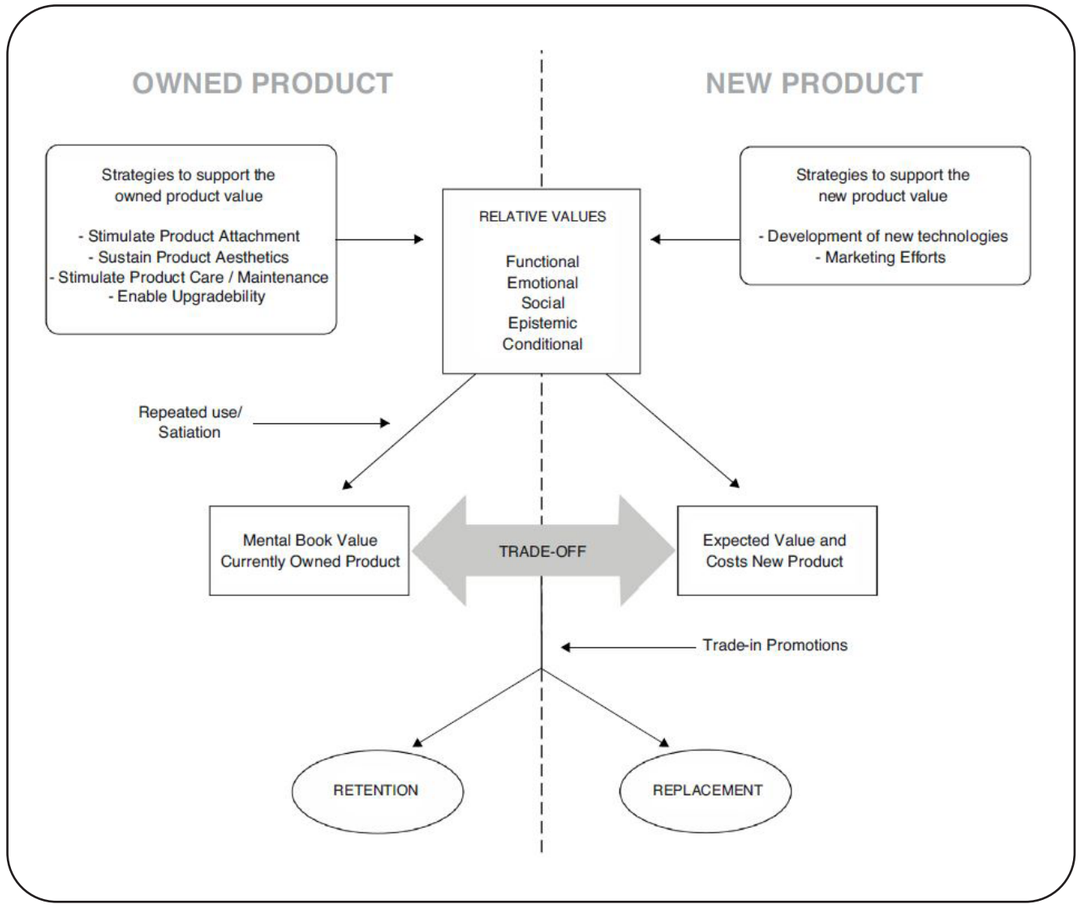


Figure 2.4. Model that theorizes the psychological process of consumers when deciding to replace their currently owned product with a new model (image from Van den Berge, Magnier & Mugge, 2021A)

The concept of psychological obsolescence suggests that a product can lose its initial value as it was perceived by the consumer, to a point where it becomes uninteresting. This process would thus drive the replacement behaviour of consumers. An overview of how consumers make replacement decisions, made by Van den Berge, Magnier and Mugge (2021A), shows the role that this value plays in the trade-off made by consumers when they evaluate the currently owned and the new product (see figure 2.4). This model suggests that the trade-off is in favour of the new product when its expected value, supported by new technologies, marketing efforts and trade-in promotions, outweighs the value of the currently owned product, referred to as mental book value. Their model also suggests that when this mental book value is still high enough, it would stimulate retention of the current product. Now, since the aim of this thesis is to find design solutions for longer use of products, it is thus very promising to explore how the concept of mental book value and mental accounting can contribute to this purpose.

2.3 Mental accounting and depreciation

The theory of mental accounting finds its purpose in the search for a descriptive explanation of certain consumer behaviour, as opposed to the established normative theories that explain how consumers should behave according to rationality (Thaler, 1980; Kahneman & Tversky, 1983). Thaler points out that consumers often do not devote extensive energy to making rational decisions, but instead they use rules-of-thumb and other heuristics to make their daily decisions (Thaler, 1980). Although some behavioural theories tend to depict consumers as rational decision-making machines, Thaler stresses the fact that they are not to be seen as experts. In this light, the theory of mental accounting may also best be seen as a conceptual auxiliary to explain certain behaviour, rather than as an active and conscious process executed by expert consumers.

Mental accounting theory suggests that consumers implicitly track the costs and benefits of a past purchase as entries in a specific account, instead of behaving rationally by consuming the benefits of this transaction as if they were free (Thaler, 1985; Prelec & Loewenstein, 1998; Okada, 2001). The entries in one account cannot be transferred to another, and as such, consumers do not behave according to normative models that suggest the fungibility of money. The purchase price is posted as a negative entry in the mental account, and benefits of use as positive entries. The resulting difference between these entries is the product's mental book value. Accordingly, Erat and Bhaskaran (2012) suggested that mental book value can be defined as:

$$MBV = p_0 - V \quad (1)$$

Here, p_0 is the initial purchase price and V the total amount of benefits from use. This equation implies that, as the amount of beneficial use experiences increase over time, the mental book value decreases. The relations between these factors of mental accounting, according to Okada's theory, is visualized in figure 2.5.

A consumer attributing a mental book value to a product that they have already paid for, could be compared to being in debt. In figure 2.6, the mental accounting process is visualized using this analogy. From the moment that, for example, a smartphone is purchased for €899, the consumer would have an imaginary debt of that amount (number [1] in the figure), which has to be paid off by experiencing beneficial moments of use with the device (number [2] in the figure). The theory was originally established to explore the possibilities for more frequent product replacement. Namely, if the producer of this

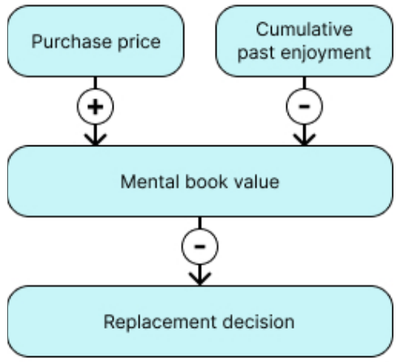


Figure 2.5. The relations of the relevant factors of mental accounting, according to Okada (2001).

particular smartphone wants to minimize its replacement cycle, they may want to learn how to let the consumer feel that their 'debt' is paid off as soon as possible. That moment of 'pay-off' is reached when the cumulative benefits (or V in equation 1) amount to €899, i.e. the initial purchase price p_0 of the smartphone. From this point of 'breakeven' onwards (Okada, 2001), the consumer may become receptive to alternatives, as they feel that they have used the device to such an extent that they have taken all the value out of it. In other words, it has then made its money worth, and the metaphorical debt is paid off (number [3] in the figure).

As long as the breakeven point has not yet been reached, replacement of the product would mean that the remaining book value must be written off. This may happen, for instance, when the product is suddenly lost or when it breaks down when it still has not made all its money worth. Write-off of remaining mental book value is suggested to induce a certain 'pain' equal to that value, which consumers have a natural tendency to avoid (Gourville & Soman, 1998). In the analogy, it means that the debt is never paid off completely, and it remains outstanding for ever (number [4] in the figure). This avoidance of pain could be attributed to the sunk cost effect, which suggests that consumers are more inclined to continue consumption when they invested money, time or effort in obtaining a product. In other words, people are loss averse (Okada, 2001), and thus may postpone their decision to replace their current product until all of its mental book value has been depreciated.

In contrast to using this theory for shortening product lifespans, it could actually be very promising for the prolongation of these lifespans to understand how mental accounting can sustain that feeling of 'being in debt', stimulate the loss aversion and thus to discourage premature replacement of the product.

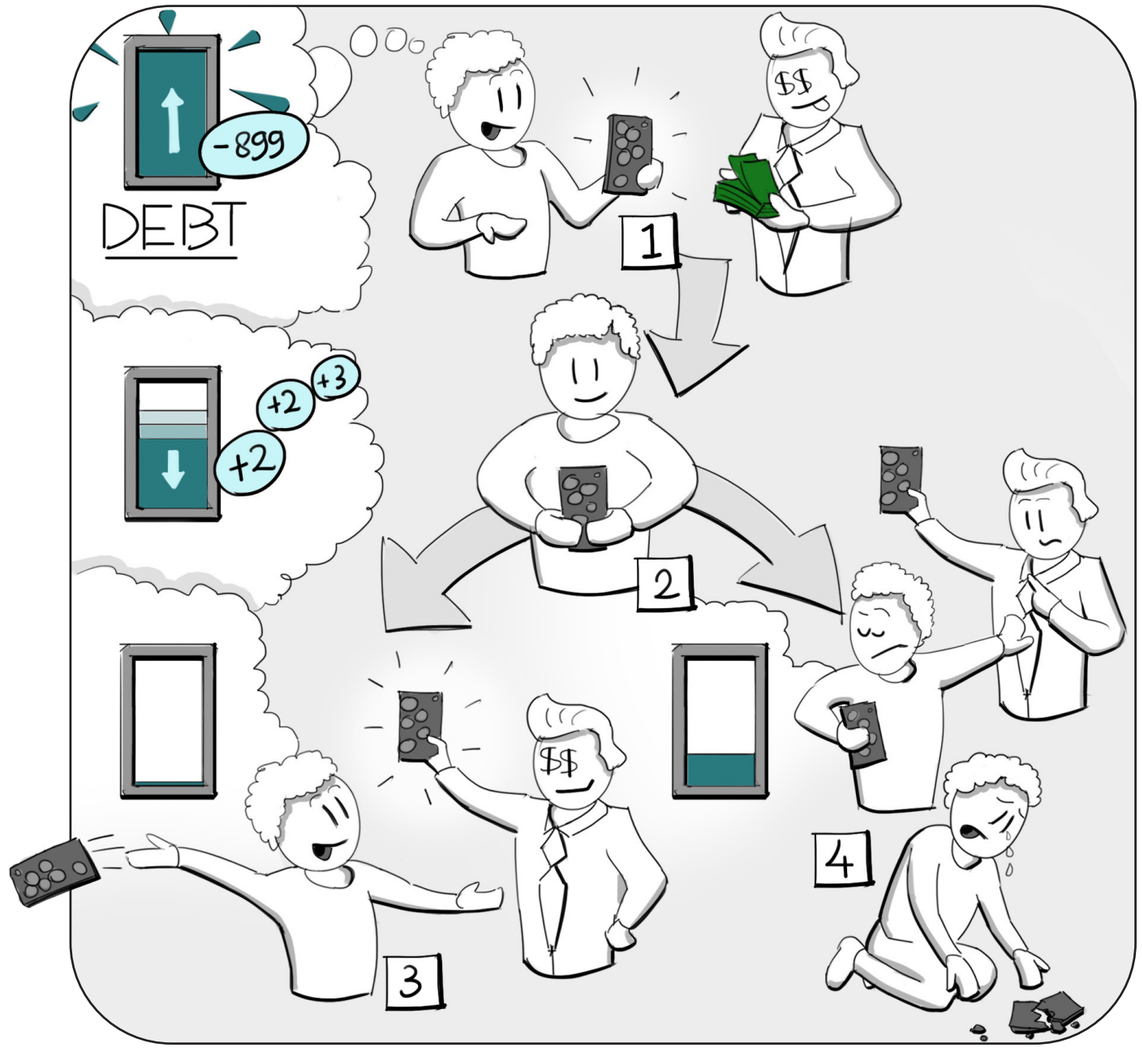


Figure 2.6. Simplified scenario of the process of mental accounting according to the theory. The analogy of being in debt serves for clarification. The debt starts when the consumer purchases a new product [1] and is paid off during use [2]. This process continues until the debt is paid off entirely, which is when replacement of the product feels easy to the consumer [3]. Before this moment, replacement of the product is avoided, and it hurts when it becomes necessary [4].

2.4 Satiation and psychological obsolescence

The mechanism that is suggested to explain the depreciation of mental book value due to past use experiences, is referred to by Hou, Sarigöllü and Jo as 'satiation' (Hou, Sarigöllü & Jo, 2020). Satiation captures how a consumer experiences less enjoyment from a product after repeated use, and becomes less interested in continued use of that product. The reason for satiation to occur may be found in the idea that people naturally tend to grow tolerant to the dopamine triggered by a new sensation and need something 'more' or 'new' to experience that same feeling again (Brendborg, 2024). Purchasing and owning a new product starts off as something new and exciting, but this feeling of 'newness' wears over time and the product becomes just another piece in the possessions of the consumer. Eventually, the product has become part of the 'status quo' of their cumulative wealth (Gourville & Soman, 1998), and the consumer has become satiated. Heath and Fennema (1996) supported how the value of a product's initial costs is depreciated by the consumer over time; the longer the product was in their possession, the less disappointed the participants responded to be by the thought of losing it.

Satiation is suggested to be an important cause for psychological obsolescence (Hou, Sarigöllü & Jo, 2020), and may be seen as a factor that stimulates depreciation of a product's mental book value (Van den Berge, Magnier & Mugge, 2021A), which happens internally in the consumer next to the external factors as discussed previously. The hypothesized relations between these factors are visualized as in figure 2.7.

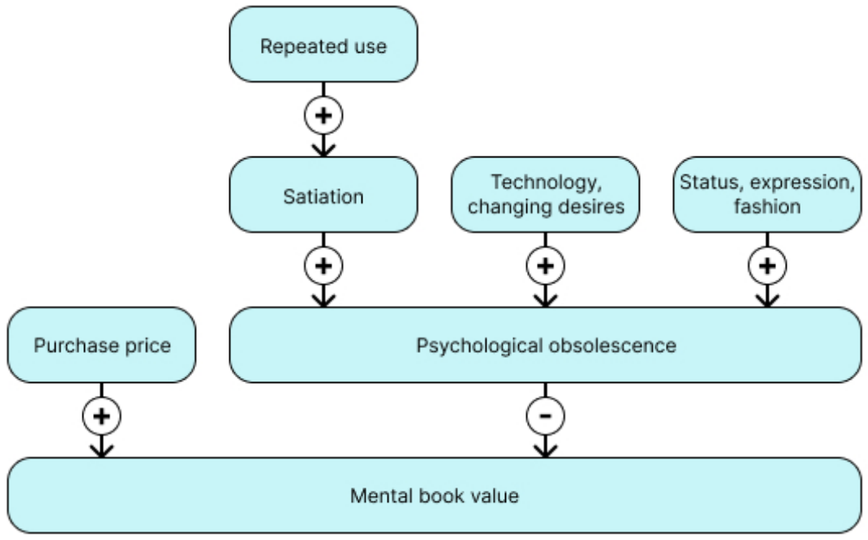


Figure 2.7. Hypothesized relations between satiation (Hou et al., 2020), psychological obsolescence (Park, 2009) and mental book value (Okada, 2001; Van den Berge et al, 2021A), as suggested by the theories about these concepts.

2.5 Psychological costs of scrapping

The definition of mental book value as given by equation (1) suggests that the only positive entry in the mental account comes from the initial purchase price of the product. However, a relevant contribution to this theory is made by Guiltinan, who argues that mental book value can also increase due to other costs that are made after the initial transaction of purchase (Guiltinan, 2010). In this case, these costs would increase the metaphorical debt that the consumer is in. Guiltinan defined three types of psychological costs, referred to as psychological costs of scrapping, which may increase the mental book value and be posted as additional positive entries in the mental account:

- Procedural costs, which are attributed to the effort of personalizing the product (for instance, with special parts built in to increase performance or identity expression) or making it compatible with other products;
- Financial costs, which, as mentioned in equation 1, comprise the extra monetary commitments made to keep the product clean and functional, but also for instance unexpired warranty coverage and prospective costs of disposal, and;
- Relational costs, which are felt when an emotional bond between the consumer and the product is broken during disposal, or when a certain loss of identity is experienced.

As Guiltinan suggests that these psychological costs increase the mental book value, I propose an addition to Okada's definition of mental book value as conceptualised in equation […], by also accounting

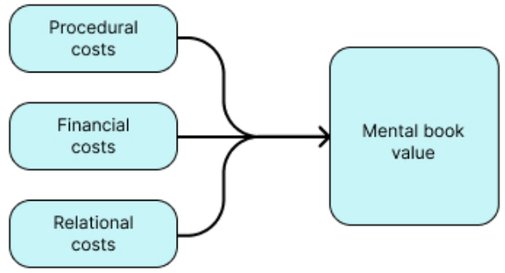


Figure 2.8. Influence of the three types of psychological costs of scrapping, as suggested by Guiltinan (2010).

for the psychological costs of scrapping the product. Mental book value would then be defined as:

$$MBV = p_0 + C - V \qquad (2)$$

In equation 2, p_0 is the initial purchase price, C is the total amount of costs during ownership, V is the total amount of benefits from use. With this addition of the extra costs, the equation accounts for extra activities that may give the consumer a sensation of 'extra value' of the product. The suggested relation between psychological costs and mental book value is visualized in figure 2.8.

A suggested hypothesis on all relations between the factors involved in mental accounting is visualized in figure 2.9. As can be seen there, the replacement decision can either be stimulated as a result of psychological obsolescence, which causes the mental book value to reach its breakeven point, or it can be inhibited as a result of psychological costs or remaining book value from the initial purchase price, which both cause loss aversion.

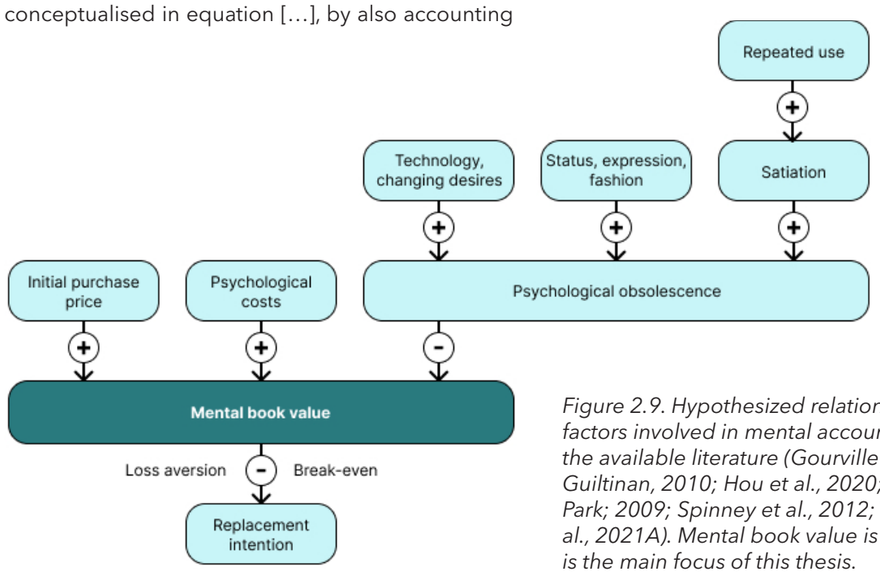


Figure 2.9. Hypothesized relations between the factors involved in mental accounting, based on the available literature (Gourville & Soman, 1998; Guiltinan, 2010; Hou et al., 2020; Okada, 2001; Park; 2009; Spinney et al., 2012; Van den Berge et al., 2021A). Mental book value is highlighted as this is the main focus of this thesis.

2.6 Mental book value and product lifetime expectation

As mentioned before, the theory of mental book value was originally established in the search for possibilities to promote product replacement. However, this thesis aims to find ways of supporting longer replacement cycles by influencing consumers' replacement behaviour. As part of this problem, the first sections of this chapter discussed consumers' increasingly lower expectations of the lifetime of new products, leading to premature replacement. In this light, a relevant next step is to explore the relation between mental book value and the expectation of the product's lifetime.

To the best of my knowledge, a direct relation between these two concepts has not been tested previously in other research. However, there does seem to be a connection between them. Central to this assumption is the notion that mental book value, despite not being explicitly calculated by the consumer, could have an influence on how long they intend to keep using the product, and therefore, how inclined they are to replace it. As suggested by Nishijima and Oguchi (2023), the probability that a product will be replaced decreases with the expected lifetime of the product. Okada's theory states that this probability of replacement decreases with the mental book value. This suggests that the lifetime expectation also plays a role in the mental accounting process. Here, it is interesting to take another look at the division between 'intended' and 'predicted' lifetime (Oguchi et al., 2016; see section 2.1 of this chapter for the different types of lifetime expectation).

To elaborate, when consumers purchase a durable product, they make an estimation of how long the product might physically last, based on the initial purchase price (Van den Berge, Magnier & Mugge, 2021A) as well as other factors that support their intuition, like the brand, salespeople, reviews from other consumers, recommendations from friends or family, and past experience (Van den Berge, Magnier & Mugge, 2021B). This expectation of the physical lifetime can be attributed to the 'predicted' lifetime or nature (Cox et al., 2013), and may positively influence the rate at which the mental book value is depreciated over the period of use; the point where they feel that the product has made its money worth (i.e. the breakeven point), would then depend on when they expect it to stop functioning properly. Predicted lifetime may then actually serve as a 'reference point' for the consumer to tend towards. Hence, I suggest that, apart from the factor 'initial purchase price' in the model from figure 2.9, predicted lifetime is also added here as a positive influence. Additionally, if the purchase price, as mentioned above, influences the predicted lifetime as well, there could be a mediating effect between purchase price, predicted lifetime and mental book value. Purchase price would then directly determine the mental book value, and influence it via the predicted lifetime of the product.

Thus, this thesis suggests that a product's predicted lifetime plays an important role at the moment of purchase. Now, after several years of use, when the product has elicited a certain amount of enjoyment, the consumer eventually reaches a point where they assess the remaining value of the product. They may start asking themselves whether the product has made its money worth – considering both the initial purchase price (Okada, 2001) and the costs made to maintain and/or personalise the product (Guiltinan, 2010) – and whether there is still more enjoyment to come, or if it is time for a new model. During this trade-off, the consumer may thus evaluate their intentions to keep using the current product, which could be linked to its 'intended' lifetime or nurture. Eventually, the trade-off would lead to the decision to either keep using the product, or replace it. In this light, the remaining mental book value of the product would influence its intended lifetime; hence, I suggest another addition to the model from figure 2.9, where a higher duration of the intended lifetime, as a result of the mental accounting process, results in a lower replacement intention.

Figure 2.10 shows these hypothesized relations between the mental book value and the predicted and intended lifetime. This figure serves as a synthesis of all the theory from this chapter, and also as the main theoretical model of this thesis. In short, the predicted lifetime is suggested as an initial reference point for the consumer, which would influence the mental book value from the moment of purchase, and the intended lifetime would then determine after repeated use whether the consumer has adjusted their behaviour to this default or not. Note that these two concepts together are suggested to form the product's 'lifetime expectation', with the 'ideal lifetime' excluded from the analysis (Oguchi et al., 2016). Also note that, different from the intermediate model in figure 2.9, the influence of the mental book value has now shifted from negative to positive, since intended lifetime was placed before the replacement intention. A higher mental book value would result in a lower replacement intention, but also in a higher intended lifetime. Next, the insights and suggestions from this theoretical model will be applied to make some first suggestions on what design can do to influence the consumer's lifetime expectations for products.

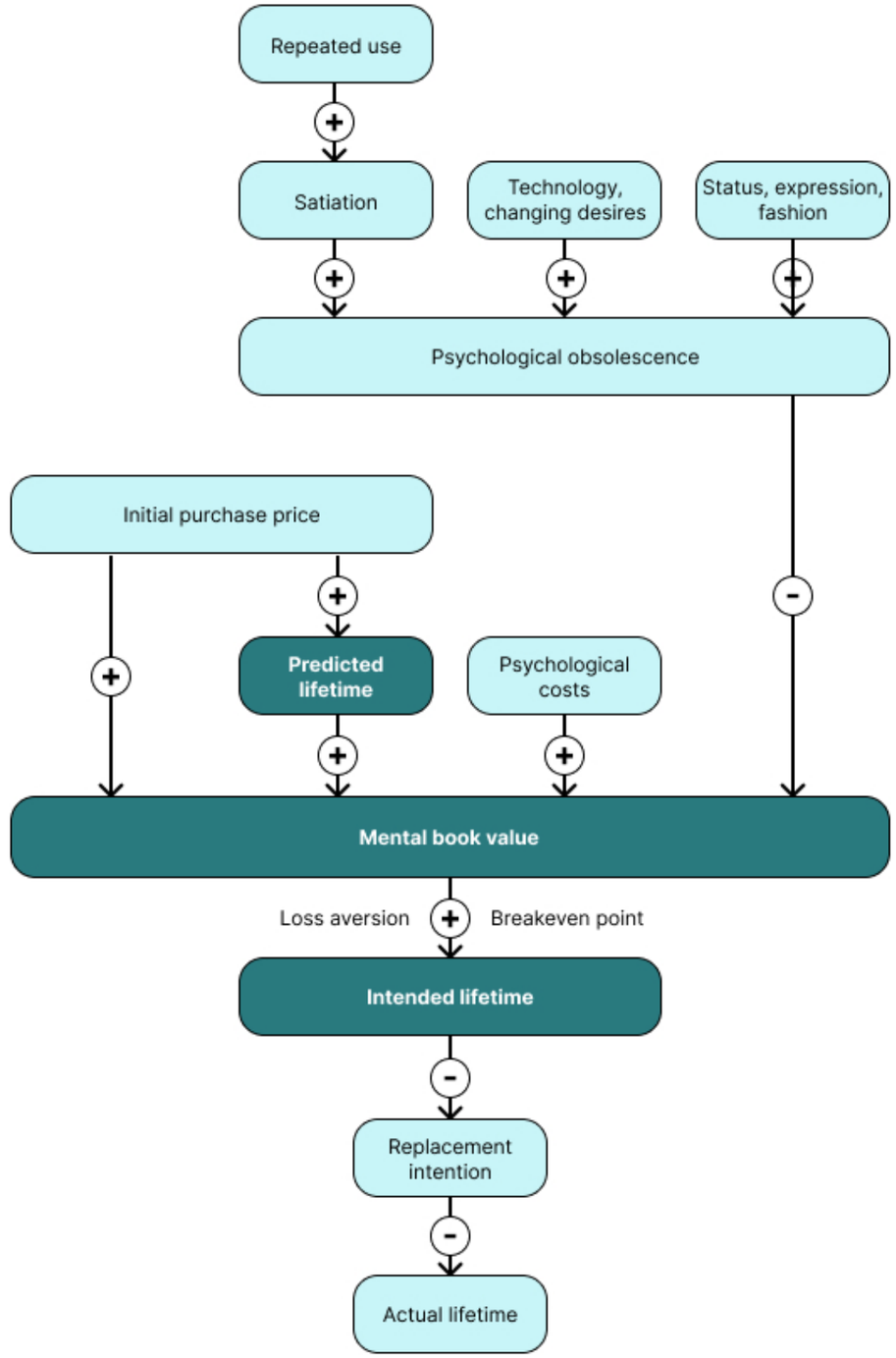


Figure 2.10. Synthesis of the processes that are suggested to play a role in consumer mental accounting and lifetime expectation of products, based on insights from the literature study. Mental book value and lifetime expectations are highlighted as they are the main focus of this thesis.

2.7 Suggestions for design

Product design may thus have an influence on both the initially predicted lifetime as well as the remaining intended lifetime, and it is interesting to explore solutions that could increase both. The different factors that play a role in the definition of mental book value, as it was suggested in equation 2, can provide a solid theoretical basis for what design can do to delay the breakeven point of the mental book value, and thus, increase the consumer's expectation of how long they will stay interested in using the product. Three approaches were defined to achieve this, which can be seen in figure 2.11.

First, designs that decrease the value of *V* would make sure that the benefits from repeated use contribute less to the (active) depreciation. This could be done by directly communicating at the time of purchase how long the product is built to last. This may cause an increase in the initially predicted lifetime, possibly making the consumer more critical about the extent to which repeated use contributes to the depreciation of mental book value. Although caution is important when providing numerical indications for product lifetime, as this may yield an opposing effect (Van den Berge, Magnier & Mugge, 2021B); a consumer may feel that the product has made its money worth once the indicated number of years is exceeded.

Second, designs that increase the value of *C*, i.e. the contingent procedural and relational costs, would amplify the feeling of loss aversion (the financial costs are not considered here as they have little to do with design). This would probably be most effective later in the product's life, as these costs are only made after a certain period of repeated use. For instance, when additional supportive products have been purchased and configured with the main product, or when the product has been maintained a couple of times.

And third, designs that increase the importance of the purchase price p_0, or an analogy that gives the consumer a more direct insight into how much of the product's initial 'value' (be it financial or something else) is left. This may work at any time during the product's life to remind the consumer of the remaining value of the product.

All three of these suggestions should contribute to keeping the mental book value up for a longer time period, as they (implicitly) convince the consumer that their product has not yet fully made its money worth, that 'there is more value to be gained', and that it is not time to replace it yet. This should result in the consumer expecting to keep using the product for a longer period of time than they normally would.

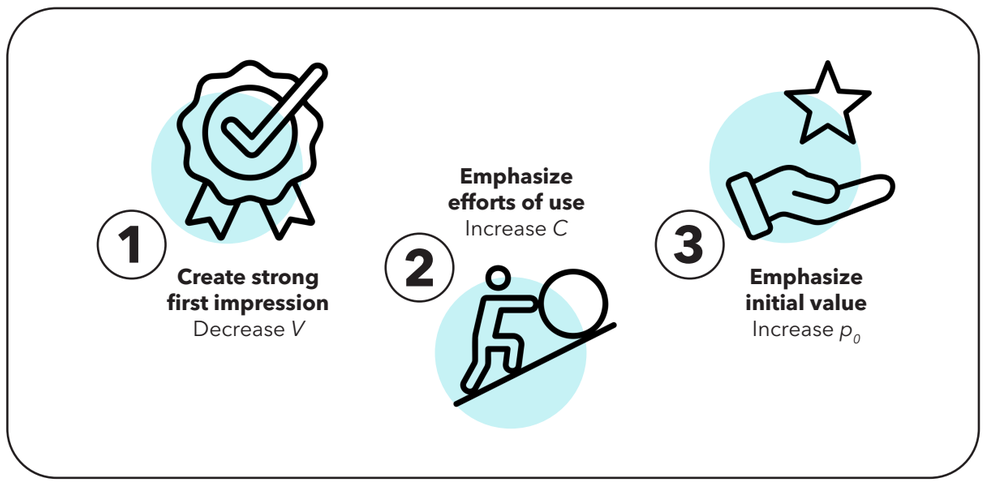


Figure 2.11. Overview of the potential strategies for design to retain a high mental book value for a longer period of time. These strategies were identified using the main theoretical model of this thesis.

2.8 Key takeaways from the literature study

No product possesses the properties to last for eternity, but the mental processes that seem to determine how long they *will* last if it was up to the consumer, suggest that there is still much room for improvement. Consumers are sensitive to the promises of more utilitarian and expressive benefits thanks to technological advances and convincing marketing strategies by companies. They tend to devaluate the products they own according to their changing desires. On top of that, they seem to have a natural tendency to develop a feeling of satiation with their products simply by being exposed to them over time, which may lead to a decreased willingness of consumers to keep using the same product even before it breaks down. This is all suggested to be a major cause for products being discarded and replaced while still functioning completely well, which contributes to a problematically large demand for new materials and deposition of harmful chemicals into the natural environment.

Fortunately, consumers' expectations of product lifetime may decrease the likeliness of this premature replacement. Suggesting a long potential product lifetime from the moment of purchase may already reduce the contribution of the benefits from repeated use (*V* from equation 2) to the depreciation of its mental book value, possibly causing the consumer to continue the use of their current product. A higher initial 'value' (either financially or otherwise; p_0 in equation 2) could have a similar effect. Additionally, the product could, throughout its lifetime, convince the consumer that it has not yet made its money worth, by emphasizing all the effort that was put into maintaining, configuring or personalizing it, or by strengthening the relational feelings of the consumer with the product (*C* from equation 2).

In short, the theories of mental accounting, satiation and product replacement behaviour have inspired the first promising strategies to influence consumers' product lifetime expectations.

3. Examples from practice

Beyond the theoretical studies that address product replacement behaviour and lifetime expectation of products, there are many examples of product developers that have used design either to inform consumers about the possible lifetime of their products, or to influence their replacement behaviour. This chapter will address the most relevant cases, which also served as inspiration for the design phase that came later in this project. First, examples of how consumers can be informed about product lifetime at the moment of purchase through product properties as well as marketing activities will be discussed. These strategies may have an in fluence on the depreciation of the mental book value, as they can support the consumer in forming an initial predicted lifetime for the product.
And second, design examples will be explored, that are aimed to encourage consumers to retain the product for longer when they already have it, thus implicitly influencing the consumer's intended product lifetime. The content of this particular overview of examples is based on design strategies for product lifetime prolongation that were identified by Van Nes and Cramer (2005), Schifferstein, Mugge and Hekkert (2004) and Van den Berge, Magnier & Mugge (2021A).

Eventually, the insights from this analysis, combined with the hypothesized strategies resulted from the literature study, served as inspiration for the design phase of this graduation thesis.

3.1 Lifetime cues

Companies have different media to inform consumers about the possible lifetime of their products. Some of these media can be applied to a range of product types, whilst others may only fit specific products. Each also has its advantages and its limitations regarding lifetime expectations of products.

3.1.1 Lifetime labels

A first example of a widely applicable medium is the LongTime label, an independent label that tells consumers the product they are looking at is designed to last (see figure 3.1). The purpose of the LongTime label is to encourage consumers to make better choices when purchasing goods, and to stimulate manufacturers to develop more sustainable products. Although the label does not give an absolute number of years that the product should last, it does make a clear statement about the superiority of the product's lifetime compared to products without the label. In this way, it may particularly stimulate the predicted lifetime of the consumer, thereby (be it implicitly) encouraging them to depreciate the mental book value more slowly during their time of ownership. A limitation to its effectiveness may be that this label makes a rather superficial statement about product lifetime; it does not inform the consumer on why the product would last longer.

Figure 3.1. The LongTime label, meant to inform consumers that they're about to buy a product that is designed to last (image from LongTime Label, 2024).

3.1.2 Warranties

Warranties are another example of explicit information on product lifetime. According to Stimmel Law, "A warranty is a legally binding commitment forming part of the sales contract which assures the buyer that the product or service is free from defects." (Stimmel Law, 2024). The fact that the warranty period refers to how long the product should function properly without defects, suggests that warranties can also inform consumers on how long the manufacturer expects the product to last. In this case, it provides them with an absolute number of years that the consumer can expect their product to work as it should. A problem with this might be that ending of the warranty period may herald that it is time for replacement. When the product still functions as it was meant to, the warranty would in this case stimulate premature replacement. Figure 3.2 shows an example of a brand that advertises its warranties.

Figure 3.2. Example of an advertisement to communicate the warranty period, which may provide consumers with a clue on how long the products are expected (by the manufacturer) to function properly (image from Kia Media, 2018).

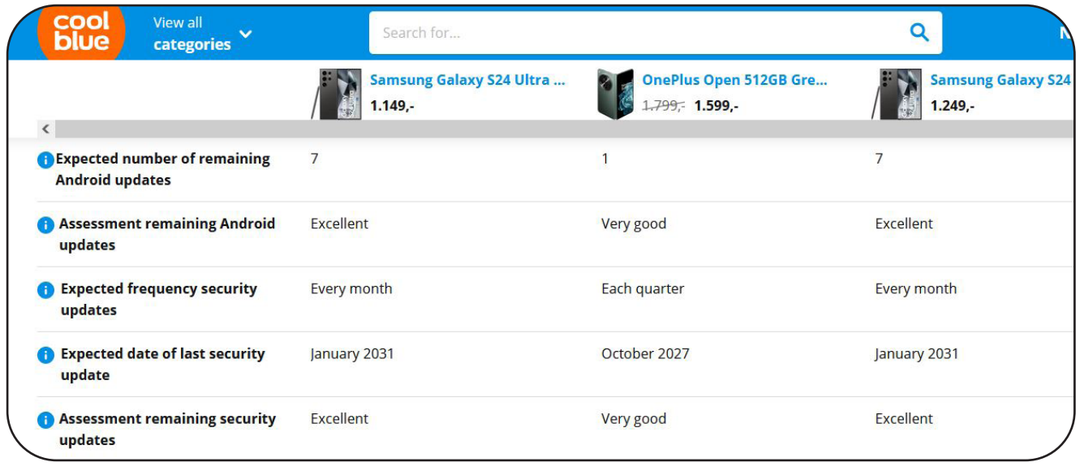


Figure 3.3. Coolblue allows online customers to compare electronic products based on how many OS and security updates are expected, which can be valuable information when they want to make a lifetime estimation (image from Coolblue, 2024).

3.1.3 Other lifetime cues

Examples of more subtle information about a product's lifetime may, first of all, include basic properties such as the used materials, build quality, weight and price. Estimating potential lifetime based on these properties can be hard for consumers (Van den Berge, Magnier & Mugge, 2021B), particularly when it concerns one specific, individual product. Nonetheless, these product properties may serve as useful cues when comparing different products before the purchase. For example, when two products are compared with one another, and one of them noticeably makes a rattling sound when it is shaken while the other is not, the consumer might instinctively conclude that the 'rattling' product probably has a poorer build quality compared to the product that didn't rattle. The same can be said for material; when comparing clothes, a T-shirt made of a material that feels thicker and sturdier than that of a comparable alternative, may be expected to last longer.

Specific to the case of electronic devices (e.g. smartphones, laptops or smart TVs), the predicted period of OS (Operating System) and security update support can be another indicator for the (functional) lifetime. Once the OS can no longer be updated or the security becomes outdated, most devices start to show a decline in performance and functionality. Online electronics retailer Coolblue allows for making comparisons based how long these update supports are expected to last (see figure 3.3).

Installing some type of meter that tracks historical data from use of the product can also provide valuable information about its lifetime, the most familiar one probably being the odometer of a car. This meter (see figure 3.4) shows how many kilometres the car has already driven, allowing the consumer to draw conclusions on the possible remaining kilometres that it will endure. It must be noted that this feature becomes more informative about the car's lifetime as the car's age increases. After all, the odometer is still at zero at the time of purchase, so the consumer would expectedly not take the presence of this feature into account when assessing their expectations of the car's lifetime at this point. When the car is bought second-hand, the odometer is already much more useful, the value on the meter potentially determining whether the car is bought or not. Besides, the odometer is often used to decide when it is time for periodic maintenance.

Figure 3.4. A car's odometer can be used to estimate how long the car may last (image from Wilmar Inc., 2023).

Another example of a meter that tracks use history is the battery capacity monitor of Apple's recent iPhone models, which provides insight into the remaining performance of the device's battery, starting from 100% and slowly dropping over the years (see figure 3.5). The water filter systems from Brita and the 3D printers from Ultimaker and Prusa (figure 3.6) have the same function, the former being compatible with an external meter that tracks how much water has gone through the filter, and the latter showing how much filament has been used and how long the printer has been running for a certain project. These last examples both give an indication of when the product (be it a water filter or a 3D printer) needs maintenance. Similar to the odometer example, these product features won't tell much about potential lifetime, although the fact these products have such a feature may convince consumers that the company cares about maintenance of their products. Although explicitly conveying this message might be more effective.

Figure 3.5. Apple's recent iPhone models indicate the maximum capacity of the battery, allowing the user to track its degradation (image from Proper Honest Tech, 2023).

3.1.4 Intermediate, critical conclusion

The examples from this first section may pose interesting strategies to stimulate consumers' expectations of the lifetime of certain products. Granted, not every example can be applied in various contexts, and not all may have an equally strong effect. It may be hard for consumers to estimate an absolute number of years that the product may last, based on the discussed indicators, but the information may support their intuition when making a lifetime prediction. Especially labels, warranties or quality-based product traits could influence the predicted and intended lifetime at an early stage in the product's life, particularly at the moment of purchase. Meters that track use history, on the other hand, may be more useful for planning maintenance or estimating where in its lifetime the product may be. All in all, the presence of these features in the product's design could have a small influence the depreciation of its mental book value, as consumers may attribute a higher predicted lifetime to the product.

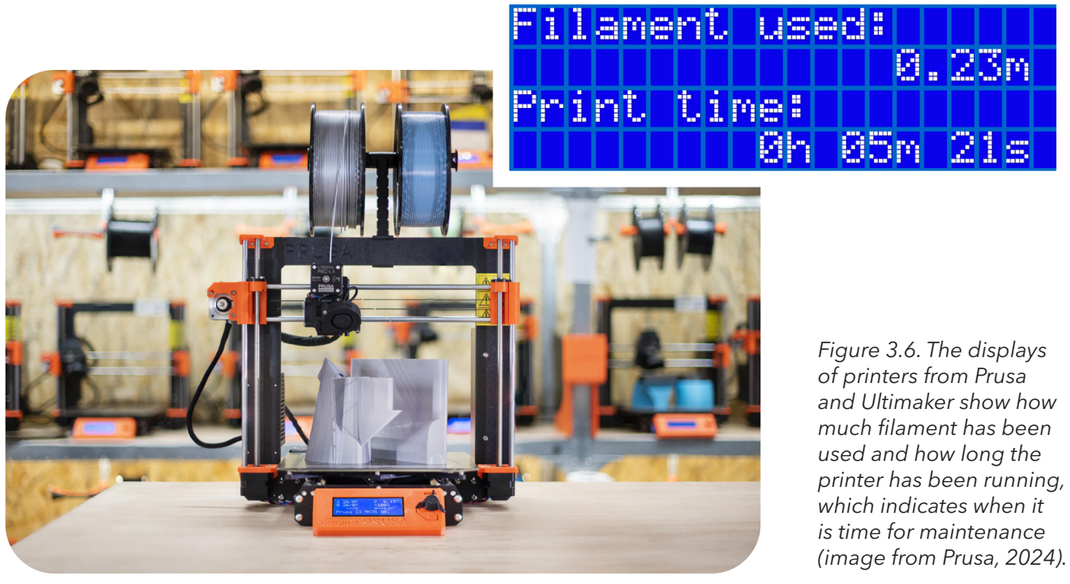


Figure 3.6. The displays of printers from Prusa and Ultimaker show how much filament has been used and how long the printer has been running, which indicates when it is time for maintenance (image from Prusa, 2024).

3.2 Examples in marketing

Apart from the design of the product itself, brands can also use marketing and communication techniques to inform consumers about the lifetime of their products at the moment of purchase. Some brands have put much effort into establishing a reputation of long-lasting, sustainable products.

A well-known example is Volvo, a brand that stands out for its high-quality, long-lasting cars. As visible in figure 3.7, they already proudly communicated this in 1980, focusing the story of their advertisements on the cars' seemingly "endless" life and the fact that they are ideal for passing on to others. Up until today, Volvo provides potential buyers with a concrete number of years that their cars could last (with the proper care) on their website (see figure 3.8).

Figure 3.7. Advertisement by Volvo from 1980, in which the company emphasizes the outstanding durability of their cars by showing concrete numbers of years of how long they can be used, and encouraging consumers to pass the cars along (image from The Drive, 2021).

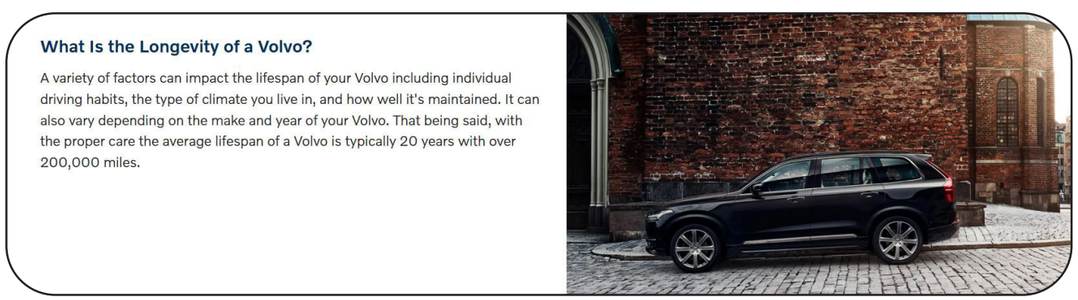


Figure 3.8. Today, Volvo still informs online customers about the average lifespan of their vehicles (image from Motorcars Volvo, 2024).

Another example of longevity-focused marketing is Miele, which is known for their long-lasting products and their corresponding branding strategies. Miele creatively compared the lifetime of their washing machines to the average 'lifetime' of marriages in one of their advertisements (figure 3.9). A higher price for Miele products can be explained by the fact that their products are expected to last longer. Toyota has adopted the long-lasting qualities of their vehicles into their advertisements in a different way, which is most compellingly visible in their communication around the Hilux pickup-model. Apart from it featuring in the famous TV show TopGear as an indestructable car, one advertisement emphasizes its durability by implying that it could withstand the apocalypse (see figure 3.10).

Figure 3.10. The Toyota Hilux would be such an indestructable pickup that it may even endure an apocalypse; or at least, "everyday life" (image from Nico Marchesi, 2018)

Duracell has been applying a different perspective for years; it has used the metaphor of rabbits racing against each other in many advertisements to communicate the superior performance and lifespan of their batteries. And LeCreuset, a brand known for their long-lasting cookware, states that their products can be used for an entire lifetime. See figures 3.11 and 3.12 on the next page for these examples.

A critical remark on these examples is that not all messages may be as consistently implemented in the overall strategies of the corresponding brands. The message from the Hilux-campaign was not as graphically communicated in adverts about Toyota's other models. And the idea of making a comparison with another context as Miele did in their marriage-advert was not used in ads about other products. Besides, some of these messages, especially the more overstated ones, may be prone to some scepsis among people that are less sensitive to these kinds of (exaggerated) messages. This scepsis could reduce the effectiveness of these efforts on consumers' lifetime expectations. For consumers that are in fact aware about durability and are sensitive to beneficial promises of brands regarding this topic, these examples may significantly influence how these consumers depreciate the product's mental book value throughout its first lifetime.

Figure 3.10. Advertisement about Miele's washing machines, aimed to convince consumers about their long lifespan (image from Ad Forum, 2017).

Figure 3.11. Duracell has used the analogy of two rabbits racing against each other in multiple generations of advertisements, implying that their batteries have a superior lifespan compared to typical examples (image from Zona C, 2020).

3.2.1 Intermediate, critical conclusion

The examples from this section illustrate how brands, either through a creative metaphor, a comparison to other products from the category, or through a concrete number of years, attempt to convince consumers about the longevity of their products. The proclaimed higher quality of the products might be an important reason for many of these brands to raise the prices of their offers, but the takes on product longevity also provide interesting insights for design; for instance, when the durability of a reusable is 'exaggerated' through its look and feel, its perceived quality, and thus, its predicted lifetime, may increase. Consumers that specifically look for durable reusables may be receptive to the messages from these examples, and prefer these products over those of competitors when making a purchase decision. They may be more critical when depreciating the mental book value of these products, compared to alternatives of which the longevity was not emphasized in an advertisement.

Of course, some consumers may be sceptical about the claims of certain brands, and prefer less superficial evidence as to why these particular products would last longer than similar offers. Design can support these preferences as well, for instance when the product informs its user about its condition or about contingent upcoming maintenance. All in all, these strategies for managing consumers' lifetime expectations can be an inspirational source for the design phase of this thesis.

Figure 3.12. Advertisement from Le Creuset about their durable kitchenware (image from Advert Gallery. 2017).

3.3 Design for emotional attachment

Once the product is purchased, the consumer may intend to use it for as long as it functions well, retain it beyond that point (and repair it), or replace it prematurely. In light of increasing consumers' intended lifetime, it is interesting to look at examples of design that encourages the consumer to keep using their products for as long as possible. One way to achieve this, is through emotional attachment, as referred to by Van Nes & Cramer (2005). Mind you, these examples do not directly tell the consumer something about the product's lifetime; instead, they may implicitly encourage them to keep using the product. They were thus considered mainly interesting for influencing the intended lifetime, rather than the predicted lifetime.

Figure 3.13. VanHulley makes unique-looking underwear, bags and household decoration from old clothes (image from VanHulley, 2024).

3.3.1 Uniqueness in product design

Consumers may become emotionally attached to a certain product when, for instance, it seems rare or unique to them, as this may result in a fear of losing their unique product and its (functional or expressive) benefits. Handcrafting products from reused materials can be an effective way to establish a unique appearance, which can strengthen the perceived emotional value for the consumer. VanHulley, Elvis & Kresse, FREITAG and LooptWorks make bags, clothing, home decoration and office appliances from waste materials such as old firehoses, discarded clothes and truck tarps (see figures 3.13 and 3.14 to view their products). The notion that something is handcrafted may further enhance a product's emotional value, which could result in an increase in its intended lifetime since it becomes harder for them to discard and/or replace the product. An example from the electronics market is Grado Labs, an American company that makes high-quality, handmade headphones (figure 3.15).

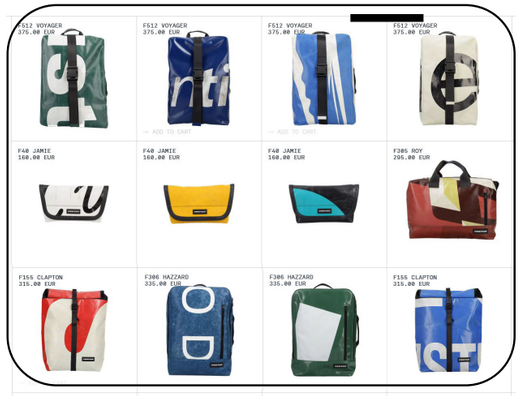


Figure 3.14. The backpacks from FREITAG are made from old truck tarps (image from FREITAG, 2024).

Figure 3.15. Grado Labs makes handcrafted, quality headphones that can give their user the feeling that they possess something unique and exclusive. (image from Grado Labs, 2024).

3.3.2 Personalization

Apart from the material or making process, personalization can also be a powerful strategy to enhance the uniqueness of a product. Dopper (figure 3.16) allows for customization of their famous water bottles, enabling consumers to buy one that truly expresses their personality; even though the shape of the bottles cannot be changed, the effort of making a personal print may already establish a more emotional value in the product. Additionally, it could increase the procedural costs of scrapping (see chapter 2 - Literature study), as the consumer has invested time and thought into configuring the product to their preferences. Regarding electronics, ColorWare (figure 3.17) is an interesting example of personalization, as they allow customers to pick their preferred colours for individual parts of several products from large tech-companies like Sony, Apple and Logitech. In the videogame industry, brands often release limited special-editions as well; Microsoft for example has made a lot of XBOX models with a special skin, in the theme of a newly released videogame (figure 3.18). The knowledge that there's only a few can make the consumer feel more attached to this device than to an ordinary model, and be less easily tempted to replace it.

Figure 3.17. ColorWare allows for customizable colours on several types of electronic products, like earpods, entertainment devices, computer mice and wireless speakers (image from ColorWare, 2024).

Figure 3.18. Microsoft often releases limited editions of their XBOX gaming console, which may cause consumers to attribute a higher value to these products. The idea that they possess something rare may increase the barriers for them to replace the console with a new one (image from Gazeta, 2023).

Figure 3.16. Dopper's online store has an interface that enables customers to personalize their water bottles with a name or graphic illustration, which together with their favourite colour may increase the emotional value of the bottle (images from Dopper, 2024).

3.3.3 Memories and graceful degradation

Emotional value of products may also be stimulated through memories of precious moments in the past (Schifferstein, Mugge & Hekkert, 2004). Throughout the lifetime of certain products, it may become harder to replace them as losing these products also means 'losing' the memories associated with the possession and/or use. A product that by design encourages the consumer to record a valuable moment may delay the replacement decision of the consumer. Examples of product categories that may collect memories over the years are cars, especially when they are used go to places where important and memorable events take place; leather clothing or furniture, which are prone to show physical marks of use over time, but this is considered to contribute to the character of the product; and pocketknives, which have the same potential as leather products to collect stories from historical adventures in the form of physical traces; see figures 3.19 and 3.20.

Figure 3.19. Cars are an example of products that may collect memories as the years of ownership by the consumer increase, as they can be used to go on holidays and experience precious moments (image from Reid, 2018).

Figure 3.20. Leather and metal have the properties to show marks of use over the years. This 'patina' is considered to give the product more character and could remind users of its past and the associated fond memories (images from Buy Leather Online Italy, 2024; and LeFort, 2024).

3.3.4 Intermediate, critical conclusion

Emotional attachment in design may be effective as a strategy to promote the intended lifetime of a product, but it may not significantly influence the predicted lifetime of a product. A consumer that possesses a product that is unique to them, for example when it is made with a special repurposed material, may intend to keep it for longer than they would with a product that is less special to them, but they may not expect this product to last significantly longer. Similarly, a personalized product or one with many associated memories may not be attributed a longer physical lifetime. Handcrafted products may be the strongest exception to this, as they are often sold for a higher price and are praised for their superior quality due to the maker's attention to detail. This higher price and expected quality may positively stimulate the predicted lifetime, and thus, the mental book value (see the main theoretical model in chapter 2 - Literature study).

Regarding the psychological costs of scrapping, it is plausible that emotional attachment would stimulate particularly the relational costs, since the stronger relational bond between the consumer and their product may pose an additional barrier against the product's devaluation. In that way, emotional attachment would have a positive effect on the mental book value, though this effect is assumably rather weak.

3.4 Design for timelessness

Another way to encourage consumers to keep using their products for as long as possible, is through a timeless design (Van den Berge, Magnier & Mugge, 2021A). Timelessness is an intriguing concept, as it says something about the sustained qualities of a product; they tend to be 'immune' to temporary fashion trends and technological advancements, and stay relevant for a longer time. There may be a certain subjectivity to the concept, but the Leica M-System cameras could be a good example. They were developed in 1954 and are beloved by photographers to this day for their minimalistic, utilitarian design, their durable and high-quality materials and their mechanical precision. The Porsche 911 and the Piaggio Vespa, with their relatively simple yet very precise and recognizable designs, are also considered by enthusiasts to possess timeless qualities. See figures 3.21 and 3.22 for these examples.

It should be noted that timelessness is not the easiest strategy to deliberately design for, neither to stimulate a longer use phase as intended by consumers. It is, after all, a rather contextually bound concept; a product may be considered 'timeless' only after a long period of time, when its proposition has proven to still hold personal, emotional or market value even after cultural changes, fashion trends or technological developments. Hence, some products may only be considered timeless after their first life, when they are bought second-hand.

Figure 3.21. The M-system cameras from Leica and the Vespa model from Scooter-manufacturer Piaggio can be considered to have a timeless design (images from Leica, 2024 and Bello Moto, 2024)

In light of the aim of this thesis, which is to explore how the mental book value of a product can be sustained throughout its first life, timeless design may thus be a challenging strategy to implement. Nonetheless, it could still play a valuable role within the main theoretical model; certain timeless elements of a product's design may convince the consumer that it will keep functioning properly for a significantly longer period of time, for instance when its minimalistic and precisely crafted appearance is associated with a robust build quality. This may then already support a higher predicted lifetime at an early stage of the product's first life. Besides, when a product is evaluated as beautiful to such an extent that the consumer barely loses interest in it, the depreciating effect of satiation on mental book value may be inhibited.

Figure 3.22. The first generation of the Porsche 911, of which the design is still considered beautiful and relevant today (Image from Porsche, 2023).

3.5 Design for upgradability and variability

Not all products benefit from emotional attachment or timelessness, as they may eventually become outdated due to the introduction of new technologies or aesthetics within their category. A camera can at its core have a beautiful and classic design, but at a certain point, the consumer may, for instance, desire new functions to make better photos. Van Nes & Cramer mentioned strategies to design for 'upgradability' and 'variability' to keep a product functionally or aesthetically relevant (Van Nes & Cramer, 2005). The notion that a product is upgradable or adaptable to cater for the consumer's dynamic needs may lead them to attribute a longer predicted lifetime to this product, and perhaps to intend a longer use period as well.

3.5.1 Upgradability

Upgradable products allow for replacement or addition of components to keep their functionality or appearance up-to-date. A general example is the modular gaming PCs, which are often built by consumers themselves to ensure optimal performance for playing videogames. They can find their preferred parts for the PC online and upgrade them when their desires have changed. Electronic products with a similar philosophy are the TMA-2 headphones from AIAIAI, which are designed for easy replacement of the speaker units, headbands, earpads and cables and for a personalized combination of components, and the laptops from Framework, which also alleviate the effort of upgrading essential components so that the laptop can keep up with new desires. See figures 3.23 and 3.24 for these examples.

Upgradability was suggested by Van Nes and Cramer (2005) to support a longer product life, however, no research that I know of has studied its effect on consumers' lifetime expectations. It is plausible that sustainability-minded consumers may show interest in an upgrade-based product concept as it supports product retainment behaviour, but the concept alone may not have much influence on the expectations of those that aren't already occupied by the topic of product lifetime.

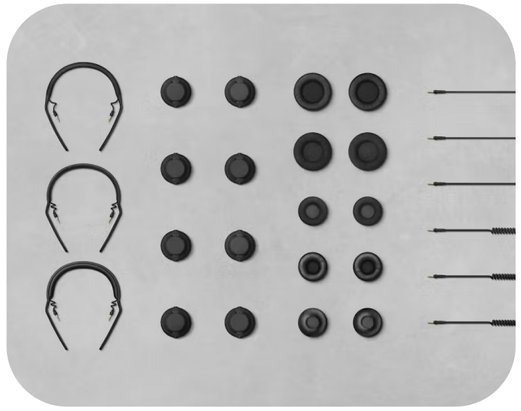


Figure 3.23. AIAIAI allows consumers to choose their preferred parts for their TMA-2 headphones model, which creates the possibility to not just repair but also upgrade the product during its lifetime (image from AIAIAI, 2024).

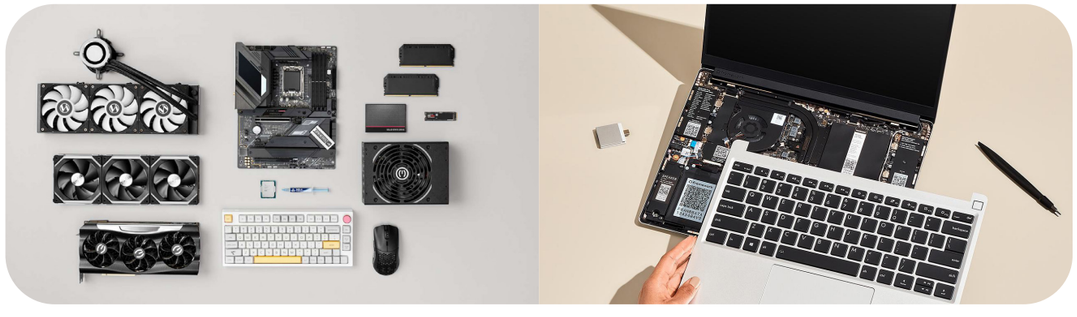


Figure 3.24. Gaming PCs (on the left) give consumers a lot of freedom in building and upgrading the product exactly to their liking. The laptops from Framework (on the right) have a somewhat similar approach, though the possibilities are limited to the parts of this brand exclusively (images from Intel, 2017 and Framework, 2024).

Figure 3.26. Mission Workshop (left) and Black Ember (right) make backpacks with a variety of modules to attach to. (images from Rushfaster, 2024 and The Radavist, 2016).

3.5.2 Variability

Products designed for variability have a somewhat overlapping approach to upgradable ones, as both cases require the possibility for removing and adding components (also referred to as modularity). The difference with variability is that the consumer can swap between different components to adapt the product to their current liking, whereas with upgradability the old components are generally discarded and won't be used again (that is, in their current state; ideally, they are returned for remanufacture or recycling of the materials). The previously-mentioned cameras (in this case, the category) are an obvious example of variability, as the diversity of lenses in particular allows the consumer to adapt the functionality of the camera to the kind of photo they want to make (see figure 3.25). For an up-close picture with much depth-of-field they pick a macro-lens, for a picture of an animal in the distance they pick a telephoto lens.

Figure 3.25. The large variety in lenses for cameras create much variability in the functionality of these products' functionality, depending on the desires of the consumer (image from Lightroom-Photoshop Tutorials, 2024).

Another example, more related to identity expression, is the protective covers for smartphones; having multiple covers with different colours or themes and switching between these every now and then may support the dynamic expressive desires of the consumer, as the appearance of the base product (the smartphone) becomes more variable. The effects of this particular example on the prevention of premature obsolescence may be limited as the primary reason for smartphones to become outdated may be technology- rather than aesthetics-related, but a simple solution such as changing the cover once in a while may encourage the consumer to appreciate their current device for longer than they would have with just one cover.

Products that were actually designed with the philosophy of variability in mind are for example the backpacks made by Mission Workshop and Black Ember, which make it easy to attach and detach different smaller modules for specific functions, like holding a water bottle. See figure 3.26 for these products. A tech-related example of this modularity in design is the Scottish brand RHA (figure 3.27 on the next page), which made earphones with swappable tuning filters for different sound experiences like 'treble', 'reference' and 'bass' (Biesemans, 2016). Being able to alter between a backpack's functionality or an earbud's sound may convince a consumer that their current product is not yet to be replaced. However, much like upgradability, variability may not significantly increase a consumer's predicted product lifetime, especially not when that consumer is not actively looking for products that exceed their expectations.

Figure 3.27. RHA made earbuds that can be combined with different 'tuning filters' (as pictured in the middle) for variety in the listening experience (image from RHA, 2024).

3.5.3 Intermediate, critical conclusion

The examples from this section illustrate how additional modules can contribute to sustaining a product's utilitarian or expressive relevance as the consumer's desires change. It must be noted that there are physical and technological limitations to strategies like upgradability and variability; as Van Nes and Cramer point out about televisions, "[…] it is physically not possible to embed the option to upgrade a tube model to an LCD screen" (Van Nes & Cramer, 2005). Efforts to increase intended product lifetime are therefore suggested to be focused on longer-lasting overall enjoyment, rather than satisfying momentary demands. Besides, similar to emotional value and timelessness, the implementation of upgradability and variability in design could serve more as a means to nudge consumers towards product retention behaviour, instead of stimulating their assessment of a product's lifetime.

3.6 Key takeaways from the examples from practice

Product lifetime has been a topic of increasing interest for companies in very diverse markets; the examples from the analysis in this chapter suggest how brands of clothing, electronics, household decoration, mobility, professional tools and travel items all make some effort that may extend the life of these products. They also illustrate how some of the strategies for product retention that emerged from the literature, can be applied in practice, such as design for emotional attachment, upgradability and variability (Van Nes & Cramer, 2005) or timelessness (Van den Berge, Magnier & Mugge, 2021A).

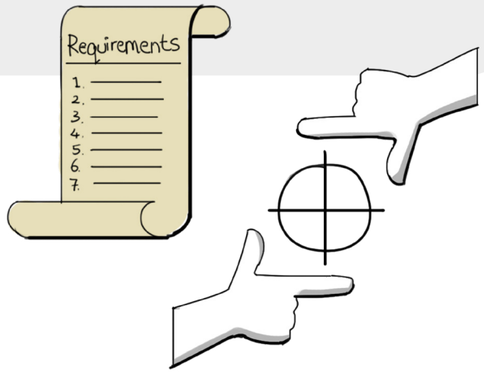
It is important to note that not every strategy is applicable to every product category, nor are they equally as effective in promoting responsible consumer behaviour. A photo camera that is aesthetically timeless may still become technologically outdated, and a backpack that is functionally upgradable may eventually be replaced due to aesthetic fashion trends. In addition, encouraging to change the colour of a smartphone's protective case may be a less effective way to increase its intended lifetime than, for example, directly emphasizing how durable its build is. The applicability and effectiveness of the strategies of these examples may also partly depend on the 'class' that the product belongs to (different product classes were defined by Cox et al. (2013) to make a distinction in consumers' considerations on the lifetime for different products; these classes will be explained in more detail in the next chapter).

Hence, the insights of these examples from practice should be used mainly as general inspiration for the design phase of this graduation thesis, and not as solid guidelines for the eventual intervention that will be tested in the experimental phase. The analysis has enabled a broad exploration of the existing strategies that focus on raising awareness among consumers about a product's lifetime, as well as what other qualities of design could implicitly increase consumers' intentions to retain their products. Since design for emotional value, timelessness, upgradability and variability operate on a more 'subconscious' level regarding product lifetime extension, they somewhat go beyond the scope of this project; predicted lifetime is assumably less strongly influenced by these strategies as compared to a lifetime label or a use history tracker. The relational costs of scrapping (*C* in equation 2 from the literature study) may actually be stimulated the most by these strategies.

It is therefore crucial for the quality of the outcome to frame the problem that will be tackled in the design phase, and to establish clear requirements for the intervention to meet. This problem framing will be discussed in the next chapter. In the subsequent design phase, the different strategies and principles from the examples from practice were also recalled to structure all the outcomes from the idea generation, and to evaluate which ones are the most promising for further concept development.

4. Framing the project

In this chapter, the scope of the graduation project will be discussed and defined. The project should eventually lead to an intervention that is relevant to the central problem, so to that end, this problem must be clear and suitable for a design process. The first section of this chapter will discuss the overall place of this project within the larger context of consumption, by looking at the different actors and their roles within the system. Then, the central problem is defined as a question that should be answered, starting with "How can I...". After that, the chosen type of products to design for was elaborated, followed by a characterization of the group of consumers that are targeted by the intervention. The chapter concludes by addressing the objectives and criteria with which the intervention must comply. The choices in this chapter are crucial for giving direction to the outcomes of the subsequent design phase.

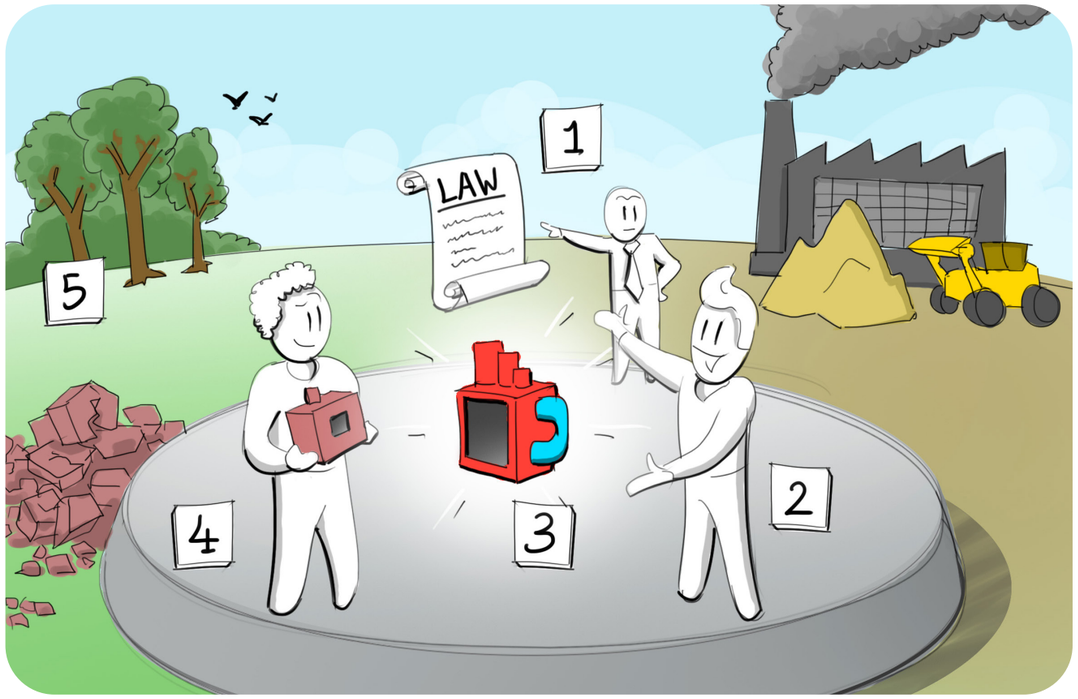


4.1 System of actors

From the existing literature it could be concluded that five important actors are involved in the question of product lifetime prolongation; as visualized in figure 4.1, these actors are (1) governments and policymakers, (2) manufacturers and brands, (3) the products, (4) the consumers, and (5) the natural environment. Together they are part of a system, in which the interrelations between the different parties are very relevant for product lifetime. Governments and policymakers define the laws and regulations for durability and repairability of products, and influence manufacturers' activities in product development and marketing (Scott, 2020; White et al., 2021). Manufacturers and brands decide how durable and repairable their products are, they define technology development cycles and promote their goods via marketing to consumers (Jensen et al., 2021; Bayus, 1988; see also chapter 3 - Examples from practice). The products of these manufacturers are bought and used by consumers, whose use behaviour is influenced by both the product's characteristics and functionality as well as their own internal psychological processes (see chapter 2 - Literature study). These four actors and their activities all exist within the natural environment, which is depleted for its finite resources (Anas et al., 2023; Kumar et al., 2024) and filled with waste as a result of these activities (Vishwakarma et al., 2023; Liu et al., 2023). Within this system, all actors have an influence on each other.

In order to reduce the harmful impact on the natural environment, efforts for product lifetime prolongation could probably most effectively be made in all above-mentioned interrelations, as a system change may be the most effective solution. Strategies that I found to address parts of this challenge make recommendations for functional product design (for instance, increasing battery life, improving build quality), marketing efforts or policies, but they seem to overlook underlying psychological processes of consumers that play a role in their consumption behaviour. To the best of my knowledge, studies that do consider consumer behaviour and product lifetime seem to have mainly attempted to explain certain phenomena, but lack on the implications for product design. Slowing down the trend of premature product replacement could result in a lower demand for the excavation of materials from the natural environment, as well as a reduction of the deposition of harmful chemicals. Cox et al. (2013) mentioned that an optimized product lifetime can be very effective "as a strategy to improve the resource efficiency and security of the economy and to contribute to global reductions in carbon dioxide and ecological footprints." It is thus very relevant for this thesis to find out what design can do to change consumer behaviour for product longevity.

Figure 4.1. *Visualization of the system of the most important actors that play a role in the context of excessive consumption. Counteracting efforts could be focused on the relations between these actors, e.g. between governments (1) and companies (2).*



4.2 Problem statement

Concluding from the main theoretical model and the examples from practice in the previous chapters, the most relevant question to ask was how the design of a product can convince the consumer at the moment of purchase to increase their expectations of how long the product would last, and how long they will use it before discarding it. Thus, the problem statement, as it is now for this project, reads:

Problem as Given (PaG)

How can I increase the consumer's lifetime expectations of the product?

This statement was phrased in the first person in order to enhance the feeling that it is 'my' problem (as a designer) to tackle. It was labelled 'Problem as Given' or PaG, as this allowed for further elaboration on the question by rephrasing it into a more inspirational 'Problem as Perceived' (or PaP) as a first step in the search for solutions (Heijne & Van der Meer, 2019). In other words, the question above is merely still a conclusion of the information-finding part of this thesis in the form of a problem statement, and will be subject to deeper analysis. The creative process will be explained in detail in the next chapter.

Apart from this one main question, it may also be supportive for the quality of the design process to ask some additional questions, based on the theories of mental accounting, satiation and product replacement behaviour. A list of these sub-questions read:

- How can I increase the consumer's predicted lifetime ('nature') for the product?
- How can I increase the consumer's intended lifetime ('nurture') for the product?
- How can I amplify procedural costs of scrapping?
- How can I amplify relational costs of scrapping?
- How can I prevent/decrease the feeling of satiation?

These additional questions also played a role in determining criteria for evaluating the most promising solution at the end of the design process (see section 'Objectives, requirements and wishes for the intervention'). Lastly, two relevant questions to ask for evaluation of the effectiveness of the intervention would be:

Does the change in lifetime expectation decrease the feeling that the product has made all its money worth? And does it delay the intention to replace it?

These questions played a role in determining criteria for the intervention as well, since the theoretic model (see the chapter 2 - Literature study) suggested that a low mental book value would result in the consumer feeling that the product has made its money worth, and in them intending to replace the product. An increase in lifetime expectations should thus result in a decrease in replacement intention.

4.3 Choice of type of product

The design and experimental phases of this thesis were focused around two types of products, as this would enable two conditions during the experiment, and a comparison between the two product types in terms of effectiveness of the intervention. These two product types are smartphones and headphones. The rationale behind this choice was based on:

- The theory of product nature and nurture from Cox et al. (2013);
- The environmental concerns associated with the production of these products;
- The relatively large gap between consumers' expectations of the lifetime of these products compared to the suggested actual situation;
- Their physical properties and typical interaction, and;
- The role they are required to play within the context of an online survey.

Cox et al. divided consumer products into three classes, namely 'up-to-date' products, 'workhorse' products and 'investments'. As the scope of this design project included only the scenario where products are replaced before they break down, in other words, the 'nurture' of products (see chapter 2 - Literature study), the most relevant product class would be the up-to-date products. Regarding this product class, Cox et al. argued: "Because these products were normally replaced before they broke, participants' 'nurturing' decisions took on far more significance for the lifetime of these products than the actual nature of the products themselves." (Cox et al., 2013).

Subsequently, since the context of this design project was based on the environmental and social problems of excessive mining of materials for electronic products (see chapter 1 - Introduction), non-electronic products from the up-to-date class (like clothing, footwear and household furnishings) would not be considered as far as the design phase was concerned. As suggested in the main theoretical model, consumers' expectations of a product's potential lifetime may have an influence on the depreciation of its mental book value, which would determine when they feel it has made their money worth and it is time for a replacement. On average, smartphones are estimated to last for about 2,5 years, according to Consumentenbond (2021), or about 3 years according to Echegaray (2015). Magnier and Mugge also showed an overview of the literature on this matter, suggesting that consumers' expected lifetimes of smartphones range between 2,8 and 5,2 years, whereas the actual lifetimes of these devices would range between 1,8 and 4 years (Magnier & Mugge, 2022). The overview can be seen in table 4.1. Interestingly, one of the studies suggested that expected and actual lifetimes of smartphones differed between 4 and 2 years, respectively (Frick et al., 2019). Another study suggested a difference between 2,7 and 5,2 years (Wieser et al., 2015). In both cases, the expectations appeared twice as high as the actual situation; this is problematic as consumers' expectations of the lifetime of electronic products are generally in decline, which could thus stimulate premature obsolescence and replacement of products that still function well (Magnier & Mugge, 2022; Gnanapragasam et al. 2017).

Now, regarding the environmental consequences and lifetime expectations of headphones, not much literature exists to the best of my knowledge. However, as another remark, it was assumed important that the product is at least a hand-held device that is used on a daily basis and is prone to impacts such as falling. Headphones were considered to be very fitting within this criterium, together with smartphones; both types of devices are often carried around by a consumer, in indoor environments as well as outdoors. Also, they are both the size of between 1 and 2 hands, and have enough 'surface' to design on; this is why for example washing machines and TVs (i.e. not handheld) and earbuds (too small to allow easily visible design changes) were not chosen. Smartphones and headphones are both used intensively and tend to be dropped several times throughout their lifetime, which stimulates satiation and premature replacement. Smartphones and headphones are thus considered ideal for this project.

Table 4.1. Adapted version of the overview by Magnier and Mugge (2022) of the most important findings regarding expected and actual lifetimes of smartphones.

	Frick et al., 2019	Wieser et al., 2015	Sabbaghi & Behdad, 2018	Wilson et al., 2017
Expected lifetime	4	5,2	2,8	-
Actual lifetime	2	2,7	-	1,8

And lastly, the design phase of this project should be followed by an experimental test phase with participants, who must be able to relate to the product. It was thus decided that it would be crucial for the participants to own at least one of the products that are central to the experiment. Since smartphones are currently the most widely owned and used electronic products that exist, it is assumed that participants of the upcoming test phase will all be able to relate to this type of product. Regarding headphones, this product type was assumed to be relatable for most participants as well, since the sampling method of the experimental phase was based for a large part on my own network of acquaintances, of which a major part consists of students and young adults. Consumers from this demographic are expected to own, apart from a smartphone, a pair of headphones as well. Hence, smartphones and headphones were decided to be suitable for inclusion in the design and experimental phases of this thesis.

4.4 Target group

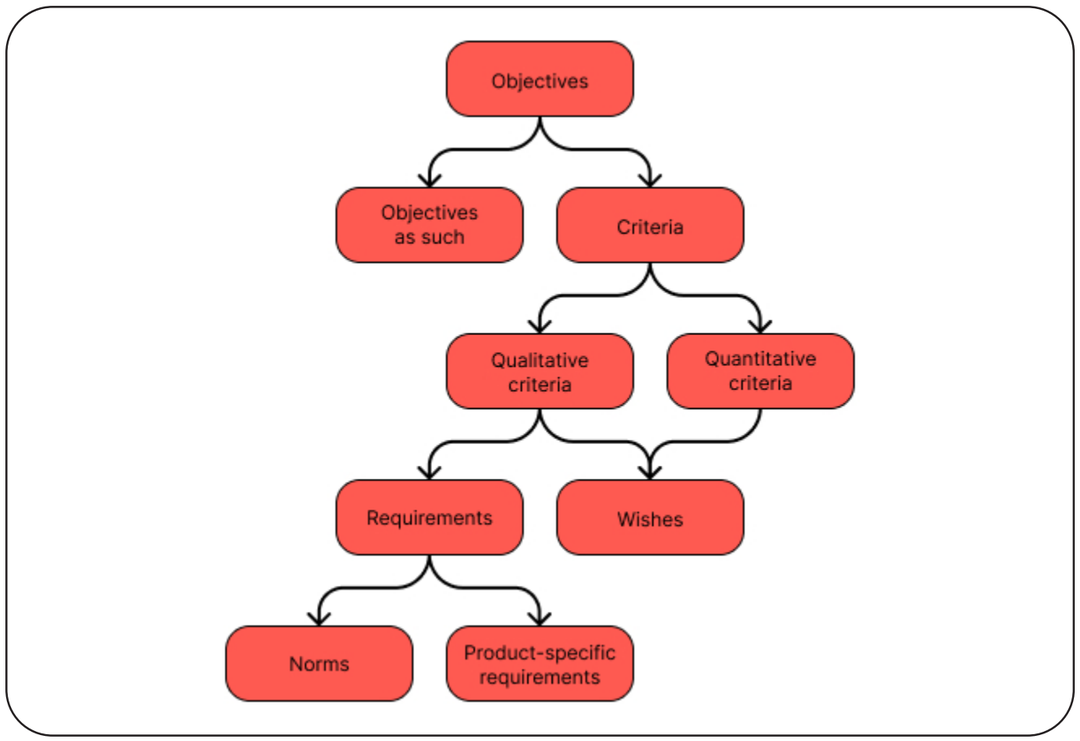
Even though the intervention that will eventually result from this project is not expected to be directly implemented into the design of actual products as it will exclusively remain a theoretically possible solution to overconsumption, it is still very relevant for the feasibility of the concept, as well as for further research within this topic, to define a target group to design for. Since the scope of this thesis only includes premature replacement of electronic products due to satiation from repeated use, the design intervention should be targeted to change the behaviour of those consumers that are most sensitive to that satiated feeling. People that are already frugal in the way they consume electronics may require less change to behave sustainably within this domain.
Hence, the target group for the design intervention would be those consumers that often replace their still-functioning electronics because they feel like it is time for a new one, or because they are curious

about the new features of the most recently introduced model. Additionally, consumers that are especially sensitive to convincing marketing or tempting trade-in promotions, as well as those that value the social benefits of possessing the latest generations of certain electronics, may also be part of the target group of the intervention. Guiltinan (2010) mentioned the concept of 'discount rate' as a characteristic to explain why some consumers tend to feel a certain urge to replace a product sooner than others. These consumers are suggested to be more impatient for waiting to buy and use a new product, thus the higher the discount rate, the shorter the replacement cycles would be. A consumer would have varying discount rates across different product categories, depending on how important that category is to them; consumers with a high discount rate for smartphones or […] may thus be relevant for the target group of this project. At least, the intervention is expected to be most effective for consumers that, for which ever reason, easily replace their still well-functioning electronic devices.

4.5 Objectives, requirements and wishes for the intervention

According to Roozenburg and Van Eekels, a design can only be considered an acceptable solution to a certain problem when it meets every requirement from a priorly established list (Roozenburg & Eekels, 2016). Within their definition, requirements are a form of qualitative criteria that say something about the objectives of the design. Qualitative means there is only a 'yes' or 'no' answer to whether the solution meets the criterium, whereas quantitative means there are various alternatives that meet the criterium to some extent. Wishes can be either qualitative or quantitative criteria. This specific type of criteria is used to evaluate the minimally acceptable solutions that were picked based on the requirements. The list of wishes then serves to find the best solution to the problem. See figure 4.2 below for an overview of these concepts and their relations.

Figure 4.2. Overview of the different types of objectives for a design project. This thesis defined 'objectives as such', as well as product-specific requirements and wishes to evaluate intermediate outcomes of the creative process. The image is a visually adapted version based on the overview from Roozenburg and Eekels (2016).



In the case of this graduation thesis, any objectives and criteria should refer to the design intervention for the experimental test, as this will be the final deliverable of the project. An 'objective' is defined by Roozenburg and Eekels as a projection of desired future conditions or situations and their associated values. Based on the problem statement as mentioned previously in this chapter, the main objectives of the design intervention of this thesis could thus be described as:

Main objectives of the intervention:

It should prolong the predicted and intented lifetime of the product, and it should be testable in the context of an online survey.

In order to make these main objectives workable for evaluating any design solutions, criteria for the intervention were defined in the form of a list of requirements and wishes. These requirements were based on (1) the insights from the literature study and the analysis of examples from practice, as well as (2) the characteristics of online survey research. The list of requirements and wishes can be found below.

The requirements from this list would be referred to after the idea finding phase of this project (see chapter 5 - Design process) to assess whether the design directions are minimally acceptable solutions to the problem; in case of a 'no', this design direction would be discontinued. The wishes would be used after the solution finding phase to evaluate which of the further developed solutions would be chosen for the eventual intervention, with W1-4 allowing for 'ranking' the most favourable design (quantitative criteria), and W5 again only allowing for a 'yes' or 'no' answer (qualitative criterium).

List of requirements and wishes for the intervention

Requirements

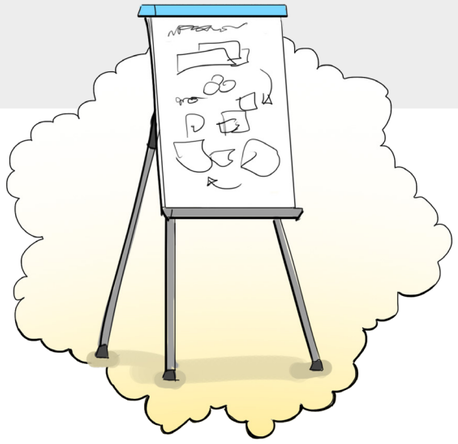
R1: The intervention must convince the consumer to consciously attribute a longer lifetime to the product than they normally would.
R2: The intervention must increase the consumer's desire to keep using the same product.
R3: The intervention must reduce the consumer's feeling of satiation due to repeated use of the product.
R4: The intervention must reduce the consumer's intention to replace the product.
R5: The intervention must elicit understanding by the consumer exclusively via visual, textual and/or auditive media.
R6: The intervention must emphasize either the procedural costs or the relational costs.
R7: The intervention must be applicable both at the moment of purchase as well as during the use phase of the product.
R8: The intervention must be applicable to both smartphones as well as headphones.
R9: The intervention must not stimulate premature replacement of the product.
R10: The intervention must be feasible within the current technological possibilities.
R11: The intervention must provide a positive addition to the product.

Wishes

W1 (based on R1): The intervention should convince the consumer to consciously attribute an as long as possible lifetime to the product.
W2 (based on R2): The intervention should increase as much as possible the consumer's desire to keep using the same product.
W3: The intervention's purpose and functionality should be as understandable as possible to the consumer.
W4: The intervention should reduce as much as possible the consumer's intention to dispose of the product.
W5: The intervention should reduce as much as possible the consumer's desire to buy a new model.
W6: The intervention should be profitable for contingent manufacturers of the product.

5. Design process

This chapter reports a design process intended to find creative solutions for the problem statement as defined in the previous chapter. This process resulted in one design intervention that was applicable to both smartphones and headphones, and could be tested in the context of an online survey. The chapter is structured as follows. First, the structure of the design process is explained, based on the methodology of iCPS. Next, the three parts that constructed the creative process, i.e. problem finding, idea finding and solution finding, are discussed and reported. The chapter closes with the choice of the most promising concept out of three alternatives, along with important considerations regarding the outcomes of the creative process.



5.1 Structure of the design process

The design process was based on elements from the principles of Integrated Creative Problem Solving (iCPS) defined at Delft University of Technology (Heijne & Van der Meer, 2019), which calls the creative part of an innovation project the phase of 'content finding'. During this phase, ideas are explored, clustered, evaluated and synthesized into workable solutions. Content finding is divided into three parts:

- Problem finding, in which the 'problem-as-given' (PaG, i.e. the starting question) of the creative process is deepened and redefined into the 'problem-as-perceived' (PaP) for optimal guidance in the next part;
- Idea finding, in which an abundance of possible solutions to the PaP is generated and evaluated for further elaboration;
- Solution finding, in which the most promising ideas from the previous part are improved and turned into feasible and detailed solutions.

Each of these three parts have their own three steps of 'diverging' (generating as many options as possible), 'reverging' (clustering all the options) and 'converging' (selecting the most promising clusters to proceed with). This entire process can be visualized as a so-called 'triple-diamond', as shown in figure 5.1. During this triple-diamond process, the requirements and wishes from chapter 4 played a key role in preceding from one diamond to the next, which can also be seen in figure 5.1.

Prior to the content finding phase, a project structured around iCPS theory typically requires another phase called 'information finding'. In this very first phase of creative projects, the context of the problem and its stakeholders or actors are explored and all these aspects are structured by mapping, visualizing or reporting them. For my graduation thesis, chapters 2 and 3 (Literature study and Examples from practice) were part of this information finding phase.

iCPS is mainly brought about for structuring creativity in group sessions. These sessions require a problem owner from an external company that wants to innovate a certain proposition, as well as a facilitator who leads the session, and a 'resource group' which executes the activities as planned by the facilitator. This thesis is mainly oriented around individual work, therefore, only some techniques from iCPS were used as an inspiration. The creative sessions were planned with external people as well, thus the techniques from iCPS were also applied here.

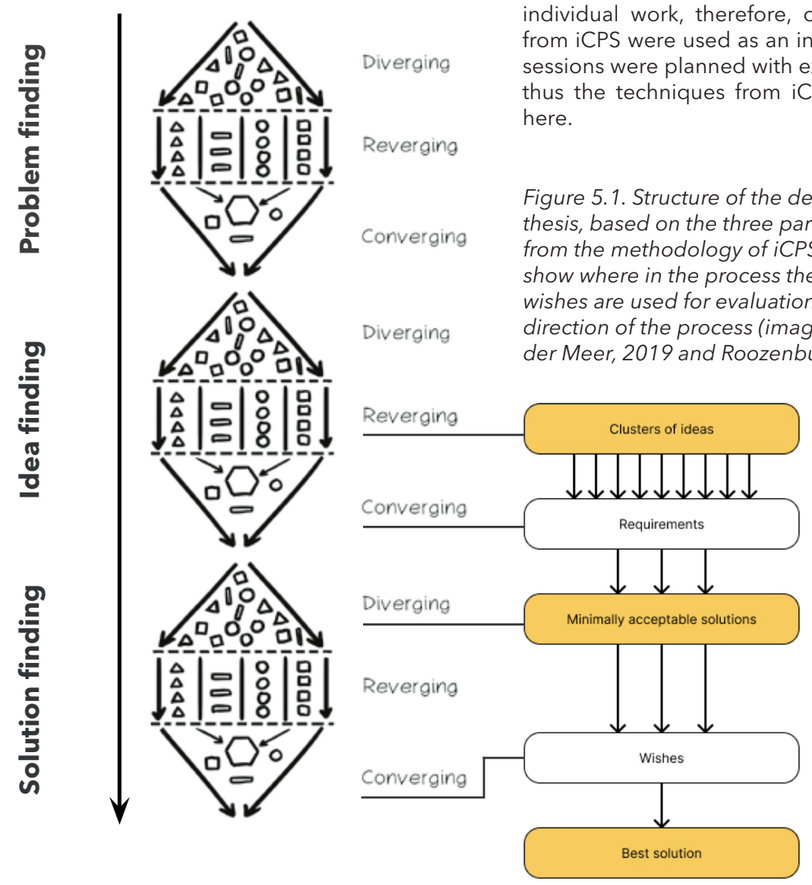


Figure 5.1. Structure of the design process of this thesis, based on the three parts of content finding from the methodology of iCPS. The blocks below show where in the process the requirements and wishes are used for evaluation. The arrow shows the direction of the process (images from Heijne & Van der Meer, 2019 and Roozenburg & Eekels, 2016).

5.2 Problem finding: rephrasing the problem statement

As a preparation for the creative 'idea finding' part of this project, the problem statement as it was derived from the theory had to be reformulated into a sentence that serves as an inspiring and exciting design guide. During this 'problem finding' part, which is the first of the triple-diamond project structure, the technique Ladder of Abstraction (LoA) was chosen for exploration of higher and lower levels of abstraction of the problem. For this technique, the PaG is typically placed in the middle of a sheet, and by questioning why and how ("Why would I want to solve this?", and "How would I solve this?"), different levels of abstraction are explored. Each answer is formulated as a "How to…" sentence. The purpose of LoA is to find the appropriate abstraction level at which to kickstart the idea finding phase, with a restated problem which is called the Problem as Perceived (PaP). In a group setting, as for which it is intended by the authors of iCPS, it also helps the entire team to get a feel for the problem they will be tackling. In the more individualistic setting of this project, it helped to explore the problem space in a less theoretical, more intuitive way.

Prior to the execution of the LoA technique, a short round of 'purging' was done. This exercise is typically practiced before any iCPS session to get any first ideas for the PaG out of the mind and onto the paper. The purge for the problem finding phase of this particular thesis was done by writing the PaG in the middle of a large sheet as the problem statement, and putting down all the first ideas that came to mind that may solve this problem. Once inspiration started to run out, this was the sign that all initial ideas were purged. Figure 5.2 shows the result of this process.

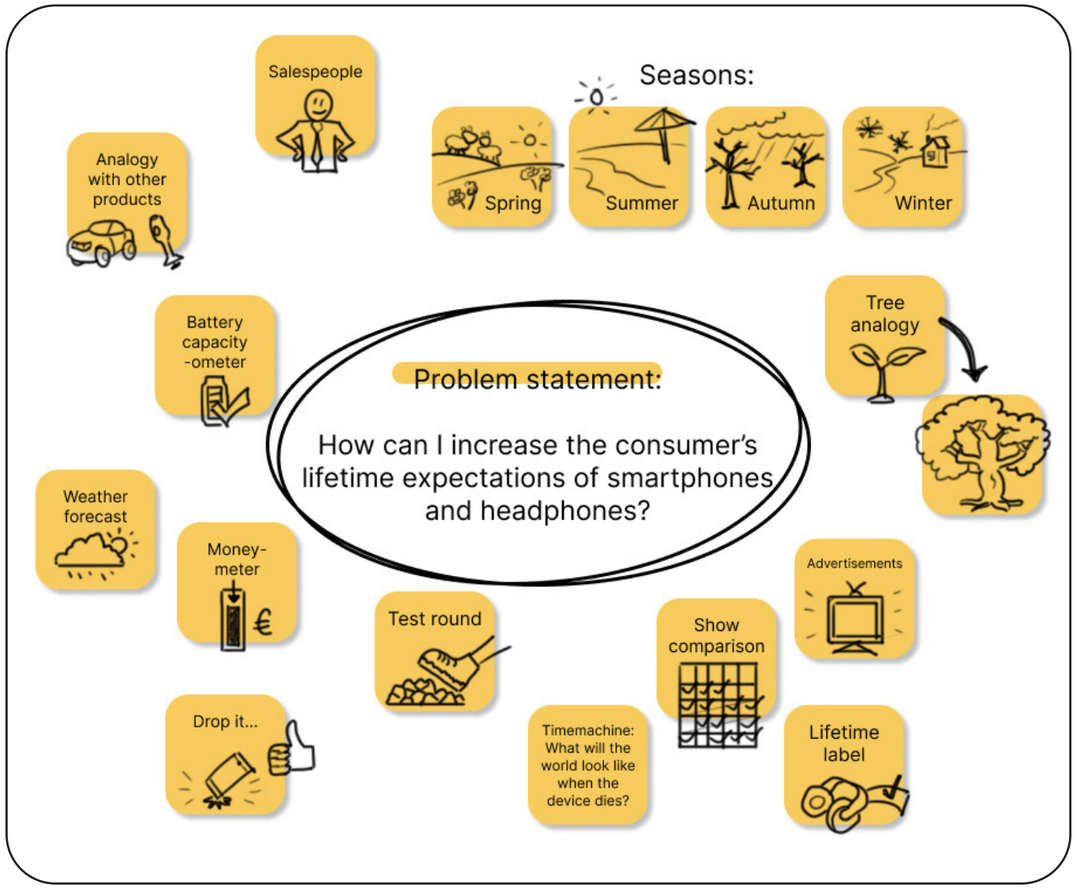


Figure 5.2. Purge of ideas for the initial problem statement (PaG).

Figure 5.3 shows the result of the LoA technique. The answers to the question Why? on the top half of the sheet provided more of a background to the problem statement, whereas the answers to How? provided more concrete solutions. These solutions not only helped to find the right abstraction level of the problem statement, but they also served as input for the later 'idea finding' phase of the design process.

From the LoA process was concluded that the question "How to make the consumer less inclined to prematurely replace the product?" provided the most interesting approach to the challenge. However, in order for a question to appropriately serve the role of PaP, the criteria of SPARK from iCPS must be applied (Heijne & Van der Meer, 2019). These criteria of SPARK read:

- Specific & sharp; the essence in one question, one concrete objective, to the point
- Positive; no denials, no criteria
- Ambitious; energizing, immersive
- Realistic; feasible, dedicated problem owner, importance acknowledged by the resource group
- Keep it simple; easy to understand, no abbreviations, no jargon

These criteria were used for this thesis as a reference to ensure that the PaP was inspiring and exciting enough to support a rich idea finding phase.

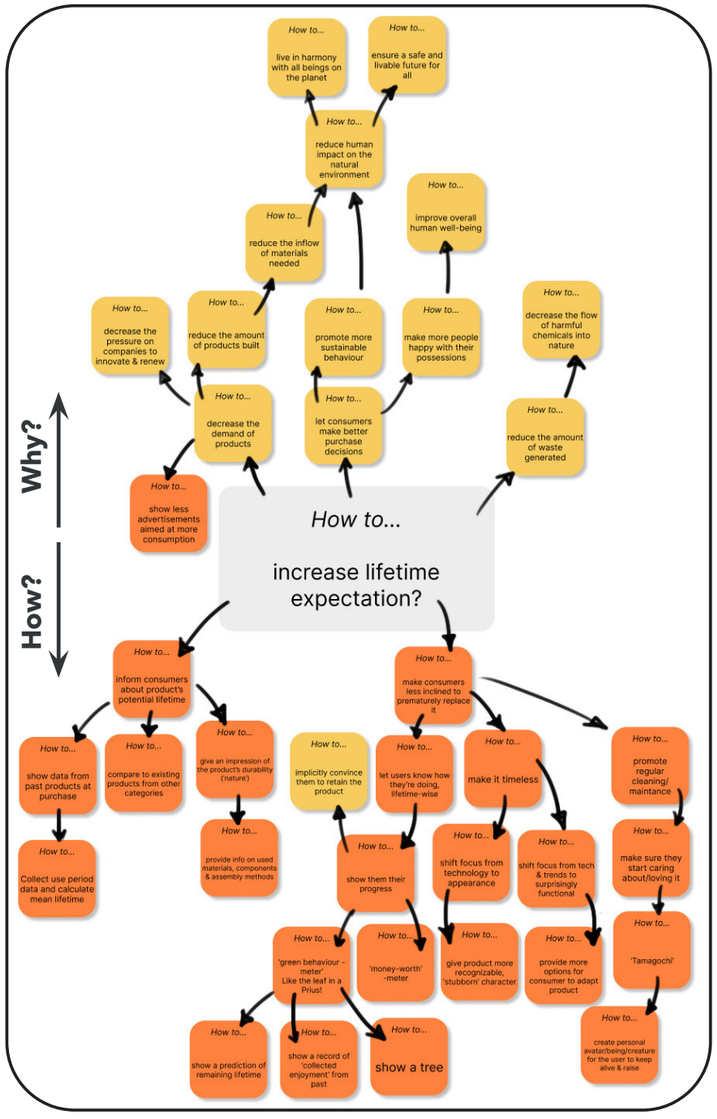


Figure 5.3. Results of the LoA technique from iCPS, in which the space of abstraction around the PaG is explored by asking "Why?" and "How?". Answers to Why? were put on yellow postits, and answers to How? on orange postits.

Judging from the SPARK criteria, the question picked from the LoA exercise appeared concrete and to the point, feasible, quite easy to understand with little real jargon. Additionally, in accordance with the qualities of a good problem statement from the Delft Design Guide (Van Boeijen et al., 2013), the question did make a point about the desired future situation rather than just the current situation (we desire that the consumer is less inclined to replace). However, as there was still a denial in the question ("less inclined") and it was not as energizing and immersive as it could be, it had to be restated to become more positive and ambitious.

The SPARK criteria served as a basis for the ideation of new, SPARKed problem statements. The outcomes of this process can be seen in figure 5.4. The resulted questions were placed in a grid, where they were judged on how specific and ambitious they would be. A too specific question gives an overly narrow direction to the rest of the design process, whereas a too general question lacks direction. A too ambitious question may set an unreachable goal for the rest of the design process, whereas a too dull question would expectedly not deliver interesting, inventive results. The most promising problem statement would thus be found in the middle of the upper right quadrant, where the (not too) specific and ambitious statements were placed.

As an additional, project-specific criterium, it was assessed whether the question-to-pick would address both the predicted as well as the intended lifetime, since I realized that the creative nature of the process caused me to somewhat deviate from these central concepts. The question from the grid that was considered specific and ambitious, and could make the consumer aware of the product's lifetime, was chosen to serve as the Problem as Perceived for this project. This question reads:

Problem as Perceived (PaP):

How can I surprise smartphone/headphones users about what their device (still) has in store?

The element of 'surprise' that this question aims at, was considered ambitious enough that it may lead to interesting, resourceful alternatives in the upcoming idea finding phase. It was also assumed to be specific enough to provide a clear direction for that phase, and since the question attempts to raise awareness (i.e. a feeling of surprise) among consumers regarding what the product 'still has in store', it would potentially address both the predicted and intended lifetime as well as the mental book value.

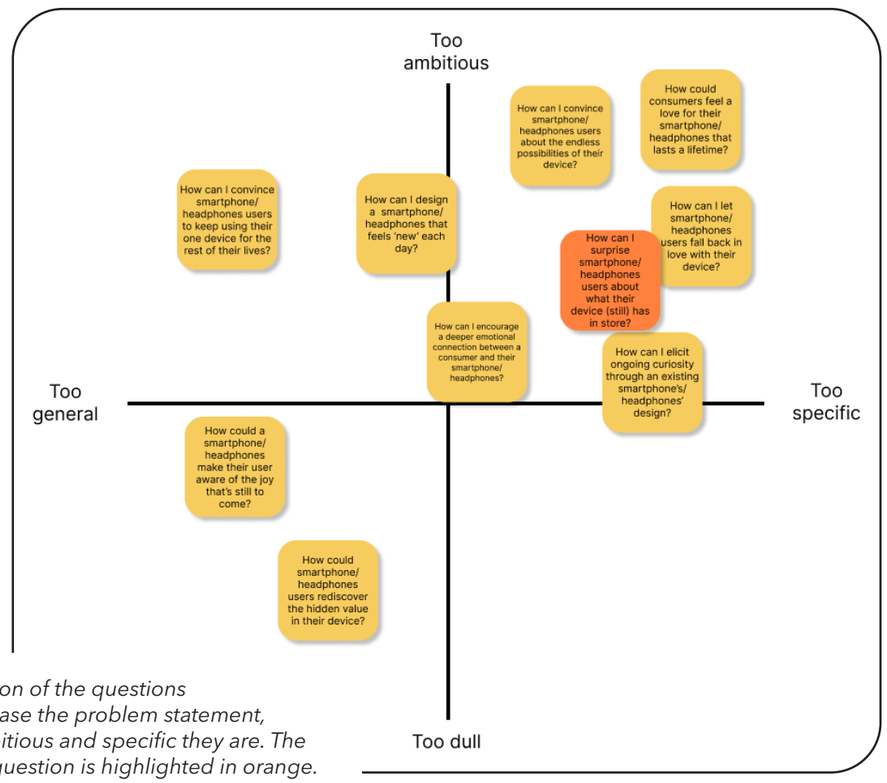


Figure 5.4. Evaluation of the questions generated to rephrase the problem statement, based on how ambitious and specific they are. The eventually picked question is highlighted in orange.

5.3 Idea finding: ideation phase

The next step of content finding was to generate a diverse set of ideas. This 'idea finding' part (Heijne & Van der Meer, 2019) was done partly in an individual setting, and partly in collaboration with other design students. Collaboration consisted of (1) a creative session, executed by me together with a MSc student of Integrated Product Design, and (2) a classroom exercise, executed by BSc students who are part of the minor-program 'Connected Creativity' led by Katrina Heijne. All people involved in these activities were part of the faculty of Industrial Design Engineering, Delft University of Technology. With inspiration from the collaborative activities, more ideas were generated individually. In total, about 118 ideas were generated during these activities, although some ideas were more detailed than others, and several ideas may overlap with or complemented each other to some extent. The complete collection of ideas was then clustered into 11 subsets with a specific theme. In this section, the structure and outcomes of the collaborative sessions, and the results of the clustering process will be discussed.

5.3.1 Diverging: structure of the creative session

The creative session with me and my fellow student consisted of several techniques from iCPS and the Delft Design Guide (Van Boeijen et al., 2013), that were planned to stimulate either our fluency or flexibility in ideation. Fluency refers to the quantity and frequency of generated ideas, flexibility refers to their variety. Eventually, the aim was to reach 'obvious' as well as 'beyond the obvious' ideas (Heijne & Van der Meer, 2019). The session in total took about 2,5 hours, after which I proceeded to generate more ideas with new inspiration from the session. The techniques from the session include:

- Flower Association (fluency); this technique was used to, again, purge some initial ideas that came to mind when looking at the PaP. This was especially helpful for my fellow student, as this was the first time for him to work on this project. For me it also posed a valuable way to write down some initial assumptions about the new problem statement.
- Brainwriting (fluency); this technique allowed us to generate more 'obvious' ideas based on four main themes that were identified from the Flower Association round.
- SCAMPER (flexibility); this technique helped us to build upon the existing ideas from the Brainwriting round and thus move beyond the mere obvious ideas, by thinking, for example, of how certain (parts of) ideas could be added, eliminated, or combined;

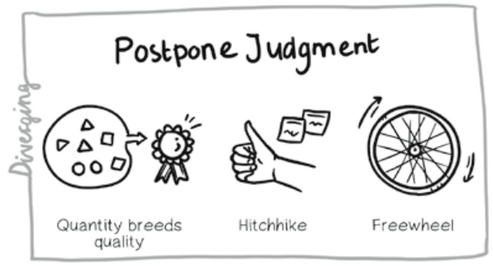


Figure 5.5. The divergent mindset (postpone judgment) and the three rules for diverging (image from Heijne & Van der Meer, 2019).

- MATEC (flexibility); this technique was used to stimulate even more creativity by exploring random associations with keywords from the problem statement, and force-fitting the resulting beyond-obvious ideas back to that statement.

Before the start of the session, the fellow student received a brief introduction on the problem, and the project's focus. He was also informed about the divergent mindset as defined by iCPS, which is to postpone judgment during the session, and the three ground rules for diverging (see figure 5.5).

The session was ended after the first round of MATEC, as my fellow student had to leave for another appointment. At this point, I executed another round of MATEC individually, and I also applied Direct Analogy, which is one of the excursions from iCPS, to generate more ideas inspired by analogies with similar problems in other contexts. A detailed explanation of the execution and results from both the session and the preceding individual activities can be found in Appendix A.2.

5.3.2 Diverging: structure of the classroom exercise

The classroom exercise was initiated by the teacher of the Connected Creativity minor, Katrina Heijne, who allowed me to introduce the problem statement to her students. They all developed one detailed idea as a solution to the question. At this point, the problem statement was still being redefined during the problem finding part, so the question that was posed to the students reads: "How can smartphone users fall back in love with their devices?". For the students, solving this question was part of the learning goal to become more comfortable and experienced in generating ideas within a short available time. The activity took 1 hour, preceded by a 15-minute presentation and Q&A by me. In total, 22 ideas were developed by the students, which were all used for inspiration in a further ideation activity that I executed individually. An overview of the students' ideas can be found in Appendix A.3.

5.3.3 Reverging: outcomes of the creative activities

A collection of the total amount of ideas generated during all the creative activities can be seen in figure 5.6. This complete set of ideas was clustered into 10 subsets using the Spontaneous Clustering technique from iCPS, which can also be seen in the figure.

The clustering was done by searching for certain connections between the ideas regarding functionality, strategy, or overall 'philosophy' behind the idea. As a result, each cluster of ideas is based on a certain theme, and was given an imaginative and inspiring ('catchy') title (Heijne & Van der Meer, 2019). The clusters can be explained as follows:

- *The power of stories*; these ideas use some kind of analogy, metaphor or story-telling strategy to give the consumer an implicit indication of the lifetime of the product

- *"ME"-edition*; these ideas stimulate the consumer's intended lifetime by using a form of uniqueness or personalization, which should convince them that the device is meant to be kept

- *Information rules!*; these ideas explore how information about a product's lifetime or durability can be directly conveyed

- *My 'human' friend*; these ideas use the prospect of a future friendship with the device to increase the relational costs of scrapping, and convince the consumer to plan for a longer use period

- *Frugal and proud*; these ideas use a form of encouragement or celebration to stimulate product retention behaviour, by rewarding consumers that use their phone for a longer time (than their peers)

- *Exciting stuff!;* these ideas use curiosity and adventure to spark a new feeling of excitement for the device, which should reduce the feeling of satiation

- *Trip down memory lane*; these ideas play into the procedural costs of scrapping and the strategy of designing for memories in products, by reminding the consumer of the history and effort that their device comprises, and what a shame it would be to lose all of that

- *A brand-new Edgar suit*; these ideas similarly attempt to tackle satiation, by exploring possibilities to make the device feel as though it was a new model, with a new functionality, technical performance or an aesthetic upgrade or maintenance

- *In the name of love*; similar to the more platonically-oriented cluster "My 'human' friend", these ideas take the relational costs of scrapping even further by using romance to convince the consumer that the device is here to stay

- *Everything has its price*; these ideas use certain strategies in pricing, sales, marketing or business models to promote longer product use (although this domain of solutions may be out of scope for this project, they were still included for the sake of making an overview)

As a general conclusion of this creative exploration, most of the outcomes seem to suggest that the smartphone or headphones should emphasize a certain growth of the device, for example in the form of a friendship or romantic relationship, a collection of memories or rewards, or a functional or aesthetic transformation. However, an important remark is that the intervention is essentially aimed to prolong the expectation of the consumer about the device's lifetime, and that this evaluation must be made consciously by the consumer. This was also priorly established in the list of requirements (see chapter 4 - Framing the project). Thus, if growth would be an important aspect of the intervention, it should at least refer to the future, and not just to the past (although the past can be used to say something about the future), as this could most effectively stimulate the consumer to consciously think about their intentions to keep using the product. As a next, converging step of the idea finding phase, the resulted clusters of ideas were evaluated for further development on the basis of the list of requirements.

5. Design process - Idea finding

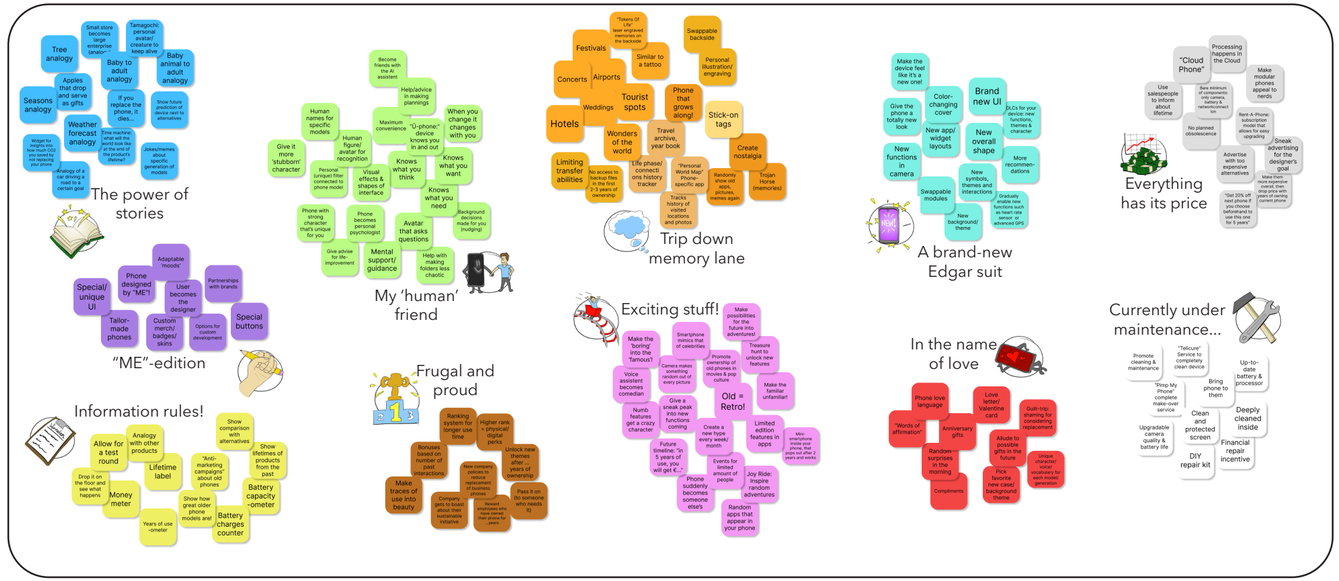


Figure 5.6. Clusters of ideas, based on what overarching themes and connections could be identified between them. Each cluster is provided with a catchy title to give them a clear and distinctive place in the overall set.

5.3.4 Converging: evaluation of the clustered ideas

Table 5.1 on this page shows the evaluation of the different clusters of ideas, based on the list of requirements with which the intervention should eventually comply. It must be noted that the requirements make statements about the final intervention, and that the clusters at this point were not to this extent an elaborate solution. Hence, each clusters was evaluated with regard to whether an elaborated solution based on its main idea *could* comply with all the requirements. In case that the cluster inherently expectedly could not comply with one or more requirements, because of certain crucial aspects that define the cluster, it was evaluated as such.

The requirements are referred to by their 'R' code along with keywords, the complete statements can be found in chapter 4 - Framing the project. Since all requirements are qualitative criteria, meaning they can only be answered by a 'yes' or a 'no' (Roozenburg & Van Eekels, (2016), each cluster of ideas was assigned with a corresponding check or cross icon.

The table shows that several clusters of ideas were expected to not meet one or more requirements, which means that these are not minimally acceptable directions for solutions. They are therefore discontinued from further development. It makes sense that some possible directions appear inherently unacceptable; after all, a creative process always explores a wide range of options. The choices resulting in discontinuation of the clusters can be explained as follows:

- *"ME"-edition*: the possibilities of personalization and special custom editions may be best understood by consumers based on their own, personal experiences and preferences (R5), and they may lead to consumers desiring and buying more (additional) products that allow for this (R9).
- *'Human' friend* and *Name of Love*: these two clusters may not sufficiently influence consumers' predicted physical lifetime of the product (R1), they may best be understood through personal experiences and preferences (R5), they may not be applicable to headphones (R8), and they may stimulate premature replacement of the product, in case that the 'relationship' between the consumer and the product crashes and burns (R9).

Table 5.1. Evaluation of the clusters of ideas, based on the priorly established requirements. The requirements and the titles of the clusters are placed in keywords.

Requirement	'Stories'	'ME design'	'Information'	'Friend'	'Proud'	'Memories'	'Exciting'	'Brand-new'	'Love'	'Price'
R1: Attribute longer lifetime	✓	✓	✓	✗	✗	✗	✗	✓	✗	✗
R2: Increase desire to keep using	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
R3: Reduce feeling of satiation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R4: Reduce intention to replace	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R5: Visual, textual and/or auditive	✓	✗	✓	✗	✓	✓	✓	✓	✗	✓
R6: Procedural/relational costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R7: Purchase moment and use phase	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R8: Smartphones and headphones	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓
R9: No premature replacement	✓	✗	✓	✗	✓	✓	✓	✓	✗	✓
R10: Technologically feasible	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R11: Positive addition to product	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗

- *Frugal and proud, Memory lane* and *Exciting stuff!*: the encouragements and celebrations, the throwbacks as well as the exciting new events from these three clusters may not sufficiently influence the consumer's predicted physical lifetime of the product (R1).
- *Everything has its price*: these ideas mainly attempt to nudge more sustainable behaviour, which means they may not sufficiently influence consumers' predicted physical lifetime of the product (R1), neither the costs of scrapping (R2), and most of them do not provide a positive addition to the product (R11), as they propose a raise in price or limitations in availability.

In general, the discontinued design directions were considered to use strategies that resembled nudging for promoting unconscious product retention behaviour, rather than to make the consumer actively think about the potential lifetime. The remaining clusters of ideas, i.e. *The power of stories*, *Information rules!*, and *A brand-new Edgar suit*, do have the potential to convince the consumer of a longer product lifetime. Additionally, an intervention developed with elements from these clusters may stimulate product retention, and was considered suitable for testing through an online survey.

This second part of the design phase of this thesis could thus be concluded with three main directions to develop further; the first one (*Information rules!*) allowing for direct information about the potential lifetime and (remaining) value of the product, the second one (*The power of stories*) using more metaphor-based strategies to this end, and the third (*A brand-new Edgar suit*) using the prospect of upgrading and regular maintenance to convince of longer-lasting physical properties and product value. These three directions were further elaborated in the final part: *solution finding*.

5.4 Solution finding: from three main directions to one proposal

In this third and final part of the triple-diamond that structures the creative process of this thesis, the three most promising design directions were developed further into more detailed and 'fleshed out' concepts that provide a relevant solution to the central problem. Again, the steps of diverging, reverging and converging were executed here, leading from a set of ideas, via three concepts, to the choice of the most favourable one. That one solution would become the intervention to test in the experimental phase.

5.4.1 Diverging: finding options for the design directions

The aim of this step was to generate a set of possible options that support either of the three design directions established in the previous part. Two techniques from iCPS (Heijne & Van der Meer, 2019) were applied in this process, namely 'How To…' for a first brainstorm of options, and SCAMPER to elaborate with more variety on those options. They were both applied on all three of the design directions, i.e. using direct information, using metaphors and using the prospect of newness to increase the lifetime expectation of the consumer. Additionally, both the moment of purchase as well as its use phase were considered during the diverging activities, the device to design for being either a smartphone or a headphone. The activities were executed individually by me, and a detailed overview of the outcomes can be found in Appendix A.4.

5.4.2 Reverging: three concepts

Similar to the reverging step of the idea finding phase, the purpose of this particular step was to create structure and order in the options generated during diverging, the difference being that, instead of clusters of ideas, the desired result was three detailed concept interventions, with a clear contribution to the functionality of the device. Crucial to this purpose was that each concept meets the requirements established prior the start of the design process, that each is developed to such an extent that they are all equal, and that they each proposes its own, unique approach to the problem. The aspects on which they are equal, read:

- They are all, at the core, based on a certain growth of the device;
- They all track data from the device's past, to provide insight into the status of the device;
- They all give a glimpse of a possible future, without giving an explicit 'expiration date';
- They all enable the consumer to increase the device's lifetime.
- They were all developed at the same level of detail, considering how they function, how they support consumers' lifetime expectations, and what their strengths and weaknesses are

In the upcoming sections, the three concepts and their expected effect on consumers' lifetime expectations will be described and clarified.

Concept I – Ring Me Up

This concept proposes a concrete interpretation of how information can refer directly to the lifetime of the device. Essentially, it tracks and shows data from usage in the past, and applies that to give the consumer an idea of what the device may still have in store.

How does it work?

Ring Me Up is a ring of LED-segments, integrated into the design of the device. Each segment symbolizes one year of use, and starts to illuminate at the beginning of this year; the Ring grows throughout the product's lifetime, showing the consumer how long they've been using the device. For a smartphone, the Ring is integrated in the back of the device, for a headphone, it is found on one of the side panels of the ear cups (see figures 5.7 and 5.8). The segments of the Ring run up all the way to 10; when this number of use years is exceeded, the ring starts over at 1.

Figure 5.7. The Ring as it is executed on the smartphone. The first segment starts to light on the bottom left of the Ring, after the first month of ownership. It starts at the bottom to make a reference to the speedometer of a car.

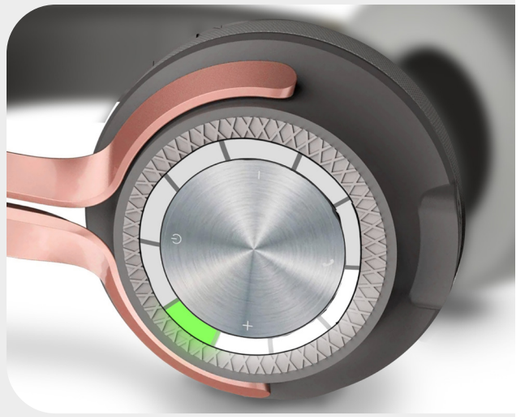


Figure 5.8. The Ring as it is executed on the headphones.

What could be its effect on the consumer's lifetime expectation?

Like all three concepts, Ring Me Up is intended to influence both the consumer's initial predicted lifetime at the moment of purchase, as well as their eventual intended lifetime after a certain period of use (for clarification on my assumptions about these concepts, see chapter 2 - Literature Study). When the smartphone or headphone is purchased, the purpose of the Ring is briefly explained. The number of segments should convince the consumer that the device is meant to last for a long time; if it is possible to fill up all these ten segments of the Ring, the device must have quite a long lifespan. Note that the device never explicitly says that it will last ten years, the Ring just suggests a certain possibility. Resultingly, the consumer should attribute a longer predicted lifetime to the device than they would normally with a typical example from its category. Its effect can be compared to that of the speedometer of a car; if it goes up all the way to 300 km/h, one can expect the car to go very fast, and at least approach that number.

This suggested 'goal' to fill up the entire ring should also encourage the consumer to keep using the device after several years of use, thus bringing up their intended lifetime. The idea that the consumer 'has already come such a long way' should amplify the psychological costs of scrapping, especially the procedural costs, which should result in a reduced feeling that the product's mental book value is close to the breakeven point.

Concept I – Ring Me Up

How does it communicate with the consumer?

Just like with the speedometer example, the consumer eventually decides how far the Ring will be filled up; their use behaviour ultimately determines the device's lifetime. Nonetheless, the Ring can do three things to provide the consumer with feedback, which are visualized in figure 5.9. First, the top segment will briefly blink once another year of use has been reached. The consumer is then made aware of this 'milestone'. Second, the entire Ring will briefly blink in green light every time the consumer has done something to support a longer lifetime for the device, e.g. installing a software update or a screen protector. And third, the top segment of the ring will briefly blink red when something is threatening the device's lifetime, e.g. when the system's memory has reached its limits or when the device has been dropped too often. To provide the consumer with some deeper insights and clarification for these functions, the Ring is accompanied by a widget that can be installed on the smartphone (in the case of a headphone, this would be an app). This widget (see figure 5.10 on the next page) not only shows the number of years that the device has been used, but also other information that has been tracked; for instance, the amount of 'impacts' (from falling or bumping) the device has endured, the amount of charging cycles it has run, and the performance of the device's system. The widget can also send sporadic notifications about the progress of the Ring, at moments of progress. The purpose of this is to inform the consumer about what influences their product's lifetime, and advise them on what they can do if they want to improve it.

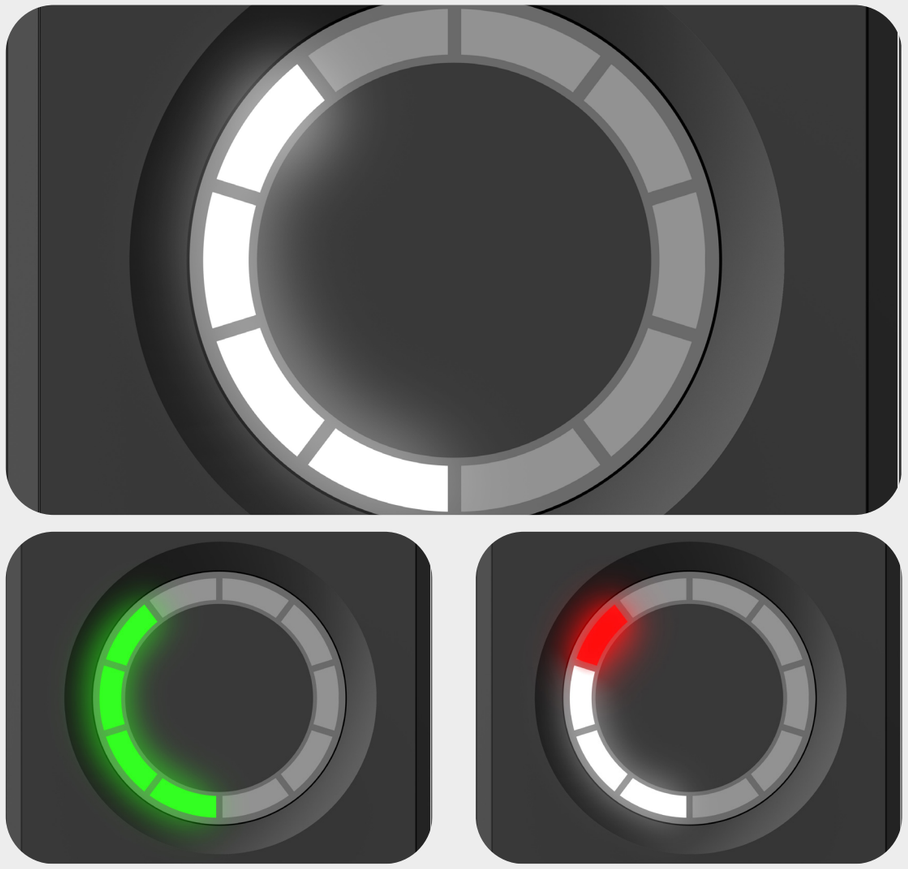


Figure 5.9. Different ways for the Ring to communicate with the consumer: glowing 'white' means a normal state, blinking 'green' means a new year of ownership was reached, and blinking 'red' means something happened that negatively affects the lifespan of the device.

Concept I – Ring Me Up

What are its drawbacks?

One drawback of this concept could be that it is always visible on the device, which may have an effect on the social aspects of owning the smartphone or headphone. If others can always see for how long you have been using the same product, they may either draw positive conclusions, e.g. that you can be proud of how you take care of your possessions, or negative conclusions, e.g. that you may be in a problematic financial situation such that you have to be frugal in order to save money. Whatever the case, the Ring may have some social implications.

In short, Ring Me Up may have some interesting effects on consumer behaviour regarding their replacement decisions and lifetime expectations. The concept does not push them into a certain direction, but it does attempt to create awareness about the potential lifetime of the smartphone or headphone. Its effect on consumers' considerations regarding product lifetime is certainly interesting to test in practice.

Strengths and weaknesses of this concept

+ Simple visualization of the device's past
+ Suggestion about possible lifetime without setting a concrete number
+ Easy to understand information
+ Possibilities for advice on how to extend the lifetime
+ Always in sight, which may have positive social effects...
− ...but potentially also negative ones
− Does not support the potential desire for 'newness'
− Needs some explanation beforehand

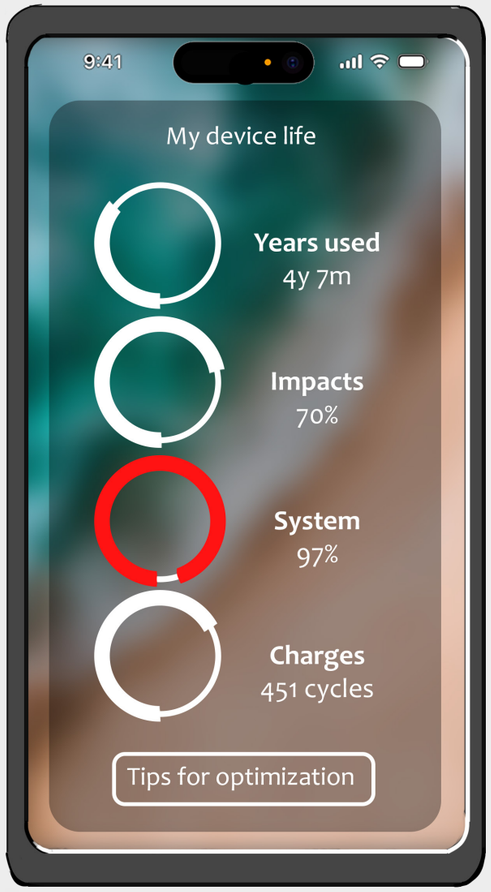


Figure 5.10. Example of the widget that gives deeper insights into the factors that affect the lifespan of the device. Just like the 'physical' Ring on the outside of the device, all meters in the widget start at the bottom

Concept II – Tree Of Life

This concept utilizes a more storytelling-based approach to refer to product lifetime. Just like concept I does, it provides insight into how long the smartphone or headphone has already been used and what is still possible, only through the analogy of a tree.

How does it work?

Tree Of Life is a widget for the smartphone that shows the growth of a tree, based on the lifetime of the device. See figures 5.11 and 5.12 of what the Tree can look like. It grows by itself while the smartphone or headphone is used normally, starting off as a small sapling and eventually becoming a gnarled, wise old tree, growing thicker and gaining branches in the process. The widget visualizes the Tree and its surroundings, and sporadically highlights changes at crucial moments of progress. When the device is replaced, the Tree does not move along to the new one; instead, it is tied to the current device, and dies when it is discarded.

Figure 5.12. Example of the first stimulus that consumers are exposed to when introduced to the intervention in the case of the headphones.

Figure 5.11. Example of the first stimulus that consumers are exposed to when introduced to the intervention in the case of the smartphone. The tagline should stimulate the desire to complete the challenge to grow the tree as old as they possibly can.

Concept II – Tree Of Life

What could be its effect on the consumer's life-time expectation?

At the moment of purchasing the smartphone or headphone, the device is accompanied by an animation of what the Tree can potentially grow into (see figure 5.15 on the next page). The concept is also briefly explained, to ensure that the consumer understands the link between the Tree and the device. The association with a thick, old tree should convince the consumer right away that the device is meant to last for a long time, which should stimulate their predicted life-time.
As the device is used over the years and the Tree grows older, seeing this progress should amplify the procedural costs of scrapping the product, making it harder for the consumer to discard it and replace it with a new one. This should stimulate the consumer's intended lifetime, as they may push back the breakeven point of the product's mental book value, knowing that the Tree can become even taller.

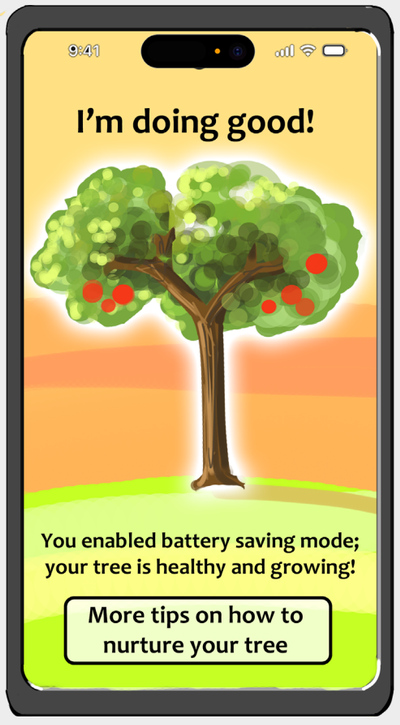


Figure 5.13. When the tree is healthy and growing well, the consumer is notified and provided with explanation on the progress.

Figure 5.14. When something negatively affects the lifespan of the device, like dropping it often, the widget gives tips on how to improve and 'nurture the tree'.

How does it communicate with the consumer?

Just like with the Ring from Concept I, the Tree will grow automatically as the device is used normally, but the consumer does have an influence on how old it will become, and additionally, how healthy the Tree is and what it looks like. The widget occasionally sends a notification about progress, for instance when the device has been used for another year. It also reacts to certain nurturing behaviour of the consumer, e.g. when they buy a new protective case, clean up unused applications or replace the battery; in this case, the Tree grows more leaves, and its soil becomes more fertile (see figure 5.13). The tree's shape and colour are unique for every consumer. They also receive a notification from the widget, letting them know that the Tree is healthy and doing well. On the other hand, when something shortens the lifetime of the product, like dropping it very often, the Tree loses some leaves or the soil becomes dryer; this is notified to the consumer as well, providing them with feedback and a realistic idea about the product's lifetime. In this case, the widget can also give advice on how to improve the Tree's health, in the form of gardening tools such as a watering can or a rake that symbolize activities such as cleaning the device or replacing components. See figure 5.14 for an example.

Concept II – Tree Of Life

Figure 5.15. When a consumer purchases the device, they are introduced to the concept of Tree Of Life through a short animation of how old the tree can potentially become.

What are its drawbacks?

All these aspects to the analogy are meant to stimulate the consumer's expectation of the life-time of their smartphone or headphone. One drawback of this concept is that they have to be able to understand the link between the analogy (i.e. the Tree and the gardening activities) and the real object (i.e. the device and how to nurture it). Some may not appreciate its more narrative qualities, and may prefer more direct information instead of 'beating around the bush' (pun intended).

In short, Tree Of Life proposes an interesting approach to influence consumers' expectations of product lifetime, using an analogy of something that can grow very old to convey the same message about the actual device. Although this concept requires more effort into understanding the meaning of the analogy, once understood it may serve as a powerful means to make the consumer aware of the potential lifetime of their device. Hence, it is also suggested as an interesting option to test for effectivity in practice.

Strengths and weaknesses of this concept

- \+ Imaginative way to convince consumer about potential lifetime
- \+ Relatable to most people (anyone who knows what a tree is)
- \+ Stimulates procedural costs, and thus, discourages product replacement
- \+ Allows for advice on how to improve life-time
- – Not so much integrated into the physical design of the product
- – Concept is more detached from the actual topic
- – Emotional bond with the Tree may induce negative feelings during replacement

Concept III - Crystal Ball

This concept uses the prospect of an evolving device to convey its potentially long lifetime. Like a magician's crystal ball, it gives the consumer a glimpse into the future of their device, showing what is still possible even when it has already been used for several years.

How does it work?

Crystal Ball is a timeline that tracks the current age of the smartphone or headphone, and shows possibilities to adapt the device to new desires in the future. The timeline (see figure 5.16 for an example) can be found in a widget in the smartphone (in the case of a headphone, the widget is also in the consumer's smartphone). At the top of the timeline, future possibilities are mapped out for keeping the device fresh and relevant to the consumer's desires; for instance, updating the software, changing components such as batteries, cameras or drivers, or adding protective accessories. The possibilities become more drastic as the product is used over time, starting with software updates, and eventually enabling upgrades of components. 'Enabling' in this case means that the consumer receives a discount on these options. The widget can be seen in figure 5.17 on the next page.

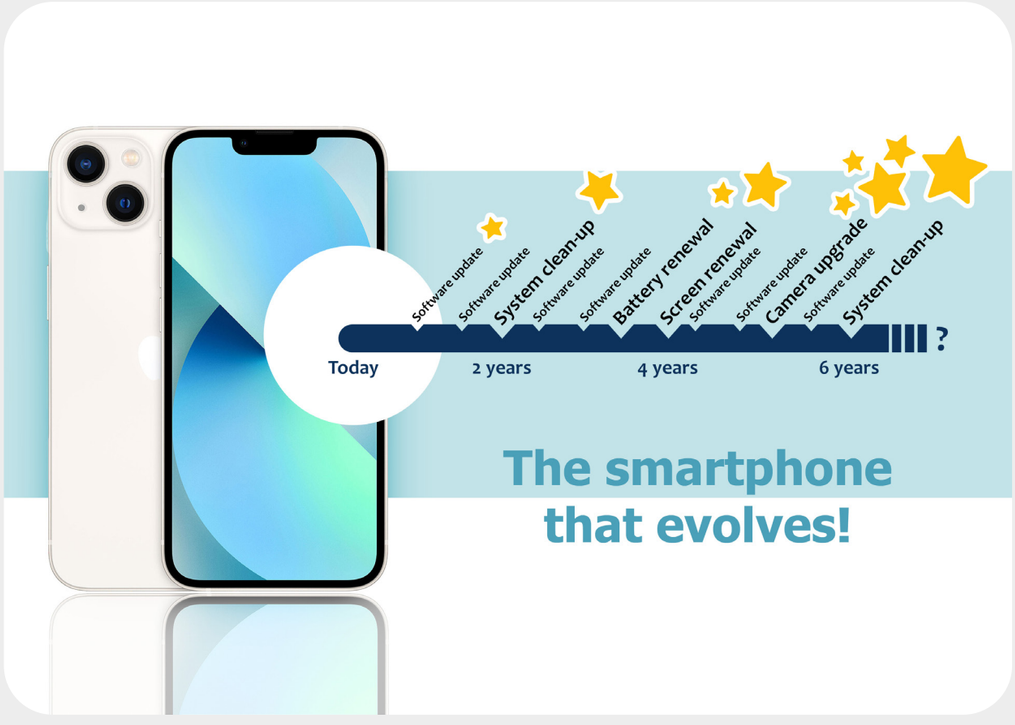


Figure 5.16. The first stimulus that consumers are exposed to when purchasing a smartphone with the Crystal Ball intervention. The timeline gives them a peak into what is possible during the first life of the device, and should increase their predicted and intended lifetime.

Concept III - Crystal Ball

Figure 5,17. Example of the widget of the Crystal Ball concept. Here, the consumer can view where on the timeline they are and what is still to come.

What could be its effect on the consumer's lifetime expectation?

At the moment of purchase, the smartphone or headphone is presented with a visual example of the timeline. When the consumer receives this information right away, they should attribute a longer lifetime to this device then they normally would, as the notion that the device can be adapted to new needs and desires may lead them to conclude that it can last for a long time. To that end, the timeline will be clarified in a brief explanation, stimulating the consumer's expectation of the potential lifetime of the product.
The prospect of newness should also encourage the consumer during the use phase to not yet replace the product. The possibilities to buy new components and accessories for a certain discount should postpone the feeling of satiation with the device, and convince the consumer that there is more value to gain from their current device. Additionally, the timeline also shows what the consumer has done in the past to maintain or upgrade the device, which should amplify the procedural costs of scrapping it. Both these aspects of the concept should stimulate the consumer's intended lifetime for the product.

How does it communicate with the consumer?

Just like the other concepts, Crystal Ball houses all its information inside its dedicated widget, which is able to notify the consumer about certain progress and offerings. For instance, the consumer may be notified after four years of using their smartphone that they can have its screen replaced for a discounted price, or that their headphone's earpads can now be renewed. Note that these are not obligations for the consumer, just possibilities that they can choose to make use of; from a certain point onwards, the possibility is 'unlocked', and the consumer should decide whether it is relevant to them or not. In case that the consumer does decide to make use of the newly unlocked possibility, the widget helps them in making the required efforts to do so. For instance, it can give advice on what new battery to order, or what to do to get it replaced by an expert.

Concept III – Crystal Ball

What are its drawbacks?

An important drawback of this concept is the fact that it requires quite a radical new approach to selling electronics, since consumers should be enabled to order and replace components by selves. It also requires the development of an infrastructure for repairing devices or installing new functions and accessories. In that light, this concept is more a service system that can be applied to several categories of products, rather than a change in the design of the device itself. Besides, one could question how effective this concept is regarding prevention of premature product replacement; when a new model is launched with more or better future possibilities than the current product, that replacement model may become more attractive after all, potentially leading to premature replacement. And lastly, this concept may induce a certain frustration, in the case that the promises of the timeline do not turn out as predicted. For instance, when a consumer has followed all the suggestions of the timeline, but the device still turns out to break down, they may end up feeling scammed.

In short, Crystal Ball could be an interesting concept to support consumers' lifetime expectations of products, as it provides them with concrete options to keep their device relevant, fresh and up-to-date for a longer period of time. It would be interesting to find out its effectivity in practice, and how it could be beneficial for businesses as well.

Strengths and weaknesses of this concept

+ Concrete evidence of how the device can stay relevant for a long time
+ Could keep the consumer invested in current product
+ Possibly applicable to many types of products
– May require radical changes in business models and infrastructure
– More an additional service than a change in product's design
– Frustration in case of 'false' prediction

Figure 5.18. The first stimulus that consumers are exposed to when purchasing headphones with the Crystal Ball intervention.

5.4.3 Converging: choice of the most promising concept

The three concepts developed in this solution finding step of the design process, were evaluated for further development into a testable design intervention. This evaluation aimed to result in the choice of one concept that would be the most promising to fulfil this purpose. To compare the concepts equally, they were evaluated on the basis of the list of wishes from chapter 4 - Framing the project, along with some additional considerations. As mentioned in the 'reverging' section of this current chapter, all three concepts are assumed to at least meet the requirements from the list, which is why only the wishes were addressed now.

Table 5.2 shows the evaluation process of the concepts based on the list of wishes. Since wishes W1-5 are quantitative criteria, meaning they allow for ranking the concepts on the extent to which they are expected to meet the wish, each concept received either 1, 2 or 3 points. Wish W6 is a qualitative criterium, i.e. it can only be answered by a 'yes' or 'no', therefore it could either earn the concept an additional point, or no point at all. This system of points was preferred over a Harris profile-style evaluation strategy with pluses and minuses (Van Boeijen et al., 2013), as the points provide a more quantified ranking instead of a visual one (Harris profile scores cannot be added up, only evaluated on 'what side the tower of blocks leans towards). Additionally, the wishes were given a 'weighing factor' to indicate the importance of each wish; wishes W1 and W3 were considered most important to be met, as W1 determines the extent to which the product's lifetime is expected to be longer, which is the main aim of the concept, and W3 determines the extent to which the purpose and functions of the concept can be understood by a consumer, which is crucial to the effectiveness of the experimental study. Wishes W2, W4 and W5 were considered less important, as these measure effects related to the central aim of the concept, i.e. the desire to keep using the product, the intention to dispose of it and to replace it. W6 was considered least important as profit is not within the scope of the project, and would require more research to make thorough predictions. The total number of points would give a first indication of what could be the most promising concept.

From the table it became clear that Concept I could be the most promising option to continue with. It may be most effective in convincing consumers about a long product lifetime, it seemed the easiest to understand in terms of purpose and functionality, and it could to some extent be effective in preventing consumers from disposing of their product. As an additional consideration to this evaluation process, the proposed solution of Concept I was suggested to fit best within the scope of this thesis, since it was the most integrated into the design of the smartphone or headphones. Thus, this concept was further developed into a testable intervention. Concept II – Tree Of Life had some advantages as well, particularly its narrative-based approach as a potentially powerful way to convey the message, but the fact that it may be harder for consumers to make the connection between the Tree and the device's lifetime ultimately made it the lesser-preferred option. And finally, Concept III – Crystal Ball proposed an interesting approach as well, as it presented concrete suggestions for the consumer to maintain their device and keep it interesting and desirable. However, its extensive possible implications for business and infrastructure when it comes to making it easier for consumers to repair products and buy components or have it done by experts, made it go somewhat beyond the scope of this thesis. Nonetheless, both these last two concepts could be interesting to test on effectiveness on consumers' product lifetime expectations in further research.

Table 5.2. Evaluation of the three concepts, based on the priorly established wishes.

Wish	Weighing factor	Concept I Ring Me Up	Concept II Tree Of Life	Concept III Crystal Ball
The intervention should convince the consumer to consciously attribute an as long as possible lifetime	3x	III	II	I
The intervention should increase as much as possible the consumer's desire to keep using the same product.	2x	I	III	II
The intervention's purpose and functionality should be as understandable as possible to the consumer.	3x	III	I	II
The intervention should reduce as much as possible the consumer's intention to dispose of the product.	2x	II	III	I
The intervention should reduce as much as possible the consumer's desire to buy a new model.	2x	I	II	III
The intervention should be profitable for contingent manufacturers of the product.	1x	I	I	I
Total		27	26	22

Key takeaways from the design process

"The ring, the old tree and the crystal ball", it could have been a beautiful plot for a fantasy movie. For this thesis, however, these three concepts have given an interesting range of possibilities for supporting consumers' product lifetime expectations. Whether using a feature on the back of the device, a story about a tree or a timeline to predict the future, consumers may alter their expectations of the product's physical lifetime as well as their intentions to keep using it when exposed to these stimuli.

Although Concepts II and III could be promising for future research, Concept I seemed to be the most valuable for testing within the scope of this project. It was thus developed into an intervention that can be tested for effectiveness in an online survey. The intervention, which slightly differs from the concept, is described in the upcoming chapter, with both its identified strengths as well as its weaknesses considered during further development.

6. The design intervention

This chapter provides an extensive description of the design intervention chosen from the concepts in the previous chapter. It will start off by briefly introducing the intervention, its final design and its relation with the concepts. Second, a detailed explanation of its functionality and required technologies will follow. Several key adaptations that were made to establish the final design, will also be addressed here. After that, the potential implications for consumers' product lifetime expectations will be addressed. The chapter will close by making recommendations for repair and maintenance, setting goals and rewarding, and by discussing social and business implications of the intervention.

6.1 Introduction to the intervention

In the images on this page, the final design intervention for this project can be seen. It builds upon the strengths of concept I 'Ring Me Up' from the design phase, but some properties and functionality of this concept have been changed, adapted, added or eliminated. The main idea behind it has remained the same; it gives a simple insight into what the device has already endured and what it may still have ahead of it, and uses that to stimulate the consumer's expectation of the device's potential lifetime. Just like the earlier concept, the intervention is a ring of LED segments that light up one by one after a certain period of use, the length of which differs between devices (see figure 6.1 for which devices it is applicable). It can be implemented both on smartphones as well as headphones. The intervention implies that, if the device is taken good care of, it should be able to last at least one circle around the ring, lighting all segments. It is up to the consumer to decide how long they want to keep circling the ring. Deeper information to support this message can be found in an additional widget that can be installed either on the smartphone itself, or on the consumer's current smartphone when it is paired with the headphones.

Figure 6.1. The rings as they would be implemented in the exteriors of smartphones and headphones. Here, these devices can be seen in a potential use context.

6.2 Functionality of the intervention

6.2.1 The ring

As can be seen in figure 6.2, the ring is located either at the back of the device (in the case of a smartphone) or at the panel on the right ear cup (in the case of the headphones). It is about as large as these components of the devices, and always subtly glows as the device is activated; only when the device is turned off, the ring turns off as well. The position, size and lighting of the intervention should make it clearly visible and easily interpretable at any time during use, in order for the consumer to become more aware of the lifetime of their device.

The segments of the ring represent certain steps in the device's lifetime. In the case of the smartphone, each segment symbolizes half a year, counting up to twelve segments in total. One circle around the ring would then take six years instead of ten, as it was originally proposed by the concept. For the headphones, each segment symbolizes one year of use, so a roundtrip takes twelve years. In this way, the ring makes a subtle reference to the 12-number division of a clock, which is normally expected to be able to keep circling around, and also strongly associated with time. To further support this analogy, the start is now at the top of the ring instead of at the bottom. More explanation on how these aspects of the intervention are expected to increase consumers' lifetime expectations can be found in section 6.3.

Figure 6.2. More detailed views on the intervention's ring, with annotations to highlight its most important functions.

6.2.2 The widget

The intervention also includes a widget that can be installed for free on the phone. In the case of the headphones, this device thus has to be paired with the consumer's smartphone. This widget collects additional data that provides deeper insights into the life of the device, such as (for the smartphone):

- The status of the battery and the total number of charging cycles it has run;
- The total number of impacts that the device has undergone, for instance when dropped from a height, hit against a hard surface, or squeezed together in a backpack;
- The remaining storage and memory;
- The performance of the cameras, and;
- The protection of installed applications.

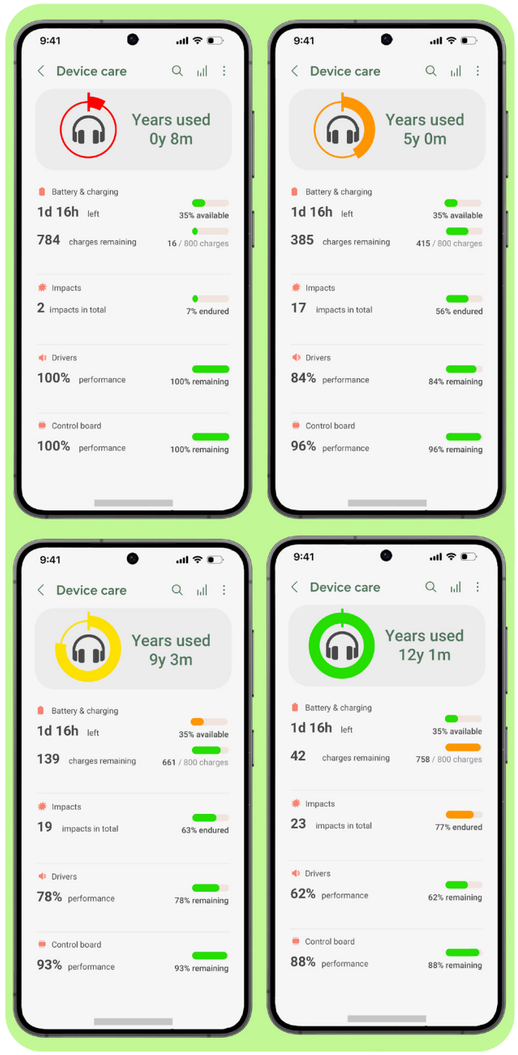


Figure 6.3. Examples of the widget that provides insight into the headphones' lifespan.

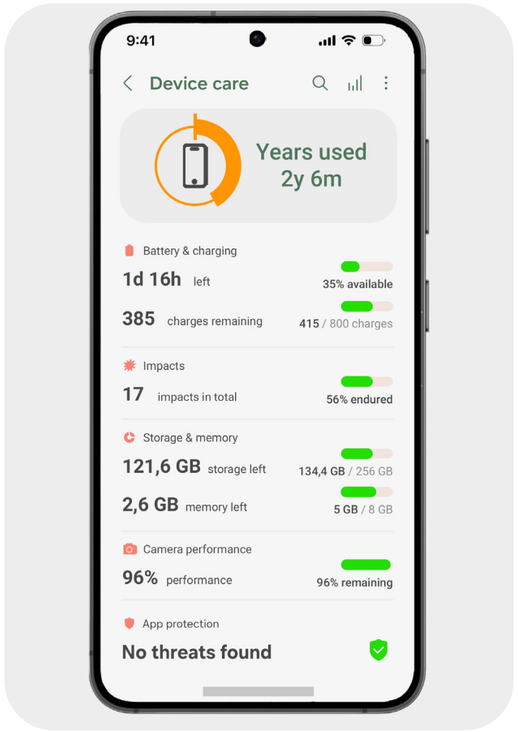


Figure 6.4. Examples of the widget for the smartphone, after 2,5 years of use.

It then shows these data in designated bars, which are coloured green at the start of the device's life, and as long as the device is performing well on these aspects. Examples of what this looks like can be seen in figures 6.3 and 6.4. When a meter reaches its limit, it turns orange, which should grab the consumer's attention. The red colour that was used in the earlier concept was assumed to be too much of an 'alarming' colour, heralding that the device is broken and should be replaced immediately. Red is generally associated with danger and warnings, whereas orange is often used to convey caution or to attract attention (Ng & Chan, 2018). Based on the assumption that a too alarming message may stimulate premature replacement, the colour orange was chosen to indicate that 'something is underperforming, but it can still be fixed'. An exception is the age ring in the widget, which is coloured the other way around; at the time of purchase, when the device is still very young, the ring's colour is red, which should imply that it is still too early to discard the device. Between 2,5 and 4 years of ownership, the ring turns orange, implying that having kept the device for this long is already a good step, but it still has much more in store. Then, between 4,5 and 6 years, the ring turns yellow, indicating that they're approaching the minimally diserable lifespan of the device. From 6 years onwards, the ring turns green. Again, this is in the case of the smartphone.

6.2.3 Required technology

Data acquisition for the ring is done by simply counting the time since the device was first turned on and set up. The day of purchase then counts as the starting point from where the ring is completed. Furthermore, the functionality of the widget may, despite its elaborate information, not require many additional sensors or components in order for it to work properly. Current smartphones already collect and provide access to data about its system and battery, which makes these functions feasible to implement in this design intervention. Counting impacts may be an exception, this would require some additional yet already existing technology, such as sensors that measure external forces on the body of the device. Another exception, and perhaps the most innovative one, is tracking the performance of the camera; smart, AI-supported software embedded in the intervention's lifetime evaluation system could be used to analyse the quality of the photos taken with the phone's cameras. These data can then be used to show the decline of the lenses and camera components and their remaining performance.

Existing headphones may, if at all, exclusively track the current battery status. Therefore, collecting data for the widget's extra information would expectedly require more innovation compared to smartphones. The placement of additional sensors that track the condition of the headphones' body, drivers and software would allow these data to be used in the widget. Consumers then just need to install this widget on their own phone, which they would already pair with the headphones for listening to music.

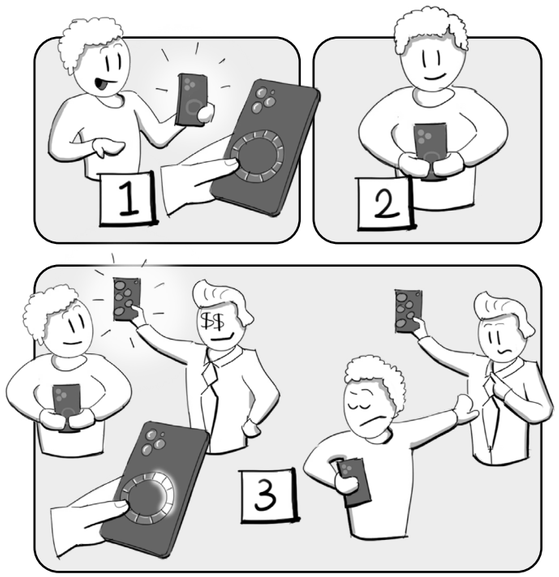


Figure 6.5. Intended effect of the intervention, [1] at the moment of purchase, [2] during use, and [3] when alternatives are presented.

6.3 Implications for expected lifetime of smartphones and headphones

6.3.1 Predicted lifetime

The predicted lifetime is influenced by suggesting a reference point of what is possible to reach for the consumer; the change from an initial 10 years on the smartphone's ring to the eventual 6 years was made to refer to what the consumer might still consider realistic for them to reach. As stated in chapter 4 - Framing the project, smartphones on average last for about 2,5 to 3 years, therefore, to double this number could already be considered ambitious. Exposing the consumer to this first stimulus at the moment of purchase may already convince them that the device is able to reach a longer lifetime than a typical alternative. Figure 6.5 shows the intended effect of the intervention on a consumer. Additionally, the analogy with a clock should convey the fact that there is no intended end to the ring; it can keep circling forever, depending on how well the device is taken care of. As a result of these aspects, the consumer may subconsciously place the breakeven point of the mental book value further into the future, as they become more critical in depreciating this value (step [2] in figure 6.5).

6.3.2 Intended lifetime

The intended lifetime is influenced through the built-up progress in the ring and the additional information in the widget. For the consumer, the ring should at a certain point symbolize the amount of time and effort they have already put into keeping the product; as hypothesized in the main theoretical model, these procedural costs of scrapping (Guiltinan, 2010) should increase the mental book value. Besides, the elaborate information of the widget should enhance the consumer's understanding of the physical state of their device, convince them that it has more in store, and stimulate their nurturing of the smartphone or headphones. They should then be less receptive to alternative offers (step [3] in figure 6.5).

Additional to these core functions of the intervention, some recommendations can be made for incorporating extra functions that stimulate consumers' involvement in their device's lifetime, but fall somewhat out of the scope for this project. These recommendations are about the possibilities for product repair, about rewarding and about social implications, and will be discussed in the upcoming three sections.

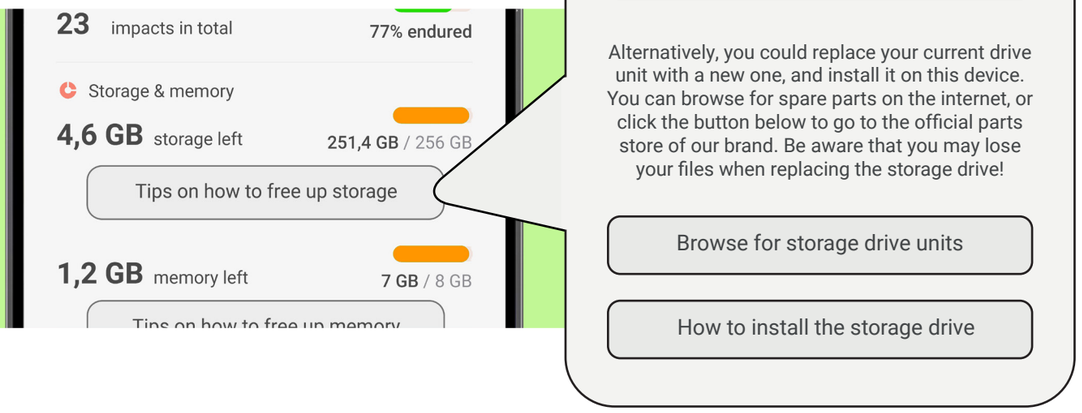
6.4 Possibilities for maintenance and repair

The intervention was designed to give the consumer insight into the lifetime of their device, and the factors that may influence this lifetime. An additional feature to include in the widget that could be interesting, is to give advice or tips on how to keep the device clean, well-functioning and aesthetically up-to-date. Since such a function was assumed to result in too much information for inclusion in the experiment, it was considered a valuable recommendation for further research and development, to explore how it could support consumers' expectations of product lifetime.

When meters in the widget reach their limit, they turn from green to orange. In figure 6.6, the example is taken of a nearly full storage. In this case, a button could pop up that directs the consumer to an explanation of the problem, and what they can do to solve it. The widget may advise to delete unused files or let the device perform a complete system cleanup. Another example: when the headphones' drivers are malfunctioning, it may give them tips on where to order new drivers and how to get them replaced or do it by themselves. This can also be possible for the device's battery, the cameras and screen (smartphone) or the headband and ear cups (headphones).

The main challenge that limits these possibilities is that these products should be designed to allow for easier (DIY) repair. While some brands already incorporate strategies and visions to enable repair (see for instance FairPhone and Framework in chapter 3 - Examples from practice), many devices currently still suffer from the image of not allowing repair once a defect has occurred (Perzakowski, 2021). Many consumers also lack the attitude to repair products themselves (Van den berge, Magnier & Mugge, 2023B). Researching these aspects of product design was considered beyond the scope of this project, therefore it is recommended for further development of the intervention. A more thorough study of the scientific literature that concerns product repairability and consumers' attitudes towards its related activities would advised in that case.

Figure 6.6. When a function of the device is reaching its performance limits, a button could pop up in the widget that directs the consumer to in-depth explanation of the issue and how to solve it. In this case when the smartphone's storage is nearly full. The presented information is based on Android Help (2024).



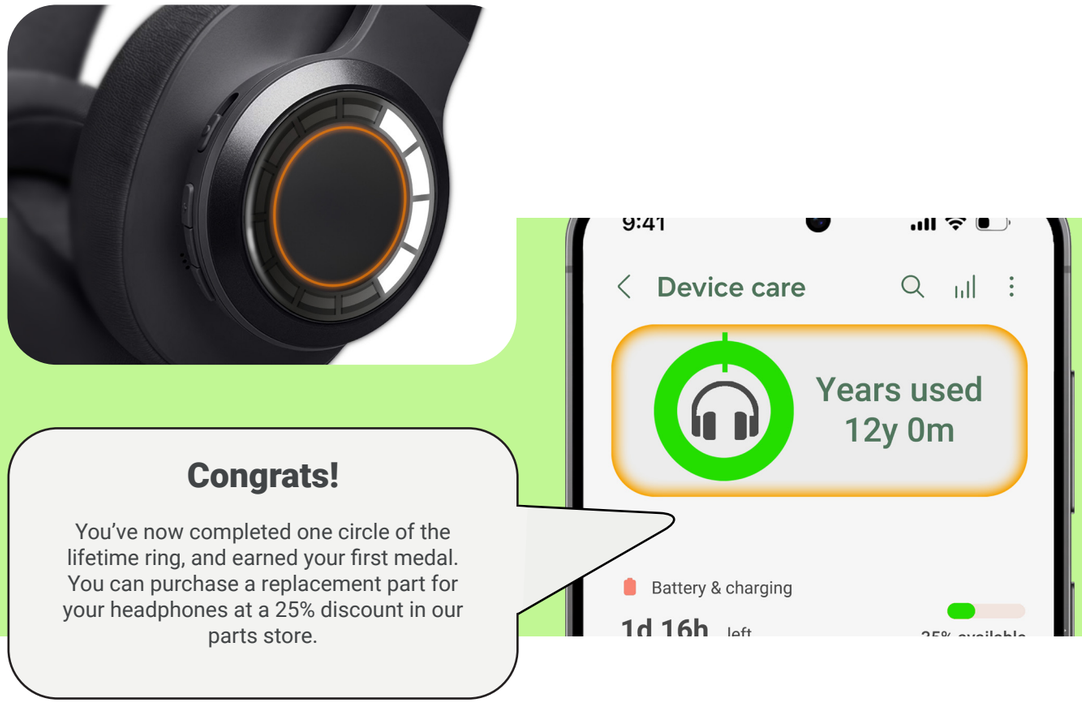
6.5 Possibilities for rewarding

Another possible addition to the design of the intervention is to reward consumers for their desirable product retention behaviour. This can be done, for instance, through medals or titles in the widget or in the physical ring, or through discounts on replacement components and accessories. Regarding medals or titles, the widget in the smartphone could inform the consumer on this newly acquired reward each time half a ring or a full ring is completed. The consumer could then be handed a title, starting for instance at do-gooder, towards master and on to veteran or legend. Referencing to repair and handiness could also be an option for awarding titles, ranging from freshman all the way to master engineer. And to make the acquired titles even more tangible for the consumer, it could also be shown in the physical ring, in the form of an inner ring that glows bronze, silver or gold. Awarding such medals or titles could turn product retention into a game or challenge for the consumer, setting a goal for them to achieve. See figure 6.7 for an example of what it could look like

Figure 6.7. After each full circle around the ring, the consumer could be rewarded by an extra ring visible on the product (here in bronze), and/or a discount on replacement parts or upgrades.

The other option is to reward product retention by enabling discounts on certain components or accessories for the device, stimulating consumers to keep their possession up-to-date and interesting. This can also be seen in figure 6.7. For example, with each time passing half a ring, an offer is unlocked that is relevant to the current state of the device; when at this point, the earcups of the headphones show severe signs of wear, the consumer is given the option to order new earcups with a 15% discount. The same can be done for its headband, drivers, battery or circuit board, as well as a smartphone's storage space, screen, protective case or cameras. Of course, this idea would require the manufacturer to incorporate a new business model to allow for easy purchasing of these items. Essentially, this idea incorporates elements of the third concept (Crystal Ball) from the design phase of this project.

The option of awarding medals or discounts as rewards was not so much considered beyond-scope for this project; it does fit well within the context of preventing premature replacement and satiation, as it may stimulate a sustained interest of the consumer in their device. However, the assumption was made that adding another rewarding feature to the intervention would require an extensive amount of additional information in the already elaborate introduction of the experiment. Since rewards would in this case be another independent variable separate from the lifetime tracking feature, it was thus not included in the final intervention as-is. Nonetheless, it could be interesting for consideration in contingent follow-up research on this topic.



6.6 Possibilities for setting goals

The number of years that are required to take one circle around the ring of the intervention, was intentionally fixed; 6 years for the smartphone, and 12 years for the headphones. This was done to make a suggestion for the participants of the experiment as to how long the device may last. Since the goal of the intervention is to positively influence the expectations of the device's potential lifetime, the assumption was that a fixed 'reference' number was needed to ensure reliable research results.

However, it may be interesting for this intervention to enable consumers to determine the required number of years to 'make a full roundtrip' for themselves. The consumer would then be able to set a certain goal, in terms of how long they expect the product to last and intend to keep it. Such an additional function may encourage consumers to stick to their original predicted and intended lifetime, and prevent them from deciding to prematurely discard the device at a later point during ownership. Especially those who are easily seduced by new technologies or advertisements of the newest models, may feel more resistance to replacing their current product when they are reminded that their 'goal' has not yet been achieved. It might even encourage them to repair or maintain it to ensure that they reach this goal.

The end of the circle may in this case represent the moment that the consumer feels that the product has made its money worth; the mental book value would then be made more tangible for them. A drawback of this function could be that consumers are no experts when it comes to estimating product lifetime (Van den Berge, Magnier & Mugge, 2021B). When they set the goal at a point where the product appears to still function completely well, they may end up prematurely discarding it after all, as it would then have made its money worth. Thus, more research is recommended to explore the potential effects of a function for setting product lifetime goals.

Besides, when asking a consumer about how long they would want a product would last, this may come closer to 'ideal lifetime' instead of predicted and intended lifetime. Oguchi et al. (2016) asked their participants "*Ideally, for how many years do you expect to use the product you own?*" to learn about this third type of lifetime expectation, and suggested that this ideal lifetime would be higher than the predicted and intended lifetimes. Ideal lifetime was, however considered beyond-scope for this thesis, it says more about consumers' ideal scenario rather than their realistic expectations. The latter were considered more relevant for the project.

6.7 Social implications

Because the design intervention is always visible on the device. The message that it conveys may have either positive or negative implications for the social status of the consumer, depending on their lifestyle and attitude towards consumption. Contingent positive social effects of the ring might have to do with a sense of pride for one's responsible consumer behaviour. Particularly, those consumers that are aware of the environmental impact of their daily activities and behaviour may see the addition of a lifetime tracker on their devices as a social benefit, since it enables them to express their perspective on consumption and product longevity to their peers. Additionally, the continuous displaying of the age of one's device may inspire those peers to keep using their products for longer as well. The previously discussed rewarding-based options for the intervention could also stimulate these social effects; enabling consumers to compare their achievements in the widget and challenge each other to acquire that 'golden medal' or 'legend' status, may strengthen their desire to keep and maintain their current product.

Potential negative social consequences are probably most relevant to consumers whose social status depends on the newness of their products. Especially for those who desire to express themselves through possession of the most recent generations of devices and technologies, it may undermine their status among like-minded peers when they cease to replace their devices frequently. Earlier studies have linked 'status consumption' to tendencies of materialism (Goldsmith, Lynn & Clark, 2024). A physical, always-visible representation of the fact that the product is used for as long as possible would thus not be a desirable feature for these consumers. A possibility for increasing the intervention's relevance to these innovative consumers, is to implement the earlier discussed options for upgrading key components of the device. This could enable them to still have the latest technologies and features and to express their innovative mindset, albeit with the same device that they have had for years. This potential addition may thus mitigate its negative social aspects.

Whether the social consequences of the intervention tend more towards the positive or the negative, thus seems to depend at least for a part on the target group. Hence, these points could be taken into consideration if a product or function similar to this intervention were to be marketed. For just the experimental phase of this current project, the social aspects were accounted for by asking the participants some questions about their general liking of the product, and their attitudes towards innovation and sustainable behaviour. This should provide insights into the participants' social considerations when assessing the intervention.

6.8 Implications for business and the market

For businesses and companies that are involved in the development smartphones and headphones, the addition of a feature similar to the intervention of this project is expected to have some fundamental implications as well. Essentially, the desired result of the intervention is that consumers purchase less new electronic products, as they are encouraged to keep using their current one for longer. This means that businesses of which their profit relies on the continuous increase of sales, may be limited in their growth plans. However, for those businesses that desire to express a responsible attitude towards consumption, the intervention may be an interesting perspective to implement. Business models that incorporate services to support sustained interest and social value as well as maintenance and repair of consumers' current devices are suggested to have the most potential in that case. Either way, the intervention asks for a different approach to business models and future visions, requiring the company to find different means to stay relevant in their market. As Raworth claims in her theory about Doughnut Economics, industries and societies in general may play a more embedded role within the natural environment when they look for ways to thrive instead of ways to grow (Raworth, 2017); in that case, if growth is no longer the ultimate goal for a business, implementation of the intervention into the designs of their next products may become a more viable possibility to stimulate responsible consumption.

At this point, it may be challenging to fit the perspective proposed by the intervention into existing business models and markets. Clever advertisements often still aim to convince consumers to buy new products by emphasizing their aesthetic values, which is suggested to stimulate psychological obsolescence and premature replacement of the current product (Bridgens et al., 2019). In the end, however, the consumer decides what is bought, and thus, where the demand is. If efforts are made to shift their perspective on excessive consumption, by making them aware of the environmental consequences and the alternative ways to behave, the demand for frequent introductions of new model generations and incremental changes in functionality and aesthetics may gradually decrease. Additionally, new legislations to mitigate environmental impacts of industries may at some point limit the stimulation of excessive consumption as well (Scott, 2020; White et al., 2021). And with decreasing demand and stricter regulation, corporations should eventually adapt their strategies.

Key takeaways from the design intervention

Through its design, the intervention aims to improve consumers' lifetime expectations of smartphones and headphones, and discourage the desire to replace them. The number of segments of the ring and the fact that it can circle infinitely, sets a high reference point for the predicted lifetime, which creates a strong first impression. The eventual buildup of ring segments should symbolize the effort put into using and maintaining the device, which keeps the mental book value high and increases the intended lifetime. This is further supported by the information in the widget. The intended effects of the intervention are of course still theoretical, based on prior research and examples from practice. Thus, the next chapter reports the experiment to test its effectiveness.

7. Experimental test with the intervention

In this chapter, the experimental test of the design intervention will be discussed elaborately. This experiment aimed to find out whether inclusion of the intervention into the design of existing electronic products would significantly affect consumers' lifetime expectations and their mental book value. A research question and its corresponding hypotheses were established, and determined the eventual design of the experiment. The chapter starts off by discussing these and the associated dependent and independent variables. Next, the control variables of the experiment will be addressed, which were considered crucial to increase validity of the study. After that, the design and method of the experiment will be described, and the considerations regarding ethics will be addressed. The last two sections of this chapter will report the results of the main anaysis and discuss additional analyses to evaluate the normal distributions, success of the manipulation, the participants' attitudes and the model established from the theory.

7.1 Research question, hypotheses and variables

The overall goal of this graduation project is to find out how an electronic product's design can positively influence its lifetime as expected by consumers. Based on the assumption that a longer predicted lifetime increases the mental book value, which in turn increases the intended lifetime (see chapter 2 - Literature study), an intervention was designed in the form of a meter that tracks the age of the electronic product. In order to find out whether this intervention has a significant effect on consumers' product replacement behaviour, an experiment was set up. This experimental phase of the graduation project should answer the research question as formulated below.

Research question:

How does the presence of the design intervention influence consumers' lifetime expectations of an electronic device?

As mentioned in the analysis of examples from practice in chapter 3, it was suggested that a meter that tracks some type of historical data from use and provides the consumer with insights into the resulting state of their product, such as the odometer of a car, an iPhone's battery capacity meter or a 3D printer's time tracker, may lead them to adjust their expectations of the product's potential lifetime and the mental book value that they attribute to it. The extra information of these types of meters may then decrease the likeliness that the consumer replaces their current product. Based on these expected effects, the following hypotheses were established to answer the research question:

H1: the design intervention has a positive influence on the predicted lifetime compared to when this intervention is absent

H2: the design intervention has a positive influence on the mental book value compared to when this intervention is absent

H3: the design intervention has a positive influence on the predicted lifetime compared to when this intervention is absent

H4: the design intervention has a negative influence on the replacement intention compared to when this intervention is absent

The aim of the experimental phase was to test whether these hypotheses were supported or not. The independent variable (IV) of the experiment consisted of both the physical ring on the device, as well as the downloadable widget to provide additional information about its use history and lifetime. The dependent variables (DVs) were (1) the predicted lifetime (product nature), (2) the intended lifetime (product nurture), (3) the mental book value, which was suggested to work as an intermediate effect between predicted and intended lifetime (see chapter 1 - Literature study), and (4) replacement intention, which would be influenced by the duration of the intended lifetime. Figure 7.1 shows these relations together with the hypotheses and the corresponding survey questions.

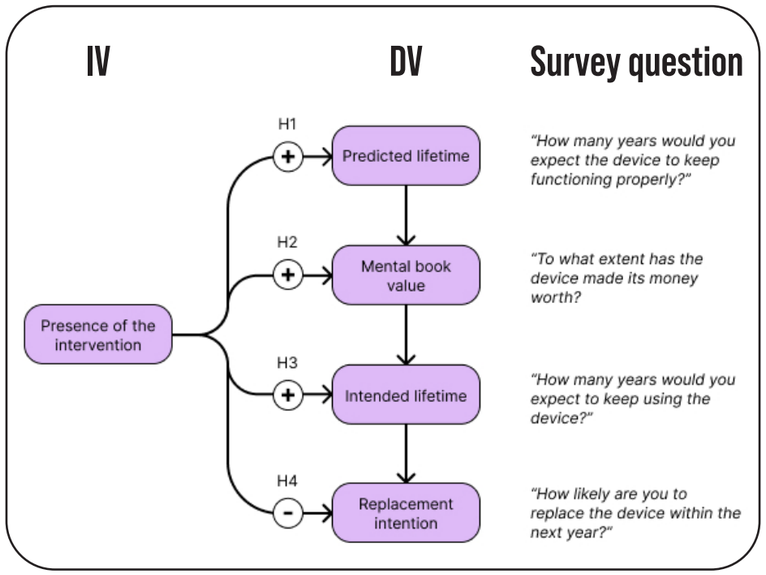


Figure 7.1. Overview of the independent variables (IV), de dependent variables (DV) and the hypotheses (H1-4) that were tested during the experiment. On the right are the most important survey questions for each dependent variable.

7.2 Control variables

Several other properties of smartphones and headphones that may influence consumers' considerations when evaluating product lifetime, were kept constant for both the control groups and the treatment groups during the experiment. These control variables for the smartphone and headphones groups can be seen in table 7.1. The models of the smartphone and headphones were based on existing products. Because past experiences with products from certain brands may influence lifetime expectations (Van den Berge, Magnier & Mugge, 2021B), these were visually adapted to enhance their unrecognizability and mitigate any potential associations with existing brands. The smartphone consists of the body from an Apple iPhone 12 Pro Max and the camera module from an NUU N10. Since the N10 only has two camera lenses, which could be considered atypical (most smartphones have three), one extra lens was added to ensure this would not influence assessment of the device. The headphones were based solely on the JBL Live 770 NC, but with all emblems referring to the brand or model removed from its exterior. Both devices were executed in the colour dark grey on a white background. The widget was also given a white background and a text in 'Roboto' font. Combining these elements was expected to give the intervention's design an anonymous yet decent quality appeal.

Table 7.1. List of control variables for the intervention's devices that were kept constant throughout the control and treatment groups.

Control variable	**Smartphone**	**Headphones**
Price	€899,-	€399,-
Brand	'New brand'	'New brand'
Colour	Dark grey	Dark grey
Charging speed	Medium	Medium
Current (imaginative) age	2,5 years	5 years
Existing lifetime information	Battery status, storage, memory, app protection	Battery status
Screen size	6,2"	-
Storage space & memory	256GB / 8 GB	-
Camera quality	50 MP	-
Sound quality	-	Very good
Carrying comfort	-	Very good

7.3 Method and design of the experiment

7.3.1 Study design

The experiment aimed to test the effectiveness of the design intervention on increasing consumers' lifetime expectations of electronic products, and was conducted in the form of an online survey. Participants were randomly assigned to one of four conditions in a 2 (device: smartphone vs. headphones) x 2 (intervention: present vs. absent), between-subjects design. All participants were shown one stimulus device that contained an intervention in the treatment groups and no intervention in the control groups. The study design and the different stimuli for each group can be seen in table 7.2.

7.3.2 Participants

In total, 204 participants participated in the experiment. The division of these participants among the four experiment groups can also be seen in table 7.2. This study adopted a mixed sampling method including convenience and snowballing, as well as two online survey distribution platforms; 121 participants were recruited through my own network of acquaintances, by contacting them via WhatsApp, by asking them in person or through an invitation with a QR code that I left at my work. The efforts of these participants were not compensated financially, but they were rewarded with eternal gratefulness. Another 57 participants filled out the survey via SurveySwap, a free online service for finding people to participate in research studies. These participants were rewarded with credits that could be used exclusively within this platform to find participants for their own studies. The remaining 26 participants were recruited via Prolific, another online distribution platform that rewards survey-takers with a monetary compensation.

Table 7.2. Division of the participants across the different conditions of the experiment, along with the stimulus that they were exposed to throughout the survey.

		Condition			
		Control group		Treatment group	
		Stimulus	Number of participants	Stimulus	Number of participants
Device type	Smartphone		50		53
	Headphones		50		51

7.3.3 Procedure and measures

In figure 7.2, the flow of the entire survey can be seen. In this figure, the order of the questions and the different variables are visualized. In this section, this survey flow will be thoroughly explained. The setup of the entire survey including the options to select can be found in Appendix A.5.

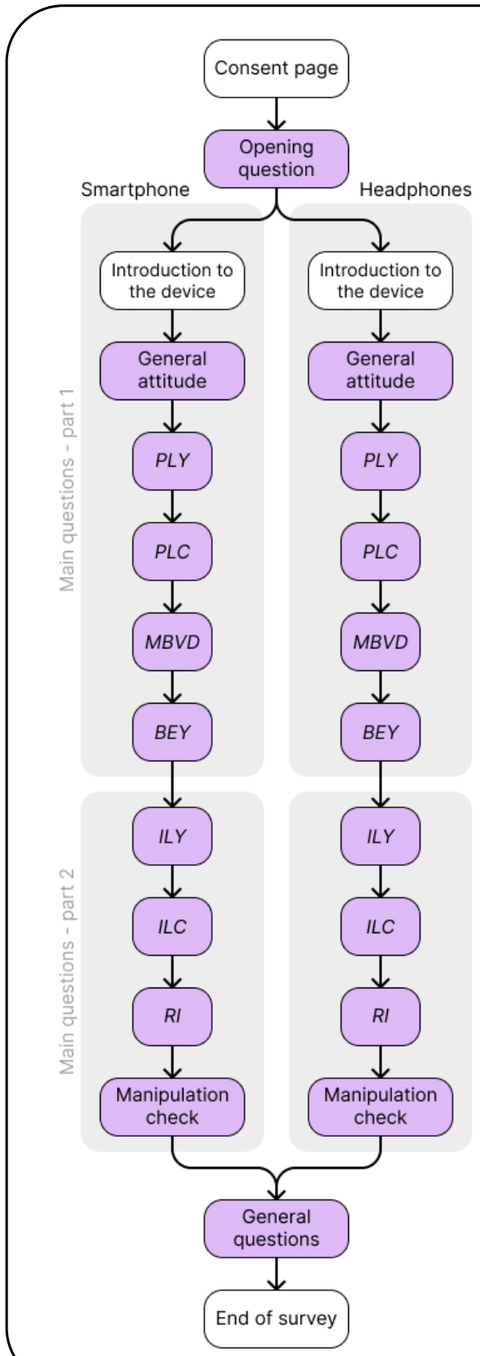
The survey consisted of two main parts respectively consisting of 7 and 8 lifetime-specific questions (including optional text boxes for explaining answers), and one section consisting of 7 general questions for determining the demographic characteristics of the participants. Prior to the main questions, an introductory question was asked to determine whether the participant should be placed in a smartphone group or in a headphones group; this procedure was applied because I assumed that more consumers own a smartphone than headphones, thus anyone with headphones should be placed in this group until the quota for these groups were met, to ensure sufficient representation and equal distribution.

The subsequent introduction of the stimulus device consisted of both text and images (and for the treatment group, a video to demonstrate the blinking of the LED ring). After that, the main questions of the survey asked participants about their expectations of the physical lifetime of the device, their intentions to keep using it, and their likeliness to replace it with an alternative.

In part 1 of the main questions, general attitude towards the device was measured using three 7-point likert scales, the first item ranging from 1 = "dislike" to 7 = "like", the second item ranging from 1 = "negative" and 7 = "positive" and the third item ranging from 1 = "bad" and 7 = "good". To evaluate the participants' predicted lifetime of the device, they were asked to indicate a rounded number of years that they expected the device to keep functioning properly (from now on referred to as *PLY* or Predicted Lifetime in Years), and to compare the expectation with their actual, currently owned device on a 7-point likert scale ranging from 1 = "much shorter" to 7 = "much longer" (from now on referred to as *PLC* or Predicted Lifetime Compared). The last two questions of section 1 measured the mental book value, by asking to what extent they felt that the device would have made its money worth after a use period of 2,5 years for the smartphone or 5 years for the headphones (from now on referred to as *MBVD* or Mental Book Value Depreciation), and after how many years they would feel that it has made all its money worth (from now on referred to as *BEY* or BreakEven in Years). The former was measured with a 7-point likert scale ranging from 1 = "it has made none of its money worth" to 7 = "it has made all of its money worth", and the latter required a rounded number.

In part 2, the questions were preceded with a brief clarification of product 'nature' and 'nurture', to ensure that the participant understands the difference between physical product life and their intentions to keep using it. The subsequent question asked them to indicate a rounded number of years that they expected to keep using the device (from now on referred to as *ILY* or Intended Lifetime in Years), and to compare their intention with this device to their actual, currently-owned device on a 7-point likert scale, again ranging from 1 = "much shorter" to 7 = "much longer" (from now on referred to as *ILC* or Intended Lifetime Compared). Next, they were asked about their likeliness to replace the stimulus device after 2,5 or 5 years of use (smartphone or headphones, resp.) on a 7-point likert scale ranging from 1 = "very unlikely" to 7 = "very likely" (from now on referred to as *RI* or Replacement Intention). The last question of this section was aimed to check whether manipulation had taken place; participants were asked how informed they felt about the lifetime of the device on a 7-point likert scale ranging from 1 = "badly informed" to 7 = "well informed".

The additional, general questions asked participants about their age, gender, nationality, innovativeness, environmental awareness and their usual product replacement behaviour, so that these variables could be measured as covariates. Participants' innovativeness was measured using four items taken from Manning, Bearden and Madden (1995), such as "*I'm continually seeking new product experiences*". Participants' environmental awareness was measured using four items from Inglehart's World Values Survey (Inlgehart, 1981), such as "*I choose household products that I think are better for the environment*". Scale items for both these measures were anchored by 1 = "completely disagree" to 7 = "completely agree". Lastly, average replacement behaviour was measured using a multiple-choice question with options ranging from "every half year" to "every >10 years".



Description	Question
	"Do you currently own/have you owned a smartphone or headphones?"
	"In general, how would you evaluate [the device]*?"*
Predicted lifetime in years	*"How many years would you expect* [the device] *to keep functioning properly?"*
Predicted lifetime compared	*"Compared to your own current* [device], *how long would you expect this one to keep functioning properly?"*
Mental book value depreciation	*"After* [2,5 or 5] *years or use, to what extent has* [the device] made its money worth?"
Breakeven point of mental book value	*"After how many years would* [the device] have made all its money worth?"
Intended lifetime in years	*"How many years would you expect to keep using* [the device]*?"*
Intended lifetime compared	*"Compared to your own current* [device], *how long would you expect to keep using this one?"*
Replacement intention	*"After* [2,5 or 5] *years of use, how likely are you to replace* [the device] *within the next year?"*
	"To what extent did you feel informed about [the device]*'s lifetime?"*
	Age, gender, nationality, innovativeness, environmental awareness, replacement behaviour

Figure 7.2. Overview of the different parts, measures and questions in the overall flow of the survey. The middle column clarifies the abbreviations.

7.4 Ethics

This project required human participants to fill out the survey. For good, ethically responsible human research, participants should feel safe, not be harmed and their privacy should be protected. Therefore, the following measures from the TU Delft Risk Planning Tool (TU Delft Integrity Office, 2024) were taken to mitigate any potential risk factors that may threaten the participants' well-being or privacy.

First of all, the survey exclusively required participants to process information in the form of text images, and answer multiple-choice, linear-scale or number-based questions. They were not asked to perform any tasks that can cause them physical or mental harm. Additionally, participants were not asked about sensitive or personal topics that may cause them to feel uncomfortable. The topic of product lifetime expectations was assumed to be sufficiently safe in that regard. The survey opened with a consent page, stating that participation is voluntary and that answer can never be wrong.

Second, the questions did not in any way refer to personal information of the participants, only to their lifetime expectations of the device in question, or to general demographic information of the participant, such as their age and gender (see the previous section 'Method and design of the experiment' for clarification). The only threat to participants' privacy was the presence of text boxes that provide the option to explain certain answers or make remarks at the end of the survey, which allow for filling in information that can be directly traceable. Participants were encouraged beforehand to not share any personal information in these boxes.

7.5 Main results

7.5.1 Main analysis: setup and included cases

For the main analysis, the hypotheses were tested using a multivariate ANCOVA executed in SPSS, with predicted lifetime, mental book value, intended lifetime and replacement intention as the DVs and the design intervention and device type as IVs. The following factors were also measured as covariates:

- Age
- Gender
- Nationality
- Innovativeness; a scale reliability test resulted in a satisfactory Cronbach's alpha of .83, which suggested that these items were internally consistent.
- Environmental awareness; a satisfactory Cronbach's alpha of .75 suggested that these items were internally consistent.
- Average product replacement behaviour

The test revealed that gender was no significant covariate, thus this variable was excluded from the analysis. Each of the upcoming paragraphs discusses the results for the four main variables and the covariates that may have influenced them. Elaborate explanations of the participants regarding their answers can be found in Appendix A.9.

Furthermore, boxplots revealed four cases where exceptionally large numbers for the *PLY, BEY and ILY* were indicated, which were thus identified as outliers. These cases were excluded from the analysis, which left 200 cases for use in the main analysis. Table 7.3 shows the division of these cases among the four groups, as well as their demographics.

Table 7.3. Division of the remaining cases among the four conditions along with their demographics, after exclusion of the outliers.

		Full sample	Smartphone, intervention	Smartphone, no intervention	Headphones, intervention	Headphones, no intervention
	N	200	52	49	49	50
Age	Mean	33.33	36.79	29.49	35.04	31.82
	S.d.	14.18	15.93	10.39	15.78	13.06
	Range	15 - 70	15 - 69	18 - 66	15 - 70	16 - 67
Gender	Male	51.0%	48.1%	36.7%	63.3%	56.0%
	Female	47.5%	51.9%	63.3%	34.7%	40.0%
	Other	0.5%	0%	0%	2.0%	0%
	Rather not say	1.0%	0%	0%	0%	4.0%
Nationality	Dutch	127	71.2%	22.4%	79.6%	80.0%
	Other from EU	23	11.5%	22.4%	6.1%	6.0%
	Outside of EU	50	17.3%	55.1%	14.3%	14.0%

Table 7.4. Results for the predicted lifetime in years (PLY) and compared to the participant's actual, currently owned devices (PLC). The significant values regard the overall effect of the intervention on the PLY and PLC.

	Smartphone		Headphones		
	Mean (intervention)	Mean (no intervention)	Mean (intervention)	Mean (no intervention)	*p*-value intervention
PLY	4.63	5.02	8.16	6.60	.20
PLC	4.31	4.92	4.33	4.60	.08

7.5.2 Main analysis: predicted lifetime

Hypothesis H1 reads: *"The design intervention has a positive influence on the predicted lifetime compared to when this intervention is absent."* The variables for predicted lifetime were the *PLY* and *PLC*.

The *PLY* of the smartphone was evaluated with mean scores of 4.63 years (s.d. = 1.69) with intervention and 5.02 years (s.d. = 2.20) without intervention. For the headphones, these means were respectively 8.16 years (s.d. = 3.70) and 6.60 years (s.d. = 2.21). The intervention was found to have no effect on the *PLY*, $F(1,191) = 1.66$, $p = .20$). The type of device was found to have a significant effect, $F(1,191) = 28.15$, $p = < .05$. There was also a significant interaction between intervention and device type for the predicted lifetime, $F(1,191) = 10.67$, $p < .05$. These results suggest that the presence of the design intervention may only influence consumers' predicted lifetime for headphones, which means that H1 is supported here. Overall, predicted lifetime was higher for headphones than for smartphones, which is logically plausible since headphones are generally expected to remain functional for longer (see chapter 4 - Framing the project). Additionally, average replacement behaviour was found to have a significant covariate relation with the *PLY*, $F(1,191) = 19.27$, $p < .05$.

The *PLC* of the smartphone was evaluated with mean scores of 4.31 (s.d. = 1.23) with intervention and 4.92 (s.d. = 1.53) without intervention. For the headphones, these means were respectively 4.33 (s.d. = 1.59) and 4.60 (s.d. = 1.09) . There was no main effect of the intervention on the *PLC*, $F(1,191) = 3.16$, $p = .08$). The type of device had no effect either, $F(1,191) = .001$, $p = .98$, neither was there an interaction between the intervention and the device type for the *PLC*, $F(1,191) = .11$, $p = .74$. These results suggest that, regardless of the type of device, the design intervention has not increased the participants' predicted lifetime when compared to their own device, which means that H1 is not supported here. Furthermore, the ANCOVA revealed that none of the covariates influenced this compared predicted lifetime. The bar charts in figures 7.3 and 7.4 show the differences of the *PLY* and *PLC* between the groups, table 7.4 shows an overview of the means and the significance of the effect of the intervention on those means.

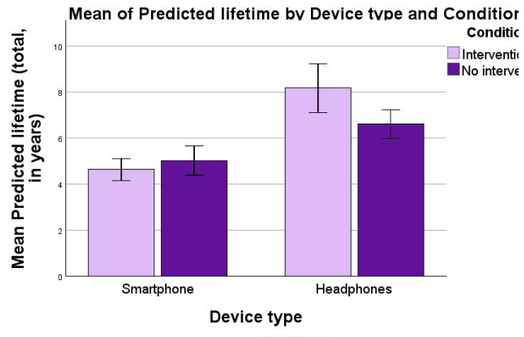


Figure 7.3. Means for the predicted lifetime in years (PLY) among the four experiment groups. Error bars represent a 95% confidence interval.

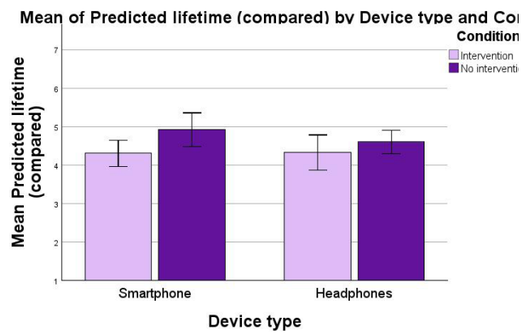


Figure 7.4. Means for the predicted lifetime compared to the participants' actual, currently owned devices (PLC) among the four experiment groups. Error bars represent a 95% confidence interval.

*Table 7.5. Results for the depreciation of the mental book value (*MBVD*) and the breakeven point in years (*BEY*). The significant values regard the overall effect of the intervention on the* MBVD *and* BEY*. The ** indicates a significant* p*-value of < .01.*

	Smartphone		Headphones		
	Mean (intervention)	Mean (no intervention)	Mean (intervention)	Mean (no intervention)	*p*-value intervention
MBVD	3.46	5.06	4.31	4.74	.01**
BEY	5.58	5.00	7.80	7.12	.52

7.5.3 Main analysis: mental book value

Hypothesis H2 reads: "*The design intervention has a positive influence on the mental book value compared to when this intervention is absent.*" The variables for mental book value were the *MBVD* and *BEY*.

The *MBVD* of the smartphone was evaluated with mean scores of 3,46 (s.d. = 1.72) with intervention and 5.06 (s.d. = 1.61) without intervention. For the headphones, these means were respectively 4.31 (s.d. = 1.88) and 4.74 (s.d. = 1.65). The main effect of the intervention on the *MBVD* was found to be significant, $F(1,191) = 7.17$, $p < .05$. The type of device also had a significant effect, $F(1,191) = 6.42$, $p < .05$. There was no interaction between intervention and device type for the *MBVD*, $F(1,191) = 1.11$, $p = .74$. These results suggest that, in the case of the smartphone, the design intervention has decreased the participants' feeling that the device has made its money worth after 2,5 years of use. This is consistent with H2. For headphones however, the intervention had no effect.

Additionally, the ANCOVA revealed that the following covariates had a significant influence on the *MBVD*:

- Participants' age; $F(1,191) = 9.72$, $p < .05$
- Participants' nationality; $F(1,191) = 11.34$, $p < .05$

The *BEY* of the smartphone was evaluated with mean scores of 5.58 years (s.d. = 2.64) with intervention and 5.00 years (s.d. = 2.18) without intervention. For the headphones, these means were respectively 7.80 years (s.d. = 3,10) and 7.12 years (s.d. = 3.31). There was no main effect of the intervention on the *BEY*, $F(1,191) = .42$, $p = .52$). The type of device was found to have a significant effect, $F(1,191) = 9.95$, $p < .05$. There was no interaction between intervention and device type for the *BEY*, $F(1,191) = 1.47$, $p = .23$. These results suggest that the presence of the design intervention has not effectively influenced the participants' expectation of breakeven point of the device's mental book value. However, it did end up higher for headphones than for smartphones, which is plausible for the same reason as with the *PLY*. Additionally, average replacement behaviour was found to have a significant covariate relation with the breakeven point of the mental book value, $F(1,191) = 19.09$, $p < .05$. The bar charts in figure 7.5 show the differences of the *MBVD* and *BEY* between the groups, table 7.5 shows an overview of the means and the significance of the effect of the intervention on those means.

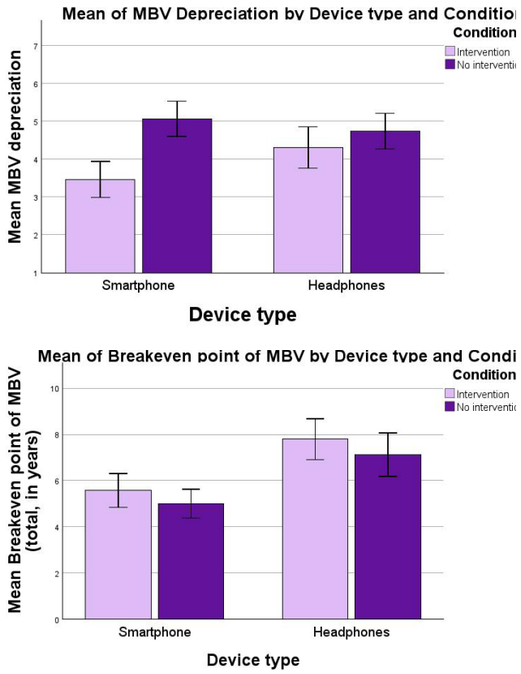


Figure 7.5. Above: means for the MBVD *after 2,5 or 5 years of use (respectively for the smartphone and headphones), among the four experiment groups. Below: means for the* BEY *among these groups. Error bars represent a 95% confidence interval.*

*Table 7.6. Results for the intended lifetime in years (*ILY*) and compared to the participants' actual, currently owned devices (*ILC*). The significant values regard the overall effect of the intervention on the* ILY *and* ILC*.*

	Smartphone		Headphones		
	Mean (intervention)	Mean (no intervention)	Mean (intervention)	Mean (no intervention)	*p*-value intervention
ILY	4.71	4.82	7.16	7.00	.36
ILC	4.38	4.80	4.59	4.10	.95

7.5.4 Main analysis: intended lifetime

Hypothesis H3 reads: "*The design intervention has a positive influence on the intended lifetime compared to when this intervention is absent.*" The variables for intended lifetime were the *ILY* and *ILC*.

The *ILY* of the smartphone was evaluated with mean scores of 4.71 years (s.d. = 1.94) with intervention and 4.82 years (s.d. = 2.13) without intervention. For the headphones, these means were respectively 7.16 years (s.d. = 3.24) and 7.00 years (s.d. = 3.00). No main effect of the intervention on the *ILY* was found, $F(1,191) = .85$, $p = .36$). The type of device was found to have a significant effect, $F(1,191) = 16.86$, $p = <.05$. Furthermore, there was no interaction between intervention and device type for the *ILY*, $F(1,191) = 1.90$, $p = .17$. These results suggest that the presence of the design intervention has not influenced the participants' intended lifetime, thus H3 was not supported here. However, similar to the predicted lifetime, intended lifetime was higher for headphones than for smartphones, which is plausible for the aforementioned reason. Additionally, participants' environmental awareness was found to have a significant covariate relation with the intended lifetime, $F(1,191) = 4.87$, $p < .05$, as well as average replacement behaviour, $F(1,191) = 32.14$, $p = <.05$.

The *ILC* of the smartphone was evaluated with mean scores of 4.38 (s.d. = 1.07) with intervention and 4.80 (s.d. = 1.46) without intervention. For the headphones, these means were respectively 4.59 (s.d. = 1.43) and 4.38 (s.d. = .99) . There was no main effect of the intervention on the *ILC*, $F(1,191) = .004$, $p = .95$). The type of device also had no effect, $F(1,191) = .005$, $p = .94$. Furthermore, no interaction was found between intervention and device type for the *ILC*, $F(1,191) = 1.07$, $p = .30$. These results suggest that, regardless of the type of device or presence of the design intervention, the intended lifetime when compared to participants' own devices remained roughly the same. This suggests that H3 was, again, not supported here. Additionally, the ANCOVA revealed that no other factors had a covariate relation with the compared intended lifetime. The bar charts in figures 7.6 and 7.7 show the differences of the *ILY* and *ILC* between the groups, table 7.6 shows an overview of the means and the significance of the effect of the intervention on those means.

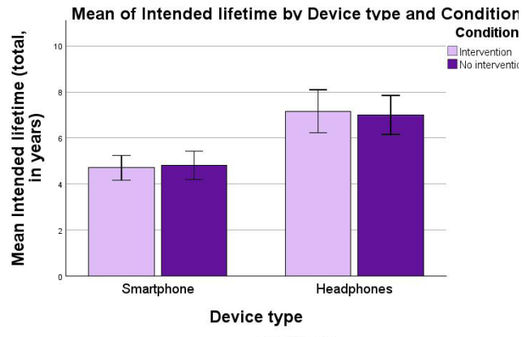


*Figure 7.6. Means for the intended lifetime in years (*ILY*) among the four experiment groups. Error bars represent a 95% confidence interval.*

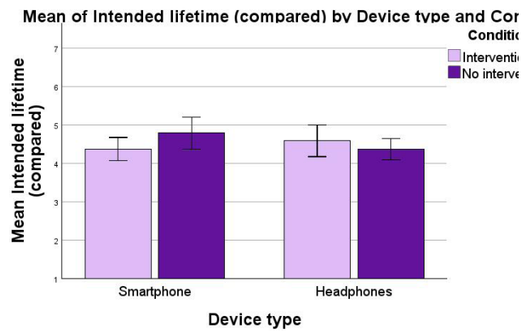


*Figure 7.7. Means for the intended lifetime compared to the participants' actual, currently owned devices (*ILC*) among the four experiment groups. Error bars represent a 95% confidence interval.*

*Table 7.7. Results for the replacement intention (*RI*). The significant values regard the overall effect of the intervention on the* RI*.*

	Smartphone		Headphones		
	Mean (intervention)	Mean (no intervention)	Mean (intervention)	Mean (no intervention)	*p*-value intervention
RI	2.63	3.59	2.96	3.24	.19

7.5.5 Main analysis: replacement intention

Hypothesis H4 reads: "The design intervention has a negative influence on the intention that the device is replaced, compared to when this intervention is absent." The variable for replacement intention was the *RI*.

In the smartphone group, the *RI* was evaluated with mean scores of 2.63 (s.d. = 1.74) with intervention and 3.59 (s.d. = 2.05) without intervention. For the headphones, these means were respectively 2.96 (s.d. = 1.85) and 3.24 (s.d. = 1.98). There was no main effect of the intervention on the *RI*, $F(1,191) = 1.72$, $p = .19$. The type of device did have a significant effect on the *RI*, $F(1,191) = 5.73$, $p < .05$. There was no interaction between intervention and device type for the *RI*, $F(1,191) = .04$, $p = .84$. Since the presence of the intervention did not significantly affect the replacement intention of the participants, hypothesis H4 was not supported.

Additionally, the ANCOVA revealed that the following covariates had a significant influence on the replacement probability:

- Participants' level of innovativeness; $F(1,191) = 12.40$, $p < .05$
- Average product replacement behaviour; $F(1,191) = 11.19$, $p < .05$

The bar charts in figure 7.8 show the differences of the *RI* between the groups, table 7.7 shows an overview of the means and the significance of the effect of the intervention on those means.

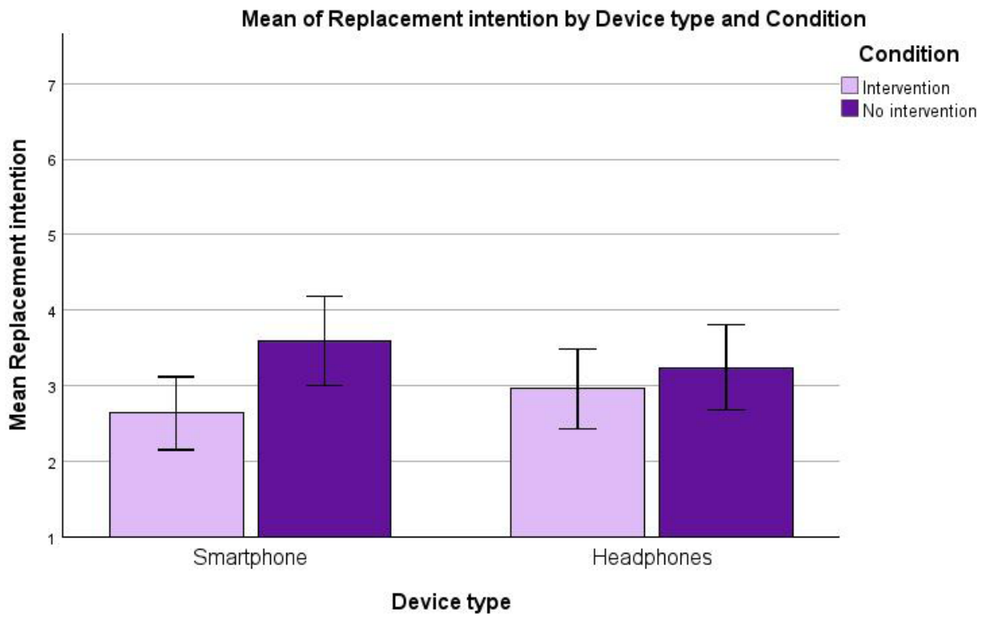


*Figure 7.8. Means for the participants' replacement intention (*RI*) among the four experiment groups. Error bars represent a 95% confidence interval.*

7.6 Additional data exploration

7.6.1 Distributions of the PLY, BEY and ILY

The results for the *PLY*, *BEY* and *ILY* were analysed in terms of their normal distribution and homogeneity of variance, to assess reliability of these measures. The normal distributions can be seen in figure 7.9. To quantify the normality, the z-scores for skewness and kurtosis were calculated and compared against known values for normal distribution (Field, 2009). In table 7.8, these z-scores can be seen. Those that were found to be significant, with a value greater than 1.96 at $p < .05$, include:

- For the smartphone with intervention, distributions of the *BEY* and *ILY* had positive skewness and kurtosis.
- For the smartphone without intervention, all distributions were positively skewed.
- For the headphones without intervention, distributions of the *BEY* and *ILY* were positively skewed.

Thus, except for the headphones with intervention, all distributions appeared to deviate from normality. Furthermore, Kolmogorov-Smirnoff tests performed for both the smartphone and headphones also resulted in significant outcomes for all three measures, which supports that these results were not normally distributed. Lastly, an analysis based on Levene's test revealed that the null hypothesis for homogeneity of variances was not rejected ($p < .05$) for all three measures, and thus, that the variances were significantly different. The outcomes of these tests suggest that the numbers of years as indicated by the participants regarding predicted lifetime, mental book value and intended lifetime led to less reliable results.

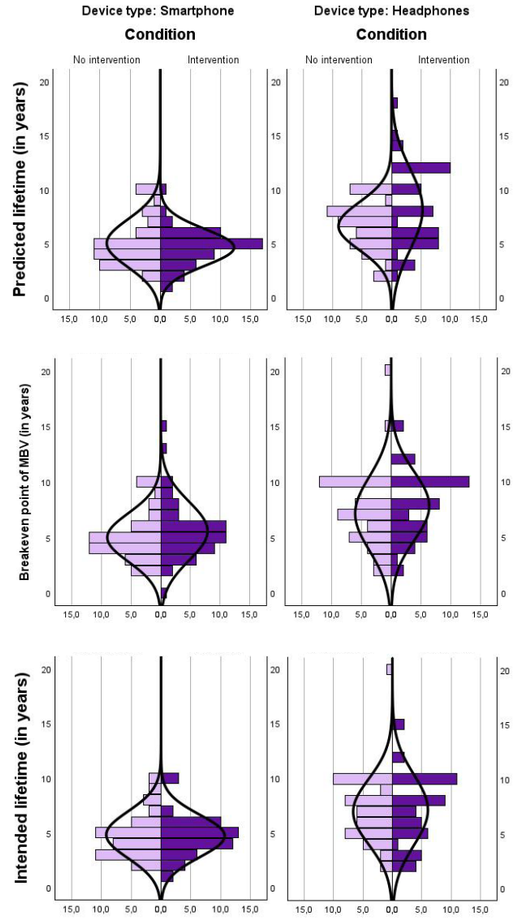


Figure 7.9. Normal distributions of the data for the PLY, BEY *and* ILY *(from top to bottom), among the smartphone (left) and headphones groups (right).*

Table 7.8. Z-scores for the PLY, *BEY and ILY among the different groups of the experiment.*

		Smartphone		Headphones	
		Intervention	No intervention	Intervention	No intervention
$z_{skewness}$	*PLY*	.61	2.86	1.35	-.80
	BEY	3.86	2.74	.66	3.67
	ILY	2.30	2.48	.82	4.47
$z_{kurtosis}$	*PLY*	1.89	.33	-.70	-.76
	BEY	4.71	.65	-.44	5.51
	ILY	2.42	.14	-.29	8.88

7.6.2 Divergent responses for the PLY

An additional remark regarding the *PLY* should be made about the cases where a number below the current age of the stimulus device was indicated. In total, 13 cases were identified where the smartphone was expected to physically last for 2 years or less, despite it already being 2,5 years old according to the survey's introductory text. Another 10 cases were identified for the headphones, with predicted lifetimes below its current age of 5 years. Logically speaking, this is not possible because the device still existed after those 2,5 or 5 years, so it cannot have physically lasted shorter than that timespan. Explanations for these 'illogical' responses could be that these participants did not properly read or understand the question, that they counted the years starting after the current age of the device instead of after the moment of purchase as it was intended by the question, or that they actually believed that the device would not last longer than its mentioned current age, and thus deliberately gave these responses. In most cases, the participants' additional explanations did not provide clarity on this matter. A separate ANCOVA without these 23 divergent cases did not result in radically different means or *p*-values for any of the study measures, although it could be argued whether the other participants did respond as intended to the number-based questions. The main analysis was therefore done with the 23 'illogical' cases included, but the data for the *PLY*, *BEY* and *ILY* may be considered less reliable, also given their non-normal distributions.

7.6.3 Manipulation check

An ANOVA was used to analyse the differences between the experiment groups in terms of how informed the participants felt about the lifetime of the stimulus device. This was done to check for successful manipulation, as its intended effect was based on informing consumers about the lifespan of their product. In the smartphone groups, participants scored a mean of 4.96 (s.d. = .24) with design intervention and 4.98 (s.d. = .25) without intervention. In the headphones groups these means were respectively 4.78 (s.d. = .25) and 3.76 (s.d. = .25). There was a significant main effect of the intervention on level of manipulation, $F(1,196) = 4.00$, $p < .05$ as well as of the type of device, $F(1,196) = 7.95$, $p < .05$. There was also a significant interaction effect between intervention and device type, $F(1,196) = 4.30$, $p < .05$. These results suggest that (1) among the two headphones groups, participants felt significantly more informed about the device's lifetime when the ring and widget were present, which was the expected effect. And (2) among the two smartphone groups, participants' feeling of being informed appeared roughly equal. Thus, the intervention only successfully established manipulation for headphones. Bar charts for the mean levels of manipulation can be seen in figure 7.10.

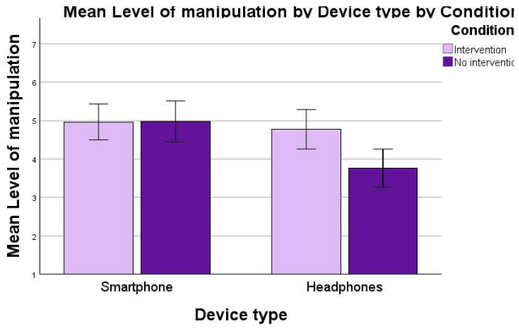


Figure 7.10. Means for the level of manipulation by the intervention among the four experiment groups. Error bars represent a 95% confidence interval.

7.6.4 Participants' attitude

The participants' general attitude towards the stimulus device was analysed to find out whether and how the addition of the design intervention affects consumers' liking of the device as a whole. The three likert scales that were used for this measure were found to be internally consistent; a scale reliability test resulted in a satisfactory Cronbach's alpha of .93. A univariate ANOVA with attitude as the DV and intervention and device type as the IVs revealed that participants evaluated the smartphone with means of 5.11 (s.d. = .17) with intervention and 5.95 (s.d. = .17) without intervention. Mean evaluations of the headphones were 5.05 (s.d. = 17) with intervention and 5.88 (s.d. = .17) without intervention. The presence of the intervention significantly affected these evaluations, $F(1,196) = 23.74$, $p < .05$. The type of device had no effect, neither was there an interaction between device type and intervention, which suggests that for both stimuli, the intervention had a negative effect on the participants' attitudes. Figure 7.11 shows the bar charts of the participants' general attitudes towards the stimulus devices.

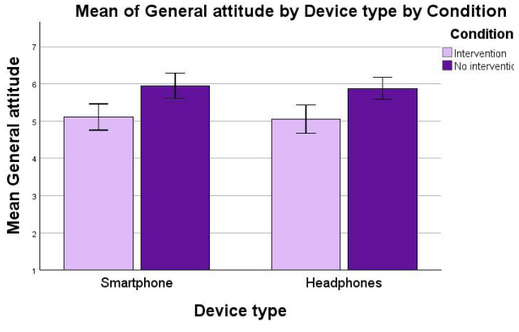


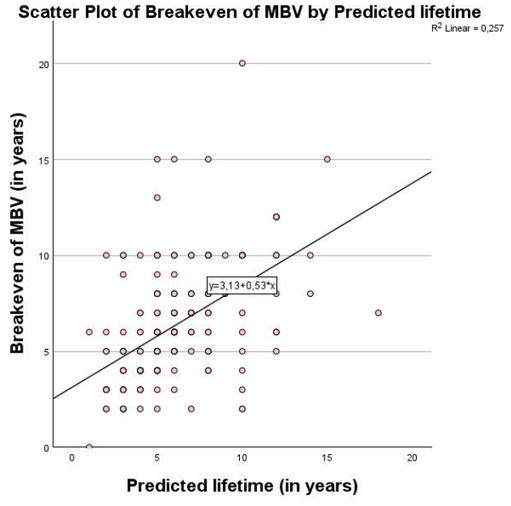
Figure 7.11. Mean general attitudes towards the stimulus device among the four experiment groups. Error bars represent a 95% confidence interval.

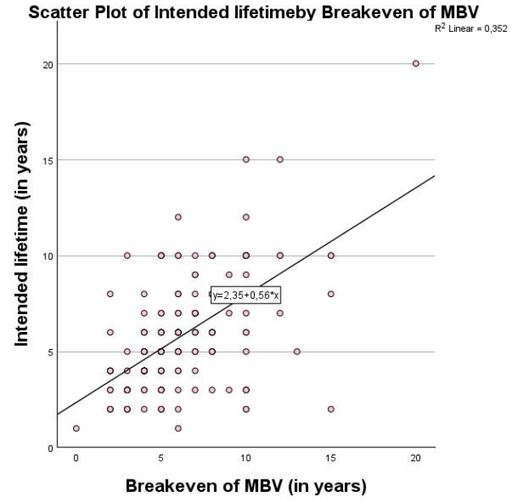
7.6.5 Test of the main theoretical model

A last additional data analysis was executed to find out to what extent the theorized relation between predicted lifetime, mental book value and intended lifetime was valid (for this theory, see chapter 2 – Literature study). For this analysis, the measures *PLY*, *BEY* and *ILY* were used. Although the data of the former three were non-normally distributed with significantly different variances, it could be valuable nonetheless to explore potential correlations between these factors. Three linear regression analyses were conducted with the following IVs and DVs, respectively:

- *PLY - BEY*
- *BEY - ILY*
- *PLY - ILY*

All tests had significant outcomes ($p < .05$) and a positive coefficient for the slope, which supports the assumptions that correlations exist between the predicted lifetime, the mental book value and the intended lifetime of consumers. The corresponding graphs for the three overall correlations can be seen in figure 7.12, the exact results are listed in table 7.9. Analyses of the correlations for the four conditions separately can be found in Appendices A.6 to A.8.





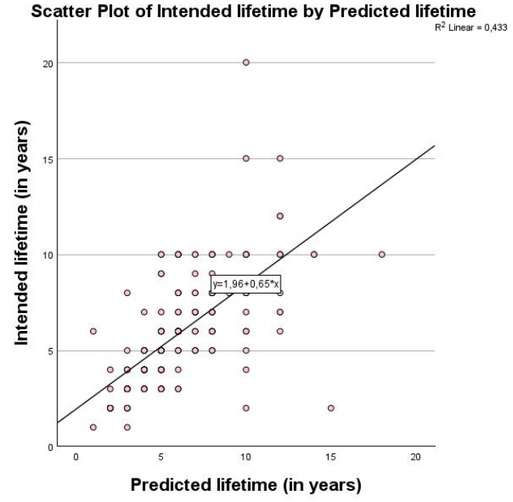


Figure 7.12. Scatterplots of the correlations between the PLY - BEY, *the* BEY - ILY *and the* PLY - ILY.

Table 7.9. Results of the analysed correlations between the PLY - BEY, *the* BEY - ILY *and the* PLY - ILY. *Note that these are the correlations over the entire research sample. The *** indicates a significant* p*-value of < .001.*

Correlation	Regression coefficient	Test result	*p*-value
PLY - BEY	.53	$F(1,198) = 68.62$	< .001***
BEY - ILY	.56	$F(1,198) = 107.33$	< .001***
PLY - ILY	.65	$F(1,198) = 151.13$	< .001***

8. Discussion

8.1 Discussion of the experiment results

8.1.1 Successful effect on MBVD and PLY

The intervention that was designed during this graduation project aimed to increase consumers' predicted and intended lifetime of electronic products, as well as the mental book value. It also aimed to decrease their intention to replace the product. The results of the experiment supported hypothesis H1 in the case of the predicted lifetime in years (*PLY*) of headphones, and hypothesis H2 in the case of the depreciation of the mental book value (*MBVD*) for the smartphone. In these specific cases, the presence of the design intervention had a significant positive influence on the predicted lifetime and the mental book value compared to when this intervention was absent. In the qualitative responses, several participants mentioned that the addition of the lighted ring and/or the widget provided them with better insights on the (remaining) lifespan of their stimulus device, which further strengthens the research outcomes. Of course, drawing conclusions about the *PLY* should be done with caution, since the analysis of the distribution and the variances of that particular measure implied a less reliable dataset.

8.1.2 Consumers struggle to estimate product lifetime

The other results for the predicted and intended lifetime, the breakeven point of the MBV and the replacement intention suggest that the design intervention may not influence consumer behaviour on these aspects. An overview of the possible explanations for the unsuccessful results can be seen in figure 8.1. The results for the *PLY*, *BEY* and *ILY* may be explained by the fact that consumers are suggested to experience much difficulty with estimating a product's potential lifespan in absolute numbers, as suggested in prior research by Van den Berge, Magnier & Mugge (2023A). They argued that expectations of product lifetime are based on the consumer's 'gut feeling', which would have resulted in the large variety of responses. Additionally, the notion that mental accounting would be part of consumers' heuristic decision-making strategies, and that they are by no means experts in this process (Thaler, 1980), may further explain the varying results of the experiment from this thesis. The fact that the participants could not physically hold the device during the experiment, but instead had to rely exclusively on images, may have strengthened their doubts as well. Besides, the main analysis resulted in a significant covariate effect of the participants' average replacement behaviour on the *PLY*, *BEY* and the *ILY*, which may also explain why the intervention had no effect on these measures.

8.1.3 Evaluation of the category

Another possible reason for the unsupported hypotheses, not only regarding the number-based measures but also the *PLC*, *MBVD*, *ILC* and *RI*, is that participants may have weighed their experiences with previously owned devices or the category in general more heavily in their assessments than the specific properties of the stimulus device. In several occasions, the qualitative responses from participants contained complaints about the poor qualities of modern electronic products in general. The earlier mentioned study also suggested that consumers value relevant and reliable information about the lifetime of products (Van den Berge, Magnier & Mugge, 2023A). Although those findings concern the potential of lifetime labels, the same motivations may be influential for the success of a lifetime tracker such as the intervention of this thesis. Furthermore, one individual complained about the rapid replacement cycles of today's consumer electronics as a result of the capitalist state of mind in our society, and pleaded for longer product lifespans. Despite only a fraction of the participants conveying these political convictions, they may still have influenced the results. It is possible that maturation has caused participants to misinterpret the question and elaborate on larger societal topics, but this could not be concluded from the data. The ANCOVA did indicate a covariate effect of participants' environmental awareness on the *ILY*, which supports how a consumer's product lifetime expectations may depend heavily on general beliefs.

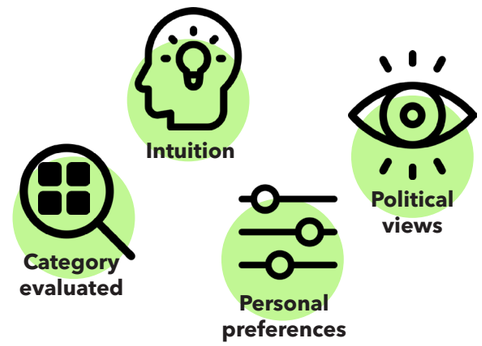


Figure 8.1. Factors that may have influenced the research results.

8.1.4 Personal preferences

In the case that the evaluation did specifically concern the stimulus device, personal preferences were relevant as well; for example, storage capacity or available charging cycles were mentioned as important factors for negatively evaluating the potential lifetime of the stimuli. Industry-average values were chosen to best represent their categories. However, participants that normally prefer high performance products may have assessed these stimuli to be inferior. The analysis did indicate that participants' innovativeness influenced their replacement intention as a covariate, however, the predicted and intended lifetime and mental book value were not affected by this. Furthermore, despite the efforts made to create a stimulus smartphone that cannot be related to an existing brand, a few individuals recognized the Apple model that was used to create the images, which appeared to affect their evaluations. A few also mentioned that the addition of the LED components negatively influenced their lifetime expectations, as they felt that it made the devices look more fragile. Some also expected it to require more energy for lighting the ring, which would negatively affect the battery life. Specific to the headphones, the fact that it operates via bluetooth and thus requires a battery was suggested to shorten the functional lifespan compared to these participants' own, wired headphones. Previous research has suggested that the use of a battery in a product does have an influence on its lifetime, with degradation of the battery being an importent cause for premature replacement of products (Woody et al., 2020).

9.2 Implications for research and management

This thesis contributes to research in the fields of responsible consumer behaviour and design. The results of the project have indicated a possible correlation between a product's mental book value and consumers' expectations of its lifetime. The outcomes have also generated new knowledge about the role that design can play in influencing those factors for the sake of reducing excessive consumption. It has become clear that showing the past years of ownership of a smartphone or headphones through a lighted ring on the device's exterior, combined with an informative widget, may elicit mixed opinions regarding its lifetime. However, the addition of this intervention could potentially have an influence on the mental book value and the predicted lifetime of some consumers, which can be considered a valuable insight to add to the existing knowledge on these topics. Moreover, the design process and the requirements for the intervention contain much information about the considerations that were made during this project. A designer who wants to develop a new proposition with a similar objective may take inspiration from this report.

OEMs and policymakers that want to adopt strategies to prolong the lifespans of the products that they make and sell, may learn from the knowledge of this thesis as well. Eventually, the intended outcome of this project is a reduction of sales of (electronic) products, which means that its implementation on these products should be accompanied by a more thorough business model redesign in order for it to become viable. As mentioned at the end of chapter 6, the intervention may be most successful in combination with other strategies as defined by Raworth (2018), such as being agnostic about growth. Policymakers and businesses that envision economies to thrive rather than to grow, may find more value in this intervention than those that want to maximize profit.

8. Discussion

8.3 Limitations and future research

This research had several limitations that may have influenced the results, and could be addressed by future studies. First, it may be valuable to test the effect of the intervention in a more realistic setting. Ideally, it would have been tested with actual devices that were owned by the participants for several years already, so that they could have had a more intuitive feeling about the mental book value of their device. Due to the lack of time and resources, the experiment now required participants to imagine having owned a device that was not theirs, with different specifications and prices, based solely on visual stimuli. This may have made it harder for them to estimate its potential lifetime and the breakeven point of its mental book value. This may have also influenced the results. If possible, future research could thus set up a more elaborate experiment, where participants would bring their own device. It may in that case be helpful to let them all bring the same type of device, such as a smartphone, and to recruit participants with roughly the same (frequent) product replacement behaviour, who at that point consider replacing that current device. After all, the composition of the experiment was based largely on chance.

Another limitation specifically regarding the intervention, is that it consisted of two parts, i.e. the ring and the widget. The reasons behind the evaluations of the ring in particular were very diverse in terms of lifetime expectations and attitude, as a considerable number of participants expected this feature to harm the device's lifetime rather than to benefit it. The widget seemed to have been met with overall more positive or neutral reactions. Hence, it could be interesting to find out which of these two aspects of the intervention has the strongest effect on consumers' lifetime expectations and replacement behaviour.

A recommendation for future research that is not linked to a specific limitation of the experiment of this thesis, would be to develop either of the discontinued concepts from the design phase into complete interventions, and conduct a study to test their effect on consumer's lifetime expectations and mental book value. Both the Tree Of Life as well as the Crystal Ball proposed some interesting approaches to informing consumers about the potential lifetime of their device, so finding out how effective these concepts are could make some valuable contributions to the current literature.

Additionally, the effect of the design intervention could be tested when implemented on other (up-to-date) devices, such as laptops, tablets, TVs or gaming consoles. The smartphones and headphones represented in the experiment were to a considerable extent chosen for the assumption that all participants would own at least one of these. The other examples, however, may be just as relevant in terms of the ecological damage of their production process and disposal. Since each of these examples also has both a physical body and an interface accessed through a screen, it is certainly possible to implement a lighted ring and/or a widget into their existing designs.

And lastly, it could be interesting for future studies to explore how design would be able to influence the factors from the main theoretical model that were to a lesser extent addressed by the intervention. The relational and financial costs (as part of Guiltinan (2010)'s psychological costs of scrapping), among others, were assumed to not be influenced during the experiment. The procedural costs, which were assumed to implicitly play a role in the participants' evaluations, were not tested for the sake of keeping the survey concise. And another factor from the theory, satiation, was not addressed in the experiment either, for the same reason. Conducting a study to test the effect on either of these factors may generate valuable knowledge.

9. Overall Conclusion

This graduation thesis aimed to explore how product design can increase consumers' lifetime expectations for electronic devices, with prevention of premature replacement of these products as the eventual desired outcome. The final design of the intervention tracks the years of ownership and shows these in the form of an LED ring. The widget that can be used with it, provides more information about the factors that influence the device's lifespan. According to the results of the experimental test, this intervention has had a significant negative effect on the depreciation of the mental book value of the stimulus smartphone, and a significant positive effect on the total predicted lifetime of the headphones. This suggests that the intervention may be able to successfully affect consumer replacement behaviour in these specific cases. However, the intervention had no significant outcomes for the other measures, which means that it did not influence all factors that were considered in this study. Overall, the intervention may be able to retain a higher mental book value, by convincing consumers that their device has not yet made all its money worth. It could then reduce the desire to replace it when it still functions without defects, although this effect may remain rather weak. It could also provide better insights for those consumers who desire more information about their device's lifetime. Those participants from the study that showed interest in this extra information, indicated that the ring and especially the widget can be valuable in that regard. The effectiveness of the intervention, however, appeared to not only depend on the type of product, but also on the consumer's personal beliefs regarding consumption, product qualities and repair.

Figure 9.1. The design intervention of this thesis is one promising step further in improving consumers' lifetime expectations towards more sustianable consumer behaviour.

10. Reflection on the project

In this chapter, I will share what I have learned from working on and completing this graduation thesis. In the box below are my brief, overall thoughts regarding the learning goals that I defined before the project kick-off, the additional paragraphs address my most valuable learnings in more detail.

Personal learning goal	Overall thoughts
Learn about responsible consumer behaviour and how to incorporate it into the design process	This field of research has sparked a lot interest in me, and despite it being a completely new world that I had to dive into, I'm proud of the amount of knowledge I have obtained on this topic.
Practice visual communication techniques, to compellingly show the problem and solution	I've learned much on how to convey messages through visual means, although I needed to be reminded sometimes by my supervisors to not stick with just writing text, which has always felt more intuitive to me.
Develop my competencies in organizing and structuring a full research project by myself	I have carried out all phases of this project separately for other projects, but now I got to experience sticking it all together and, with helpful feedback, manage the largest project I have ever worked on.
Further develop my data analysis skills	The endless clicking through SPSS has made me much more comfortable with processing and analyzing large datasets, although I believe I could have done more to explain certain unsuccessfull results of my intervention.
Improve skills in finding people to participate in a (research) project	Although I still felt slightly uncomfortable during the process of convincing family, friends and coworkers to participate in my experiment, I got to be more active in it and learned that it is easier than I expected.

The planning is not carved in stone

Prior to the start of this thesis, I wanted to put to practice everything I learned during my study programme about planning and managing a full research and design project. I was already familiar with the use of GANTT charts but I hoped to learn how I can use it effectively for such a large, individual project as a Master's graduation project. The very first feedback I received from Ruth, after enthusiastically setting up all my tasks and their estimated durations, was already very valuable; do not limit yourself with such a planning, but instead use it as a guideline for what needs to be done, and stay free to move around it. It was an important realization to have beforehand, that I may not always feel inspired to work on the task that I set for a particular day. Sometimes I may prefer creating a visual, even if my planning tells me I should write introductions and update my reference list. And sometimes I may feel more like doing 'brainless' tasks such as writing an appendix for the report rather than making important decisions for the project. I've been aware of this approach to planning throughout the process and it very much supported me to keep going. Being aware of the variety in the work to do and using that in adapting my planning every so often, has helped me to stay motivated throughout the project.

It is not just about writing a paper

Related to project planning was mapping out the different project phases that I wanted to go through. Ruth had to remind me a couple of times that it is not just about writing a scientific paper. Since I realized I was about to start a university-level graduation project, I took most of my previous knowledge on project planning from the SPD Research course, in which we had to do a literature study, conduct an experiment and then report and discuss the results. But of course, graduating at a design faculty means setting up a *design* project, not just an experiment. Giving the design phase more room in the overall planning was a crucial and teachable decision, as this phase ultimately made up more than a quarter of the project. Additionally, not just extracting knowledge from existing scientific papers but instead also exploring examples from practice as a source of inspiration, was another important shift in approach toward the planning of this project.

I cannot cover the entire VICI

The addition of the 'examples from practice' step to the process brings me to one of my most fundamental learning moments, which is about scope. It seems that at this particular point in the project, my curiosity got the better of me, and for a couple of weeks during this explorative phase, I lost track of the scope: lifetime expectations of products. I wondered off into other aspects of the wider topic of 'product lifetime extension', of which increasing consumers' lifetime expectations is one potential strategy, next to, for example, emotional value and epistemic value. My underlying assumption was that the prospect of more emotional or epistemic value may subconsciously increase a consumer's intention to keep using the product, thus increasing the intended lifetime, which is one type of lifetime expectation according to my literature study. However, I realized that these topics, apart from them not being part of my mentor's research, were more about implicitly nudging consumers' intentions rather than making them aware of these intentions and expectations regarding product lifetime. Since I had also included some strategies based on emotional and epistemic value in the ideation process, I rightly received the feedback that I should steer back towards lifetime expectation.

People genuinely want to help

The last learning goal that I set for myself, was to become more active and confident in recruiting participants for an experiment. Contacting people for such purposes has always made me feel like I'm begging for their help and bothering them in their busy schedules. However, talking a lot about my not-yet-finished work with acquaintances and relating with them about the topic has taught that people are often willing to participate. Sending so many WhatsApp messages to friends and coworkers, sharing links with anyone that seemed interested, and even leaving a QR code for the survey on the bar at my work, were things I had not done during earlier projects. The goal of reaching 200 participants, a new record for me, definitely pushed me to take these measures. It also helped to keep my requests manageable for them within their own free time, and to keep the information on the subject as understandable and relatable as possible. As soon as the information or the questions become too abstract, people may lose interest and drop out.

List of terms and abbreviations

BEY: The BreakEven point in Years of the mental book value (study measure). This measure was used to evaluate how many years in total the participants estimated that the stimulus device would have made all its money worth, counted from the moment of purchase.

Content finding: The second phase of a creative process according to the theory of iCPS, after the information finding phase. Content finding consists of three parts, namely problem finding, idea finding and solution finding. Each of these parts consists of a diverging, reverging and converging step.

Converging: The third and final step of a creative process, according to the theory of iCPS. When converging, the resource group assesses the clusters or posters from the reverging step against priorly established criteria.

Criterium: A type of objective in the form of a statement, that must be met by the end product of a design process. Criteria can be either qualitative (requirement or wish) or quantitative (wish).

Device: Electronic consumer product, such as a smartphone, headphones, laptop, TV or tablet.

Diverging: The first step of a creative process, according to the theoryof iCPS. When diverging, the resource group generates as many (crazy) ideas as possible while postponing judgment and building upon each other's ideas. Diverging is done during the problem finding, idea finding and solution phase.

Flexibility: One of the two qualities of a creative process, as opposed to fluency. Flexibility refers to the variety in the generated ideas.

Fluency: One of the two qualities of a creative process, as opposed to flexibility. Fluency refers to the amount and frequency of the generated ideas.

Idea finding: The second part of the content finding phase, in which large amounts of ideas are generated by the resource group with the help of different iCPS techniques.

Ideal lifetime: One of the three types of product lifetime expectations. It concerns the timespan across which the consumer would want a product to keep functioning without any functional defects according to their ideal scenario.

ILC: Intended Lifetime Compared (study measure). This measure was used to evaluate how long the participants expected themselves to keep using the stimulus device, compared to the actual device that they currently owned.

ILY: Intended Lifetime in Years (study measure). This measure was used to evaluate how many years in total the participants expected themselves to keep using the stimulus device, counted from the moment of purchase.

Impact: The sudden force exerted on and absorbed by a product when it is hit against a hard surface, for instance when it is dropped on the floor or thrown.

Information finding: The first phase of a creative process according to the theory of iCPS. During information finding, the resource group gathers as much data as possible about the context, target group and company to design for, and structures these data by mapping, visualizing or reporting it.

Intended lifetime: One of the three types of product lifetime expectations. It concerns the timespan across which the consumer expects to keep using a product before discarding (and replacing) it.

Lifetime expectations: The overall expectations of a consumer regarding the potential lifespan of a product. These expectations can be divided into predicted, intended and ideal lifetime.

MBV: The mental book value, which is the difference between the initial purchase price of a product and the cumulative beneficial experiences that a consumer has had with it.

MBVD: Mental Book Value Depreciation (study measure). This measure was used to evaluate the extent to which the participants felt that the stimulus smartphone has made its money worth after 2,5 years of use, or the headphones after 5 years.

Objective: The projection of desired future conditions or situations and their associated values. Objectives can be divided into objectives as such and criteria.

PaG: The Problem as Given, which is the initial version of the problem statement to design for, prior to the start of a creative process, according to the theory of iCPS. The PaG is usually defined by an external client, but for this graduation project, it was defined by me based on the outcomes of the literature study and examples from practice.

PaP: The Problem as Perceived, which is the problem statement resulting from activities in the problem finding part of a creative process, according to the theory of iCPS.

PLC: Predicted Lifetime Compared (study measure). This measure was used to evaluate how long the participants expected the stimulus device to keep functioning without any functional defects, compared to the actual device that they currently owned.

PLY: Predicted Lifetime in Years (study measure). This measure was used to evaluate how many years in total the participants expected the stimulus device to keep functioning without any functional defects, counted from the moment of purchase.

RI: Replacement intention (study measure). This measure was used to evaluate the likeliness that the participants would replace the stimulus smartphone within the next year, after 2,5 years of use, or the stimulus headphones after 5 years of use.

Predicted lifetime: One of the three types of product lifetime expectations. It concerns the timespan across which the consumer realistically expects a product to keep functioning without showing any functional defects.

Problem finding: The first part of the content finding phase, during which the resource group applies several iCPS techniques to rephrase the problem statement into a sentence that enough direction and inspiration for a fruitful idea finding phase.

Requirement: A type of criterium that the intermediate results and end product of a creative process must meet. Requirements are always qualitative criteria, i.e. they can only be answered by 'yes' or 'no', and they are usually referred to after the first selection of design directions.

Resource group: The collection of individuals who execute a creative process (using the iCPS techniques). For this graduation thesis, the resource group sometimes consisted of me and a fellow student, a class of BSc students or myself alone.

Reverging: The second step of a creative process, according to the theory of iCPS. When reverging, the resource group collects all outcomes from the diverging step and structures them, for example by creating clusters or making a poster.

Solution finding: The third and last part of the content finding phase, in which the resource group uses different iCPS techniques to build upon the outcomes of the idea finding part and develop a complete, final design.

Wish: a type of criterium that the end product of a design process must to some extent meet. Wishes can be either qualitative criteria, i.e. they can only be answered by 'yes' or 'no', or quantitative criteria, i.e. they allow for a ranking of the best alternatives. Wishes are usually referred to further into the process, after development of several concepts.

List of references

Anas, M. et al. (2023). Moving towards sustainable environment development in emerging economies: The role of green finance, green tech-innovation, natural resource depletion, and forested area in assessing the load capacity factor. *Sustainable Development, 32* (4), 3004-3020. Retrieved 5 December, 2024, from Wiley Online Library.

Android Help. (2024). *Free up space*. Retrieved 4 December, 2024, from https://support.google.com/android/answer/7431795?hl=en.

Bayus, B. L. (1988). Accelerating the Durable Replacement Cycle with Marketing Mix Variables. *Journal of Product Innovation Management, 5* (3), 216-226. Retrieved 13 June, 2024, from Wiley Online Library.

Brendborg, N. (2024). *Gewoontedieren – Waarom we altijd meer willen en wat we daartegen kunnen doen.* (L. Post-Oostenbrink, Trans.). Amsterdam: Uitgeverij Unieboek | Het Spectrum bv. Original work published 2024.

Bridgens, B., Lilley, D., Zeilig, H. & Searing, C. (2019). Skin deep. Perceptions of human and material ageing and opportunities for design. *The Design Journal, 22*, 2251-2255. Retrieved on 22 January, 2025, from Taylor & Francis Online.

Biesemans, J. (2016). Review RHA T20i: in-ears met filters. Retrieved 10 October, 2024, from https://hifi.nl/artikel/24543//Review-RHA-T20i-in-ears-met-filters.html.

Cooper, T. (2004). Inadequate life? Evidence of consumer attitudes to product obsolescence. *Journal of Consumer Policy, 27*, 421–449. Retrieved 20 September, 2024, from Springer.

Cooper, T. (2020). *Slower cycles: An essential characteristic of the circular economy*. The Circular Economy in the European Union, Springer, Cham (2020), 99-116. Retrieved 9 September, 2024, from Springer.

Cox, J., Griffith, S., Giorgi, S. & King, G. (2013). Consumer Understanding of Product Lifetimes. *Resources, Conservation and Recycling, 79* (2013), 21-29. Retrieved 11 June, 2024, from ScienceDirect.

Erat, S. & Bhaskaran, S. R. (2012). Consumer mental accounts and implications to selling base products and add-ons. *Marketing Science, 31* (5), 801-818. Retrieved 4 September, 2024, from Informs PubsOnLine.

Field, A. (2009). *Discovering Statistics Using SPSS*. London, Los Angeles, New Dehli, Singapore, Washington DC: SAGE Publications. Gourville, J. T. & Soman, D. (1998). Payment Depreciation: The Behavioral Effects of Temporally Separating Payments from Consumption. *Journal of Consumer Research, 25* (2), 160-174. Retrieved 4 September, 2024, from Oxford Academic.

Goldsmith, R. E., Reinecke Flynn, L. & Clark, R. A. (2014). The etiology of the frugal consumer. *Journal of Retailing and Consumer Services, 21* (2014), 175-184. Retrieved 22 January, 2025, from ScienceDirect.

Guiltinan, J. (2010). Consumer Durables Replacement Decision- making: An overview and research agenda. *Marketing Letters, 21*, 163–174. Retrieved 10 September, 2024, from Springer.

Gnanapragasam, A., Oguchi, M., Cole, C. & Cooper, T. (2017). Consumer expectations of product lifetimes around the world: a review of global research findings and methods. In: PLATE Proceedings, 2017. Retrieved 20 January, 2025, from IOS Press.

Heath, C. & Fennema, M. G. (1996). Mental Depreciation and Marginal Decision Making. *Organizational Behavior and Human Decision Processes, 68* (2), 95-108. Retrieved 12 September, 2024, from ScienceDirect.

Hou, C., Jo, M. & Sarigöllü, E. (2020). Feelings of Satiation as a Mediator between a Product's Perceived Value and Replacement Intentions. *Journal of Cleaner Production, 258*. Retrieved 11 June, 2024, from ScienceDirect.

Inglehart, R. F., (1981). *World Values Survey - Welcome to the World Values Survey site*. Retrieved 22 November, 2024, from https://www.worldvaluessurvey.org/wvs.jsp.

Jensen, P. B., Laursen, L. N. & Haase, L. M. (2021). Barriers to product longevity: A review of business, product development and user perspectives. *Journal of Cleaner Production, 313*. Retrieved 6 September, 2024, from ScienceDirect.

Kahneman, D. & Tversky, A. (1983). Choices, Values and Frames. *American Psychologist, 39* (4), 341–350. Retrieved 10 September, 2024, from APA PsychNet

Kumar, R., Saxena, A., Chawla, J & Kumar, V. (2024). Environmental Impacts of E-Waste: Pollution and Resource Depletion. *Sustainable Solutions for E-Waste and Development*. Retrieved 5 December, 2024, from IGI Global

Liu, K., Tan, Q., Yu, J. & Wang, M. (2023). A global perspective on e-waste recycling. *Circular Economy, 2* (1). Retrieved 21 June, 2024, from ScienceDirect.

Magnier, L. & Mugge, R. (2022). Replaced too soon? An exploration of Western European consumers' replacement of electronic products. *Resources, Conservation & Recycling, 185* (2022). Retrieved 11 June, 2024, from ScienceDirect.

Manning, K. C., Bearden, W. O. & Madden, T. J. (1995). Consumer innovativeness and the adoption process. *Journal of Consumer Psychology, 4* (4), 329-346. Retrieved 22 November, 2024, from ScienceDirect.

Ng, A. W. Y. & Chan, A. H. S. (2018). Color associations among designers and non-designers for common warning and operation concepts. *Applied Ergonomics, 70*, 18-25. Retrieved 15 January, 2025, from ScienceDirect.

Nishijima, D. & Oguchi, M. (2023). Measuring product lifetime extension potential by increasing the expected product lifetime: Methodology and case study. *Business Strategy and the Environment, 32* (4), 1218-1231. Retrieved on 16 September, 2024, from Wiley Online Library.

Oguchi, M., Tasaki, T., Daigo, I., Cooper, T., Cole, C. & Gnanapragasam, A. (2016). Consumers' expectations for product lifetimes of consumer durables. Electronics Goes Green 2016+ (1-6). Berlin, Germany: IEEE.

Okada, E. M. (2001). Trade-ins, Mental Accounting, and Product Replacement Decisions. *Journal of Consumer Research, 21* (4), 433-446. Retrieved 11 June, 2024, from Oxford Academic.

Park, M. B. (2009). Product Life: Designing for Longer Lifespans. [Doctoral thesis, Kingston University London].

Perzanowski, A. (2021). Consumer Perceptions of the Right to Repair. *Indiana Law Journal, 96* (2), 360-294. Retrieved on 17 January, 2025, from Maurer School of Law Digital Repository.

Prelec, D. & Loewenstein, G. (1998). The red and the black: Mental accounting of savings and debt. *Marketing Science, 17* (1), 4-89. Retrieved 4 September, 2024, from Informs PubsOnLine.

Raworth, K. (2017). *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Dublin: Random House Business Books.

Reddit. (2024). *How long does your headphone last for you? 2 years? 5 years? or even more?* Forum topic initiated by user 'RazInHigh0710'. Retrieved 21 November, 2024, from https://www.reddit.com/r/headphones/comments/1as9p7j/how_long_does_your_headphone_last_for_you_2_years/?rdt=34525.

Roozenburg, N. F. M. & Eekels, J. (2016). *Productontwerpen, structuur en methoden*. Amsterdam: Boom.

Sarigöllü, E., Hou, C. & Ertz, M. (2020). Sustainable product disposal: Consumer redistributing behaviors versus hoarding and throwing away. *Business Strategy and the Environment, 30* (1), 340-356. Retrieved 9 September, 2024, from Wiley Online Library.

List of references

Schifferstein, H.N. J., Mugge, R. & Hekkert, P. (2004). Designing consumer-product attachment. In D. McDonagh, P. Hekkert, J. Van Erp & D. Gyi (Eds.), Design and Emotion: the Experience of Everyday Things (pp. 378-383). London, New York: Taylor & Francis.

Scott, M. J. (2020). Promoting product longevity. Report for the Policy Department for Economic, Scientific and Quality of Life Policies. Retrieved 5 December, 2024, from the Archive of European Integration (AEI).

Sound Is Working. (2023). *How Often Should You Replace Headphones?*. Blog from unknown writer. Retrieved 21 November, 2024, from https://soundisworking.co.uk/how-often-replace-headphones/.

Spinney, J., Burningham, K., Cooper, G., Green, N. & Uzzell, D. (2012). 'What I've found is that your related experiences tend to make you dissatisfied': Psychological Obsolescence, Consumer Demand and the Dynamics and Environmental Implications of De-stabilization in the Laptop Sector. *Journal of Consumer Culture, 12* (3), 347–370. Retrieved 11 June, 2024, from Sage Journals.

Stimmel Law. (2024). *The Basics of Warranties*. Retrieved 9 October, 2024, from https://www.stimmel-law.com/en/articles/basics-warranties

Thaler, R. (1980). Toward a Positive Theory of Consumer Choice. *Journal of Economic Behavior and Organization, 1* (1), 39-60. Retrieved 17 September, 2024, from ScienceDirect.

Thukral, S., Shree, D. & Singhal, S. (2022). Consumer behaviour towards storage, disposal and recycling of e-waste: systematic review and future research prospects. *Benchmarking: An International Journal, 30* (3), 1021-1072. Retrieved 9 September, 2024, from Emerald Insight.

TU Delft Integrity Office. (2024). *Managing Risk in Human Research*. Retrieved 14 October, 2024, from https://www.tudelft.nl/en/about-tu-delft/strategy/integrity-policy/human-research-ethics/research-design-2-risk-planning-session.

Van Boeijen, A. G. C., Daalhuizen, J. J., Zijlstra, J. J. M. & Van der Schoor, R. S. A. (eds.) (2013). *Delft Design Guide*. Amsterdam: BIS Publishers.

Van den Berge, R., Magnier, L. & Mugge, R. (2021A). Too good to go - Consumers' Replacement Behaviour and Potential Strategies for Stimulating Product Retention. *Current Opinion in Psychology 2021, 39*, 66–71. Retrieved 7 June, 2024, from ScienceDirect.

Van den Berge, R., Magnier, L. & Mugge, R. (2021B). A poorly educated guess: consumers' lifetime estimations, attitudes towards repairability, and a product lifetime label. In: Paper presented at the Plate Conference, online.

Van den Berge, R., Magnier, L. & Mugge, R. (2023A). Until death do us part? In-depth insights into Dutch consumers' considerations about product lifetimes and lifetime extension. *Journal of Industrial Ecology, 27* (3), 908-922. Retrieved 7 June, 2024, from Wiley Online Library.

Van den Berge, Magnier & Mugge (2023B). Sparking the Repair "Can-Do" Attitude. *International Journal of Design, 17* (3), 25-39. Retrieved 7 June, 2024, from ResearchGate.

Van Nes, N. & Cramer, J. (2005). Influencing product lifetime through product design. *Business Strategy and the Environment, 14* (5), 286-299. Retrieved 3 September, 2024, from Wiley Online Library.

Vishwakarma, A., Kanaujia, K. & Hait, S. (2023). Global scenario of E-waste generation: Trends and future predictions. *Global E-Waste Management Strategies and Future Implications, 2023*, 13-30. Retrieved 10 September, 2024, from ScienceDirect.

White, P., Fellmeth, E. & Robinson, D. (2021). US Legal Frameworks: A Path to Product Longevity? *Journal of Sustainability Research, 3* (3). Retrieved 5 December, 2024, from Hapres.

Woody, M., Arbabzadeh, M., Lewis, G. M., Keoleian, G. A. & Stefanopoulou, A. (2020). Strategies to limit degradation and maximize Li-ion battery service lifetime - Critical review and guidance for stakeholders. *Journal of Energy Storage, 28* (2020), 101-231. Retrieved 20 January, 2025, from ScienceDirect.

Yu, J., Williams, E. & Ju, M. (2010). Analysis of material and energy consumption of mobile phones in China. *Energy Policy, 38* (2010), 4135–4141. Retrieved 6 November, 2024, from ScienceDirect.

Images

Ad Forum. (2017). *Miele - "Partner"*. Retrieved on 9 October, 2024, from https://www.adforum.com/creative-work/ad/player/31662/partner/miele.

Ad Gallery. (2017). *Le Creuset Own Your Cookware For A Lifetime Ad*. Retrieved 9 October, 2024, from https://www.advertgallery.com/newspaper/le-creuset-own-your-cookware-for-a-lifetime-ad/.

AIAIAI. (2024). *TMA-2*. Retrieved 10 October, 2024, from https://aiaiai.audio/headphones/tma-2.

Bello Moto. (2024). *1951 Vespa Faro Basso V30 (BM408)*. Retrieved 14 October, 2024, from https://www.bellomoto.com/1951-vespa-faro-basso-v30-bm408.

Buy Leather Online Italy. (2024). *"Old England" - Distressed Upholstery Leather*. Retrieved 11 October, 2024, from https://buyleatheronline.com/en/upholstery-leather/448-4010-old-england-premium-distressed-upholstery-leather.html

Carton, B., Mongardini, J. & Li, Y. (2018). *A New Smartphone for Every Fifth Person on Earth: Quantifying the New Tech Cycle*. IMF Working Paper. Retrieved 15 January, 2025, from Semantic Scholar.

ColorWare. (2024). *Logitech G502 X Plus Mouse*. Retrieved 10 October, 2024, from https://www.colorware.com/p-1412-logitech-g502-x-plus-mouse.aspx?c=variant-149*l4l-9qaf*l4n-9qc8*l4p-9qen*l4r-9qgb*l4t-9qh9*l4v-9qhe*l4x-9qjj.

Coolblue. (2024). *Coolblue – Anything for a smile*. Retrieved 9 October, 2024, from https://www.coolblue.nl/en.

Davenport, C. (2024). *I used an original iPod in 2024, and it was pretty fun*. Retrieved 14 Oktober, 2024, from https://www.spacebar.news/original-ipod-hands-on-2024/.

Dopper. (2024). *Personalize your Dopper bottle.* retrieved 9 October, 2024, from https://www.dopper.com/products/personalise-a-bottle.

Framework. (2024). *Fix Consumer Electronics.* Retrieved 10 October, 2024, from https://frame.work/nl/en/about#what-we-re-fixing.

FREITAG. (2024). *Online store*. Retrieved 9 October, 2024, from https://freitag.ch/en_NL/products.

Gazeta. (2023). *Atomic Heart Xbox Series X*. Retrieved 9 October, 2024, from https://www.gazeta.ru/tech/news/2023/04/07/20159953.shtml.

Grado Labs (2024). *Headphones*. Retrieved 9 October, 2024, from https://gradolabs.com/pages/headphones.

Intel. (2017). *How to Build a Gaming PC*. Retrieved 10 October, 2024, from https://www.intel.com/content/www/us/en/gaming/resources/how-to-build-a-gaming-pc.html.

Kia Media. (2018). *Kia Motors Europe produces three-millionth car with industry leading seven-year warranty*. Retrieved 10 October, 2024, from https://press.kia.com/ie/en/home/media-resouces/press-releases/2018/Kia_with_industry_leading_seven-year_warranty.html.

LeFort, N. (2024). *Bushcrafters & Survivalists Unite, This Gnarly Knife Is Just for You: Benchmade P.S.K. Review*. Retrieved 11 October, 2024, from https://gearjunkie.com/knives/benchmade-psk-review.

List of references

Leica. (2024). *Leica M-Series*. Retrieved 10 October, 2024, from https://leica-camera.com/en-SE/photography/m#.

Lightroom-Photoshop Tutorials. (2024). *Different Types of Lenses | A Complete Guide to Types and Use Cases of Camera Lenses*. Retrieved 14 October, 2024, from https://lightroom-photoshop-tutorials.com/different-types-of-lenses/.

LongTime Label. (2024). *LONGTIME®, a label for products designed to last*. Retrieved 10 October, 2024, from https://longtimelabel.com/en/.

MacRumors. (2023). *MacRumors Giveaway: Win Custom-Colored AirPods or AirPods Pro From ColorWare*. Retrieved 9 October, 2024, from https://forums.macrumors.com/threads/macrumors-giveaway-win-custom-colored-airpods-or-airpods-pro-from-colorware.2386818/.

Marchesi, N. (2018). *Toyota Hilux Print Campaign*. Retrieved 28 November, 2024, from https://www.behance.net/gallery/60503449/TOYOTA-HILUX-PRINT-CAMPAIGN.

Motorcars Volvo. (2024). *Volvo Vehicle Longevity: How Long Do Volvo's Last*. Retrieved 10 October, 2024, from https://www.motorcarsvolvocars.com/how-long-volvo-vehicles-last.htm.

Porsche. (2023). *A brief history of the Porsche 911*. Retrieved 10 October, 2024, from https://www.porsche.com/stories/innovation/a-brief-history-of-the-porsche-911/.

Proper Honest Tech. (2023). *18 Settings that have almost DOUBLED my iPhone Battery life!* [Video]. Youtube. Retrieved 9 October, 2024, from https://www.youtube.com/watch?v=PsKSWAJzpbg.

Prusa. (2024). *Original Prusa 3D printers directly from Josef Prusa*. Retrieved 9 October, 2024, from https://www.prusa3d.com/.

Reid, A. (2018). *VW restores woman's daily-driver Beetle after it hits 350,000 miles*. Retrieved 11 October, 2024, https://www.northernnews.ca/auto-news/news/vw-restores-womans-daily-driver-beetle-after-it-hits-350000-miles.

RHA. (2024). *Tuning filters*. Retrieved 10 October, 2024, from https://www.rha-audio.com/headphones/accessories/tuning-filters.

Rushfaster. (2024). *Black Ember Modular Water Bottle Holder*. Retrieved 10 October, 2024, from https://rushfaster.com.au/products/black-ember-modular-water-bottle-holder.

The Drive. (2021). *Ad of the Week: The Amazing, Long-Lasting Volvo*. Retrieved 9 October, 2024, from https://www.thedrive.com/news/38492/ad-of-the-week-the-amazing-long-lasting-volvo.

The Radavist. (2016). *Mission Workshop: the R6 Arkiv Modular Backpack is Even Better*. Retrieved 10 October, 2024, from https://theradavist.com/mission-workshop-the-r6-arkiv-modular-backpack-is-even-better/.

University of Leeds. (2025). *What is Doughnut Economics?* Retrieved 15 January, 2025, from https://pg-online.leeds.ac.uk/blogs/what-is-doughnut-economics/

VanHulley. (2024). *Producten*. Retrieved 9 October, 2024, from https://www.vanhulley.com/shop/.

Wilmar Inc. (2023). *6 Reasons Why Accurate Odometer Readings are Key to Fleet Management*. Retrieved 9 October, 2024, from https://www.wilmarinc.com/blog/6-reasons-why-accurate-odometer-readings-are-key-to-fleet-management.

Zona C. (2020). *Duracell commercial - Duracell Running Bunny* [Video]. Screenshot from Youtube. https://www.youtube.com/watch?v=pLOgN5k-HoEQ.

Appendices

Contents

Click any of the chapters to jump to the corresponding page.

A.1 Approved project brief

DESIGN FOR our future

TU Delft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Ruth Mugge

Digitally signed by Ruth Mugge
Date: 2024.09.11 10:04:25 +02'00'

Name Ruth Mugge Date 11 Sep 2024 Signature

CHECK ON STUDY PROGRESS

To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total ____ EC

Of which, taking conditional requirements into account, can be part of the exam programme ____ EC

★	YES	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Rik Ledoux
2024.09.13 09:10:32 +02'00'

Name Rik Ledoux Date 13 Sep 2024 Signature

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique von Morgen

Digitally signed by Monique von Morgen
Date: 2024.10.08 11:09:58 +02'00'

Name Monique von Morgen Date 8 Oct 2024 Signature

A.1 Approved project brief

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Exploring how design can extend consumers' expected lifetime of electronic products.

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Overconsumption and early replacement of electronic products are generally known to cause severe damage for the natural environment, as it results in an increased demand for materials and a larger flow of solid waste. Each year, more than 50 million tons of electronics are disposed of and end up as landfill, and this number is found to grow with 3 to 5% per year [1]. It is therefore very relevant for the future of our planet to find out what product developers can do to stimulate consumers to postpone replacement and prolong the first life of their electronic products. For consumers, it is also beneficial to save money and being happy with their product for a longer period of time. Designers can contribute in reversing the throwaway society, thereby reducing the tension that is put on the natural environment. This should ensure that future generations can live in a clean environment, without being threatened by natural disasters as a result of climate change.

An opportunity is to change consumers' expectations of an electronic product's lifetime, so that they might retain it for a longer period and postpone its disposal. There's a number of factors that influence the trade-off a consumer makes when they're considering to replace their (electronic) product - see also the image on the next page [2]. Using these factors in the design process is expected to result in more responsible consumer behavior. A limitation may be how product developers can still survive when their products are sold less frequently, as consumers use their products over a longer period before replacing them.

[1] Liu et al. (2023). A global perspective on e-waste recycling. *Circular economy, 2*. Retrieved on 21-06-24 from ScienceDirect.

[2] Van den Berge, R., Magnier, L. & Mugge, R. (2020). Too Good to go? Consumers' replacement behavior and potential strategies for product retention. *Current Opinion in Psychology, 2021* (39), 66-71.

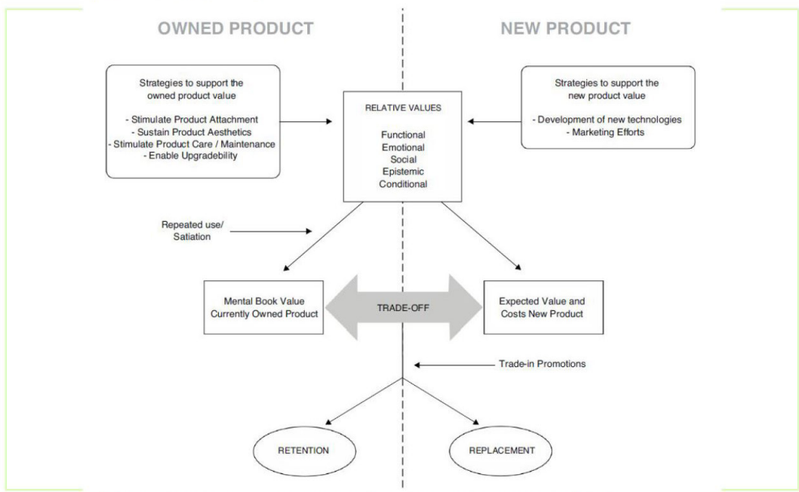


image / figure 1 The factors that influence the decision whether to retain or replace a product [2].

A.1 Approved project brief

DESIGN for our future

Personal Project Brief – IDE Master Graduation Project

TU Delft

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Consumers tend to mentally 'write off' a product's value, which is based on the initial purchase price. I want to find out how design can help to extend an electronic product's lifetime, and specifically I want to create knowledge on how a product's design can decrease the rate at which this 'mental book value' drops in the mind of the consumer during the first use phase. This mental depreciation is influenced by the product's lifetime expected by the consumer at the moment of purchase, as this expected lifetime plays a role in the consumer's perception of whether the product has made their money worth [3]. At that point, the mental book value has dropped to a point where it no longer outweighs the value of a replacing model, and thus has reached a break-even point. A product that is designed to extend its lifetime as expected by the consumer, may postpone that break-even point, and therefore encourage the consumer to prolong the use phase. So the challenge is to find out how the design process can accomplish this. I think this knowledge can contribute to more responsible product development and consumption.

[3] Okada, E. M. (2001). Trade-ins, mental accounting and product replacement decisions. *Journal of Consumer Research, 27*.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for.
Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence)
As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Validate two possible design strategies to extend the expected lifetime of electronic products for consumers, in order to postpone early product replacement and thus, reduce overconsumption.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

To start off, I want to do a literature study for a good theoretical basis, followed by one or more hypotheses that I can test. The factors that will play an important role are the expected product lifetime, the intention to replace it after a specific use period, and the mental book value. Next, I want to indentify design interventions that can influence consumers' expected lifetime of an electronic product; this more creative phase will be structured based on the triple-diamond from the theory of ICPS [4]. Depending on the outcome, I then want to test which intervention works best - or in which case one specific intervention works best. I want to measure how the participants' intention to replace a certain electronic product changes as a result of the design intervention(s). It would also be interesting to ask the participants some questions, for example if they feel like the product has gotten their money worth. From the results of this study, I hope to learn what would be the most promising design solution for the goal as described in the problem definition.

[4] Heijne, K. & Van der Meer, H. (2019). *Road Map for Creative Problem Solving Techniques*. Amsterdam: Boom.

Project planning and key moments

To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a ***kick-off meeting, mid-term evaluation meeting, green light meeting*** *and* ***graduation ceremony****. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief. The four key moment dates must be filled in below

Kick off meeting	2 sept 2024
Mid-term evaluation	25 okt 2024
Green light meeting	20 dec 2024
Graduation ceremony	31 jan 2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

With this project, I hope to learn a lot about responsible consumer behaviour, and how to incorporate it into the design process, as I consider it to be a very relevant topic. I realise there's still a long way to go in shifting our societal throwaway mindset, but it's a fulfilling prospect to be part of any effort in doing so. I wish to deepen this interest, and with a result in this topic, hopefully it opens a door for potential work. I would also love to practice some of the visual communication techniques that learned during master electives, to compellingly show the problem and solution of my project. Besides, I hope to develop my competencies in organizing and structuring a full research project by myself, and as a part of that, improve my skills in finding people to participate in a (research) project, as I haven't been the best at recruiting participants in past projects. Lastly, I hope to further develop my data analysis skills.

A.2 Detailed structure and results of the creative exercises

Duo exercise 1. Flower Association

During the Flower Association activity, me and my fellow student wrote the Problem as Perceived (PaP) in the middle of a large flip-over sheet; the PaP was at that point still focused on smartphones exclusively. The purpose of this activity was to write down any initially inspired thoughts on this question, and thus 'purging' any assumptions that we had.

The procedure was to put those associative thoughts into leaves around the question in the middle, creating the shape of a flower (if you use some imagination). New associations that came with these thoughts were formed as smaller leaves. Thoughts were allowed to comprise concrete solutions to the problem, as well as more conceptual associations. Figure A.1 shows the results of this process. At the end of this activity, we concluded that the four main themes that stood out were:

- Thrill seekers/dopamine junkies;
- Adding functions later;
- Unique generations of models, and;
- Not used to (bored with) what you have

These four themes were used for the subsequent activity: Brainwriting.

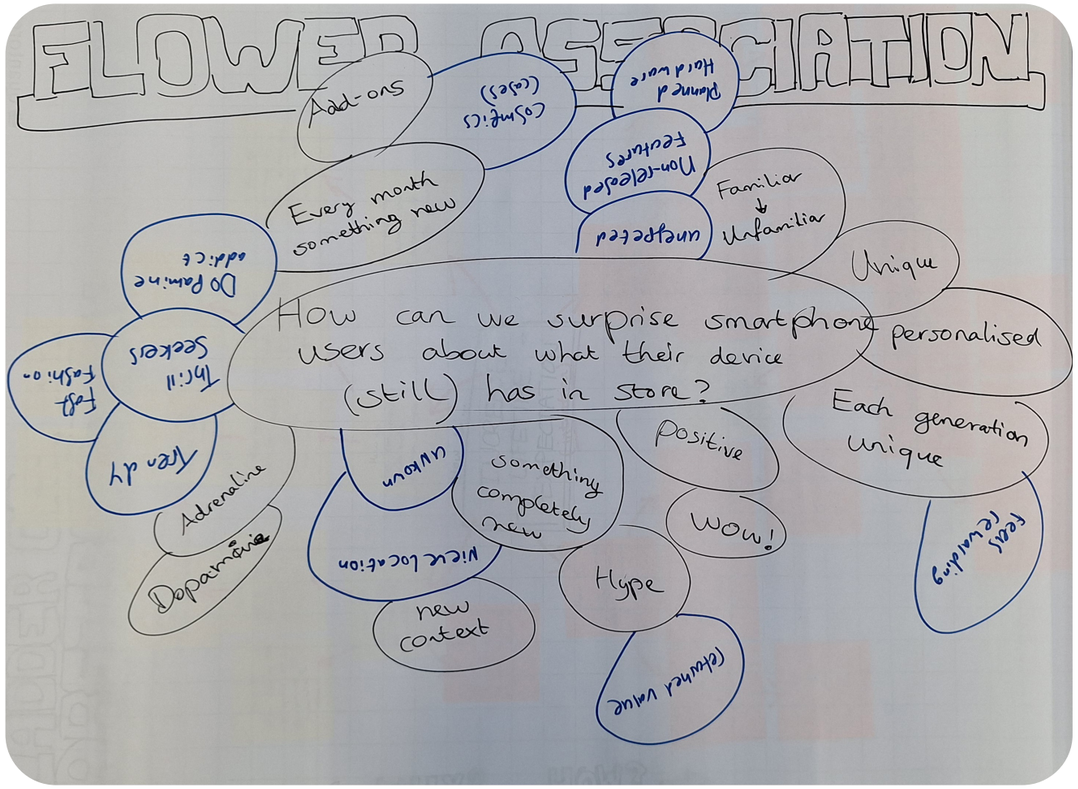


Figure A.1. Outcome of the Flower Association activity, as part of the creative session of the idea finding phase of the project.

A.2 Detailed structure and results of the creative exercises

Duo exercise 2. Brainwriting

During the Brainwriting activity, we used the themes defined after activity 1 to further explore the solution space that we already touched upon. We wrote these four themes at the top of a flipover sheet, and used the two colours of postits that I supplied to make a division for the ideation: yellow was for software-related ideas, and orange for hardware-related solutions. With these two distinct areas to ideate for, we shared any ideas out loud, tried to hitchhike on each other's ideas, and sought to find solutions beyond the obvious. The results of this activity can be seen in figure A.2 below.

Duo exercise 3. SCAMPER

After about 20 minutes of brainwriting, we applied the techniques of SCAMPER to expand upon the set of ideas we generated (Van Boeijen et al., 2013). The techniques of SCAMPER include:

- Substitute aspects of existing ideas
- Combine existing ideas into new ones
- Adapt (aspects of) existing ideas
- Modify, maximize or minimize (aspects of) existing ideas
- Put existing ideas to another use
- Eliminate aspects of existing ideas
- Reverse (aspects of) existing ideas

The ideas generated with these techniques are also included in figure A.2.

Figure A.2. Outcome of the Brainwriting activity, as part of the creative session of the idea finding phase of the project.

A.2 Detailed structure and results of the creative exercises

Duo exercise 4. MATEC

During the MATEC activity, we took another look at the Problem as Perceived (for this session, it was still stated as can be seen on the right, focusing on smartphones exclusively). The purpose of this technique is to move beyond the obvious space of ideas, and it is executed by taking the most important terms from the PaP, and creating a grid of randomly associated words based on each of these words. We decided that the keywords of the PaP were 'surprise' and 'in store'. The first step out of three, was now to put the keyword in the upper left corner of a 5x5 grid, and fill out the grid by first moving to the right, and then moving down, with each subsequent word being the first association with the preceding one. The grid can be seen in figure A.3.

After the grid was filled out, the second step was to pick two random words from the grid (in this case, 'anxiety' + 'desk'), and think of five possible words or phrases that connect those two words. After that, the third and final step was to pick one of these connections (which became 'psychologist') and force-fit it onto the PaP, by asking ourselves how it could relate to the PaP, what it suggests for the PaP, and what it could mean for possible solutions to the PaP. The ideas that we thought of during this step were written on postits, as can be seen in figure A.4. After ideating for the first pair of words from the grid, we continued with another pair of words: 'unexpected' + 'anonymous'.

Keywords from the PaP:

How can we **surprise** *smartphone users about what their device (still) has* **in store***?*

SURPRISE	UNexpected	Jack-in-a-Box	Scary	HAUNTED HOUSE
INFlicted	Pregnancy	Toy-Making	anxiety	Mirror
CONSENT	parenthood	Wooden cars	public places	Lake
SuSPense	organised	Primitive	anonymous	Tranquility
Mission impossible	Desk	Campfire	shy	Spa
X	Y	X	X	X

MATEC

Figure A.3. Grid of random word-associations from the first keyword of the PaP: 'surprise'. The words that were chosen for the first and second round of ideation are highlighted in red and green, respectively.

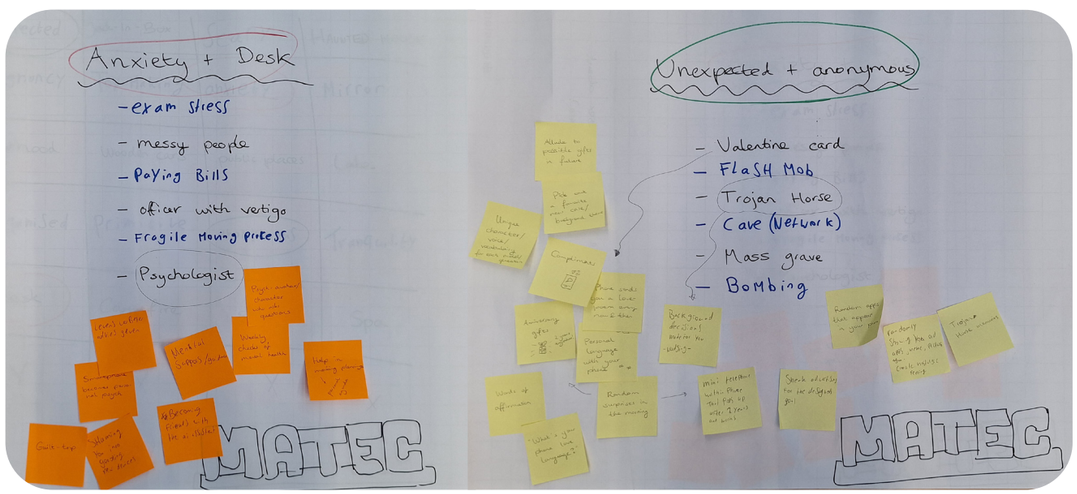


Figure A.4. Outcomes of the first and second round of MATEC, based on the keyword 'surprise'.

A.2 Detailed structure and results of the creative exercises

Individual exercise 1: MATEC

After closing the creative duo session, I continued with the rest of the MATEC activity individually, as we only explored the first of the keywords: 'surprise'. As can be seen in figure A.5, I executed another round of MATEC based on the keyword 'in store'. The first random combination of words from the generated grid was 'Hollywood' + 'umbrella', which resulted in the five connections in the lower left of the image. For the connection 'most famous umbrella ever', six additional ideas were generated, which were placed at the upper right corner of the sheet.

After that, the random combination of the words 'exciting' + 'rich kids' and the resulting connection 'joy riding' inspired me to think up another two ideas, placed in the lower right corner.

Even though this type of exercise does not always promote fluency of ideas (i.e. generating a large set of ideas), and it tends to work better in a group setting, it did inspire some interesting additions to what we already come up with during the day.

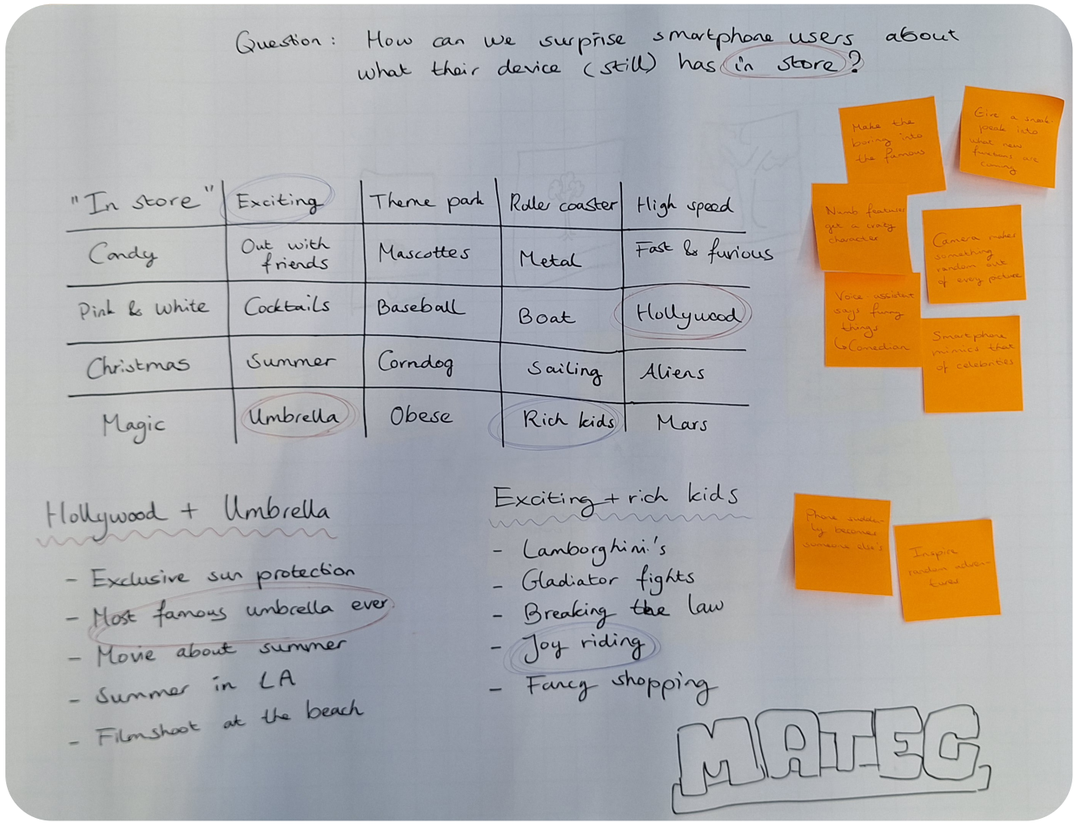


Figure A.5. Outcome of the second, individual round of MATEC, based on the keyword 'in store'.

A.2 Detailed structure and results of the creative exercises

Individual exercise 2: Direct Analogy

To complement the established set of ideas from the collaborative exercises, I executed one more round of ideation with help of the Direct Analogy technique. This technique is part of the creative excursions, and is mainly used to enhance flexibility (Heijne & Van der Meer, 2019). With this technique, the resource group comes up other domains, and describes situations with the same essence of the PaP. Analyzing how a similar problem in another context is solved or approached, can result in valuable inspiration for ideas to apply on the problem of the project itself. The ideas from the analogy exercise must then be forced fitted onto the PaP.

For this project, I used this technique individually, meaning that I alone could be considered the 'resource group'. The results can be seen in figure A.6. I took some ideas for contexts from the analysis of examples from practice (chapter 3 of this report), such as Duracell, powertools and clothing. I also thought of other analogies such as Tesla, videogames and furniture. I then wrote on orange postits how the problem "How to convince consumers that there is more in store" is approached or solved in these situations. After that, I forced fitted the solutions onto the product type focused on by my project, and wrote the ideas down on yellow postits. These ideas were collected for clustering in the reverging step of this idea finding part.

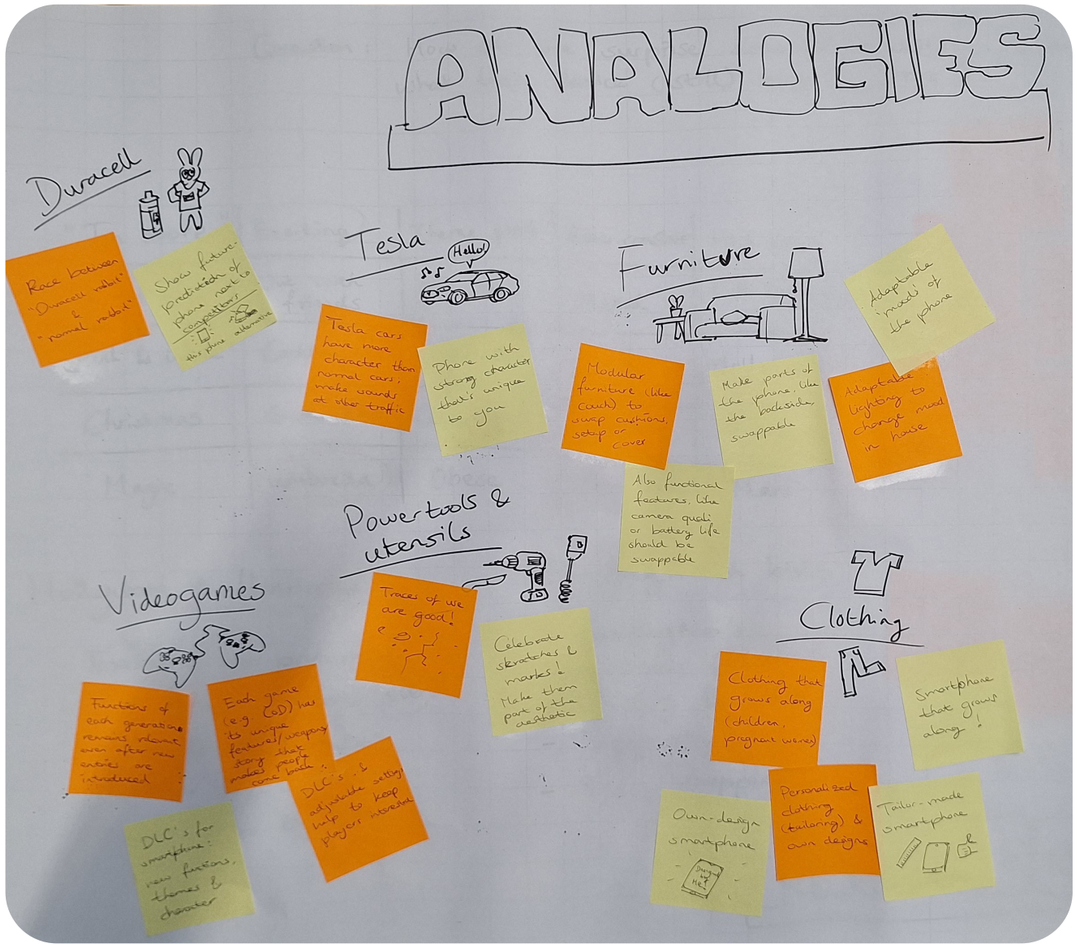
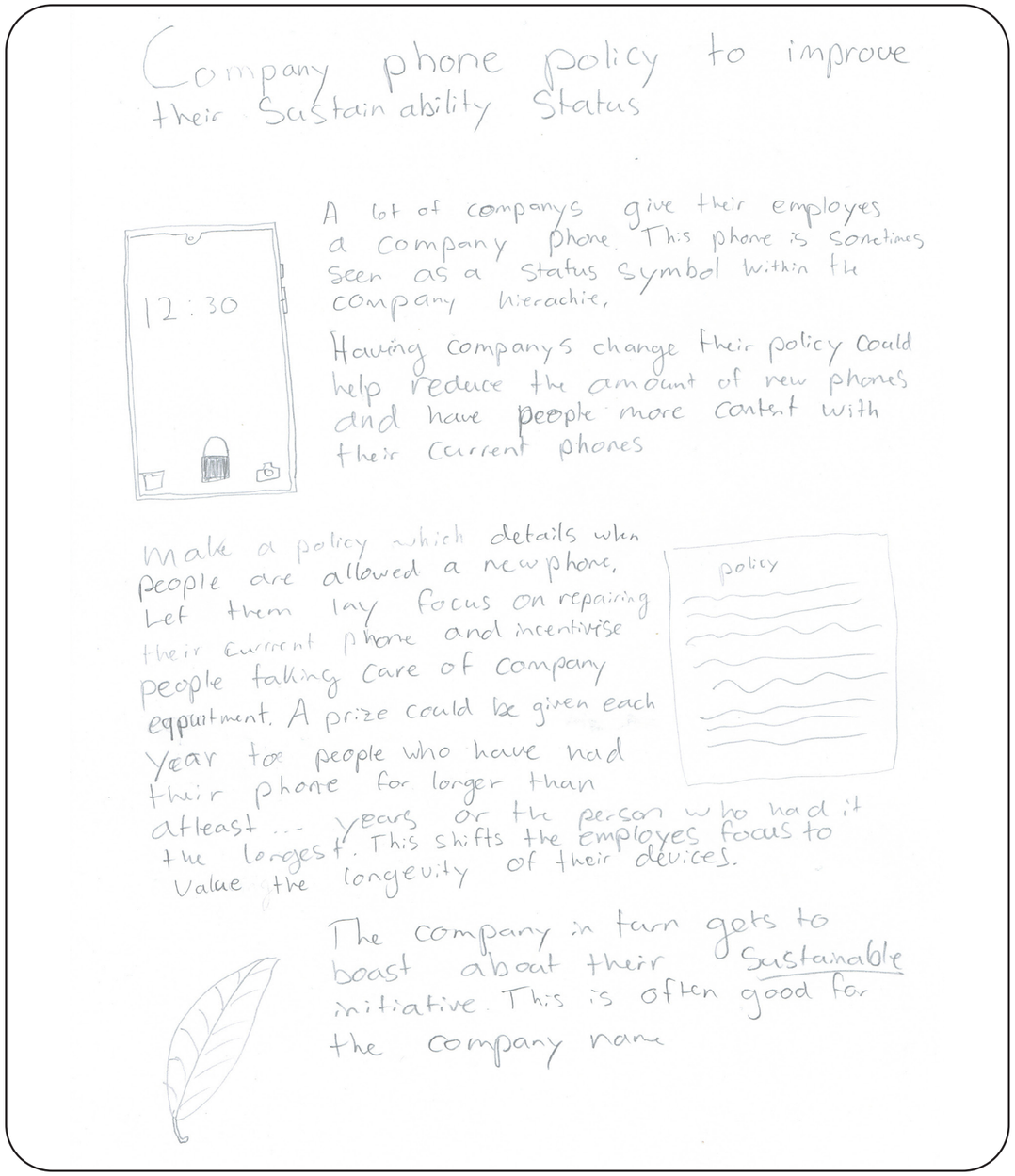


Figure A.6. Outcome of the analogies exercise.

A.3 Results of the classroom creative exercise

This appendix shows the 22 individual ideas that were generated by the students from Katrina Heijne's minor-class. The structure of this exercise is described in chapter 5 - Design process. Some ideas were delivered with an explanatory text on the back of the sheet; these can be found in separate blocks next to the images. Also, bear in mind that the students were presented an intermediate version of the problem statement, which reads: "How can smartphone users fall back in love with their devices?". In hindsight, this question may not have sufficiently addressed the predicted lifetime, which was a key concept for the project. Nonetheless, the ideas generated by the students were all considered a useful source of inspiration, if only to explore the more 'obvious' possibilities.

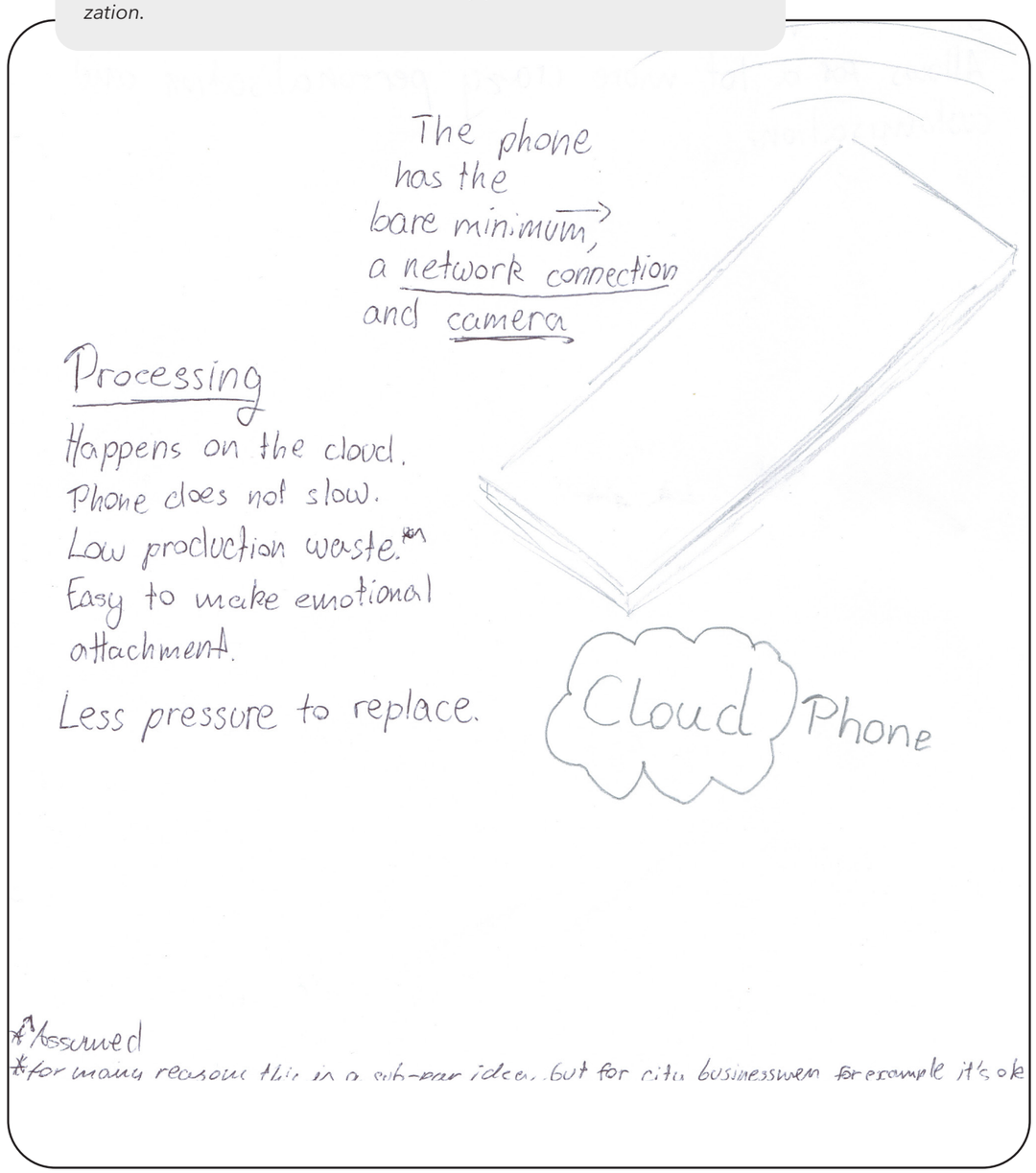


A.3 Results of the classroom creative exercise

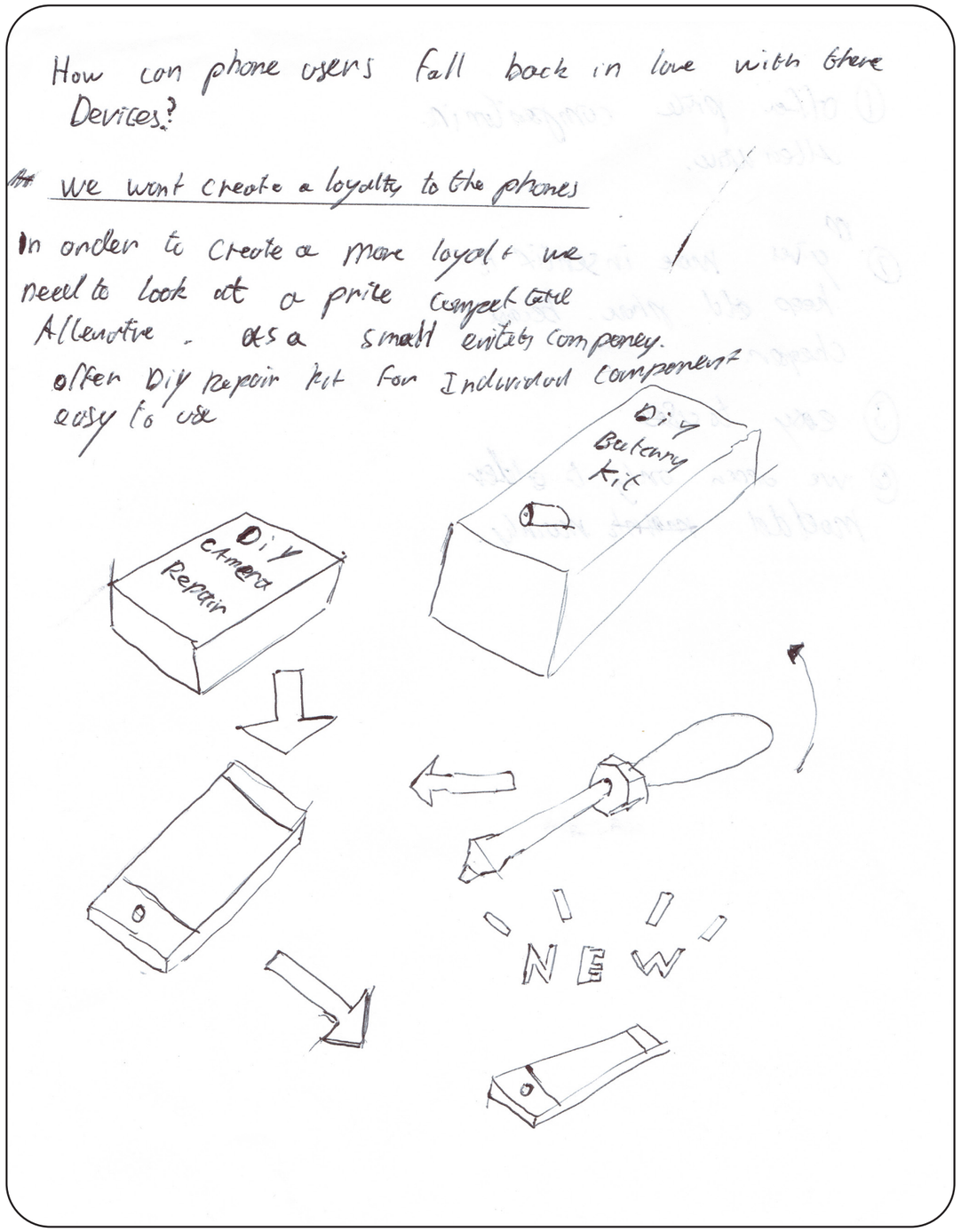
Explanation to the idea

The goal is to reduce waste, this can be done by making them simpler to manufacture. Less components and (this is not the pitch just context) smaller batteries are better.

The phone won't slow down either, reducing that pressure. There is less pressure to replace the phone, many cool features depend on what you enable instead. Allows for a lot more crazy personalization and customization.

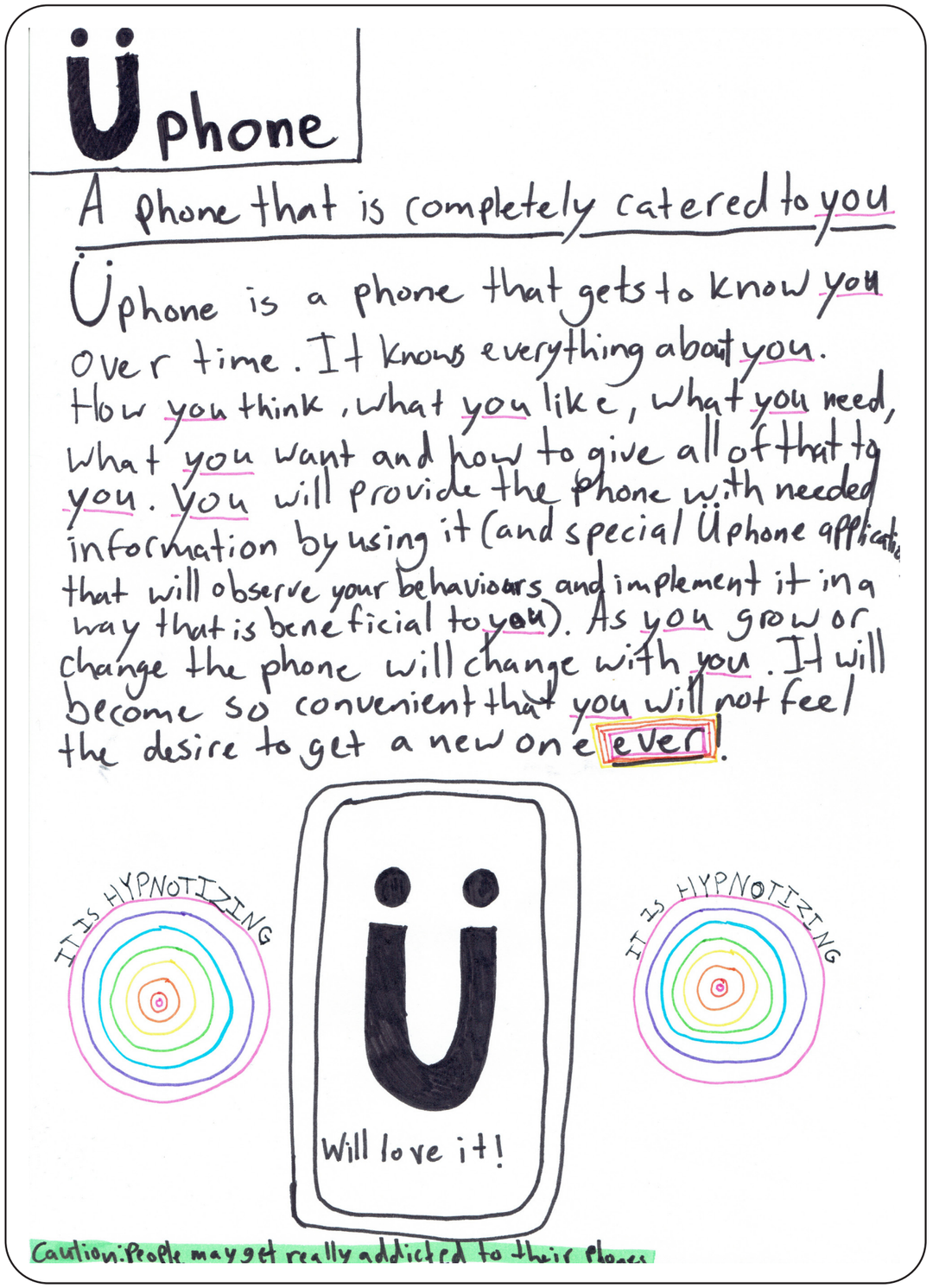


A.3 Results of the classroom creative exercise

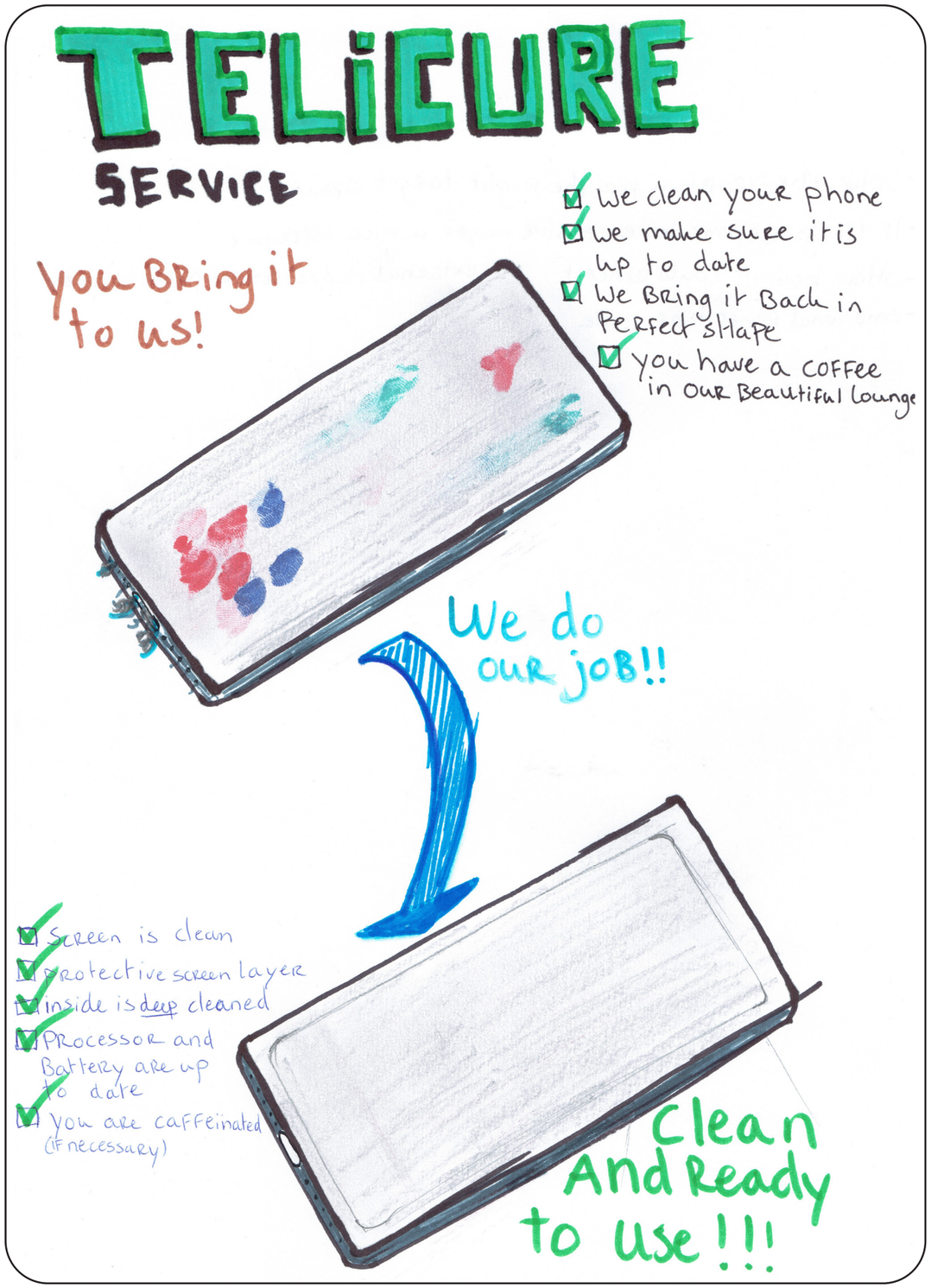


Appendices

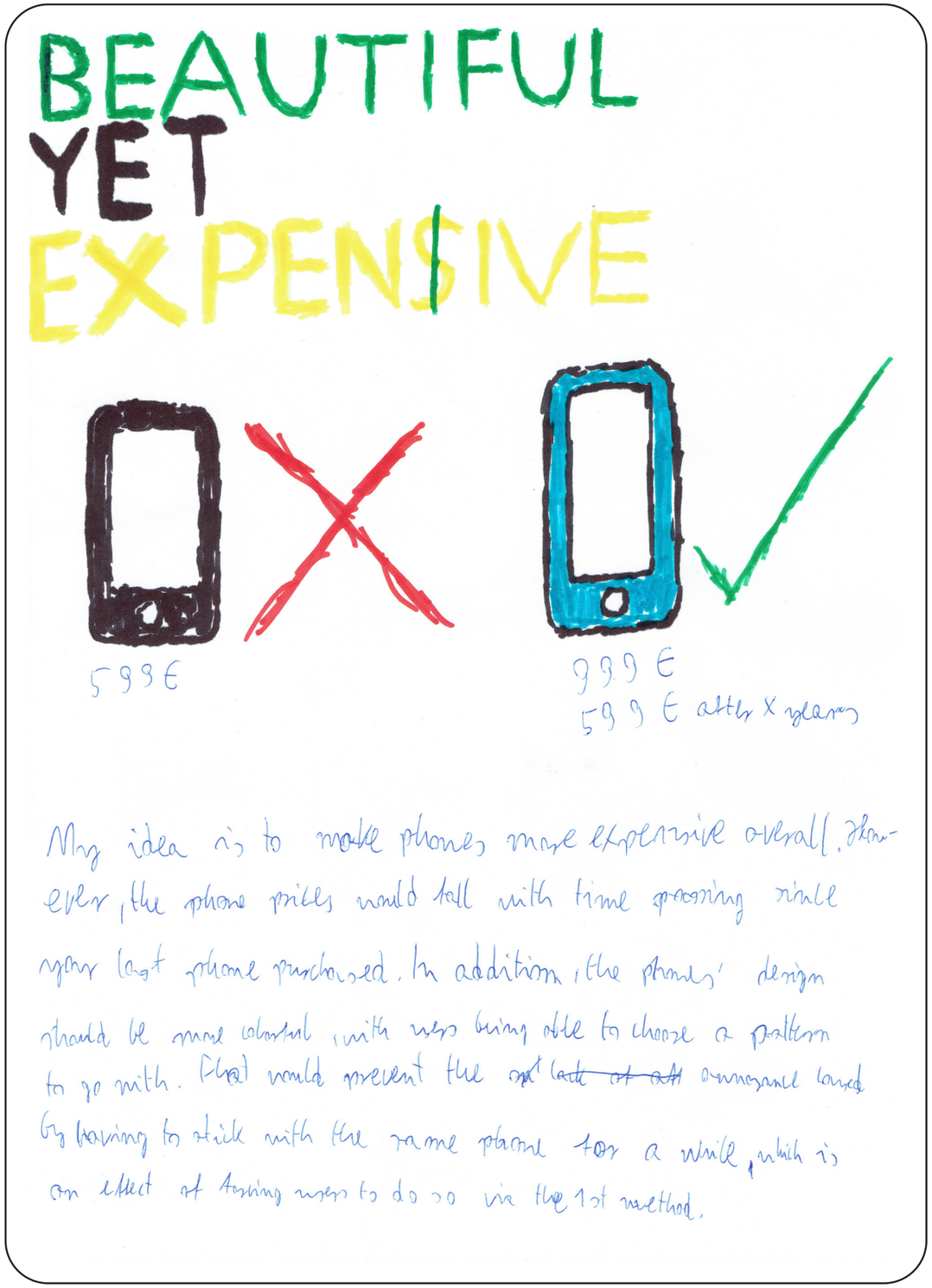
A.3 Results of the classroom creative exercise



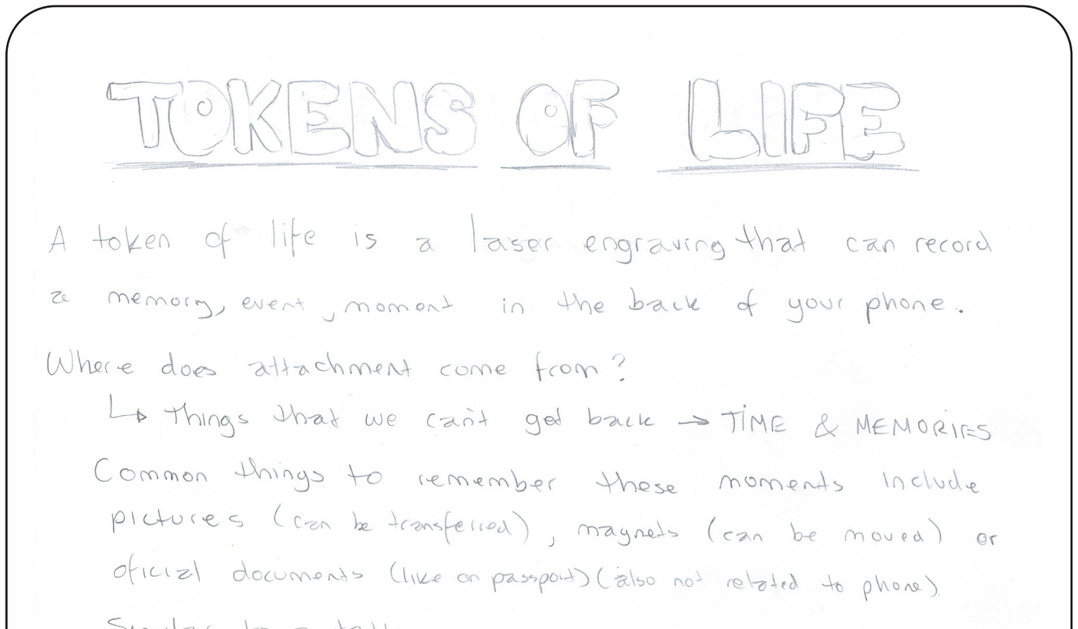
A.3 Results of the classroom creative exercise



A.3 Results of the classroom creative exercise



A.3 Results of the classroom creative exercise

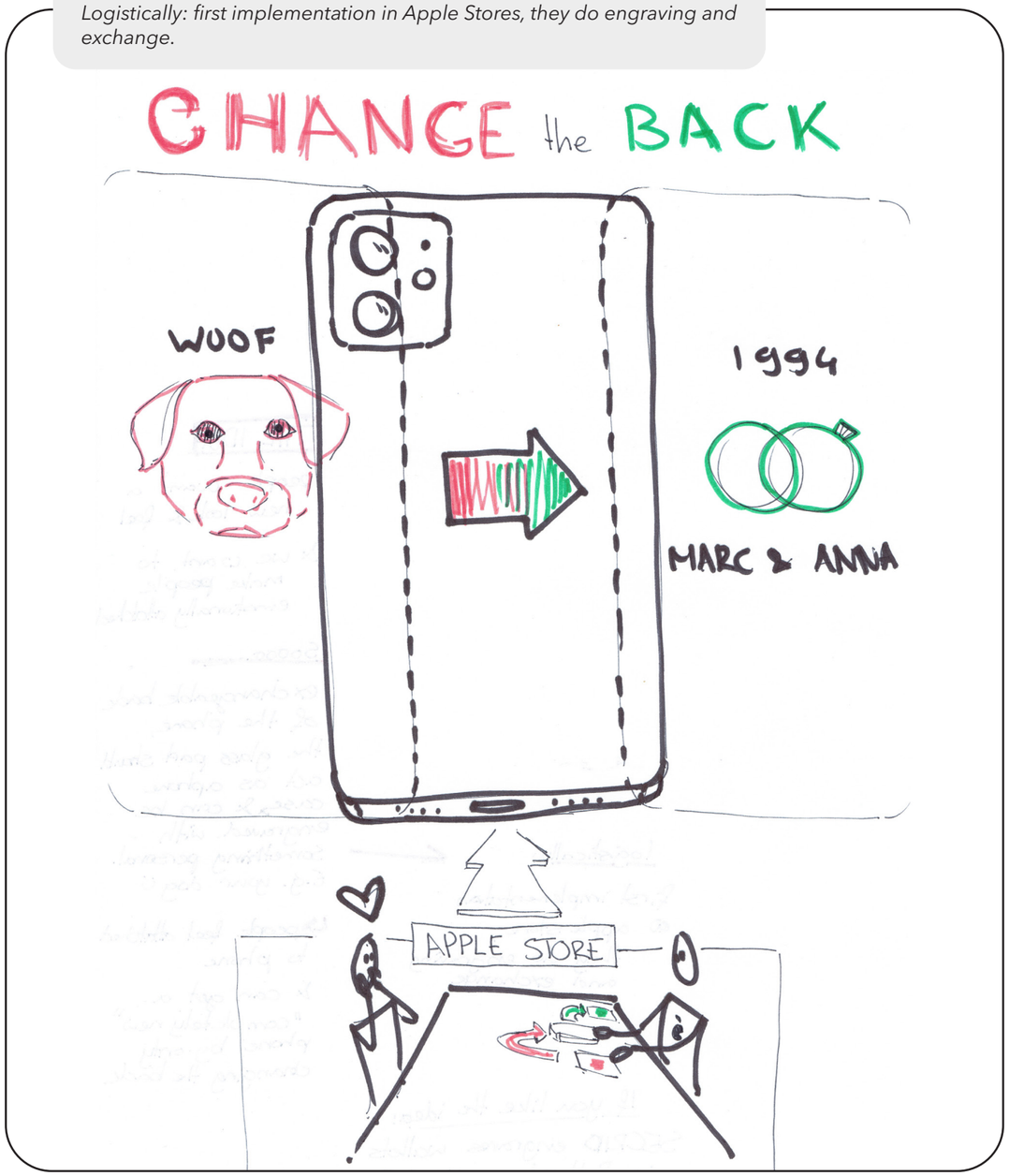


A.3 Results of the classroom creative exercise

Explanation to the idea

The idea: people want a new look and feel, and we want to make people emotionally attached. So exchangeable back of the phone, the glass pad should act as a phone case and can be engraved with something personal, e.g. your dog :) People feel attached to the phone, and get a "completely new" phone by only changing the back.

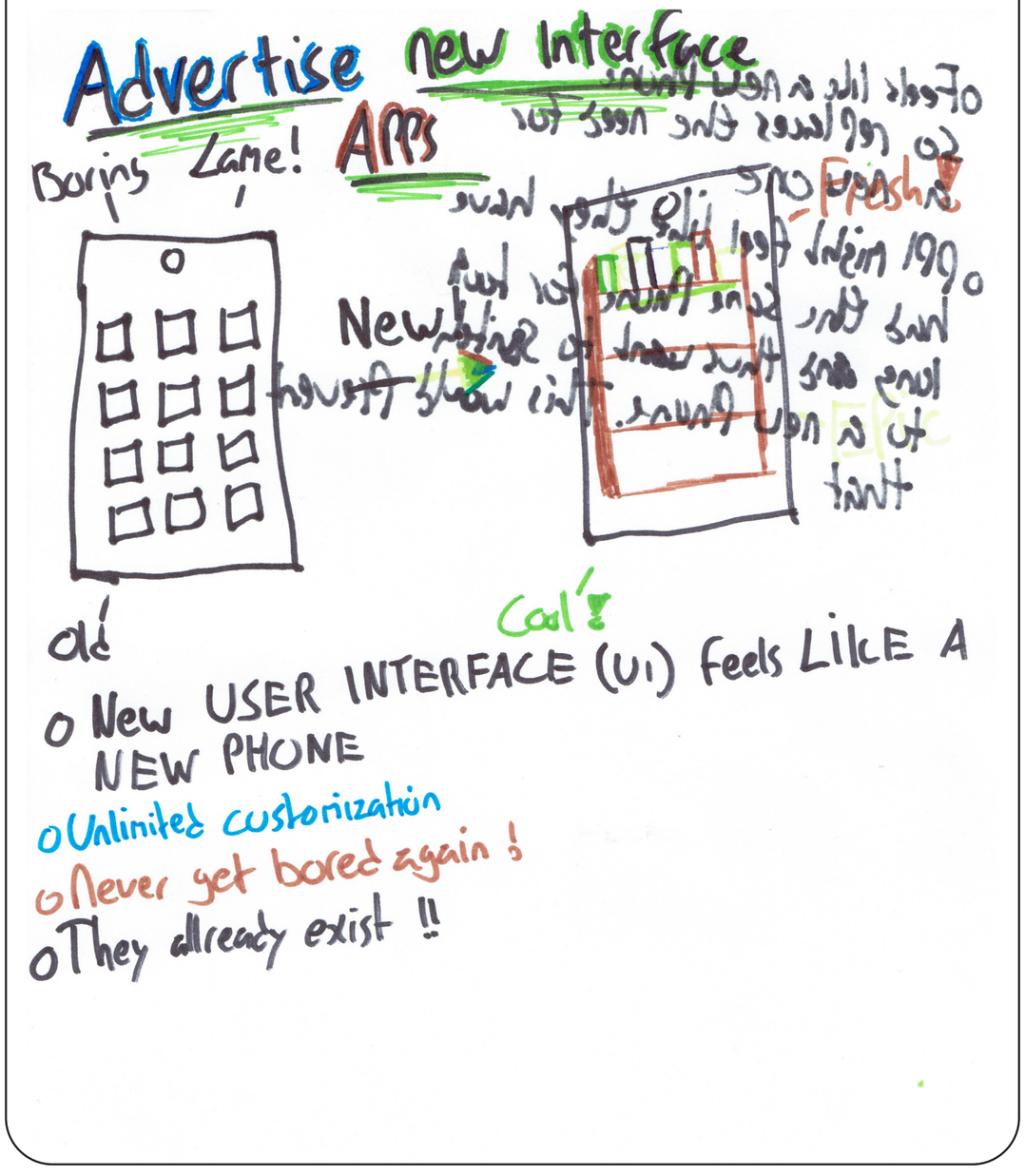
Logistically: first implementation in Apple Stores, they do engraving and exchange.



A.3 Results of the classroom creative exercise

Explanation to the idea

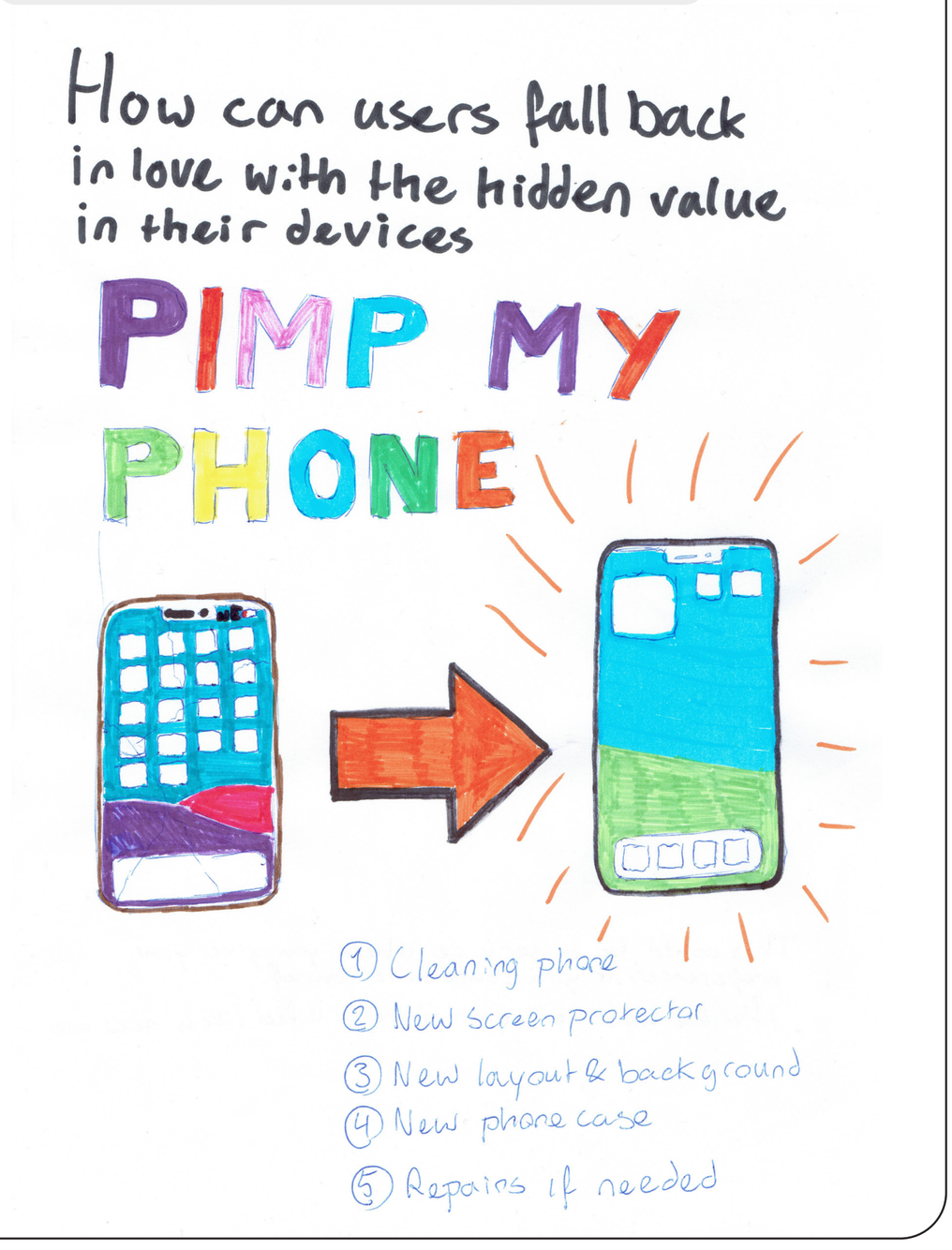
Feels like a new phone so replaces the need for a new one. People might feel like they have had the same phone for too long and thus want to purchase a new phone. This would prevent that.



A.3 Results of the classroom creative exercise

Explanation to the idea

This could be a service where you give your preferences or could it yourself. After the steps 1 to 5 your phone will feel like a new one.



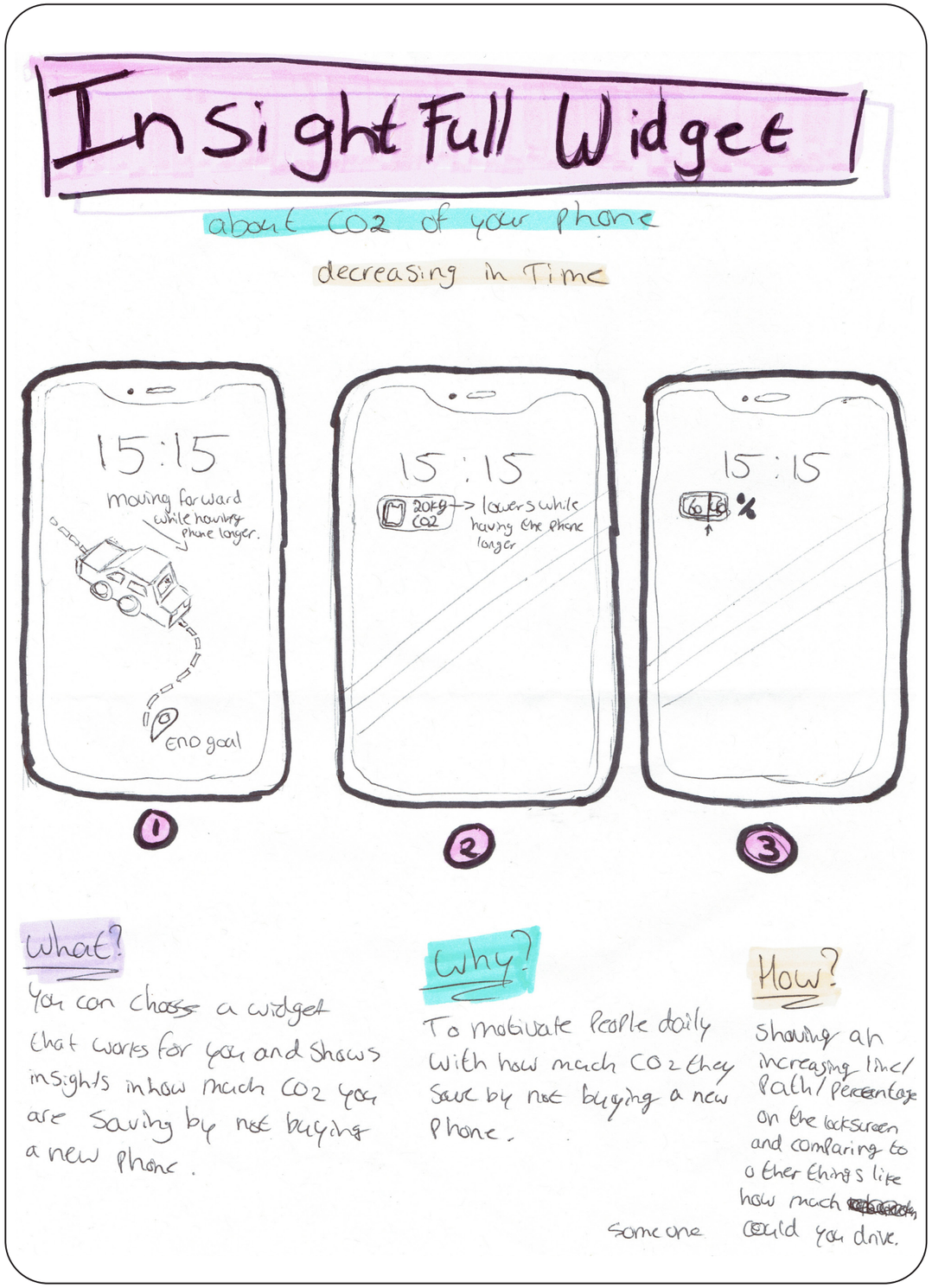
A.3 Results of the classroom creative exercise

Explanation to the idea

Technology becomes retro. We want to start a movement where there are only older phones in big hollywood movies and pop culture so that these older phones would be considered cool.

A.3 Results of the classroom creative exercise

A.3 Results of the classroom creative exercise



A.3 Results of the classroom creative exercise

1. Create a special map application that differs from all kinds of map in its domain.
2. ~~Fu~~Property of the app: you can upload your own photos when you reach every location (particular store/shop/restaurant/landmark/building). This make sure that every time you open the map application and you click every location you can immediately see your photos. The idea behind is to use "your world map" as an archive photos in relation to precise locations.

3, Every account of the app can only be used/edited on the same phone.
If you change your phones in the meantime, you need to register a new account, and the previous account can only be read, rather than edited. ↳ permanent archive.

4. Custom year book of your world map. (free) reward for users who keep with their phones over 1 year. / 2 / 3 / 4 years.

□ → can be a default app.

~~You can set the default map app as two ve.~~

Benefits of this idea:
▷ associate most commonly used app (map) to people's favorite mundane act (R take photos).
▷ If you use this app, you can create your own life journey by seeing the app as travel archive.

These two characteristics encourage users to retain the phone.
⇨ Marketing quote: Create your life journey archive in Your world map!

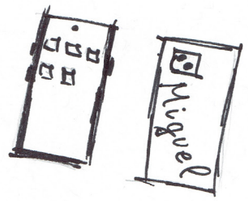
A.3 Results of the classroom creative exercise

How can phone users fall back in love with the hidden value in their devices?

~ How to make the current phone indispensable?~

Main ideas:

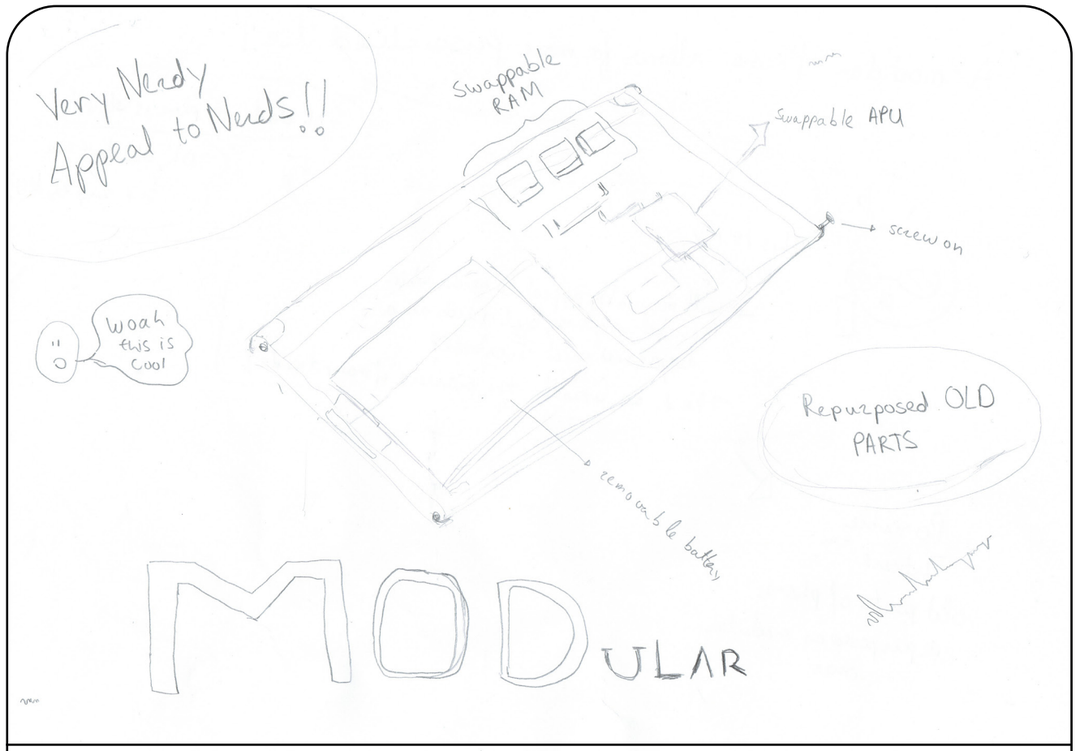
- constant updates
- no back up
- personalized exterior

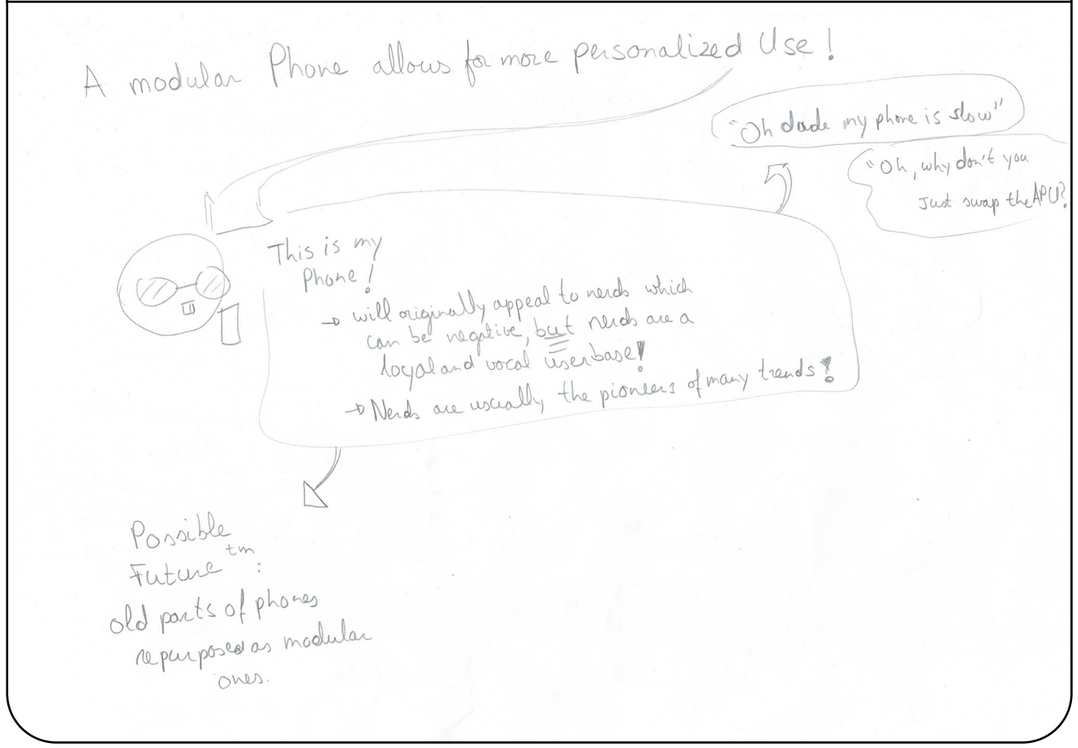


Details:

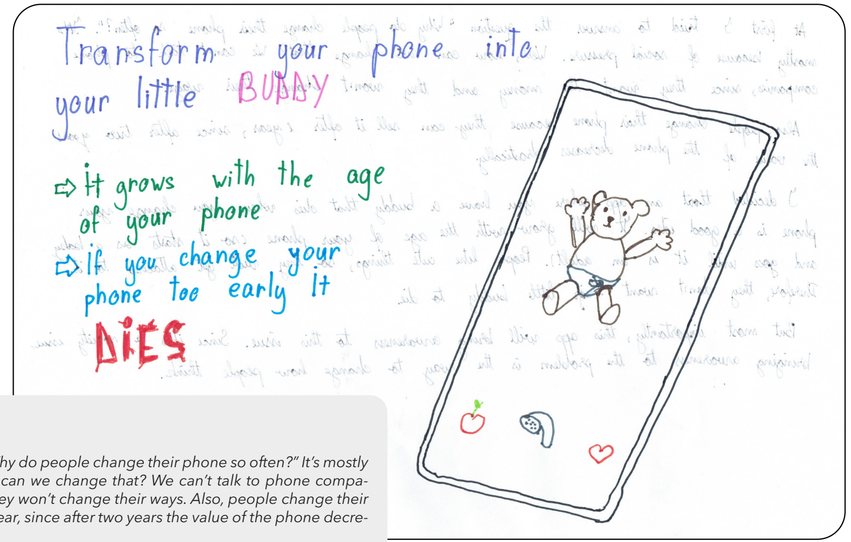
- the user will be able to buy one phone and personalize it as he wants, he can add his name/ pictures/ anything else to enhance emotional value
- the phone will have constant updates to ensure it stays up to date with the current trends and that the user doesn't get bored => a lot of changes to the interface for each update
- additionally, the personal files of the user will be backed up by the company, but the user won't have access to them for the first 2/3 years, so in case he wants to change his phone, he will lose all files on the old one.
  - └>unless ~~they~~ he can prove ~~their~~ his phone actually doesn't work anymore

A.3 Results of the classroom creative exercise





A.3 Results of the classroom creative exercise

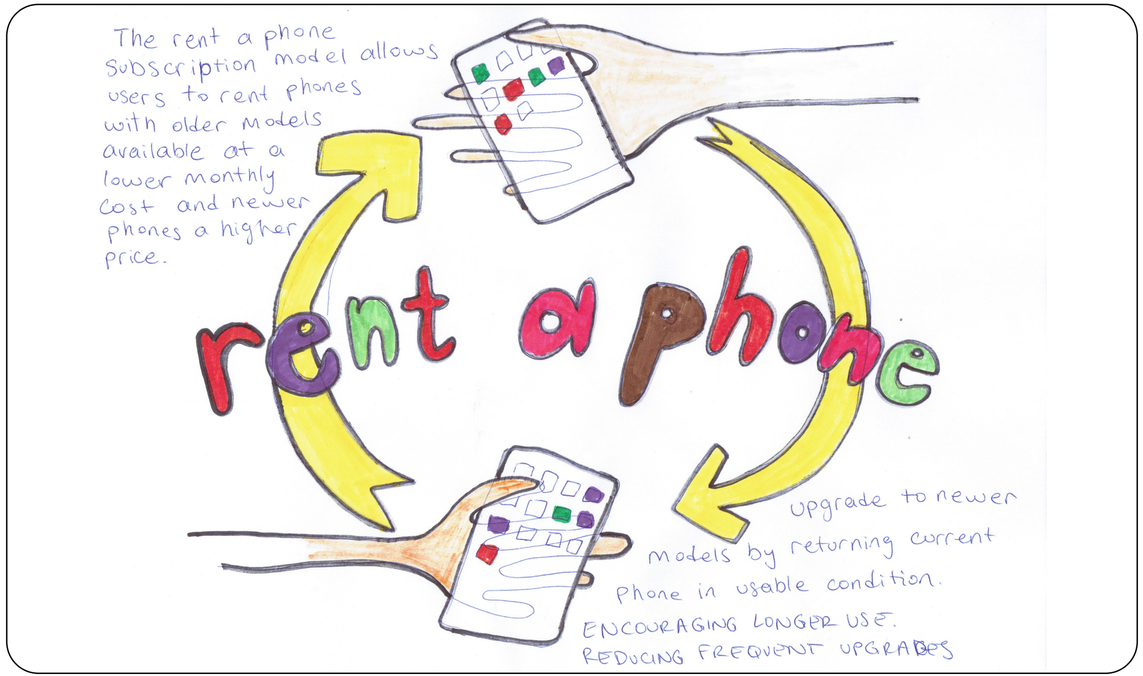


Explanation to the idea

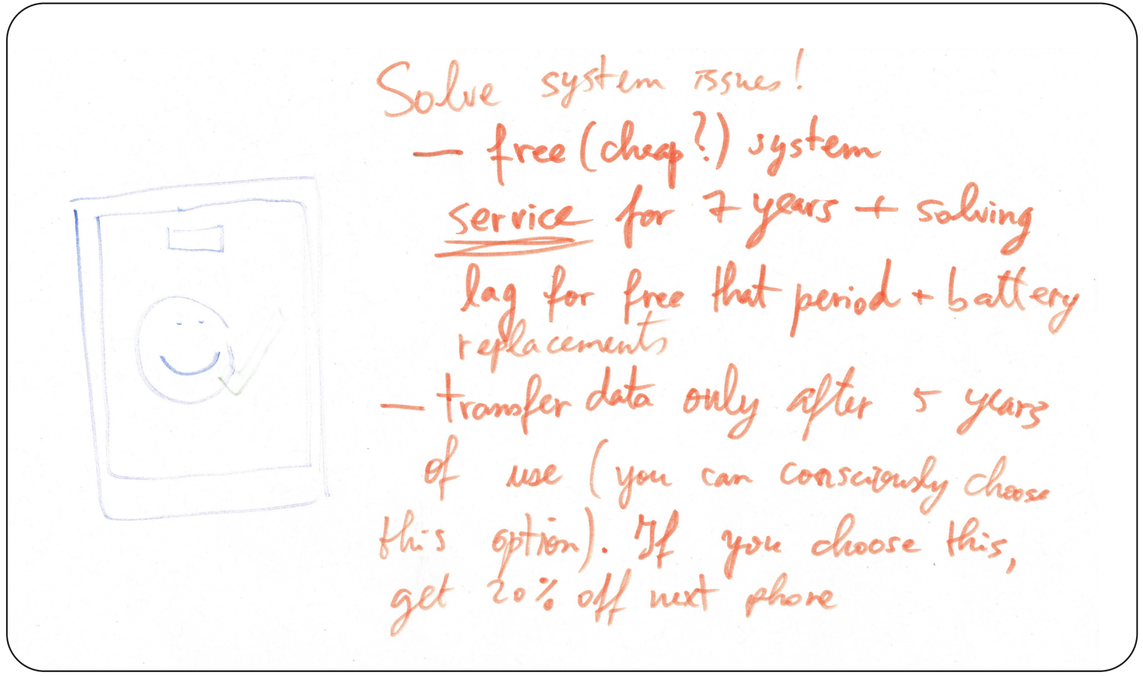
At first I tried to answer the question "Why do people change their phone so often?" It's mostly because of social pressure. Well, how can we change that? We can't talk to phone companies, since they want the money and they won't change their ways. Also, people change their phone because they can sell it after 1 year, since after two years the value of the phone decreases drastically.

I decided that an app where you have a buddy that dies when you change your phone is a good idea. It will grow with the age of your phone (so it starts as a baby and grows until it is an adult). People like cute things, so theywill get attached to it. Therefore, they don't want their little buddy to die. But most importantly, this app will bring awareness to this issue. Since it's a society issue, bringing awareness to the problem is the way to change how people think.

A.3 Results of the classroom creative exercise



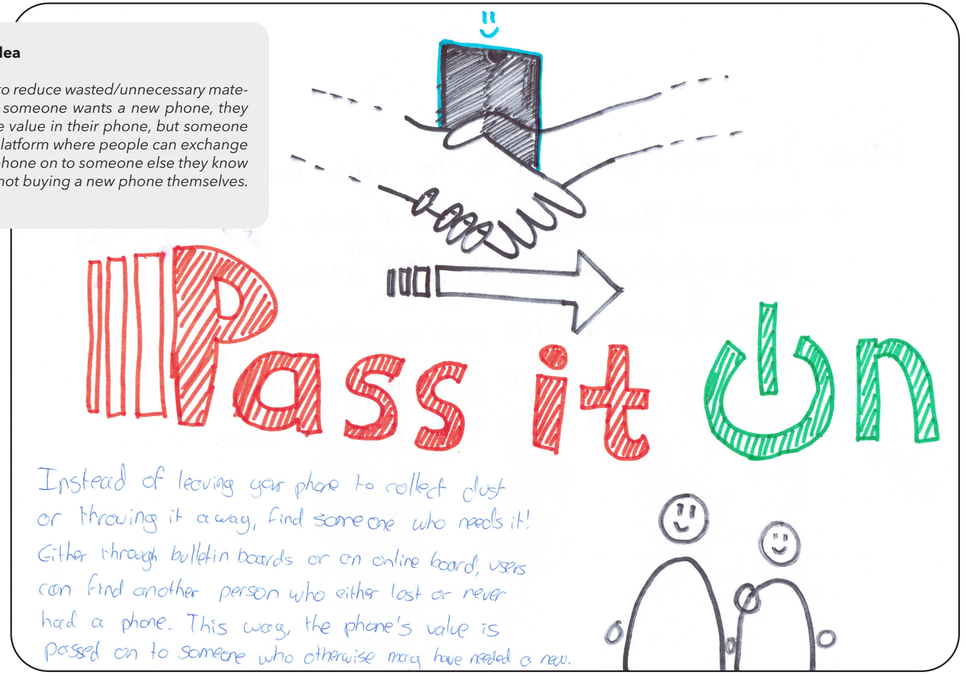
A.3 Results of the classroom creative exercise



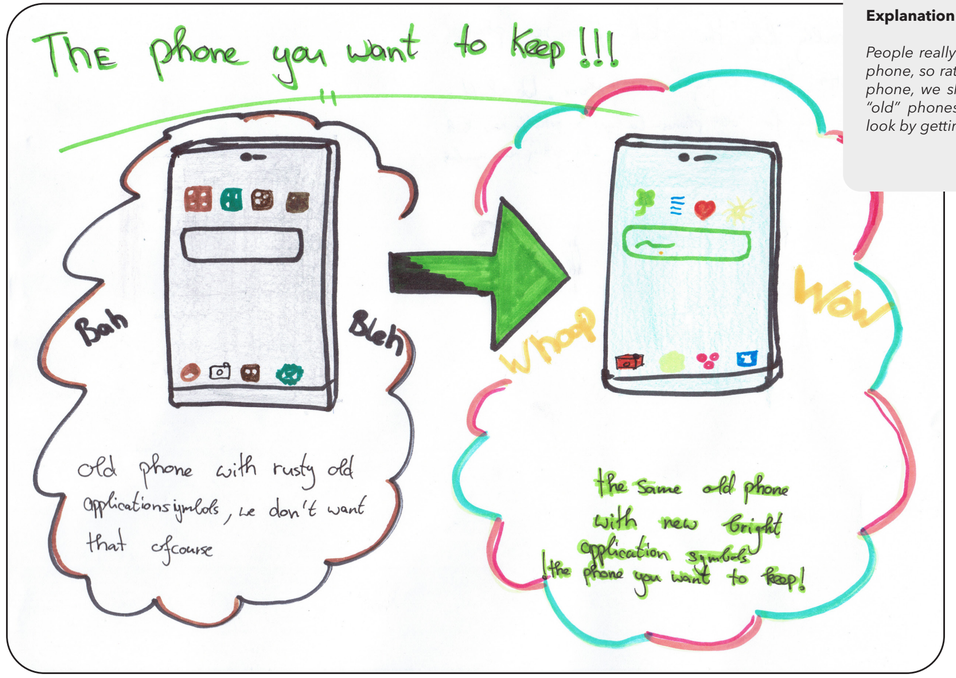
A.3 Results of the classroom creative exercise

Explanation to the idea

The main goal here is to reduce wasted/unnecessary materials. Therefore, when someone wants a new phone, they may no longer see the value in their phone, but someone else might. This new platform where people can exchange phones or pass their phone on to someone else they know leads to the recipient not buying a new phone themselves.



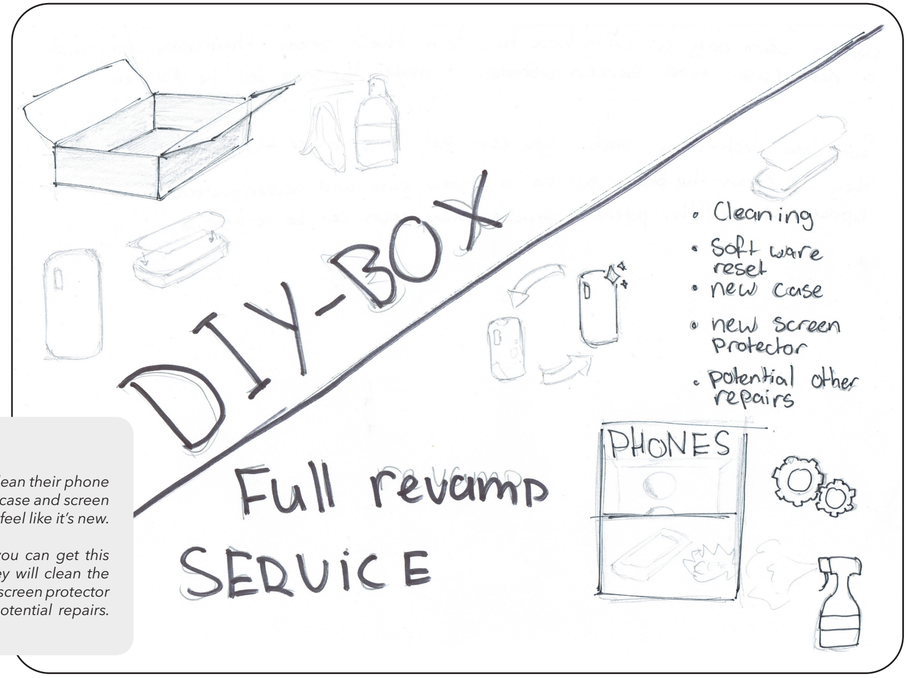
A.3 Results of the classroom creative exercise



Explanation to the idea

People really like the look of a new phone, so rather than buying a new phone, we should make it easy for "old" phones to get a totally new look by getting new symbols.

A.3 Results of the classroom creative exercise



Explanation to the idea

Person can buy a DIY box to clean their phone themselves, along with a new case and screen protector. It makes the phone feel like it's new.

For less tech-savvy people, you can get this service at a phone shop. They will clean the phone, put on a new case and screen protector and update software/other potential repairs. Phone cases can be reused.

A.4 Outcomes of the diverging step for solution finding

Direct information for increasing lifetime expectations

This first of the three design directions focused on providing direct, lifetime-related information to the consumer about their product. The goal of diverging into more ideas for this direction was to find more concrete solutions to the rather 'vague' cluster of ideas 'Information Rules!' that resulted from the idea finding part of the creative process. I did this part individually, and used the How-To (or H2) technique (Heijne & Van der Meer, 2019; Van Boeijen et al., 2013) to move from an abstract to a more concrete solution space. I also applied some of the SCAMPER techniques to enhance flexbility, these ideas are next to the postits on the sheet. I thought of solutions for smartphones and headphones.

I ideated for the for the questions of how to use a meter, how to show the degradation process and how to let consumers try out the limits of the device. These are part of the question how to give the consumer a solid first impression, which I considered important because the predicted lifetime is formed by the consumer right at the first exposure to the product, according to the theory (see chapter 2 - Literature study). I then also ideated for the question how to remind the consumer during use of the device's life, because the intervention must raise awareness about this, and remind them that it has more in store, even after several years of use. The results of this exercise can be seen in figure A.7.

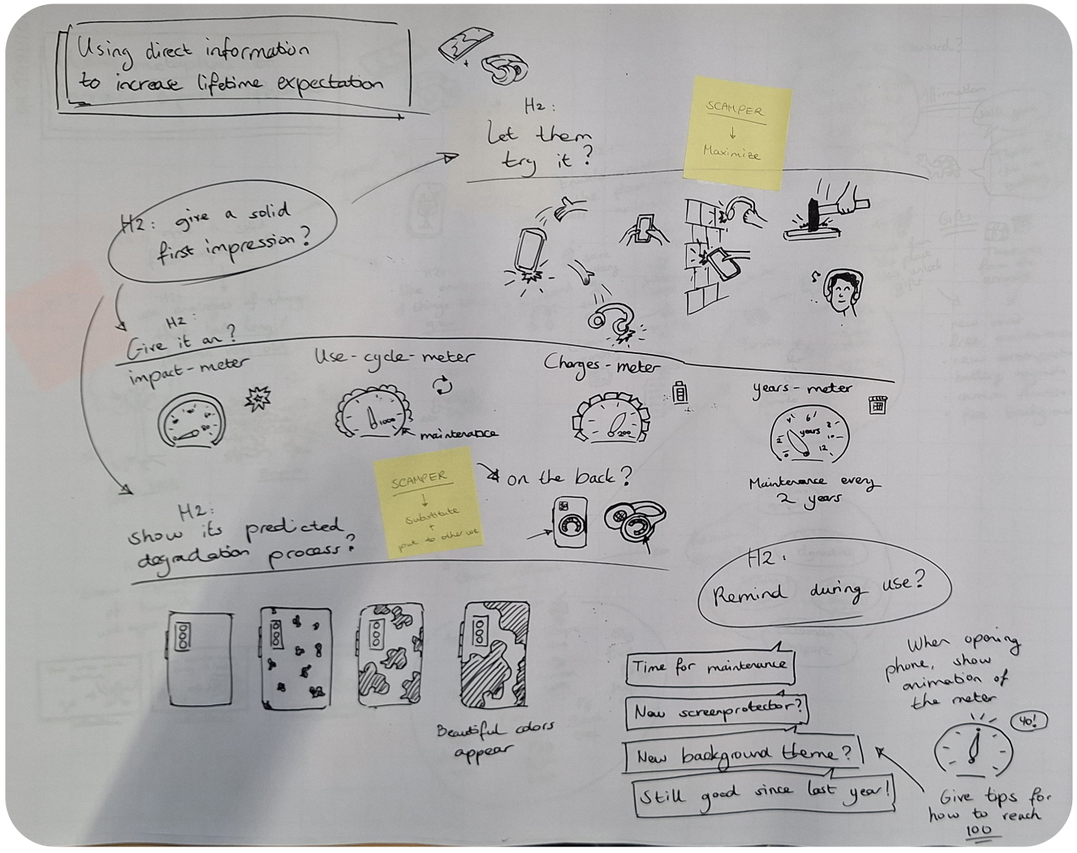


Figure A.7. Solution ideas for the first design direction 'Information Rules!' from the idea finding step.

A.4 Outcomes of the diverging step for solution finding

Analogies for increasing lifetime expectations

This second of the three design directions focused on using an analogy to convince the consumer about the potential of their product. The goal of diverging into more ideas for this direction was to find more concrete solutions to the cluster 'The Power of Stories'. Ideas where the SCAMPER techniques were applied are again marked by the postits on the sheet.

See figure A.8 for the results of this exercise. I first sought again for solution to give a solid first impression about the potential lifespan. I did this mainly by thinking of examples of things that are associated with 'lasting long', such as a tree, an empire or certain animals that can age very old, such as turtles, sharks, parrots and whales. I also looked at how the aging process can be shown at the moment of purchase, and how it may allow for choosing your own, personal variation of the analogy, such as an oak, a lemon tree or a grapevine, the roman empire, Chinese dynasty or ancient Egypt, and the different animals. These ideas should form the predicted lifetime of the consumer by emphasizing how old these examples can become. After that, I ideated on the questions how these examples could be nurtured and sustained over time, for example by cleaning the device, protecting it or saving the battery. And lastly, I thought of how these analogies could support a rewarding system, for example when the tree gives fruit, the animal gives a present or the empire yields treasures. These gifts could then symbolize discount for a new protective case or new functions.

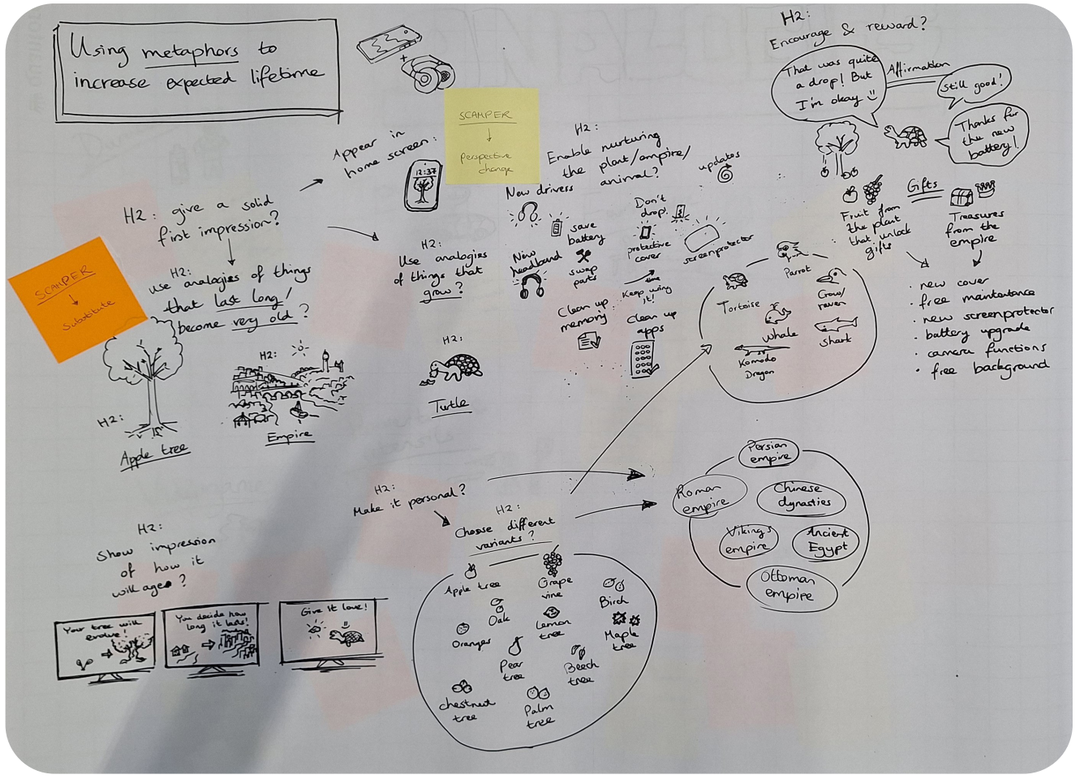


Figure A.8. Solution ideas for the second design direction 'The Power of Stories' from the idea finding step.

A.4 Outcomes of the diverging step for solution finding

Analogies for increasing lifetime expectations

This third and last design direction focused on using the prospect of newness to convince the consumer about the potential of their product. The goal of diverging into more ideas for this direction was to find more concrete solutions to the cluster 'A Brand-new Edgar Suit'. Ideas where the SCAMPER techniques were applied are again marked by the postits on the sheet.

During this exercise, I thought of how a timeline or analogy (combination with the second design direction) can be used to give a first surprising impression of what the device may have in store in the near and farther future. The results can be seen in figure A.9.

These ideas are mainly based on promising various upgrades or additions for the device, which should make the consumer realize that it can evolve and grow along with their changing desires. This should make it stay relevant and convey a longer functional lifetime compared to products that are unchanging.

Furthermore, I ideated on the question how the consumer can be reminded over time that their device can adapt to their needs, through simple communication. These reminders should make the consumer aware of where in the device's life they are, and show them that there is more value to gain from it.

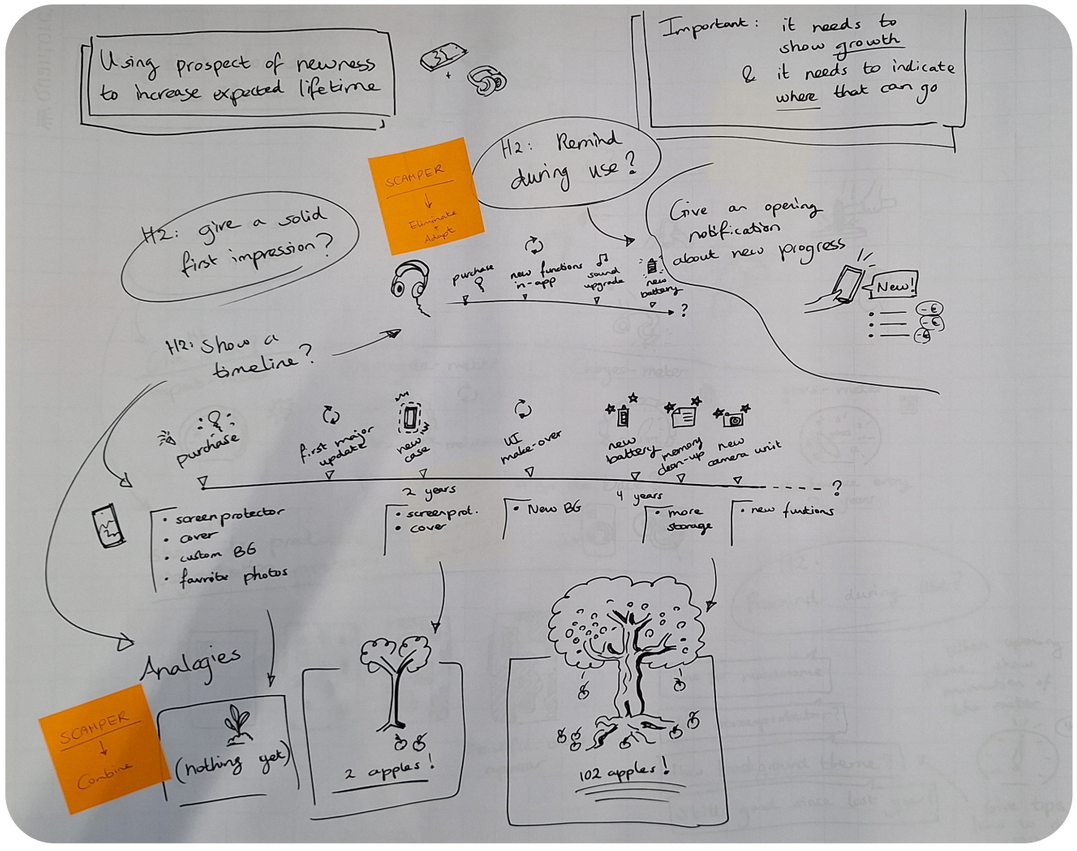


Figure A.9. Solution ideas for the third design direction 'A Brand-new Edgar Suit' from the idea finding step.

A.5 Survey flow including options to select

This appendix shows the flow of the textual and visual stimuli of the survey from the experiment, as well as the questions and the corresponding options to select. The condition of the smartphone with intervention is taken as an example, the other three conditions had the same setup but with different images and adjusted text.

Consent page

Hello!

Thank you for participating in this online research survey. This research is part of a graduation project of the MSc study Strategic Product Design at the faculty of Industrial Design Engineering, TU Delft.

In this questionnaire, you will be asked about your expectations of the lifetime of an electronic device. Please note that your evaluations on this subject can never be wrong, even though for some it may be hard to estimate how long products may last; you can be completely honest, there are no wrong answers! Also be aware that your participation in this study is entirely voluntary and you are free to withdraw at any time. You will first be asked specific questions about an example electronic device, and then some general questions about you. Answering them should take you approximately 10-15 minutes.

The data of this study will be stored on a private drive unit and in a physical storage place with limited access at TU Delft. After completion of the project, they will be deposited in the university's online data repository, stored for ±10 years and potentially used for educational and research purposes at TU Delft. Please be aware that your answers will be completely anonymous and cannot be used to trace any personal information. Apart from multiple-choice answers, this survey will also allow you to write some text in dedicated fields; please do not include any personal information in these text fields that can be traced directly to you!

By selecting the box below, you acknowledge that:

- you participate in this research voluntarily and are free to withdraw at any time;
- you can be completely honest in your answers;
- you received sufficient information and explanation about the research, and;
- your data will be anonymously collected and stored during and after the study.

☐ Yes, I have read the above and agree with these statements.

Thank you for helping me with my project and have fun filling out this survey!

Mark Verhoef
Phone: **********
Email: **********

A.5 Survey flow including options to select

Opening question

Before we begin: do you currently own a smartphone and/or headphones (for example, for listening to audio), or have you ever owned one?

- ◯ I own a smartphone and headphones
- ◯ I do own a smartphone but no headphones
- ◯ I do own headphones but no smartphone
- ◯ I don't have either of those

A.5 Survey flow including options to select

Introduction to the device

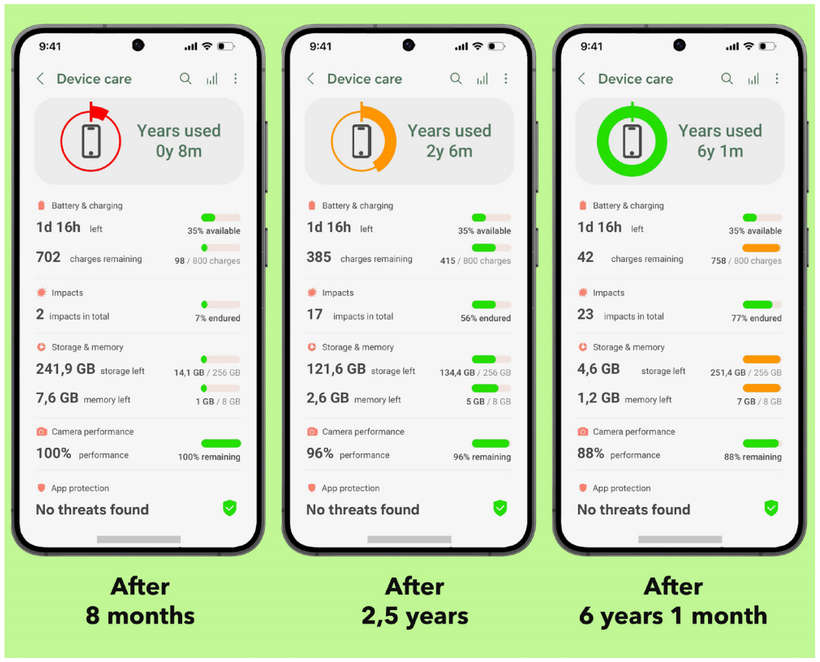
Please read and view carefully the text and images below.

Imagine you've bought a new smartphone from a new brand, 2,5 years ago.
Its screen size is 6,2", it has 256 GB of storage, a 50 MP camera and a medium charging speed. You bought it for €899,-. Additionally, this smartphone has a new feature: it tracks the number of years it has been owned, and shows this on the back of the device through a ring of glowing LED-segments. Each segment of the ring represents one half year of ownership; when you purchase the smartphone, none of the segments glows, but with every next six months a new segment subtly blinks and then becomes part of the ring. The lighted ring thus shows the age of your smartphone. In six years the ring is full, after which it starts again; it is up to you how far it goes.
You can see what the smartphone and the ring look like after 2,5 years in the images below.

A.5 Survey flow including options to select

Introduction to the device

As an addition to the ring on the back of the smartphone, you can install a free widget that shows more specific information about the life of your device. You can see examples of what this widget looks like at different stages of the smartphone's life in the images below.



As you can see, apart from the age of your phone, the widget provides you with statistics on:

- How charged the battery currently is
- The total number of charging cycles it has run
- The number of times the phone endured an impact (for example from falling)
- The remaining storage and memory of the phone
- The performance of the cameras
- The protection of your applications

When the smartphone is doing well on certain functions, these meters glow green. When a function is nearing its limit, this meter glows orange. For the meter that tracks the smartphone's age (on the top), it's the other way around: it starts in red and goes via orange towards green.

A.5 Survey flow including options to select

Main questions 1/2

You've now had this smartphone for 2,5 years, so the ring and the widget in the phone look as in the images here.

In general, how would you evaluate this smartphone?

Dislike	○	○	○	○	○	○ Like
Dislike	○	○	○	○	○	○ Positive
Dislike	○	○	○	○	○	○ Good

A.5 Survey flow including options to select

Main questions 1/2

How many years in total would you expect this smartphone to keep functioning properly? Please indicate a round number starting from the day of purchase. (no wrong answers, you may use just your intuition)

Compared to your own current smartphone, how long would you expect this smartphone to keep functioning properly?

Much shorter ○ ○ ○ ○ ○ ○ ○ Much longer

Could you explain why you would expect the smartphone from this survey (not) to keep functioning properly?

To what extent would you feel this smartphone has made its money worth after 2,5 years of use?

It has made none of its money worth ○ ○ ○ ○ ○ ○ ○ It has made all of its money worth

After how many years would you feel that this smartphone has made all of its money worth? Please indicate a round number starting from the day of purchase.

A.5 Survey flow including options to select

Main questions 2/2

In the previous questions I asked you how long you'd expect the smartphone to keep functioning properly. I now want to know how long you expect to keep using the smartphone. Namely, not all smartphones are kept until they no longer function. Sometimes they are discarded even though they still function properly, and sometimes they are still in use even though they may have some defects.

How many years in total would you expect to keep using this smartphone? Please indicate a round number, starting from the day of purchase.

Compared to your own current smartphone, how long would you expect to keep using this smartphone?

Much shorter ○ ○ ○ ○ ○ ○ ○ Much longer

A.5 Survey flow including options to select

Main questions 2/2

Could you explain what makes you (not) want to keep using the smartphone from this survey?

You've had this smartphone for 2,5 years now. How likely are you to replace it with an alternative within the next year?

Very unlikely ○ ○ ○ ○ ○ ○ ○ Very likely

Could you explain what makes you (not) want to replace the smartphone after 2,5 years?

How informed do you feel about this smartphone's lifetime?

Badly informed ○ ○ ○ ○ ○ ○ ○ Well informed

Could you explain which part of the smartphone or widget made you feel most (or least) informed about its lifetime?

A.5 Survey flow including options to select

General questions

What's your age?

What's your gender?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to say

What's your nationality?

- ○ Dutch
- ○ Other from Europe
- ○ Outside of Europe

A.5 Survey flow including options to select

General questions

To what extent do you agree with the following statements?

	Completely disagree						Completely agree
I frequently look for new products and services	○	○	○	○	○	○	○
I am continually seeking new product experiences	○	○	○	○	○	○	○
I like magazines that introduce new brands	○	○	○	○	○	○	○
I take advantage of the first available opportunity to find out about new and different products	○	○	○	○	○	○	○
I would buy products at 20% higher than usual prices if it would help protect the environment	○	○	○	○	○	○	○
I choose household products that I think are better for the environment	○	○	○	○	○	○	○
I try to save water for environmental reasons	○	○	○	○	○	○	○
Humans should coexist with nature	○	○	○	○	○	○	○

On average, how often do you buy a new smartphone?

- ○ Every half year
- ○ Every year
- ○ Between 1 and 2 years
- ○ Between 2 and 3 years
- ○ Between 3 and 4 years
- ○ Between 4 and 5 years
- ○ Between 5 and 10 years
- ○ Every >10 years

A.6 Correlations between PLY and BEY per condition

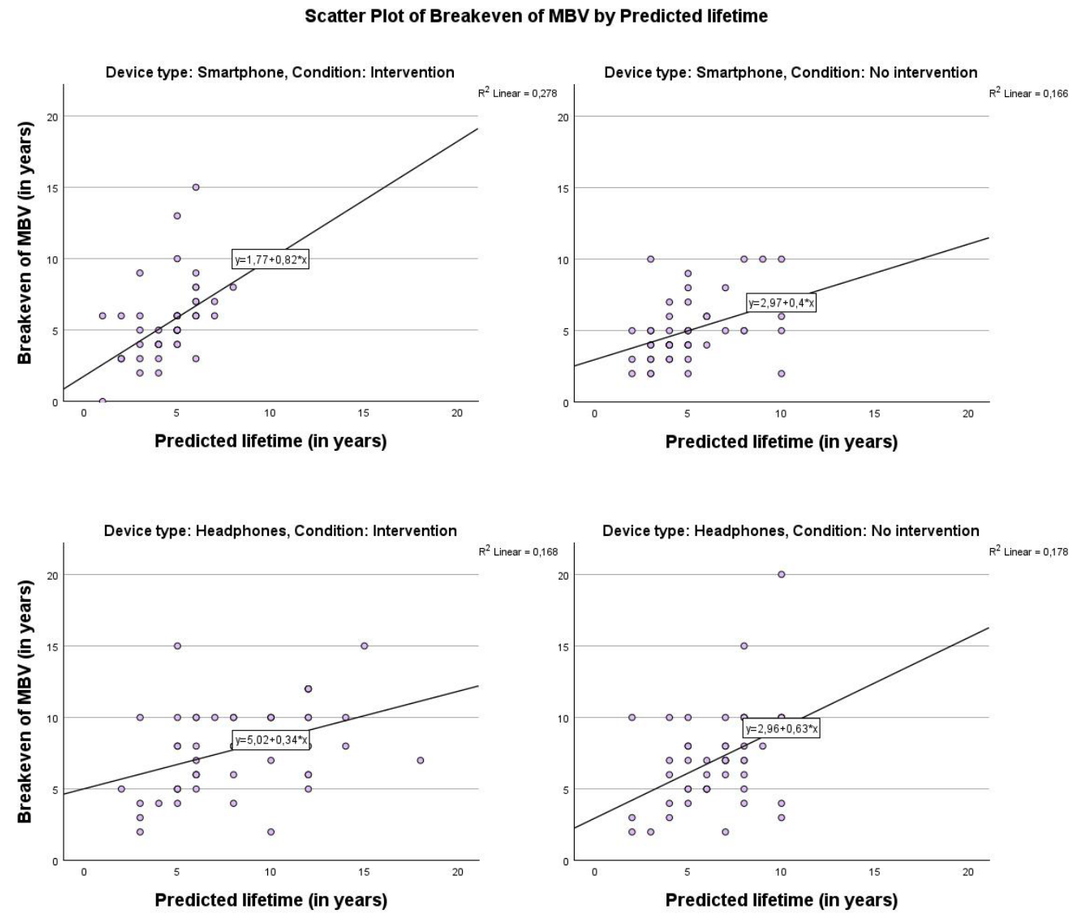


Figure A.10. Scatterplots of the correlations between the PLY *and the* BEY*, across the four experiment conditions: smartphone with intervention (upper left), smartphone without intervention (upper right), headphones with intervention (lower left) and headphones without intervention (lower right). The four cases identified by SPSS as outliers were excluded from this analysis.*

Table A.1. Results of the analysed correlations between the PLY and the BEY*, based on linear regressions for all four experiment conditions. The *** indicates a significant* p*-value of < .001.*

Device	Condition	Regression coefficient	Test result	Significance
Smartphone	Intervention	.82	$F(1,50) = 19.23$	< .001***
	No intervention	.40	$F(1,47) = 37.93$	.004***
Headphones	Intervention	.34	$F(1,47) = 9.47$	.003***
	No intervention	.63	$F(1,48) = 10.38$	.002***

A.7 Correlations between BEY and ILY per condition

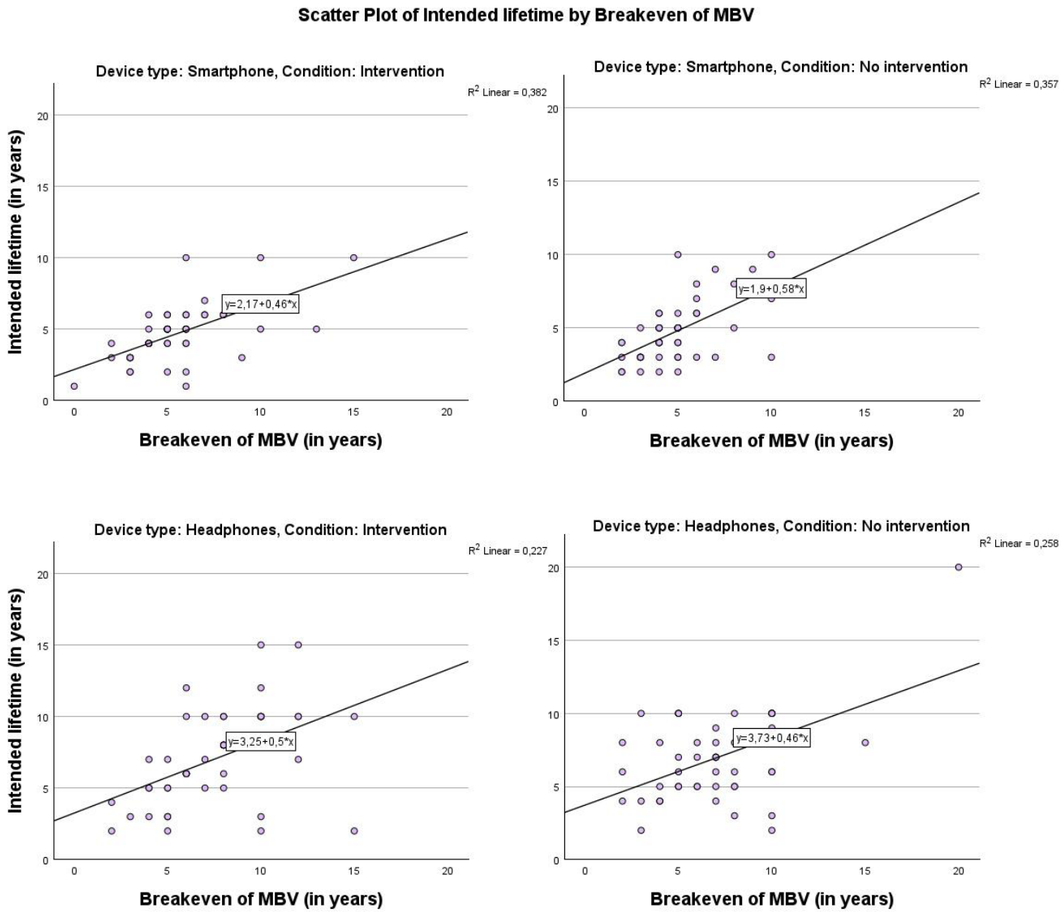


Figure A.11. Scatterplots of the correlations between the BEY *and the* ILY*, across the four experiment conditions: smartphone with intervention (upper left), smartphone without intervention (upper right), headphones with intervention (lower left) and headphones without intervention (lower right). The four cases identified by SPSS as outliers were excluded from this analysis.*

Table A.2. Results of the analysed correlations between the BEY and the ILY*, based on linear regressions for all four experiment conditions. The *** indicates a significant* p*-value of < .001.*

Device	Condition	Regression coefficient	Test result	Significance
Smartphone	Intervention	.46	$F(1,50) = 30.96$	< .001***
	No intervention	.58	$F(1,47) = 26.09$	< .001***
Headphones	Intervention	.50	$F(1,47) = 13.81$	< .001***
	No intervention	.46	$F(1,48) = 16.70$	< .001***

A.8 Correlations between PLY and ILY per condition

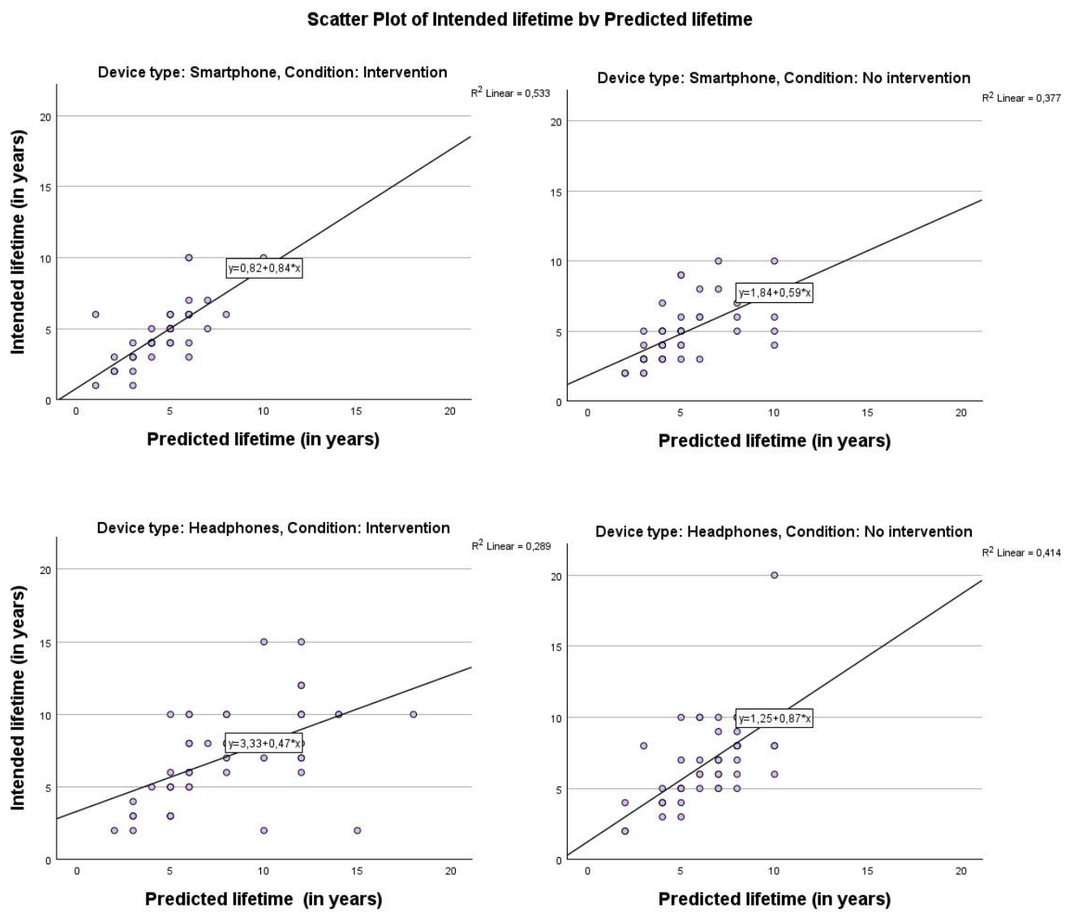


Figure A.12. Scatterplots of the correlations between the PLY *and the* ILY*, across the four experiment conditions: smartphone with intervention (upper left), smartphone without intervention (upper right), headphones with intervention (lower left) and headphones without intervention (lower right). The four cases identified by SPSS as outliers were excluded from this analysis.*

Table A.3. Results of the analysed correlations between the PLY and the ILY*, based on linear regressions for all four experiment conditions. The *** indicates a significant* p*-value of < .001.*

Device	Condition	Regression coefficient	Test result	Significance
Smartphone	Intervention	.84	$F(1,50) = 57.16$	< .001***
	No intervention	.59	$F(1,47) = 28.45$	< .001***
Headphones	Intervention	.47	$F(1,47) = 19.07$	< .001***
	No intervention	.87	$F(1,48) = 33.86$	< .001***

A.9 Qualitative responses from the participants

Measure: predicted lifetime

Question: "*Could you explain why you would expect the smartphone from this survey (not) to keep functioning properly?*"

Condition:

Smartphone,
with intervention

*Note: cases that were identified as outliers by SPSS, or where no responses were given, are excluded from the table. Invalid responses, such as "*Idk*", "*No*", "*Not sure*" or "*N/a*", are also excluded.*

Case	Response
1	Ik denk omdat deze telefoon wat meer hightech is dan de telefoondiensten ik zelf heb. Ik denk ook dat mijn telefoon het iets korter volhoud dan de voorbeeld telefoon. Puur geschat op het gevoel dat de voorbeeld telefoon verder/beter ontwikkeld is dan mijn telefoon
2	Een telefoon hoeft van mij niet veel te kunnen. Dus dan denk ik dat die 6 jaar realistisch is.
3	Alle balkjes staan op groen en het jaren gebruiktsymbooltje is nog niet voor de helft oranje. De telefoon heeft ook nog genoeg opslag en geheugen.
4	Ik verwacht van mijn eigen smartphone ook een levensduur van circa 6 jaren, dus gelijk.
5	De ervaring met mijn huidige smartphone leert dat zodra het geheugen vol loopt en de batterij het aantal maximale laadcycli heeft doorlopen + niet meer in aanmerking komt voor updates hij niet goed blijft functioneren.
6	Based on the data on the app, the phone seems to be in average conditions and to keep working
10	If it has reached its total number of charges, or has had its total number of impacts meaning it can't have any more.
11	De batterij is van gemiddelde duur. Tegenwoordig wil je als consument wel een smartphone hebben met een goede tot zeer goede gebruiksduur.
12	Meer dan de helft van de oplaad cycli na 2.5 jaar bereikt...haalt dus de 6 jaar niet
13	Je gaat misschien bewuster om met dingen als opladen als je ziet dat je in principe nog maar een x aantal keer hebt om op te laden. Ipv dat ik hem nu gewoon elke nacht oplaad ook als is hij niet bijna leeg.
15	The lifecycle of the smartphone is made apparent to the customer, which influences how customers treat the product (i.e., being more conservative using/charging the phone)
17	old
18	The functioning will stay the same
19	It looks more advanced than my current smartphone
20	It's already well used, so it only has a few more years where it will be usable
22	Big LED lights is something that could easily go wrong, one hit to the ground might hit the vitals
23	The phone doesn't take that much damage after 2.5 years.
24	Na lang genoeg gebruik (> 4 jaar) zou ik verwachten dat de balken van groen naar meer oranje/ rood kunnen gaan. De batterij krijgt mankementen en het systeem raakt veroudert door nieuwe software updates.
25	Doordat die goed de statistieken bijhoudt
28	Niet veel oplaad sessies mogelijk
29	Upgraded technology mean efficient system
30	Smart phone batteries dont last that long. After 2 yers, going into the third year, the battery needs to be charged way more often
31	Meeste telefoons na vier jaar wel ongeveer einde, dus deze ook.
33	Met de widget lijkt het redelijk voorspelbaar hoe lang dit ding het nog gaat doen.
34	hij lijkt het nog goed te doen, en ik verwacht dat een telefoon 3 jaar meegaat
35	Wellicht door de oplichtende ring wordt je batterij slechter
36	Hoe meer functionaliteiten hoe eerder het apparaat versleten is
37	Vergelijkbare telefoon met mijn telefoon nu (evenveel opslag etc) en doe zelf al 4,5 jaar met mn telefoon en het einde nadert
38	Het is meer een vergelijking met m'n vorige mobiele telefoon. Die had ongeveer dezelfde prijs en specs (wel al 7 jaar geleden gekocht). Deze heb ik 5 jaar gehad en had aan het eind wel allemaal 'kwaaltjes'. Zo kon ik alleen bellen op luidspreker, oplader moest er onder een bepaalde hoek in etc. Daardoor is m'n verwachting dat smartphones, van deze prijs, die nu verkocht worden zo'n 5 jaar max. mee gaan en goed blijven functioneren.
39	Het is dan inzichtelijk in plaats van op gevoel
40	Verbetering van technologie
41	Ik doe geen rare dingen met mijn telefoon en ben er zuinig op daarom verwacht ik dat een smartphone lang mee gaat dus ook deze
42	Leuk bedacht maar het neemt het belangrijkste punt van slijtage, de accu, niet weg. Lithium-accu's zullen na 2-3 jaar hard achteruit gaan. Zonder batterijwissel zal elk electornisch apparaat een beperkte levensduur hebben.
43	Ik zou niet iets anders doen
44	De kwaliteit is meetbaar , dat geeft vertrouwen. Het zal dan wel een goede smartphone zijn.
45	Because it's still performing well
46	groene balkjes gemiddeld halverwege
47	Het lijkt mij een verkooptruc en eige Een soort van dwingend om na zes jaar maar iets nieuws aan te schaffen. Daarvoor worden er steeds meer facette rood en oranje.
51	Je let meer op de oplaad cycli en de status zorgt denk ik op een zuiniger/zorgvuldiger gedrag
52	de batterij lijkt rap achteruit te gaan
53	Doordat je het apparaatonderhoud in kan zien, ben je je bewuster over de status van je telefoon en ga je er misschien voorzichtiger mee om.

A.9 Qualitative responses from the participants

Measure: intended lifetime

Question: "*Could you explain what makes you (not) want to keep using the smartphone from this survey?*"

Condition:

Smartphone,
with intervention

Case	Response
1	Omdat dat moet van mijn abonnement
2	Omdat dan waarschijnlijk de laadcycli op zijn.
3	Ik gebruik mijn telefoon totdat hij het niet meer doet. Ik hoef niet met de mode mee te gaan en vind het niet duurzaam om steeds een nieuwe te kopen.
4	Ik verwacht een smartphone te kunnen gebruiken totdat deze echt niet meer functioneel is.
5	Ervaring leert dat m'n smartphone na een jaar of 5 aan z'n einde komt. Dan ga ik opzoek naar een opvolger.
6	The older the phone gets, the worse its capabilities get
10	Might stop working after its completion.
12	De batterij is al 100% op na 4.5 jaar, dat is te kort
13	Ik gebruik nu mijn telefoon ook tot hij niet meer goed functioneert: heel traag wordt, stuk gaat doordat ie valt, etc. Dat zou ik dus op die manier blijven doen.
15	I would want to use this smartphone because its lifecycle is defined clearly. I will know (ostensibly) when the product needs to be replaced, so I can plan ahead (saving money, searching for alternatives, etc.)
18	The visual of years is colored orange. This would give me the indication it is almost finished
19	If it works perfectly fine then I will continue to use it
20	Compared to my current smartphone, it has less wear
22	It might soon be out-dated
23	It seems to be pretty well specs and the price is fairly high. So, I'm trying to get my money worth it.
24	Door de widget geeft het een duidelijk beeld in hoeverre de telefoon mankementen heeft. Normaal gesproken heb je hier geen inzicht in. Persoonlijk gebruik ik een telefoon maximaal 4 jaar of hij nu mankementen ervaart of niet.
25	Geen sociale status
28	Huidige telefoon is refurbished dus dat houdt het minder lang vol
29	Innovative features
31	Gebruik totdat een aantal belangrijke functies of apps niet meer functioneren.
32	Ik heb een fairphone die is modulair. Dus gaat al erg lang mee.
33	Met die widget lijkt het alsof dit apparaat nog niet eens op helft van zijn levensduur is.
34	hij is 2x zo duur als mijn eigen telefoon, dus ik verwacht hem langer te gebruiken
35	Wellicht zijn er in de tijd dat de telefoon in gebruik is verbeterde technologieen ontwikkeld
36	Zie eerder antwoord
37	De ring volmaken, dus dan maar eventjes een minder goed werkende telefoon
38	Specs lijken me prima. Maar heeft denk ik niet te maken met deze informatie over de levensduur. Tenzij je bijvoorbeeld garantie hebt, of gratis reparatie etc als de telefoon niet voldoet aan wat er wordt beloofd. Dat zou ik wel interessant vinden.
39	Veel inzichtelijker
40	Ik vind dat een smartphone zeker 3 jaar mee moet gaan.
41	Als hij het goed doet en ik nog tevreden ben ga ik hem niet vervangen tenzij hij vol raakt of gebreken gaat vertonen
42	Door de accu
43	Ik denk als er goede oplossingen zijn om de ring weer goed te laten beginnen op 0 dus wel. Bv je krijgt een 'telefoonbeurt' bij een volle ring en alle tellers beginnen weer op 0 en zijn groen.
44	Meer info over hoe goed ie nog werkt en daarnaast vertrouwen in de kwaliteit
45	It's still performing well
46	lijkt beter dan huidige telefoon hoop wel dat ie waterdicht is
47	Gelet op het feit dat de batterijen vrij snel niet meer goed op te laden zijn. Daar is nu nog maar 35 procent van beschikbaar en deze telefoon is nog maar /,5 jaar oud.
50	Zolang deze goed functioneert 1 dag accu en voldoende geheugen heeft voor een maand foto's maken is het prima.
51	Na 4 jaar is ie denk op, als hij het nog goed doet(geen schade) dan vervangen we hem niet.
52	zo lang hij goed werkt
53	Zolang de smartphone het nodige blijft doen zonder problemen blijf ik hem gebruiken.

A.9 Qualitative responses from the participants

Measure: replacement intention

Question: *"Could you explain what makes you (not) want to replace the smartphone after 2,5 years?"*

Condition:

Smartphone,
with intervention

Case	Response
1	Omdat er een grote kans is dat er een betere versie is
2	Tenzij hij helemaal kapot is vind ik 2,5 jaar wel erg kort om met een telefoon te doen
3	Ik neem aan dat hij het na 2,5 jaar nog steeds doet (zeker gelet op het aankoopbedrag).
4	Ik verwacht een levensduur van 6 jaren en heb geen behoefte de smartphone voortijdig te vervangen.
5	Hij is nog goed, dat geeft de data aan. Zonde om hem weg te doen.
6	I use my phone daily, therefore I need an efficient technology with me
10	If the phone is keeping up with the current specs (apple releases a new phone every year!)
11	Als de smartphone nog naar behoren functioneert, dan zie ik geen reden om deze te vervangen.
12	Omdat hij nu nog goed is. Ik gebruik hem tot hij niet meer bruikbaar is. Dwz meerdere oplaad beurten per dag nodig
13	Ik vind het zonde om zoveel geld aan een telefoon uit te geven. Ik gebruik mijn telefoon altijd tot hij niet meer functioneert, daarnaast vind ik het zonde om een goed product weg te doen.
15	I believe the phone will last longer than 2.5 years or will have used it conservatively.
18	Too short
19	If it's not broken then don't fix it (or replace it)
20	It's still too early, and changing phones too often is expensive and puts strain on the environment
22	If I could still use it why change it
24	Na 2,5 jaar doen de meeste telefoons het nog prima en ik hoef persoonlijk niet altijd de nieuwste van de nieuwste
25	Te vroeg
26	hij moet veel langer meekunnen dan 2,5 jaar
28	Smartphone kan langer mee
29	Advanced development in technology will give better options in future
30	I signed a contract that gives me a new one every 24 months
31	Als alles goed werkt niet nodig.
32	Geen heftige gebruikerseisen
33	Gaat nog prima toch? Persoonlijk koop ik graag duurzame apparatuur die duurder is in aanschaf maar veel langer mee gaat, dus: goedkoper.
34	hij zou het nog prima moeten doen
35	Wellicht zijn er in de tijd dat de telefoon in gebruik is verbeterde technologieen ontwikkeld
36	Normaliter functioneert het apparaat dan nog goed
37	Heb mijn huidige telefoon ook al 4,5 jaar
38	Tot nu toe vervang ik mobieltjes alleen als ze echt niet meer werken. En van deze telefoon verwacht ik dat ie nog wel langer dan een jaar mee gaat. Hoe kan ik zorgen dat de prestatie van m'n camera minder achteruit gaat, of dat ik minder laadcycli gebruik etc.
39	Nee
40	Afgezien van de kosten vind ik dat een smartphone best een tijd mee mag gaan. We moeten duurzaam gebruik maken van deze technologie.
41	Voelt voor mij nog als nieuw
42	Nieuwe features op nieuwere telefoons en het verval van de accu
43	Ik vervang hem als hij niet meer functioneert. Uitvalt, toetsenbord niet meer werkt of t scherm kapot is bv
44	Als ie t nog goed doet wil ik m niet vervangen
45	Want to upgrade features
46	het is nogal een dure, koop meestal niet boven 250 euro
47	Zonde van het milieu en het geld. Ik vind dat smartphones in het algemeen veel te kort meegaan, voordat ze echt niet meer goed functioneren. En dat zou moeten veranderen.
48	te kort
50	Pas als deze stop met werken vervang ik de telefoon
51	Als hij het nog goed doet, batterij en appstore doen het dan is ie nog niet aan vervanging toe
52	vanwege de batterijduur
53	Een telefoon zou het nog moeten doen na 2,5 jaar, dus ik zou hem nog langer blijven gebruiken.

A.9 Qualitative responses from the participants

Measure: feeling of being informed about the lifetime

Question: *"Could you explain which part of the smartphone made you feel most (or least) informed about its lifetime?"*

Condition:

Smartphone,
with intervention

Case	Response
1	Meeste: de cirkel achterop de telefoon + de mobile data die over is Minste: app beveiliging + cameraprestaties + aantal schokken
2	De dure prijs indiceert een lange levensduur voor mij
3	De oranje gebruiksduur en de opslag- en geheugencapaciteit.
4	De cameraprestatie.
5	Batterij + opslag en geheugen + ringen het meest. Wat ik nog zou willen zien is in hoeverre de software up-to-date is en hij nog in aanmerking komt voor updates.
6	The app functions
10	Camera performance.
11	Er is geen widget dat laat zien hoelang de telefoon zelf nog mee gaat.
12	Dat hij na 6 jaar overnieuw begint terwijl hij na 2.5 jaar al >50% van z'n oplaad cycli verbruikt heeft
13	Ik denk dat met name de laadcycli inzicht geven, omdat je daar zelf ook iets aan kan doen. Als ik dit zou doen zou ik toch geneigd zijn minder vaak op te laden, alleen als het nodig is.
15	I liked the insights into the remaining charges and its impact on battery life.
18	Not clear UI design. A lot of words, visualisations would make it more intuitive
19	The widget is good because it gives you and in depth insight into the phones "health" the ring light on the back is good but it may not be visible if you have a phone case on it
20	Remaining charges
22	Battery life
23	Impact, Since percentage endured barely means anything. total charges and battery percentage also feels off. Feels like it should be battery health (how much percentage of the battery can still charge/ discharge).
24	De batterijduur vind ik altijd een belangrijk aspect in de overweging om een nieuwe telefoon aan te schaffen. Deze widget geeft dit netjes weer.
25	De ring
26	de schijf op de achterzijde
28	Hoe lang de telefoon nog goed blijft werken
29	The back light
31	Door ervaringen uit het verleden hecht je niet zoveel waarde aan de gegevens die de telefoon levert. Leuk dat een cirkel tot zes jaar gaat, maar dat zegt niets. Eerst zien...
32	Achterkant
33	Als eerste: de gebruiksduur. Maar is het eigenlijk niet veel simpeler om gewoon een smartphone te verkopen met bijvoorbeeld: 7 jaar garantie bij normaal gebruik? Doet Kia ook bij auto's.
34	het bovenste deel (aantal jaar met cirkeltje)
35	De widget geef duidelijk meer informatie betreffende de levensduur
37	De ring, opslag, en de percentages geven duidelijk weer hoe goed je telefoon nog is
38	Ik denk dat ik voornamelijk de widget het meest informatief vind. Vooral laadcycli in combinatie met de levensduur zou ik wel interessant vinden. Bijv. als de levenduur halverwege is, zou ik ook wel proberen dat m'n laadcycli ook ongeveer halverwege is. Ik mis wel een beetje de educatie over hoe je bepaalde statistieken zou kunnen verbeteren.
40	De kant met informatie over het apparaatonderhoud
41	Ik verwacht niet dat de smartphone het niet meer doet als het rondje vol is. Ik vind dit dan ook geen meerwaarde op de telefoon.
42	De accu
43	Je weet nog steeds niet hoeveel ringen die gaat doorlopen. En wat betekend als hij 12x is gevallen? En wat als je oplaadcyclussen op zijn?
44	Widget
45	Battery charging cycles
46	denkinfo over aantal laadcycli
47	Op zich staat alles er wel in, maar door het rondje met 6,5 jaar zou ik bij aankoop verwachten dat de telefoon het 6,5 jaar goed zou doen. Gelet op de meters bij 2,5 jaar denk ik dat deze aanname niet klopt.
48	alles samen
50	Ik gebruik telefoons normaal heel lang tot voorbij de verwachte levensduur. En repareer ook tot dit financieel niet haalbaar is.
51	De achterkant met ledjes. Daarna de widget met de info
52	de batterijduur
53	De ring, hij geeft de leeftijd weer, maar deze kan je ook vinden in de widget. Het heeft wel een zichtbare toevoeging, waardoor je meer herinnert wordt aan de levensduur.

A.9 Qualitative responses from the participants

Measure: predicted lifetime

Question: *"Could you explain why you would expect the smartphone from this survey (not) to keep functioning properly?"*

Condition:

Smartphone, without intervention

Case	Response
55	de smartphone zelf zal wel goed blijven functioneren, maar de apps die je gebruikt hebben steeds meer geheugen nodig, en dan zal hij niet goed meer werken omdat er dan niet genoeg geheugen meer is.
56	Na 2,5 jaar nog voldoende intern geheugen en opslagcapaciteit over voor nog anderhalf jaar.
57	The battery life is so short after 2.5 years
58	Old phones cant be updated to new software so you are forced to buy a new phone
61	It has good battery life, memory is full but I expect that to be a problem of the user - storage can be cleared and memory too
62	errors
63	hij ziet er hetzelfde uit als mijn iphone nu en ook de gegevens lijken erop
64	Ik heb nu een iphone en ik verwacht dat die niet 6 jaar mee kunnen, mede dankzij de systeemupdates die na een aantal jaar niet kunnen worden geïnstalleerd. De smartphone uit het voorbeeld ziet er nog goed uit, de batterij doet het nog goed er is niet veel geheugen meer over maar ik verwacht na 2 jaar niet heel veel meer nieuwe apps te downloaden.
65	Ik verwacht dat de smartphone heel gemiddeld zal functioneren
66	Binnen een paar jaar is het geheugen vol
67	Using the widget to keep track of the performance, one might be more conscious about their use, prolonging product life.
68	Cost
69	it seems to have enough storage, the battery seems okay and so do the other criteria
71	its an apple
73	not enough memory
75	becuse of the storage issue
76	aangezien de batterij
77	Na 2,5 jaar lijkt hij nog geen krassen of beschadigingen te hebben. Ik heb een vergelijkbare prijss betaald voor mijn huidige mobiel en die functioneert na 4 jaar nog steeds prima.
78	if it keeps getting the relevant software updates for long enough it will run properly, if not then it will fade over the years and not run properly
79	I would say the same expectation because I have a great phone.
80	Smartphones degrade over time. Planned obsolescence.
81	It will probably get slower due to the storage available, and you will have to delete apps and photos to keep using it
82	It is a newer version with bigger GB

Case	Response
83	Its a very good phone and from a very good brand so it has the potential
84	Because it was shown to me that it will probably last longer since the only thing that gets worse with my phone is the battery
86	after a few years the memory and storage seem to be running out rapidly
87	Software updates not done in time can affect the phones functionality and over charging the phone can cause the battery life to go down.
88	If it wont work pro-actively as it does when its new.
89	The storage and memory are well enough to make it function properly
90	Long battery life
91	more than a day of battery at 35% leads me to believe this device will keep functioning properly
92	It looks like a quality phone with good storage, but like any other phone life span, Usually after two years you start experiencing problems
93	it still have the memory and the battery is still good
94	Because it would have worked for quite a while so it might get difficult for it to keep doing good
95	Because the one above has a lifespan of 2.5 years and it still looks in a good condition as opposed to mine.
96	because old phones have low durability and fewer software updates
97	phones get's tired easily and to much storage may lead to the phone not functioning properly
98	Material used is not quality
99	The battery's health is still good and it's seems to be still working properly. But, you might want to free up some storage if you want to keep using it for a longer period.
100	It is more expensive, so I would assume better materials/equipment used to create the phone.
101	the price and its specifications
102	because of its price and age.
103	because of repairs

A.9 Qualitative responses from the participants

Measure: intended lifetime

Question: *"Could you explain what makes you (not) want to keep using the smartphone from this survey?"*

Condition:

Smartphone, without intervention

Case	Response
55	Als je de apps niet meer kan updaten omdat er niet genoeg geheugen is. Of omdat de batterij niet meer goed oplaadt of te snel leegloopt.
56	Na 3 of 4 jaar geen beveiligingsupdates meer. Dan moet je hem vervangen ook als de smartphone nog goed werkt
57	Bad battery life
58	I think it's the same thing as previous one
61	I would keep it because the battery seems not to get worse and that's the biggest issue with my latest phones
62	errora
63	het lijkt op dezelfde telefoon
64	Het liefst doe ik er zo lang mogelijk mee
65	Hij is iets duurder dan mijn telefoon dus ik hoop dat hij wat langer mee gaat
66	Geheugen zit nog niet vol, batterij werkt nog, krijgtwaarschijnlijk nog updates
68	Long battery life
73	There is nothing new about old cell phones.
75	This is not beacuse of survey. This is my personal preference. I only use phones upto 5 years maximum. But this phone alredy reached 6 years.
76	grote opslag goeie batterij
77	Als ik zoveel geld besteed aan een voorwerp dan wil ik die blijven gebruiken totdat hij het niet meer goed doet. Ik verwacht dat de smartphone 5 jaar lang goed blijft functioneren.
78	if i buy another phone i want to be able to use it way longer without having to upgrade
79	The same as I have a great phone and my expectation is for it too last a very long time.
80	Over the years it will get worse and just may want to get something different eventually
81	Storage for apps and photos
82	It is much bigger and has more feastures than my phone
83	The device has a good camera quality and its has sufficient space ,it is a very good model phone
84	It seems reliable and easy to use so it's a no brainer
86	It seems that once the memory becomes full i'll have to move on
87	It's design is not durable

Case	Response
88	Battery Life Concerns: While the iPhone has good battery life, it's not always the best in its class, especially if I'm using power-hungry apps like gaming or video streaming. Over time, the battery can degrade, and replacing it costs a fair amount of money, which is frustrating.
89	I usually don't change my smartphone until it is no longer useable or it is outdated for software and features, Usually a smartphone can survive till 5 years until some significant change comes that makes you upgrade it.
90	High quality
91	the smartphones battery life is still very good
92	Like most phones, You start experiencing problems after 2 years, so I expect the same from this one
93	it still has a good memory
94	Because the phone would have worked its best for a while so it might get difficult to keep doing good
95	I'm planning to buy another one because the one that I own tend to lose battery levels within a short period of time.
96	it wont have the latest features like good camera and better screen for protection against falling
97	nothing everything is perfect plus storage size
98	Material used
99	It's still doing its job so I see no use in replacing it. As they say: Don't fix it if it's not broken.
100	Battery seems to be the same, and that is one of the most important things for me personally to have for such a device. And I assume it will still have updates, so it is a win-win.
101	nothing i would love to use it
102	quality and new features added to smartphones
103	expensive

A.9 Qualitative responses from the participants

Measure: replacement intention

Question: *"Could you explain what makes you (not) want to replace the smartphone after 2,5 years?"*

Condition:

Smartphone,
without intervention

Case	Response
55	Als alles nog gewoon werkt zie ik er het nut niet van in om hem te vervangen.
56	Daar was hij te duur voor
57	Good storage
58	I feel like as the phones get older they get slower
61	Depends, I dont really know the phones software characteristics
63	ligt eraan hoe goed alles het nog doet
64	Niet vervangen om geld te besparen
65	Hij doet het nog goed, en 2.5 jaar is te kort om hem al te vervangen voor mij. Ik wil hem nog langer blijven gebruiken
66	Zonde van het geld
68	Cost
69	if it still functions, i would not change it
70	because it looks like it is still working funtionally
73	New phones have better performance.
75	if its functiones properly like the old days then its fine. But probably after few years defenitly the battery wont works that good. But on this survey phone its works same even after 5 years. But the storage is almost full
76	als die goed functioneert niet slomer word en genoeg opslag heeft
77	Zonde van het geld
78	if it works perfectly fine, then i will not need a new phone, i dont do enough with the phone to need an upgrade
79	It is still just too good to replace.
80	I think a smartphone should be used for 4+ years
81	Better updates, probably better camera
82	I like to get my full monies worth
83	financially its not needed if the phone is functioning well .
84	Only because I want the freshest one out
86	phones are expensive, like this one was almost 900, its a big investment to make every 2 years, so i'd push it little longer
87	If the phone is still working fine, then there is no need to replace it

Case	Response
88	Ecosystem Integration: The iPhone integrates so well with other Apple devices. If I have an iPad, MacBook, or Apple Watch, everything syncs effortlessly. Features like AirDrop, iCloud, and Handoff make it easy to transition between devices, which I really appreciate.
89	again If it's working and has no major updates, I will not replace it.
90	High quality
91	the smartphone is still in good condition and seemingly still functioning properly
92	I prefer to keep up with newer model
93	its still functioning well the battery still good
94	Because the phone would be out of fashion after 2,5 years
95	Because it still in a good condition and it look durable to me.
96	phone might have any more software updates and will i will like to have the latest technology
97	i would 2 years its alot for a phone
98	It has fetures i want
99	I won't even consider replacing it until it stops working entirely.
100	It was quite expensive. If it were very faulty there would be problems for the company as many people would complain that it could not survive for a couple of years.
101	with its specifications, i don't think it will be out dated in 2,5 years
102	because it still functioning at its best capacity.
103	new release of smartphone

A.9 Qualitative responses from the participants

Measure: feeling of being informed about the lifetime

Question: *"Could you explain which part of the smartphone made you feel most (or least) informed about its lifetime?"*

Condition:

Smartphone,
without intervention

Case	Response
55	Ik zou de status van de batterij het meest informatief vinden over de levensduur van de smartphone.
56	Batterijstatus zegt niet zo veel, hangt af van het gebruik. Informatie over opslag en intern geheugen is wel fijn. Wat mist is info over beveiligingsupdates. Is telefoon up to date en hoe lang ontvang je ze nog? Dat is meestal de reden waarom een nog goed werkende telefoon toch vervangen moet worden.
58	I didn't get the information from the smart phone, I watched it on a documentary
61	Battery
63	batterij
64	Batterijduur en geheugen
65	Alleen de opslag meter laat mij iets zien van capaciteit. Maar deze kan ik gewoon weer leeg maken. Dus ik heb weinig informatie over de levensduur
66	Hoe lang krijgt deze nog Apple updates?
73	battery
75	Battery
76	batterij
77	Ik denk dat geen van de delen van de widget echt informatie geven over de levensduur van een mobiel. Het zou interessanter zijn om iets te zien over hoe goed de batterij nog presteert ten opzichte van hoe hij presteerde toen hij nieuw was. In hoeverre de batterij is opgeladen kan ik ook boven in het schermpje zien.
78	the lack of info about its specs and the battery etc.
79	Understanding the metrics shown.
80	I cant actually see how it performs. Sometimes the battery timer is wrong as it gets older. Lr theres glitches etc.
81	The battery life
82	The device care
83	The device care section
84	It is the battery life
86	I'd like more on teh battery, i find it hard to believe its battery wouldnt get worse
87	The 'no threats found' I don't find it to be accurate with the amount of downloads going on

Case	Response
88	The part of the iPhone that has made me feel most informed about its lifetime is the way Apple handles software updates and the clear communication around device lifespan. Apple provides detailed information about how long software updates will be available for each iPhone model, which gives me confidence that my phone will continue to function well and receive new features for several years. For example, Apple typically supports iPhones with major iOS updates for around 5 to 6 years, which is much longer than many Android phones. This means I don't feel like my device will quickly become obsolete.
89	mostly, its memory used and space
90	Battery life
91	the battery life and storage capacity made me feel most informed about its lifetime
92	The information provided was open and honest
93	battery
94	The honesty of the company about this smart phone's capabilities and life span even after years of use
95	Because it shows the basic qualities of a good mobile phone.
96	the device care app shows lot of good clear information and the battery life still looks good so that would show the phone is still good
97	memory
98	Its appearances and the material used to manufacture it
99	There was enough info on the storage, the battery's life and so on. So I feel like I could get a general idea about it.
100	The description, app info, price - all let me assume that it could last for quite some time.
101	The battery health and Space
103	the years it could last without battery repair

A.9 Qualitative responses from the participants

Measure: predicted lifetime

Question: *"Could you explain why you would expect the smartphone from this survey (not) to keep functioning properly?"*

Condition:

Headphones, with intervention

Case	Response
105	Een metertje zegt niets over e kwaliteit van de koptelefoon
106	Mijn huidige koptelefoon is bedraad. Ook zegt die van mij niet dat hij maar x aantal keer kan vallen
107	de basis functie is niet anders, is een vrij simpel proces dat blijft het wel doen
108	The price is higher tier then my current headphones
109	Tierelantijntjes of niet het gaat om de basisfunctie ik verwacht dat die net zo lang meegaat als mijn huidige
110	Er zit een oplaadbare batterij in. In mijn huidige niet, is bedraad.
111	Ik verwacht dat de nieuwe opzet voor geluidskwaliteit en batterijduur niet veel verschil zal maken
112	ik denk dat mijn huidige koptelefoon vrij lang (goed) blijft functioneren, maar dat de zojuist omschreven koptelefoon iets langer mee zou gaan omdat er een nadruk wordt gelegd op de lengte van gebruik
113	It has no app to show how much battery is left on the headphones to use to it's best ability
114	Meer functies betekent meer dingen die kapot kunnen gaan. Bovendien hoger energieverbruik.
115	Omdat er toegelicht was dat dat er 12 lichtbalkjes zijn, 1 voor elk jaar
116	het is een duur apparaat en lijkt mij niet al te ingewikkelde technologie. Bovendien zouden de oplichtende vakjes na 12 jaar weer opnieuw beginnen, dus verwacht ik dat het apparaat langer dan 12 jaar meegaat
117	Als de cirkel 12 ringen heeft, zijn die er niet voor niets en ga ik er dus vanuit dat ie meer dan de helft van die cirkels zal halen
118	Er zitten vele opties op, dus ook een aanzienlijke kans dat dit op enig moment niet meer werkt.
119	Omdat de meter tot 12 jaar gaat, ga je ervan uit dat die minimaal lang genoeg mee gaat om de meter vol te krijgen
120	battery cells die with time
122	Technology advancement
123	Normal wear and tear
124	my headphones were very worn out (especially the ear pads) after 2 years
125	Its very clear that it is made to last 12 years or longer.
126	Door het open aangeven van de levensduur geef je mij vertrouwen dat je zeker van bent dat deze hoofdtelefoon lang blijft werken
129	De app is handig voor inzicht.
131	if it has 12 rings i assume that the company is certain that the product would at least reach this number

Case	Response
133	Ik gebruik een koptelefoon met snoertje van welk het design al sinds de jaren 70 bestaat. Een vriend van mij heeft er ook eentje uit 1978, mijn exemplaar is uit 1999. Ik denk dat de batterij van degene uit de vragenlijst stopt met functioneren of de app wordt niet meer gesupport
134	Batterijduur neemt nog steeds snel af, door extra electriciteits-vragende features dus nog sneller leeg
135	Batterijduur loopt terug terwijl er weinig laadcycli zijn geweest
136	omdat hij tot 12j functionering kan laten zien
137	Door de extra functies met de lichtjes zou ik eerder verwachten dat hij minder lang meegaat omdat dit extra functionaliteiten zijn die stroom etc kosten
138	omdat hij heel erg bewust is van de levensduur en de kwaliteit over tijd
139	The headphones still have plenty of charge, driver and control board performance left in them. The rings also suggest that a 12-year life is possible. My only concern is that the materials of the headphones may not hold up as well (based on my experience with similarly priced headphones). I had to replace the ear pads after 4 years.
140	Hij heeft 12 lichtjes. Dan ga ik er vanuit dat je die ook kan vol maken. Dus een gebruik van 12 jaar
141	Weer meer tech, waardoor hij makkelijker kapot kan gaan
142	Je hebt inzicht over de levensduur, dus dan is er ook nagedacht over de levensduur. Waardoor hij waarschijnlijk langer mee gaat dan een normale koptelefoon.
143	Veel duurder
144	i currently have cheap headphones
145	ik zie de meerwaarde niet omdat ik zelf niet gauw een gebruikte zou kopen. Ik ga er vanuit dat deze flink slijten aan de buitenkant, oorafsluiting draad verbinding veerelementen e.d. waardoor de latente kwalitatief zover achteruit gaat.
146	Veel functionaliteit maakt kwetsbaar
147	It has a monitoring app showing me how well it's functions are, which is a good way to show its 'Life-time'. Just like in the setting of a smart phone, you have the info about the performance of the phone. I have my phone bought for 3 years and the battery performance is still around 90%, for which I feel proud of keeping it in good condition and also believe it will sustain longer.
148	Bij vallen/stoten kan de werking van de lampjes verminderen?
150	Mijn koptelefoon is al 10bjaar oud, de kappen zijn perfect en het geluid is nog uitstekend
151	Als de koptelefoon elk jaar een vlakje extra laat branden en na 12 jaar opnieuw begint, dan moet die dat wel waar kunnen maken.
154	Kwaliteit van huidige koptelefoons in algemene zin is onder de maat. O.a. Schuim is minder. Daarnaast verwacht ik dat de batterij minder zal zijn en helaas niet vervangbaar is.

A.9 Qualitative responses from the participants

Measure: intended lifetime

Question: *"Could you explain what makes you (not) want to keep using the smartphone from this survey?"*

Condition:

Headphones, with intervention

Case	Response
105	Blijven gebruiken tot hij kapot is, onafhankelijk van het metertje
106	Hij is duurder, dus wil ik het volledige gebruik eruit halen.
107	verwacht nadelige slijtage na 12 jaar
108	If they get scratches or the quality gets effected
109	Opnieuw als t t doet is t goed
110	Batterij slecht
111	Waarschijnlijk door te zien wat er nog goed aan is, ben ik minder geneigd een nieuwe te kopen
112	ik denk dat de nadruk op gebruiksduur en het feit dat je kunt bijhouden hoe goed de koptelefoon presteert ervoor zorgen dat ik hem iets langer zou blijven gebruiken
113	Hopefully good quality and value for money.
114	Een grote reden dat ik de koptelefoon zou kopen zijn die functies die op tijd gebaseerd zijn. Hier zou ik meer uithalen als ik hem langer blijf gebruiken.
115	€399 is een flinke investering dus dan wil ik er wel een heel leven mee door willen. Als er niks mis mee is en het fijn is verder gebruik ik het tot de laatste druppel, ga niet weer zoveel geld besteden.
116	liefst zo lang mogelijk om verspilling tegen te gaan én omdat het altijd een gedoe is om weer iets nieuws uit te zoeken. Pas als de kwaliteit echt achteruit gaat en er betere apparatuur beschikbaar is zou ik vervangen, of als de koptelefoon niet meer compatibel is met laptop en smartphone.
117	Hij is tijdloos, ik zal er altijd een nodig blijven hebben, zie geen reden om geen koptelefoon meer nodig te hebben. Ik geef niet om het uiterlijk van een apparaat, mits het er netjes (niet kapot) uitziet.
118	Er wordt weer nieuw aantrekkelijk model uitgebracht
119	Geluidskwaliteit, noise cancelling of batterijduur die misschien beter zou zijn bij nieuwere modellen. Dus technologische vooruitgang
122	seems more durable
123	The app almost provides to much information. i would not be intereted in knowing how many times I had dropped the headphones.
124	they still look good
125	I think the technology would make me extremely aware of the imperfections in my device. I would appreciate if I had a feature that told me how to fix it.
126	Omdat je exact kan zien wat de staat is ipv het zelf te moeten schatten
129	Duur en lijkt lang mee te gaan.
131	my headphones are much cheaper so i expect less from them

Case	Response
133	Bevat een batterij en waarschijnlijk wireless technologie die veroudert. Geen behoefte aan draadloos of app
134	Teveel technologische vooruitgang t.a.v. duur, comfort, geluid.
135	Batterijduur
136	ik zou hem gebruiken tot hij kapot gaat
137	Ik raak hem bijna altijd kwijt.
138	ik gooi m pas weg wanneer hij kapot is denk ik
139	If I buy headphones for this price, I will use them until they no longer function
140	Omdat het een koptelefoon van kwalitiet is. Niet omdat er features met leeftijden op zitten
141	Het idee is wel cool
142	Deze koptelefoon heeft al vrij veel innovative functies, waardoor hij minder snel zal gaan verouderen.
143	Lijkt duurdere kwaliteit, dus langer meegaan
144	new features on newer headphones, batterylife that gets worse over time, and faster charing on new devices
145	Deze is duurder dan die van mij
147	I think it's still the reason of the app, showing all the conditions :)
148	Praktisch
150	Slijtage van de luidsprekers gaat te snel
151	Ik wil producten blijven gebruiken tot ze stuk zijn.
152	Improvements/developments in sound quality
154	Heeft geen batterijen. Gewoon bedraad met een verwisselbare 3,5 inch mini jack

A.9 Qualitative responses from the participants

Measure: replacement intention

Question: *"Could you explain what makes you (not) want to replace the smartphone after 2,5 years?"*

Condition:

Headphones, with intervention

Case	Response
104	Omdat er waarschijnlijk alweer betere koptelefoons zijn. Lichter, langere batterijduur etc.
105	Zolang er geluid uit komt blijf ik hem gebruiken
106	Ik ga niet iedere 2,5 jaar 400€ uitgeven aan een koptelefoon. Dat is dubbel de prijs van mn telefoon en die gebruik in over het algemeen 4 jaar. Verder houdt ik wel van muziek maar een koptelefoon of oortjes gebruik ik alleen voor meetings of muziek luisteren op de fiets. Dan heb ik minder hoge kwaliteitseisen dan wanneer ik thuis een plaatje opzet.
107	functioneerd nog naar behoren
108	The look if it gets scratches or the quality
109	Als t t doet doet ie t
110	Doet het nog prima en was een dure aanschaf.
111	Hij doet het zo te zien nog goed
112	ik hoop dat een koptelefoon wel langer mee gaat dan 2,5 jaar, maar als deze niet meer presteert dan vervang ik hem wel
113	I would expect them to last longer than the 2.5 years.
114	Ik heb er best veel voor betaald. Zolang hij goed werkt, zou ik hem blijven gebruiken. Ook als hier en daar secundaire functies het niet meer doen.
115	Nogmaals. €399. Als het lekker op mn hoofd en oren zit, goed geluid, fijne werking, niet uit elkaar vallend; waarom moet ik het dan vervangen?
116	als het ding het gewoon doet, is dat voor mij goed genoeg
117	Als hij nog goed werkt vind ik het zonde om hem te vervangen.
118	Niet omdat ik het zonde vind van de investering om een goed product zo snel te vervangen.
119	Als die het nog goed doet en er zijn geen modellen op de markt gekomen die het veel beter doen qua geluidskwaliteit, noise cancelling en batterijduur
120	if they work no need to
122	Technology breaking headphone, but unlikely to change if still working
123	If they still work and emit good sound, I see no reason to replace them.
124	if they still look good and work well why throw them out
125	I would feel guilty, because clearly they have more to give.
126	Nieuwe kopen zijn altijd leuk! Anderzijds biedt het inzicht in de levensduur mij misschien een beeld dat het nog niet nodig is om een nieuwe te kopen
129	De kwaliteit verbetering/innovatie van andere koptelefoons.
131	cuase i thnik they will last much longer

Case	Response
133	Dat is veel te kort
135	Geen geld voor
136	hangt ervan af of hij nog werkt
137	Als hij het goed doet zou ik hem niet vervangen. Daarom denk ik dat de functionaliteit van kunnen zien hoe goed hij het doet niet veel brengt want dan zou ik hem alleen maar sneller vervangen maar dat is niet heel sustainable.
138	omdat hij nog niet kapot is en prima functioneert
139	There is no reason to replace them, I am used to the sound quality now and I can plan my next purchase based on the statistics in the app
140	Als die het nog goed doet, waarom zou ik dan geld uit geven aan een nieuwe?
141	Ik heb hem dan al te vaak laten vallen, dus tijd voor een nieuwe
142	Omdat hij vrij duur was, en ik denk dat hij dan nog best wel mee zou kunnen met de tijd.
143	Als hij het nog goed doet, zie ik geen reden voor een nieuwe.
144	if they work properly, it is a waste of money, and the lights make me want to keep it
145	Omdat deze nog genoeg kwaliteit heeft denk ik en zonde vind om deze al af te danken.
146	Ik ben zuinig
147	It's still usable! unless parts are falling apart, I usually won't replace my device
148	Nieuwere versie/ nieuwe features
150	Geluidskwaliteit gaat te hard achteruit.
151	Als die nog werkt blijf ik hem gebruiken. Geen reden om hem te vervangen.
152	Whether or not the improvements in sound quality are worth replacing headphones
154	Zit nog goed.

A.9 Qualitative responses from the participants

Measure: feeling of being informed about the lifetime

Question: *"Could you explain which part of the smartphone made you feel most (or least) informed about its lifetime?"*

Condition:

Headphones, with intervention

Case	Response
104	Prestatie en batterijperformance
105	Er wordt een suggestie gedaan dat hij 12 jaar mee gaat door de blokjes in het metertje
106	De onderste 3 gaan met de loop van tijd en gebruik naar links terwijl de bovenste 2 naar rechts gaan. Dat is een beetje vaag. Verder snap ik niet echt waarom de koptelefoon 32 schokken zou kunnen doorstaan. Is dit elektrisch of impact? En wat als hij 1 keer van 5 meter valt en 1 keer van 1 meter? Telt dat beide als 1 schok? Ik zou liever een melding krijgen als er iets niet goed werkt (door bijvoorbeeld een valpartij). Ook lijkt het me niet nice als je kan zien dat je speakers degraderen. Beetje wat niet weet wat niet deert zou ik zeggen.
107	ik wordt niet geïnformeerd over de verwachtte levensduur maar over de gebruiksduur en dat had ik zelf ook nog wel kunnen bedenken
108	The drivers and control boards percentage in the widgets, don't know anything about that
109	Hoe lang ik hem heb zegt niets over de levensduur
110	Vooraf geen verwachting totale levensduur.
111	de leds op de koptelefoon
114	De ring informeert mij niet zo. Aangezien deze ververst als deze vol is. Er wordt verder niet aangegeven of 1 volle cirkel ongeveer gemiddeld is.
115	Uitleg vd lichtbalkjes en de lichtbalkjes zelf.
116	het aantal lichtjes op de koptelefoon komt niet overeen met de tijd die verstreken is (vier streepjes terwijl ik het ding pas 2,5 jaar heb).
117	De app en de cirkel laten me denken dat de koptelefoon 12 jaar mee zou kunnen gaan. Het is mij nog niet helemaal duidelijk of de koptelefoon bij wijze van spreke een eeuwig leven heeft als hij niet gebruikt zou worden. Ofwel, of door veroudering van de hardware los van slijtage door gebruik de gebruiksduur ook kan afnemen.
118	Laadcycli info
119	Het lampje aan de zijkant
122	the light clearly indicates its lifetime
123	The app more so than the visible rings. I have concerns abot the rings
125	The performance of the drivers and the control board in the widget. I do not want to have a tally counter of the number of impacts, it seems stressful, instead I just want to know if the impact(s) have affected the (soft/hard)ware performance, and how much.
126	batterijleven
129	schokken?

Case	Response
131	the pictures of the phones being used 12 years, the number of impacts and the number of battery charges
133	Er staat nergens een echte design lifetime, bijvoorbeeld X jaar of X laadcycli
134	Een beetje zoals de batterij leeftijd en capaciteit functie op een iPhone. Hoeveel % nog 'resteert'.
135	Control board
136	de visual aan de zijkant
137	De widget, de ring op de koptelefoon zegt niks want ik weet zelf heus wel hoe lang ik hem al heb. Ik vraag me wel af hoe nauwkeurig de widget is en zou niet het gevoel hebben dat ik nu goed kan voorspellen wanneer hij stuk gaat. Hij kan altijd vallen of nat worden etc, ook gaat de padding vaak als eerste stuk, dat zie je niet in de widget . Het lijkt me waarschijnlijker dat hij daaraan stuk gaat.
138	vooral de info over geluidskwalitieit en de andere dingen in de app. de meerwaarde van die levensduur cirkel aan de zijkant snap ik niet helemaal, het is toch juist naar om steeds te zien dat hij ouder wordt en 'waarschijnlijk' dus ook slechter
139	The app shows me in detail what part could be the issue if the headphones don't work as they should. I could also choose to replace parts like the battery to expand the life expectancy
140	Het meeste, de lichtjes en de levensduur in de widget. Die maken het duidelijk dat je er 12 jaar mee kan doen. Het minste is de batterij van het moment
141	Toch wel die ring met hoeveel jaar hij mee gaat
142	Ik denk de streepjes, want je weet dan niet of hij echt die 12 jaar mee gaat of niet.
143	De volledige cirkel van 12 jaar.
144	the lights that go up to 12, indicating 12 years. what makes it that the headphones are made to last 12+ years
145	Beide zijn wel goed bedacht alleen de betrouwbaarheid vind ik lastig te beoordelen.
146	De laadduur en cycli
147	charges remaining & impacts
148	Is overzichtelijk. Geen op of aanmerkingen
150	Speaker kwaliteit, dus is immers het belangrijkste van de koptelefoon
151	Ik heb nog geen daadwerkelijk verwachte levensduur gezien. Wel aantal oplaadcycli maar dat hangt nogal af van hoeveel je hem gebruikt. Hoelang deze koptelefoon op 1 lading mee gaat is me niet bekend. Of ik heb er overheen gelezen.
152	Widgets on phone.
154	Was geen review over levensduur beschikbaar.

A.9 Qualitative responses from the participants

Measure: intended lifetime

Question: *"Could you explain what makes you (not) want to keep using the smartphone from this survey?"*

Condition:

Headphones,
without intervention

Note: unfortunately, the qualitative responses regarding the predicted lifetime and the replacement intention somehow got corrupted and could not be restored, therefore they are not reported here.

Case	Response
155	komt steviger over
156	Het is veel geld voor een koptelefoon dus ik gebruik hem waarschijnlijk tot hij echt niet meer te gebruiken is. Zolang er geen grote problemen mee zijn en hij nog steeds goed geluid geeft, lekker zit en de batterij niet binnen een dag al leeg is, zal ik hem blijven gebruiken.
157	ik gebruik alles totdat het op is en ik verwacht dat hij het 4 jaar uithoudt. mocht hij het daarna toch nog langer blijven doen zonder mankementen blijf ik m ook langer gebruiken
158	Zolang hij goed blijft functioneren en ik geen nieuwe eisen ontwikkel waaraan de koptelefoon moet voldoen, dan blijf ik hem gebruiken. Wederom lijkt dit erg op mijn huidige koptelefoon dus vandaar dat ik deze even lang verwacht te gebruiken.
159	Lange batterij duur
160	Ziet er nog beter uit dan mijn eigen koptelefoon. Ook meer batterij!
161	Ik heb een vergelijkbare koptelefoon
162	Ik denk dat ik deze koptelefoon nog wel even zou gebruiken, ook als er kleine mankementen zijn. Maar dat zou ik met mijn huidige koptelefoon ook doen, dat is niet specifiek aan deze.
165	I might want to buy a new pair that is introduced into the market
166	i would want to use them until they stopped working
167	They've lasted 5 years and seem in good condition based on the battery.
168	Maybe battery is not good anymore
169	New options may be better or I'd want to upgrade to USB-C in order to homogenise my tech.
171	Verouderd model, mankementen
172	ik vind hem er wat professioneler uitzien, en ik heb het gevoel dat hij betere kwaliteit geluid geeft waardoor ik hem ook langer zou gebruiken. het design vind ik ook redelijk tijdloos.
173	Omdat hij het nog goed doet en ik in principe alleen geen koptefoon meer gebruik als hij nbiet meer goed werkt
174	Er zit geen noice canceling op. Dat is in de context waarin ik werk super belangrijk.
176	They're still working great after 5 years
178	Nieuwere versie
179	I have good headphones
180	for me functionally is a driver. So, as soon as they are functional- I use them. Battery is the leading factor here, except mulfunctioning of other parts.
182	Het ziet er beter uit dan die van mij (heeft ook nog een draadje en wiebelt al een beetje bij de pootjes)

Case	Response
184	Er komt ieder jaar weer wat nieuws en beters uit, na een aantal jaar is er toch vaak veel verbeterd in de nieuwe modellen
185	ik zou hem wel lang willen gebruiken aangezien hij duur was en van goede kwaliteit lijkt
186	Zou deze net zo lang gebruiken als mijn huidige. Ik zou 'm niet meer gebruiken vanaf het moment dat hij het niet meer doet of de geluidskwaliteit ondermaats is.
187	Want hij doet het prima zo
188	I happen to have studio headphones, so the latency and quality should have to be better.
189	Ik denk dat de batterij steeds slechter wordt door het herhaaldelijk opladen
190	For me there is no much difference between headphones for 200 and 400. My Bose headphones on discount were for 170 and have all the features a Sony for 350 has and maybe a little less solid sound but is this a problem :)
192	They look like they work quite well, the only reason I mighy want to change them would be the color
193	Ik vind dat dure elektronische producten lang mee moeten gaan.
194	Ik gebruik hem tot hij niet een mankement heeft dat niet cosmetisch is. Ik verwacht niet dat hij langer mee gaat
195	Als hij het met geen mogelijkheid meer doet cq accu op is en niet vervangen kan worden
196	Op gebruiken tot hij het niet meer doet
197	te zwaar
198	Te warm op de oren, te groot voor in tas
199	Ik hoef geen nieuwe zolang hij het blijft doen. Ik koop alleen een andere voor een ander doel; Shinzo om mee te rennen/ fietsen. Noise canceling in ear onder mijn motor helm en als ik met mijn hoofd in een afzuigkap sta te koken. De over ear nice canceling als het heel lawaaiig is. Bedraadde in ear als ik met muziek in slaap wil vallen en niets kwijt wil raken. Dus zo lang het werkt en goed geluid geeft hoef ik geen nieuwe.
201	Als de kussens of geluid niet meer comfortabel is dan zou ik het van vervangen.
203	Zolang hij het doet gebruik ik hem
204	Het design

A.9 Qualitative responses from the participants

Measure: feeling of being informed about the lifetime

Question: *"Could you explain which part of the smartphone made you feel most (or least) informed about its lifetime?"*

Condition:

Headphones,
without intervention

Case	Response
155	ik krijg nog niet een beeld van hoelang het mee gaat. kan alles zijn
156	Die app met de batterijduur informeert me het meest over de levensduur maar ik vraag me wel af hoe accuraat dat is en of dat soort apps echt hlde achteruitgang van een batterij goed in kaart kunnen brengen.
157	uiterlijk, info in de widget over de batterijleeftijd en of de geluidsqualiteit het goed blijft doen
158	Als de batterij duur die de widget aangeeft steeds minderlang duurt bij een vol opgeladen batterij, of als er steeds groetere verschillen ontstaan tussen de batterij duur die de widget aangeeft en de werkelijkheid, zijn dat op basis van wat ik tot zover heb gezien de belangrijkste informatie punten voor het inschatten van de levensduur.
159	Lange batterij duur en geen zichtbare schade
160	De batterij status zegt wel hoeveel batterij ie nu nog heeft, dat is fijn, maar het zou ook fijn zijn om te zien wat de capaciteit is vergeleken met de originele capaciteit
162	Ik weet niet zeker of ik de widget goed begrijp: betekent 35% dat hij nu voor 35% opgeladen is? Of dat de volledig opgeladen batterij nog 35% van de originele capaciteit heeft? Ik heb deze vragenlijst beantwoord alsof het de eerste optie is
163	Door de batterijduur te zien weet ik nog wel hoe goed de batterij is. Als hij het met 30% nog meer dan een dag volhoudt dan is dat best goed.
165	Quality of materials that might start to wear down.
166	the cost suggests it's probably a long time
168	app
169	I know they function for as long as I've had them, but know nothing about the future durability.
172	ik kan me niet herinneren dat er daadwerkelijk iets is gezegd over de levensduur? alleen de widget met het batterij vermogen.
173	De foto hoe hij er nog uitziet
174	Er staat niks over de levensduur. Alleen iets over de huidige batterij lading.
176	It shows me the battery percentage and how much time is left, which tells me they only need to be charged every 3-4 days
178	Totale levenduur: indicator van totaal gebruik
179	Only pictures, no specs or reviews
180	battery, textile, chip
181	State of charge and estimated runtime seem still good, look and wear seem good
183	hoe die eruit ziet
184	De batterij duur, daardoor merk je of de koptelefoon verouderd

Case	Response
186	De batterijduur
188	The imaginary headphones?
189	De widget en de tode batterijen
190	Just images do not tell the full story. The tech specs are important to determine the cost vs value ratio and a test to see if the specs meet the real experience.
194	Wat ik mis zijn features over de levensduur van de batterij en andere componenten. Is het geluid nog wel goed genoeg? En kan ik er allicht ook makkelijk reserve onderdelen voor krijgen
195	Er was helemaal geen technische specificatie
196	Het is puur op gevoel gebaseerd dmv de toegevoegde foto's. Er is namelijk nergens over levensduur van de koptelefoon en of widget gesproken.
197	widget
198	Batterij levensduur
199	De informatie aan het begin
201	35% dan weet ik dat het laag is maar aan de tijdsduur 1 dag en 16u is voor mij duidelijker
204	De batterijduur