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DESIGN FOR **PRODUCT CARE**

Laura Ackermann

Design for Product Care

Design for Product Care

Dissertation

for the purpose of obtaining the degree of doctor

at Delft University of Technology

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There is a crack in everything.
That's how the light gets in.

Leonard Cohen

Contents

List of Figures

List of Tables

Summary

In the famous story of Le Petit Prince, one can not only read about friendship but also about product care: The little prince feels responsible for his rose, so he supplies it with everything it needs and he protects it from possible damage. Just like the little prince, we should feel responsible – for creatures as well as for our belongings. Taking care of our products is one way to extend their lifetimes, which in turn benefits the environment because fewer materials and energy are wasted.

This PhD project focuses on product care and the main research question is: How can design foster product care among consumers? Product care is defined as all activities initiated by the consumer that lead to the extension of a product's lifetime. It thus includes repair and maintenance, but it also includes preventive measures, such as protective covers for smartphones, or a general careful handling of the product. In this definition, the consumer is the one who initiates the care behaviour, but not necessarily performs the care himself/herself.

After introducing the concept of product care and its relevance for the Circular Economy in Chapter 1, Chapter 2 provides a state-of-the-art review of research in the field of product care that is relevant for this thesis. Fogg's behaviour model served as a theoretical background for this PhD project. It states that motivation, ability as well as triggers have to be present for a behaviour to occur. We present several approaches that aim to stimulate a more sustainable behaviour through design, and discuss their implications for product care. The chapter continues with an overview of currently known determinants of product care that can either foster or hinder product care among consumers. We identify gaps in the current literature that we aim to address with our research.

In Chapter 3, we present Study 1 that aimed to understand why consumers take care of certain products but not of others. We used Fogg's behaviour

model as a theoretical framework to understand consumers' motivation, ability and triggers related to product care. Fifteen in-depth interviews were conducted to explore consumers' current product care behaviour. We were able to identify sources of motivation for product care, which were related to the product, the consumer, or the consumer-product relationship. In addition, we learned about the ability of consumers to take care of their products as well as triggers that are relevant in this context. We discuss these findings and give suggestions for their practical implementation in order to support companies interested in a shift towards the Circular Economy.

In order to be able to assess product care quantitatively in future studies, a product care scale was developed and validated in a set of four related studies which are presented in Chapter 4. In Study 2.1, we asked experts to examine the face validity of a set of 35 items. In Study 2.2, we reduced the initial set of items to 10 items using exploratory factor analysis. A subsequent confirmatory factor analysis supported a three-factor solution. Study 2.3, a nomological network study, demonstrated that the construct measured by our scale is related but still distinguishable from existing concepts, such as frugality, use innovativeness and attachment towards the product. Study 2.4 was a known-groups test with participants from two different countries and with various previous experiences in visiting repair cafés. The final 10-item product care scale includes three factors: relevance, easiness and positive feelings. The developed scale enables a deeper understanding of product care and offers a valid approach to quantify the effect of different interventions to stimulate product care.

Designers need more knowledge and distinct strategies in order to evoke product care among consumers. Chapter 5 presents the development of design strategies for product care as well as their evaluation by consumers and their transfer into a toolkit for designers. By the means of a multi-method approach – individual and group brainstorming sessions as well as an analysis of existing solutions – we created a large amount of ideas on how to stimulate product care from a consumer perspective in Study 3.1. We were able to summarize these ideas in a clustering session into eight strategies and twenty-four sub-strategies that can foster product care through design. These eight strategies are: informing, awareness, antecedents & consequences, social connections, enabling, appropriation, reflecting, and control. In Study 3.2, we conducted an interview study with fifteen consumers to evaluate these strategies. The integration of the consumer perspective into strategies for

product care extends currently known design strategies for repair and maintenance. To support designers in the implementation of these strategies, we then developed and tested a toolkit, which can be used in the product development process of different kinds of products (Study 3.3).

In access-based product-service systems, the consumer pays a fee in order to get access to a product, while ownership of the product remains with the provider company. These business models have often been promoted as a more sustainable alternative compared to traditional sales models, because products are only kept as long as they are needed and can then be used by another person. In Chapter 6, we explore product care of newly bought, second-hand, and long-term accessed bicycles and washing machines through an online survey (Study 4). Our analysis demonstrates lower product care for products from long-term access-based product-service systems compared to owned products. Based on the findings, we argue that the sustainability potential of access-based business models is limited because consumers do not take care of the products properly, and that these business models can, in fact, be more unsustainable than ownership.

The final Chapter 7 summarises the main findings of this thesis together with their implications for theory and practice. It also presents limitations as well as suggestions for future research and discusses the impact of recent developments on the future of product care.

This PhD thesis adds to the knowledge on product care by focusing on the role of the consumer. We present design strategies as well as a corresponding toolkit that helps designers to create products and services that foster product care. Additionally, we developed a scale to measure product care quantitatively. Product care can support the transition from our current way of consumption towards a Circular Economy, but it is necessary to transfer our research into design practice and to spread the findings on product care beyond the field of design research.

Samenvatting

Het bekende verhaal van De Kleine Prins is niet alleen een verhaal over vriendschap maar ook over *product care*, oftewel het verzorgen van producten: De kleine prins voelt zich verantwoordelijk voor zijn roos, dus voorziet hij het van alles wat de roos nodig heeft en beschermt hij het tegen mogelijke schade. Net als de kleine prins zouden we ons verantwoordelijk moeten voelen - voor zowel levende wezens als ook voor onze producten. Het verzorgen van onze producten is namelijk een manier om hun levensduur te verlengen, wat gunstig is voor het milieu omdat er dan minder materialen en energie verspild worden.

Deze thesis gaat over product care. De centrale onderzoeksvraag van de thesis is: Hoe kan design product care bij consumenten bevorderen? Product care wordt gedefinieerd als alle door de consument geïnitieerde activiteiten die die resulteren in een verlenging van de levensduur van een product. Het omvat dus reparatie en onderhoud, maar ook preventieve maatregelen, zoals beschermhoezen voor smartphones of een zorgvuldige omgang met het product. In deze definitie is de consument degene die het zorggedrag initieert, al hoeft hij/zij deze zorg niet per se zelf te verrichten.

In Hoofdstuk 1 wordt het product care concept en de relevantie hiervan voor de Circulaire Economie uiteengezet. Hoofdstuk 2 geeft een state-of-the-art overzicht van het onderzoek op het gebied van product care dat relevant is voor deze thesis. Het gedragsmodel van Fogg diende hierbij als theoretische raamwerk. Dit model stelt dat motivatie, bekwaamheid en triggers aanwezig moeten zijn om een gedrag te laten plaatsvinden. We presenteren verschillende theorieën en methoden die gericht zijn op het stimuleren van meer duurzaam gedrag en beschrijven de implicaties voor product care. Het hoofdstuk vervolgt met een overzicht van de tot nu toe bekende product care determinanten die product care bij de consument kunnen bevorderen of belemmeren. We identificeren lacunes in de bestaande literatuur die we in ons onderzoek streven te adresseren.

In Hoofdstuk 3 presenteren we de eerste studie (Studie 1) die als doel had te begrijpen waarom consumenten voor bepaalde producten zorgen, maar niet voor andere. We gebruikten het gedragsmodel van Fogg als theoretisch raamwerk om de motivatie, bekwaamheid en triggers van consumenten met betrekking tot product care te begrijpen. Er zijn vijftien diepte-interviews gehouden om het huidige product care gedrag van consumenten te onderzoeken. We waren in staat om verschillende motivaties voor product care te identificeren die verband hielden met het product, de consument of de relatie tussen consument en product. Verder werd duidelijk dat vaardigheden en bekwaamheid van consumenten om voor hun producten te zorgen en triggers die aanzetten tot product care relevant zijn. We bediscussiëren de bevindingen en geven aanbevelingen voor de praktische implementatie om zo bedrijven te ondersteunen die geïnteresseerd zijn in de transitie naar een Circulaire Economie.

Om de mate waarin consumenten zorgen voor een product, kwantitatief te kunnen meten is een product care schaal ontwikkeld en gevalideerd door middel van vier gerelateerde studies. Deze schaalontwikkeling wordt beschreven in Hoofdstuk 4. In Studie 2.1 hebben we experts gevraagd om de indruksvaliditeit te beoordelen van een set van 35 items. In Studie 2.2 is deze initiële set items teruggebracht tot 10 items met behulp van een exploratieve factoranalyse. Een daaropvolgende confirmatieve factoranalyse ondersteunde een driefactoroplossing. Studie 2.3, een nomologische netwerkstudie, toonde aan dat het construct gemeten aan de hand van onze 10-item schaal gerelateerd, maar desalniettemin nog steeds te onderscheiden is van bestaande concepten, zoals zuinigheid, innovativiteit en hechting ten opzichte van het product. Studie 2.4 was een test met groepen waarvan vooraf bekend is dat ze verschillen in product care: Deelnemers uit twee verschillende landen en met verschillende eerdere ervaringen in het bezoeken van repair cafés. De uiteindelijke 10-item product care schaal omvat drie factoren: relevantie, gemak en positieve gevoelens. De schaal geeft een beter begrip van product care en biedt een valide aanpak om het effect van verschillende (design) interventies ter bevordering van product care te kwantificeren.

Om producten te kunnen ontwerpen die bij de consument meer product care gedrag oproepen, hebben ontwerpers meer kennis en specifieke ontwerpstrategieën nodig. Hoofdstuk 5 presenteert de ontwikkeling van ontwerpstrategieën voor product care, de beoordeling van deze strategieën door consumenten, en de toepassing van deze strategieën in een toolkit voor ontwerpers. Door

middel van een multi-methode aanpak, in de vorm van individuele en groepsbrainstormsessies en een analyse van bestaande oplossingen, zijn in Studie 3.1 een grote hoeveelheid ideeën gecreëerd over hoe product care bij consumenten gestimuleerd kan worden. Deze ideeën zijn in een clustering sessie samengevat in acht hoofdstrategieën en 24 sub-strategieën die product care kunnen bevorderen door middel van het productontwerp. Deze acht strategieën zijn: informeren, bewustzijn, antecedenten & consequenties, sociale connecties, mogelijk maken, toe-eigenen, reflecteren en beheersen. In Studie 3.2 hebben we interviews gehouden met vijftien consumenten om deze strategieën te evalueren. De integratie van het consumentenperspectief in strategieën voor product care breidt de reeds bekende ontwerpstrategieën voor reparatie en onderhoud verder uit. Om ontwerpers te ondersteunen bij de implementatie van deze strategieën, hebben we vervolgens een toolkit ontwikkeld die gebruikt kan worden in het productontwikkelingsproces van verschillende soorten producten (Studie 3.3).

In zogenaamde 'access-based' product-service systemen betaalt de consument een vergoeding om een product te gebruiken, terwijl de aanbieder de eigenaar van het product blijft. Deze business modellen worden vaak aangeduid als een duurzamer alternatief dan traditionele verkoopmodellen, omdat producten alleen gebruikt worden indien nodig en deze producten ook door andere mensen kunnen worden gebruikt. Hoofdstuk 6 vergelijken we door middel van een online enquête Studie 4) de mate waarin consumenten product care vertonen voor fietsen en wasmachines die hun eigendom zijn (nieuw en tweedehands gekocht) met de product care voor fietsen en wasmachines die gebruikt worden via een 'access-based' product-service system. Onze analyse toont aan dat er minder zorg is voor producten in een 'access-based' systeem dan voor producten die men in eigendom heeft. Op basis van deze bevindingen beargumenteren we dat het duurzaamheidspotentieel van „access-based" business modellen mogelijk beperkt is omdat consumenten niet goed voor deze producten zorgen, wat deze business modellen wellicht minder duurzaam maakt dan eigendom.

Hoofdstuk 7 vat de belangrijkste bevindingen van dit proefschrift samen en bespreekt implicaties voor theorie en praktijk. Het presenteert ook tekortkomingen van het onderzoek, suggesties voor toekomstig onderzoek en bespreekt de impact van recente ontwikkelingen op de toekomst van product care.

Dit proefschrift draagt bij aan de kennis over product care door te focussen op de rol van de consument. Wij presenteren ontwerpstrategieën en een bijbehorende toolkit die ontwerpers ondersteunt bij het ontwikkelen van producten en diensten ter bevordering van product care. Daarnaast hebben we een schaal ontwikkeld om product care kwantitatief te kunnen meten. Product care kan bijdragen aan de transitie van ons huidige consumptiegedrag naar een Circulaire Economie, maar daarvoor is het wel nodig dat onze onderzoeksresultaten worden toegepast in de design praktijk en dat de bevindingen omtrent product care ook buiten het vakgebied van design worden verspreid.

1

Introducing the Concept of Product Care

> *'Because it is she that I have watered; because it is she that I have put under the glass globe; because it is she that I have sheltered behind the screen; because it is for her that I have killed the caterpillars (except the two or three that we saved to become butterflies); because it is she that I have listened to, when she grumbled, or boasted, or even sometimes when she said nothing. Because she is my rose.'*

While this paragraph from Le Petit Prince (de Saint-Exupéry, 1943) can be seen as a metaphor for friendship and love, it also relates to the topic of this thesis: product care. The little prince feels responsible for his rose, so he supplies it with everything it needs and he protects it from possible damage. Just like the little prince, we should feel responsible – for creatures as well as for our belongings. We should try to make our products last as long as possible, not only for our personal pleasure, but also to save resources and thereby our planet.

If one looks for signs of product care in everyday life, one can find examples of niche hobbies, such as young men in Germany and Austria, hanging around at gas stations, showing off their cars. Even if these cars are very old and barely able to drive, their owners polish them to an extremely shiny state, and they get every single small scratch repaired. One can also find these people on social media: Searching for #carcare on Instagram leads to over 1.6 million pictures and videos of people showing their shiny, well-maintained cars and how their owners repair, clean and polish them. These young men behave like the little prince, even though it is probably more for their own entertainment than to save resources.

However, if one looks for other signs of product care on social media, one can tell that the majority of people does not seem to care about their products: #sofacare has only 272 pictures and videos on Instagram, and #dishwashercare (15 hits) and #washingmachinecare (25 hits) merely exist. These observations make one wonder why people only care about certain products they own, and not about others, and how they can be encouraged to see all their products as their 'roses'.

This PhD project is focusing on product care and how it can be stimulated by design. Product care is defined as all activities initiated by the consumer that lead to the extension of a product's lifetime. It thus includes repair and maintenance, but it also includes preventive measures, such as protective covers for

smartphones, or a general careful handling of the product (see also Gregson et al., 2009). In this definition, the consumer is the one who initiates the care behaviour, but not necessarily performs the care himself/herself. Even if legal regulations require the consumer to get his product repaired, for example as part of an annual car check, the initiative for this activity still lies with the consumer and can thus be seen as product care. Consequently, bringing shoes to the shoemaker is part of product care, as it is initiated by the consumer.

1.1 Background

Product care is of high relevance for environmental issues and, therefore, for society. Since a few years, it became impossible to ignore the challenges our society is facing due to our current way of consumption. Civil initiatives, such as the Fridays for Future[1] movement remind people of the climate change and resource scarcity as well as the consequences they impose on mankind unremittingly. Politics has also put this topic on their agendas: The Sustainable Development Goals by the United Nations went into effect January 1, 2016, with the purpose of serving as a 'blueprint to achieve a better and more sustainable future for all' (United Nations, 2020).

Product care supports the concept of Circular Economy which has become an epitome for sustainability (for a discussion see Geissdoerfer et al., 2017). The Circular Economy has been developed as a counterpart of the existing linear consumption model. While the latter follows a 'take-make-dispose' pattern, which is based on unrestrained access to raw materials and the possibility to dispose waste in unlimited amounts after usage (Cooper, 2013), the Circular Economy intends to 'keep products, components and materials at their highest utility and value, at all times' (Webster, 2015, p. 16). The aim of the Circular Economy is the creation of 'environmental quality, economic prosperity and social equity' (Kirchherr et al., 2017, p. 225). It can thus be seen as an operationalization of the sustainable development concept for businesses and has traditionally been focusing on materials and the role of manufacturers, which also becomes visible in the butterfly diagram (Figure 1.1).

Visualizing the basic ideas of the Circular Economy, it shows the circles in which either biological (left side) or technical (right side) materials flow. In addition to this diagram, some main principles of the Circular Economy were formulated.

[1] https://fridaysforfuture.org

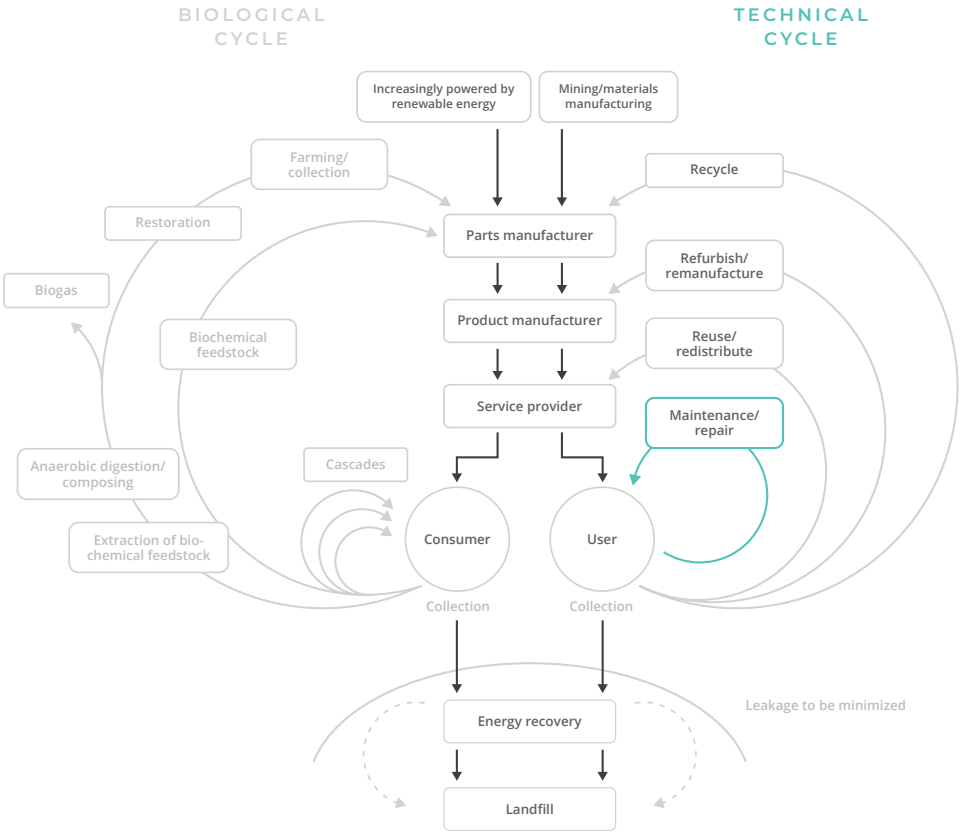

Figure 1.1: The Butterfly Diagram of the Circular Economy (Ellen MacArthur Foundation, 2013, p. 6)

One of them, the 'power of the inner circle' principle, states that the tighter the circles are, the larger the savings are in terms of material, labour, energy, capital and of further externalities, such as greenhouse gas emissions, water, or toxic substances (Ellen MacArthur Foundation, 2013, p. 30). This means that strategies of the inner loop, such as maintenance, should be preferred over outer loops, such as reuse and recycling. This is also the main idea of the so-called Inertia principle by Walter Stahel, one of the pioneers of the Circular Economy: 'do not repair what is not broken, do not remanufacture something that can be repaired, do not recycle a product that can be remanufactured' (Stahel, 2007, p. 10). Product care is part of that inner circle (see also the highlighted circle in Figure 1.1) and thereby a preferred strategy for the Circular Economy.

Another Circular Economy principle, the 'power of circling longer', asks for the maximization of the number of consecutive cycles a product passes through and/or of the time a product remains in each cycle (Ellen MacArthur Foundation, 2013, p. 7). As an example, Bakker et al. (2014b) showed that fridges and laptops bought in 2011 should be used for 14 and 4 years respectively in order to reduce their environmental impacts. Because this is longer than their current median lifespan, lifetime extension should be the preferred strategy for designers in a Circular Economy. Taking these considerations together, fostering product care seems to be a valid approach for the Circular Economy, because it prolongs the time a product stays with the first consumer, thus keeping the product in the inner loop as long as possible.

Access and performance business models focus on providing the service to the consumer while the ownership of the product remains with the consumer (Bakker et al., 2014a). In this case, repair and maintenance is often conducted by the manufacturer or service provider so that the consumer does not have to worry about it (Bocken et al., 2016). Within the scope of this PhD thesis, we focus on product care from a consumer perspective. As mentioned above, we therefore define product care as all activities initiated by the consumer that lead to the extension of a product's lifetime.

Two major product care activities are repair and maintenance.

Repair is about restoring a product to a sound state by replacing a part or by putting together what is torn or broken (Merriam Webster, 2020b). As concluded by King et al. (2006), repair is indeed the most beneficial alternative in terms of environmental benefits compared to remanufacturing, recycling or reconditioning. Bakker et al. (2014b) as well as Schick et al. (2019) were able to demonstrate that repairing dishwashers, washing machines and fully automatic coffee machines is better for the environment than replacing them. Only a few products and components, such as motors or printed circuit boards, should better be replaced if they fail towards the end of the product's lifespan, because the environmental benefits of extending the product's lifetimes do not compensate for the environmental impact of the repair (Bovea et al., 2020).

Maintenance is defined as the process of keeping something in an existing state and to preserve it from failure or decline (Merriam Webster, 2020a). Repair can often be prevented by executing proper maintenance activities (e.g., Harmer et al., 2015; Rodrigues et al., 2015; Salvia et al., 2015; Cooper & Salvia,

2018) so regular maintenance also leads to less repair needed. However, for many products, maintenance does not only prevent failure, but also allows the product to work on an optimal performance level (Young, 2017).

Despite environmental issues being present in the media on a daily basis (Sachsman & Valenti, 2020), research indicates that consumer behaviour does not necessarily change towards a more sustainable way of consumption. With respect to the environmentally-friendly behaviour of repair and maintenance, studies indicate even the reverse: Asked about their washing machines, consumers in the UK responded that 50 years ago, 57 % had their first washing machine repaired when it broke down, but only 43% did so for their last washing machine. In addition, 25 % bought a new washing machine while their last one was still working fine – compared to only 12% for their first washing machine (Which?, 2011). The same holds true for maintenance: Hebrok (2014) states that fewer consumers maintain their products and that especially younger people spend less time on maintenance than young consumers 30 years ago. In general, repairing products at home as well as repair services are on the decline because products are often disposed at the earliest opportunity, if they are faulty and repair is either not possible or seen as too complicated or expensive (McCollough, 2009; Cooper & Salvia, 2018). In order to prolong products' lifetimes and therefore contribute to a more sustainable way of consumptions, consumers' behaviour has to change.

The consumer's role in the transition towards a Circular Economy has in general been not sufficiently addressed so far (Ghisellini et al., 2016; Piscicelli & Ludden, 2016; Kirchherr et al., 2017; Wastling et al., 2018), but is crucial for a successful implementation. In comparison to other approaches of the Circular Economy, such as recycling or remanufacturing, repair is the alternative with the greatest barriers for consumers, because it requires mainly their initiative, time and effort. That explains why it is even more important to consider the consumers' perspective on repair in order to implement it on a wide scale (King et al., 2006). The same issue applies product care, because it is also initiated by the consumer and requires his/her resources.

1.2 Research Questions and Contribution

In this thesis, we focus on product care among consumers and how this can be stimulated through design. As described above, product care plays an important role in the shift towards a Circular Economy because it can lead to the extension of a product's lifetime. Considering consumers' perspective on product care is important to foster product care as the care behaviour is always initiated by the consumer himself/herself. Design has the potential to influence consumers' behaviour. While several approaches have been developed to stimulate more sustainable behaviour through design (e.g., Wever et al., 2008; Bhamra et al., 2011; Boks, 2017), it remains unclear how design can encourage consumers to take better care of their products.

We aim to answer the following main research question:

How can design foster product care among consumers?

In order to answer this question, it is important to understand consumers' current product care behaviour, which includes drivers as well as barriers of their product care behaviour. These insights serve as a basis for the development of design strategies that stimulate product care. Designers need to know how to evoke product care among consumers, so the strategies need to be presented in a way that supports their implementation in design practice. If consumers recognize the effectiveness of these strategies, this would be a first step for the general acceptance of products designed to foster product care. In order to measure the effect of these strategies, an instrument for the assessment of product care is needed. Finally, it is also interesting to explore the role of product care in business models in which consumers do not own products, such as long-term renting.

These considerations led to the following sub-questions which will also be addressed in this thesis:

- *Why do consumers (not) take care of their products?*
- *How can we measure the degree to which consumers take care of their products?*
- *What are possible design strategies to stimulate product care among consumers?*

- *How do consumers consider the suitability of these design strategies?*
- *How can these design strategies be transferred into design practice?*
- *What are the effects of non-ownership (vs. ownership) on consumers' product care activities?*

This PhD thesis adds to the knowledge on product care by focusing on the role of the consumer. For researchers in the field of design and pro-environmental behaviour, this thesis allows a deeper understanding of care activities such as maintenance or careful handling that have barely been researched but are an important aspect of the shift towards a Circular Economy. Besides determinants of product care, we present a validated 10-item scale to measure product care. The scale can be used for an existing product and for a product designed to foster product care, thereby assessing the impact of design on product care in a quantitative and thus efficient way. These insights are relevant for further approaches to foster product care through design but also deepen the knowledge on product care, because they can help to quantify the impact of different determinants on consumers' care behaviour. We also expand the research on product care for owned products to product care for products that are offered in access-based product-service systems (AB-PSS), such as renting. However, the thesis does not only enlarge the theoretical knowledge about product care, but also provides practical implications for designers as well as for researchers: In order to transfer the insights into design practice, we present specific design strategies for product care. To ensure the effectiveness of these strategies, models of behaviour change have been used as a basis, and consumers have been asked to evaluate the strategies. Knowledge on the determinants of product care is especially important for designers who want to create products that consumers actually take care of, and we present a toolkit that aims to transfer the theoretical insights on product care into design practice.

1.3 Structure of This Thesis

The following section presents the structure of this thesis, which is also visualized in Figure 1.2.

Chapter 2 provides the theoretical background of this thesis. It presents Fogg's behaviour model (2009) and different design approaches that aim to foster sus-

tainable behaviour, as well as a literature review on determinants of product care.

Figure 1.2: Structure of the Thesis

In order to understand the current care behaviour of consumers more detail, this PhD project started with an exploratory interview study (Chapter 3).

The interviews were analysed based on the main components of the Fogg behaviour model. The findings revealed different sources of motivation, ability and triggers for product care. In addition, it became apparent that a tool to measure product care quantitatively was missing in order to enable large-scale and quantitative studies. We therefore developed and validated a 10 item-scale for product care (see Chapter 4). This process consisted of four related studies: An expert study to assess the face validity, an online survey to determine the factors of the scale, a nomological network study and finally a known-groups test.

In Chapter 5, design strategies for product care were developed with the help of workshops with designers and design students. In order to assess the reaction of consumers towards our design strategies, we conducted an interview study. The results of this study provide insights into the different fields of application for each design strategy, such as for which products or contexts the strategies can be used best. Afterwards, these strategies were transferred into a toolkit for designers, and its applicability was tested within a workshop.

While the previous studies all dealt with products owned by the consumers, the final study in Chapter 6 explores the influence of ownership on product care, which is for example relevant for AB-PSS such as renting.

The thesis ends with a discussion of the main findings as well as their implications for theory and practice (Chapter 7).

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2

Theoretical Background

After introducing the concept of product care and its relevance for the Circular Economy in Chapter 1, this chapter provides a state-of-the-art review of research in the field of product care that is relevant for this thesis. The Fogg behaviour model served as a theoretical background for this PhD project. It states that motivation, ability as well as triggers have to be present for a behaviour to occur. We present several approaches that aim to stimulate a more sustainable behaviour through design and discuss their implications for product care. The chapter continues with an overview of currently known determinants of product care that can either foster or hinder product care among consumers. We identify gaps in the current literature that we aim to address with our research.

In order to foster product care among consumers, we have to change their current behaviour. Design has the potential to influence consumers' behaviour and can therefore be considered a valid approach to stimulate product care. Models of behaviour change try to explain the determinants of human behaviour and ways to change this behaviour. Many models that target behaviour change were developed in the field of (public) health, with the aim to stimulate a healthier lifestyle or disease prevention through fiscal measures or legislation (for an overview see also Michie et al., 2014).

Because the aim of this PhD project is to stimulate behaviour change through design, we aimed for a model that considers design as a mean for behaviour change. We chose Fogg's behaviour change model as a starting point for our research. The model (2009) has its background in persuasive technology, i.e., the use of technology (e.g., apps) to influence human behaviour and has been applied to various kinds of behaviour change, such as a healthier lifestyle (Van Gemert-Pijnen et al., 2011) or engagement in e-learning (Muntean, 2011). In addition, there is much agreement between Fogg's behaviour change model and other models from the field of pro-environmental behaviour, such as the Needs-Opportunities-Abilities Model (Gatersleben & Vlek, 1998) or the Motivation-Opportunities-Abilities Model (Ölander & Thøgersen, 1995).

2.1 Fogg's Behaviour Model

Fogg's model (see Figure 2.1) states that for behaviour to occur, motivation, ability and triggers have to be present at the same time. Motivators in this model are pleasure, hope, or social acceptance, as well as the corresponding negative aspects of pain, fear or social rejection. Pleasure or pain are immediate reactions to a situation. For example, when a person enjoys riding his/her bike, he/she will be motivated to repair it when it breaks down. Hope and fear are reactions that are anticipated by the person not only as an immediate consequence, but also on a long-term perspective. Consumers might for example decalcify their kettle regularly because they fear it will break down early if they don't do so. The wish to be socially accepted or avoid social rejection strongly influences people's everyday behaviour: Owning the latest version of a smartphone is often seen as a status symbol. Consequently, taking care of your smartphone in order to prolong its lifetime is not seen as necessary for many consumers.

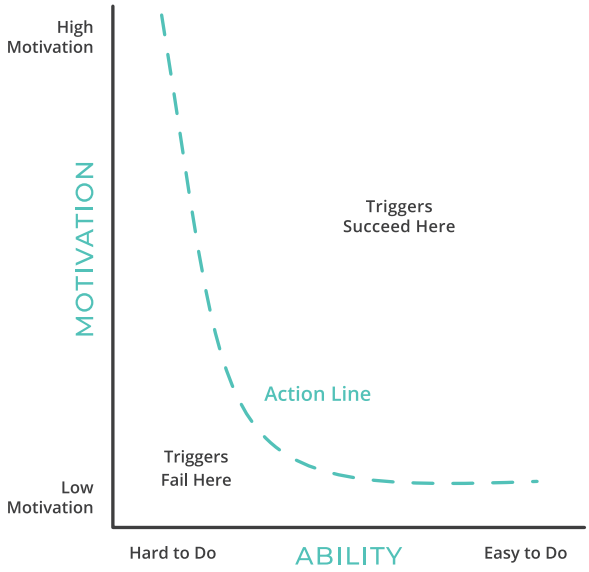

Figure 2.1: Fogg's Behaviour Model (Fogg, 2009, p. 2)

Ability in the model of Fogg consists of six parts: time, money, physical effort, brain cycles, social deviance, and non-routine. If a behaviour requires a lot of time, money, cognitive or physical effort, the required ability is perceived as demanding. If a behaviour means that one has to break with socially accepted rules or norms, this is classified as social deviance. People prefer things they do regularly, so non-routine behaviour is rated as less simple than everyday tasks. The assessment of ability depends on the person: While some people may regard 20 euros for a new shirt as too much money and therefore look for an alternative, such as repair an existing t-shirt, others would simply buy a new one. If a product care activity requires a demanding ability from the consumer, this can be regarded as a barrier towards product care.

A trigger is generally something that pushes people to perform a behaviour. Triggers always take place in the moment in which the behaviour should take place, so they lead to an immediate behavioural reaction. For triggers to succeed, timing is crucial: Only if motivation and ability are high enough to be above the action line (see Figure 2.1), it is the right opportunity for triggers to give the last small push towards the intended behaviour. The right timing of triggers is often the missing element in behaviour change (Fogg, 2009).

Fogg describes three types of triggers: First, there are so-called sparks. A spark increases the person's motivation. An example is a sign near a public bicycle pump that tells you how much energy you can save by refilling your tyres. The sign thereby enhances your motivation before the actual product care behaviour takes place.

Second, facilitators enable a person to behave in a way that he/she wants to. This means that the person is already motivated, but is lacking the ability. For example, gas stations often offer a bucket full of water and cleanser to make it easy for consumers to clean the windows of their car while waiting at the petrol pump for the car to be refuelled.

Third, signals are triggers that work if a person is motivated and has the ability needed; they often serve only as a reminder. Examples are notifications from a garage that remind customers of regular check-ups of their cars or a light that indicates a necessary repair on a coffee machine.

The action line in Figure 2.1 shows that motivation (y-axis) as well as ability (x-axis) have to be present to a certain extent to lead to an action: Motivation and ability can thereby compensate for each other: If motivation is high, people will try to realize a behaviour when a trigger occurs even though their ability is low. For product care, that would mean that even if it concerns a complex product that needs to be repaired (resulting in low ability for many consumers) this barrier could still be overcome if we manage to create a high motivation and a corresponding trigger. If a behaviour is easy to execute, triggers can push people to conduct care activities, even at a low level of motivation. If either motivation or ability (or both) are very low, triggers will fail and no action will take place. In order to foster product care through design, we have to find ways to stimulate consumers' motivation and ability. In addition, we have to design triggers that stimulate product care in a specific situation.

One of the benefits of Fogg's behaviour model (2009) is that is formulated in a general way. It can thereby be applied to promote various kinds of behaviour change, such as a healthier lifestyle (Van Gemert-Pijnen et al., 2011) or engagement in e-learning (Muntean, 2011). However, for each new field of application, it is necessary to understand what motivation, ability and triggers exactly mean in order to be able to design for behaviour change. For product care, this means that we first have to understand the current product care behaviour as well as its determinants in a better way before we can actually develop design

strategies to foster product care. This step was done in the first study (see Chapter 3) in which we used Fogg's behaviour model as a basis for the analysis of our interviews.

2.2 Stimulating Sustainable Behaviour Through Design

Because many models for behaviour change come from the field of public health, interventions[1] are often addressing policy-makers, who can influence behaviour for example through legislation, financial incentives, or with the government serving as a leading example for a certain behaviour (see e.g., DEFRA, 2008). By nature, designers differ in their possibilities to change consumers' behaviour, because they cannot offer incentives or sanction a lack of product care. Instead, they have to focus on consumers' motivation and ability as well as triggers in order to achieve behaviour change. This section presents different approaches from the field of design that aim to stimulate sustainable behaviour.

2.2.1 Dimensions of Behaviour Change

Daae and Boks (2014) define nine dimensions that can be used in order to stimulate a more sustainable behaviour through design. The focus of the dimensions has originally been on the usage phase, with the aim to reduce the environmental impact (e.g., energy demand) of consumer products. These dimensions represent aspects designers can consider during the development of interventions that aim to stimulate sustainable behaviour:

- control (Does the consumer or the product determine the behaviour?)
- obtrusiveness of the design (Does the product demand attention from the consumer or does it use a subtle approach to reach a goal?)
- encouragement (Does the design stimulate the desired behaviour or lead away from undesired behaviour?)
- meaning (Does the design focus on rational or emotional purpose?)

[1] interventions are 'coordinated sets of activities designed to change specified behaviour patterns' (Michie et al., 2011)

- direction (Is the desired behaviour in line or opposing the wishes of the consumer?)
- empathy (Is the consumer focusing on himself/herself or on others?)
- importance (How important is the behaviour to the consumers and how can design make the consumer feel strong pressure vs. weak pressure?)
- timing (When does the design target the consumer: before, during or after the interaction?)
- exposure (How often is the consumer affected by the design?)

A later publication (Daae et al., 2018) connects the dimensions to the goals of the circular economy, such as repair and maintenance, and discusses a few case studies of existing products and brands where the dimensions have been considered. The authors state that it was easy to identify existing examples for the field of repair and maintenance. For example, the authors define the modular concept of the Fairphone[2] as an application of the control dimension, because it enables the consumer to influence the lifetime of the product by replacing broken parts. It is designed in a way so that different modules, such as camera, battery, display etc., can be replaced easily when broken or not functioning properly anymore. Encouragement can for example be provided by online videos of how to fix products.

2.2.2 Design Intervention Strategies

The seven design intervention strategies by Bhamra et al. (2011) aim to reduce the negative social and environmental impact of consumption. These interventions are:

- eco-information: to make consumers reflect upon their use of resources through the product itself
- eco-choice: to make consumers think about their behaviour and take responsibility of it
- eco-feedback: provide consumers with real-time feedback about their actions to help them making responsible decisions
- eco-spur: rewards and punishments in order to encourage the intended behaviour

[2] https://fairphone.com

- eco-steer: prescriptions or constraints of use that facilitate the intended behaviour
- eco-technical intervention: to restrain existing use habits; to persuade or control consumer behaviour
- clever design: innovative product design that automatically makes the consumer acting in an environmental or social way

The interventions vary in the level of control they share between the consumer and the product: Eco-information refers to a design-oriented education, making the consumer aware of his/her resource consumption through product design. This purely informational approach offers the largest amount of control or freedom to the consumer. Least control is given through clever design, which describes a design that automatically leads to a more environmentally friendly behaviour, without the consumer being aware of it.

2.2.3 Design for Repair and Maintenance

Design research in the field of repair and maintenance has focused on the product and how to change its design in such a way that repair and maintenance activities are feasible and easy (see e.g., Cooper, 1994; Van Nes & Cramer, 2005). The Design for Repair & Maintenance principle (see also Van Hemel, 1998; Charter & Tischner, 2001) has been suggested as part of some approaches to postpone product replacement (see e.g., Mugge et al., 2005; Cooper, 2010; Bakker et al., 2014a). It includes strategies to facilitate maintenance, such as a product design that avoids narrow slits and holes for easier cleaning, enabling the use of standard tools or a simplified access to components that should be maintained (Vezzoli & Manzini, 2008). Easy maintenance and repair could for example be realized through a general low need for maintenance, indications on how to open the product and indications for the parts that have to be maintained or cleaned (Van Hemel, 1998). Also, spare parts made available by the producer of the product (Mashhadi et al., 2016) or a product design that enables the disassembly and reassembly of a product can make repair easier for the consumer. The latter approach is also known as Design for Disassembly and can facilitate the maintenance, repair, updating and remanufacturing of products as well as their recycling processes (Boothroyd & Alting, 1992; Harjula et al., 1996).

Modular product design, as used for the Fairphone, can be used in order to facilitate repair for the consumer by not only allowing easy access to the components, but also by grouping components into modules which can then be exchanged easily (Nissen et al., 2017). Reparability indicators for electronic products (Flipsen et al., 2016; Ellen et al., 2019; Flipsen et al., 2019), including aspects such as number and types of tools needed, risk of injury, or availability of a repair guide, help to evaluate the ease of repair for different products. This allows consumers to consider the reparability of products for purchase decisions.

2.2.4 Interim Conclusion

This section presented different approaches on how design can stimulate a more sustainable consumer behaviour in general. The design dimensions suggested by Daae and Boks (2014) indicate which aspects that may be relevant to consider when designing for sustainable behaviour and the authors were able to show that there are already products on the market that represent these dimensions, also with a specific focus on repair and maintenance. The same holds true for the design intervention strategies by Bhamra et al. (2011) that focus on sustainable design in general. Because both approaches address sustainable behaviour in general, it remains difficult for designers to apply them with the aim to stimulate product care. Also, they include aspects that should be considered by designers, but no specific design strategies that designers can follow in order to foster product care.

The Design for Repair & Maintenance Principle, on the other hand, offers quite specific guidelines on how product can be designed in order to facilitate repair and maintenance. What is missing here is consumers' motivation and triggers: As stated in Fogg's behaviour model (2009), ability is not enough for a behaviour to occur, and motivation as well as triggers should also be considered.

2.3 Possible Determinants of Product Care

Prior research has identified some factors that might contribute to or hinder product care, with repair being more widely researched than maintenance and other care activities. The following section will present these determinants as they have been described in literature by now. It is structured according the three factors of Fogg's behaviour model (2009): motivation, ability, and triggers.

2.3.1 Sources of Motivation for Product Care

Motivation is a relevant factor to consider when designing for behaviour change. It is typically determined by individual attitudes, values and beliefs (see also Verplanken & Holland, 2002). A low motivation might be (partly) compensated by high ability or because the task does not require high knowledge and skills (Fogg, 2009) but is still a crucial component.

Previous Care Experiences

The motivation of a consumer towards product care can be based on former product care experiences. If product care is perceived as pleasurable, consumers will less likely declare a product as 'broken beyond repair' although it could still be repaired (Salvia et al., 2015). Additionally, positive previous care activities will lead to a higher positive attitude towards product care in general (Ko et al., 2015). If they are seen as positive, regular care activities can become an integral part of the activity (Young, 2017), such as cleaning the bike after each day trip. Positive repair experiences have a strong impact on future purchase decisions as well as on recommendations of the brand or the product (Mashhadi et al., 2016; Sabbaghi et al., 2016), underlining the relevance of this topic for the business sector as well.

Emotional Attachment towards the Product

Emotional attachment, which describes the presence of a strong emotional bond between consumer and product, has in general been identified as one factor that motivates people to invest time, money and energy into a product (see e.g., Belk, 1991; Van Hinte, 1997; Chapman, 2005; Walker, 2006; Mugge, 2007; Niinimäki & Koskinen, 2011; Page, 2014). Product attachment leads to an increased likelihood of care activities towards the product and can help to postpone replacement (Belk, 1991; Schifferstein & Zwartkruis-Pelgrim, 2008). However, there are not that many products people feel attached to, because this requires a special meaning of the product for the consumer (Mugge et al., 2010). The latter in turn can be achieved through the origin of the product that can hold a special meaning for the consumer, for example because it is a heirloom (Price et al., 2000; Chapman, 2005; Mugge et al., 2006), or through personalisation of the product (Mugge et al., 2009). Materials that age with dignity and become more beautiful or interesting the longer they remain with the

consumer (Schifferstein & Zwartkruis-Pelgrim, 2008; Page, 2014) can be one approach to remind the consumer of the shared history with the product.

The history of a product can even create an emotional bond if traces of use, such as scratches or wear and tear, result from usage of the previous owner. Consumers reported that while they take care of their products and even bring them to repair professionals, they do not necessarily want the professionals to repair traces of use and ageing, because these traces are appreciated (Zijlema et al., 2017). These consumers kept traces from previous owners, because they made them aware of the long life of the product.

Financial Considerations

When products are expensive, consumers are more motivated to take care of them. Cheap products are in general often not considered worth to be repaired (Dewberry et al., 2017) or cared for (DEFRA, 2011), also because they are often associated with shorter lifetimes. Especially in relation to the initial price, repair is often considered as too expensive (Cooper, 2004; Diddi & Yan, 2019) and for cheap products, alternatives such as replacement often seem more attractive to consumers (McCollough, 2007; Park, 2019). However, consumers are aware that regular maintenance can also save money by postponing or avoiding repair (Young, 2017). Financial considerations, emotional attachment and product care might also influence each other (DEFRA, 2011): Expensive products are initially often only being taken care of because of their monetary value. After some time, care activities may also lead to a stronger bond between consumer and product, because the consumer has invested time and effort in the product, and thereby got to know the product. This creates a personal connection, which then becomes the main motivation for further product care.

Assumptions about the Product's Lifetime

The expected lifetime of a product is related to the motivation to take care of it. As soon as consumers have the feeling that a product is old enough, i.e., it reached the expected lifetime, they lack the motivation to take care of it any longer (Braithwaite et al., 2015; Wieser et al., 2015). The same holds true as soon as an upgrade for a product becomes available: consumers tend to re-act – often unconsciously – with carelessness and neglect towards their current product, thus trying to justify the purchase of the newer version (Bellezza et al.,

2017). Consumers then often declare a product as broken, although brokenness at that point is rather perceived as such by the consumer, and less a factual condition of the product (Salvia et al., 2015; Wieser & Tröger, 2018; Park, 2019). Consumers assume that failure of electronic products is mainly caused by wear and tear; in comparison, the influence of inadequate handling and lack of maintenance is seen as low, ranging from less than 10 % for a fridge or a PC to around 25 % for smartphones, tablets, and notebooks (Jaeger-Erben, 2019). Although numbers of the percentage of breakdowns caused by a lack of product care are missing, consumers' perception may cause them to see product care as not very important.

Ownership vs. Non-Ownership of a Product

The role of ownership of a product for product care has not been fully explored in research, but is crucial in order to judge the sustainability potential of business models in the Circular Economy. Access-based product-service systems (AB-PSS, Bardhi & Eckhardt, 2012) are one form of circular business models in which companies, rather than selling merely products, keep the ownership of their products. Consumers can use products based on their demand, which could potentially reduce the amount of products needed and therefore contribute to sustainability. The consumer pays a fee either regularly or based on the usage and can use the product, while repair and maintenance are provided as an integrated service (Catulli, 2012; Edbring et al., 2015; Ertz et al., 2019).

Recent examples for access-based home appliances are Bundles[3] in the Netherlands or BSH in the Netherlands and Belgium (Dworak & Longmuss, 2019). AB-PSS for clothing (e.g., MUD Jeans[4], worldwide) and transport are relatively common (e.g., Greenwheels[5] and Swapfiets[6], both in the Netherlands and Germany), but the level of consumer acceptance is often low (Camacho-Otero et al., 2017). The acceptance of these business models among consumers is especially problematic for certain product categories such as clothing, where psychosocial aspects such as status, a sense of control or self-expression are relevant (Hirschl et al., 2003; Armstrong et al., 2015). While some authors suggest that consumers handle products in access-based models with more care

[3] https://bundles.nl
[4] https://mudjeans.eu
[5] https://www.greenwheels.com/
[6] https://swapfiets.nl/

because they feel more restricted in their use or are worried about potential consequences of usage signs (Tukker, 2015; Cherry & Pidgeon, 2018), other authors found that consumers behave more recklessly as they do not bear the responsibility and risks of wear and tear, and hidden damages (Bardhi & Eckhardt, 2012; Schaefers et al., 2015).

2.3.2 Determinants of Ability

The perceived ability often hinders consumers in taking care of their products. Ability depends on the person, the product and on the intended product care activity. Some general insights can be derived from research on repair and are presented in this subsection.

Knowledge and Skills

The ability to take care of products asks for particular knowledge and skills. Indeed, one major problem that hinders consumers in taking care of their products is a lack of knowledge and skills on repair or care activities (see e.g., Terzioğlu et al., 2015; Young, 2017). Consumers often respond that they are interested in learning those skills, such as how to repair a smartphone, especially if they get good instructions (Richter & Dalhammar, 2019). In general, consumers tend to conduct repair activities that only need limited knowledge and skills, while at the same time they expect the repair to last for a long time (Terzioğlu, 2017). Mashhadi et al. (2016) have shown that many damaged parts of electronic devices can be replaced by unprofessional consumers if spare parts are available, but Bakker et al. (2014b) argued that it is still difficult for consumers to repair products such as a laptop or a fridge due to expensive spare parts or bad product design (e.g., unibody laptop designs). Repair of clothes also seems to be strongly influenced by consumers' skills (McLaren & McLauchlan, 2015; McLaren et al., 2015). Knowledge on how to repair clothes is often based on knowledge that has been passed down through family members (Gwilt et al., 2015). It is also dependent on culture and therefore varies strongly between countries (Diddi & Yan, 2019; Laitala, 2019). Sometimes it already helps to provide the consumer with information about how to repair or take care of the product in order to foster product care (Cox et al., 2013; Sabbaghi et al., 2016; Bovea et al., 2018) although other studies suggest that consumers often do not follow care instructions (Gwilt et al., 2015).

Resources

Product care also requires resources such as time, a deliberate effort (Cooper, 2010) and equipment by the consumer. This holds true even for small, everyday practices such as sewing on a button (Hielscher & Jaeger-Erben, 2019). Lack of time was identified as a relevant aspect for the repair of clothing (Diddi & Yan, 2019) and for product care (Jaeger-Erben, 2019) in everyday life. It is especially relevant for people with a high income, who often prefer to spend money for a new product instead of time (Guiltinan, 2009). Also, the effort that is needed to get a product repaired is often too high, especially if consumers feel the urgent need to use the product, for example a coffee machine (Pérez-Belis et al., 2017; Jaeger-Erben, 2019). In any case, there has to be a balance between the time required for care and repair (see also Page, 2014) and the reward of that effort in terms of satisfaction, financial benefits etc.

Repair Communities

Repair communities are places where consumers meet and repair products together with volunteers. Repair communities provide a social environment for repair where people can share their knowledge, help each other and socialize (Keiller & Charter, 2016; Prendeville et al., 2016; Cole & Gnanapragasam, 2017; Dewberry et al., 2017). Repair Cafés[7] are usually organized as events that take place more or less regularly in public spaces such as community centres or universities. By now, over 1500 repair cafés exist worldwide, with the number growing rapidly (Keiller & Charter, 2016). Repair communities do not only serve as sources of motivation, but also facilitate product care (Dewberry et al., 2017).

iFixit.com is a platform that offers more than 65000 free repair guides online. It is based on the belief that 'people should be able to use their stuff how they want to, for as long as they possibly can' (Wiens, 2015, p. 124). While iFixit.com is also selling spare parts and tools as part of their business model, it is also a kind of digital repair café: a community of people who are interested in repair and who try to support each other with tips and recommendations. In addition, online tutorials for repair can be found online, for example on YouTube. These tutorials are mainly provided by other consumers in order to help each other, and only seldom by the manufacturer[8].

[7] https://repaircafe.org
[8] see for example https://www.w6-wertarbeit.com or https://fairphone.com

2.3.3 Triggers for Product Care

According to Fogg (2009), triggers enhance the motivation or the ability in a certain situation or serve as reminders for a behaviour to be executed. In practice, triggers are often reminders from service providers, such as garages that let their consumers know that it is time for the annual check-up of the car. While we are not aware of research on triggers for repair and maintenance, triggers have been researched as 'prompts' in the field of environmental psychology. Prompts are 'simple reminders to behave in an appropriate way' (Abrahamse & Matthies, 2013, p. 228). They draw the attention of people to a specific behaviour in a given situation. An example are pictograms that encourage recycling and proper disposal of trash. If they were placed directly above the receptacles, correct disposal of trash and recyclables improved by 54 % (Austin et al., 1993). Prompts have been uncovered as an effective instrument if the person is already motivated to conduct the behaviour, and if this behaviour is easy to conduct (Lehman & Geller, 2004; Abrahamse & Matthies, 2013). Triggers have also been researched in the field of interaction design. For smartphone apps, it has been suggested that triggers may remind users of using the app, but that they can also be perceived as annoying and interruptive, thereby resulting in disengagement (Bakker et al., 2016). Reminders also seem to prevent the development of habits (Stawarz et al., 2015).

2.3.4 Differences in Products and Consumers

Prior research identified different categories of products that can be classified based on their relevance for product care, and also different groups of consumers based on their product care behaviour.

Classification of Products

Products can be broken down into investment products, workhorse products and up-to-date products (DEFRA, 2011; Cox et al., 2013).

Investment products are expensive products, not only with respect to their financial value, but also because they are seen as precious by the consumer, for example because they were difficult to get (e.g., limited editions of a product). Typical examples are major appliances, large furniture or high-quality electronic products. Consumers conduct activities for investment products beyond repair

and maintenance, such as using them only for special reasons, placing fragile products in safe places and cleaning for example furniture to keep it looking good.

On the other hand, participants did not invest much time and effort in so-called workhorse products, which mainly serve a functional purpose and are expected to be reliable. Examples of workhorse products are household appliances, such as a washing machine or a lawn mower.

The third category of products this study looked at were up-to-date products, such as clothing or smartphones. These usually short-lived products are often replaced because they are not in vogue anymore or because consumers buy a new product spontaneously. Smartphones, clothes and household furnishings such as lamps or curtains usually fall into this category. While repair and maintenance activities are limited for these products, consumers still wanted them to be usable as long as they wanted to use them and not be limited by early damage or failure.

This classification of products represents a combination of different determinants of product care: The products are differentiated based on their financial value, their functional value and their relevance for the consumer.

Characteristics of Consumers

Other authors argue that consumers can be clustered into different groups, based on their level of product care. Evans and Cooper (2010) clustered consumers into non-optimising, moderately optimising and highly optimising consumers, based on their tendency to show life-span optimizing behaviour in the acquisition, use or disposal phase of consumption. They included everyday footwear, large kitchen appliances and upholstered chairs into their study. Based on their classification, only highly optimising consumers take great care of their products during the use phase and try to extend the products' lifetimes, while moderately optimising consumers conduct only minimal activities to extend product life. Non-optimising consumers fail to take care of their products and do not extend the products' lifetimes. Evans and Cooper (2010) uncovered a high inconsistency of individual behaviour patterns, both across the consumption phases and between product categories. Seventy-three percent of the participants did not show any highly optimizing behaviour in the usage phase of any product category; this means that almost two third of the participants do

not take great care of these products. While footwear was the product category participants do take care of least and upholstered chairs get the greatest care, individuals did not show a consistent behaviour across the product categories but were rather only interested in product care for one product category.

Scott and Weaver (2014) developed a scale to measure the individual repair propensity of consumers. The authors compared the scores on the repair propensity scale with other variables, such as frugality, environmental concern or considerations of reparability acquisition. They even included four items to assess product care ('*I work hard to protect my material possessions.*', '*Keeping my possessions in good working order is very important to me.*', '*Material things should be guarded from harm.*' and '*I am very conscious about keeping my material possessions safe.*'), although this aspect was not the focus of their research.

Scott and Weaver (2014) found that repair propensity is strongly related to personal traits and barely changes over time. Their findings also revealed that economic factors, such as perceived cost of replacement and relationship between item cost and repair, are especially important for consumers with low repair propensity. In addition, product attachment was more prominent along consumers with high repair propensity, but it remained unclear if it should be seen as an antecedent or an outcome of repair propensity.

In general, the role of consumers' personality traits on product care is not clear by now: While Evans and Cooper (2010) state that environmental concern is not a typical driver for lifetime optimising behaviour, Fujii (2006) suggests that environmental concern as well as frugality may contribute to pro-environmental behaviour. Frugality and use innovativeness also seem to be significant factors for repair propensity (Lefebvre et al., 2018).

2.3.5 Conclusion

Fogg's behaviour model (2009) provides a theoretical background for our research on product care. It states that only if motivation and ability are above the action line, triggers can push consumers into the intended direction, i.e. to perform the desired behaviour. We were able to identify sources of motivation, ability and triggers from the literature that seem relevant for product care. Some determinants are not easy to assign to the three factors in the Fogg model, because they can serve as sources of motivation and as triggers, or as

ability factors and as triggers, depending on the timing of their occurrence. For example, the availability of tools can be relevant for ability, because consumers feel well prepared for care activities. Providing consumers in a specific situation with a specific tool that is needed for repair or maintenance can also serve as a trigger, because it facilitates product care in this moment, but not in the long term.

The aim of this PhD thesis is to foster product care through design. This makes it necessary to understand the desired behaviour in depth. Previous studies have often only focused on specific aspects of product care, such as repair, and a comprehensive overview of the topic is still missing. Chapter 3 follows a qualitative approach in order to understand determinants of product care in more detail.

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3

Consumers' Current Product Care Behaviour

In the previous chapter, design for behaviour change was identified as a valid approach to foster consumers' product care behaviour. This study contributes to the literature by taking a consumer's perspective on product care, which is essential to develop design strategies for product care. We used Fogg's behaviour model as a theoretical framework to understand consumers' motivation, ability and triggers related to product care. Fifteen in-depth interviews were conducted to explore consumers' current product care behaviour. We were able to identify sources of motivation for product care, which were related to the product, the consumer or the consumer-product relationship. In addition, we learned about the ability of consumers to take care of their products as well as triggers that are relevant in this context. We discuss these findings and give suggestions for their practical implementation in order to support companies interested in a shift towards the Circular Economy.

Parts of this chapter have been published in Ackermann et al. (2017) and Ackermann et al. (2018)

3.1 Introduction

Chapter 2 has presented an overview of the state of research on product care. It revealed that product characteristics as well as the consumer may play a crucial role for product care (e.g., Evans & Cooper, 2010; DEFRA, 2011; Young, 2017). Some determinants for product care have already been identified, although most of them are based on research on repair and maintenance only (e.g., Cooper, 2004; Terzioğlu et al., 2015; Cooper & Salvia, 2018; Diddi & Yan, 2019). Researchers by now focused on the determinants of repair and maintenance, but did not connect them with models of behaviour change. However, understanding a behaviour is a first necessary step when designing for behaviour change (see also Steg & Vlek, 2009).

Fogg's behaviour model (2009, see Chapter 2), which serves as a theoretical background for this PhD thesis, states that motivation, ability as well as triggers should be considered in order to understand and potentially change a behaviour. The aim of this first study was to systematically look for the presence and absence of these three factors in current consumer behaviour. We wanted to understand if consumers take care of their products, and what their motivation to (not) do so is. We also tried to understand how consumers perceive their own ability to take care of products. Finally, we were looking for triggers that actually push consumers to take care of their products, by serving as reminders or by enhancing motivation and/or ability.

The insights of this exploratory study serve as starting point for the development of our design strategies. This study contributes to literature by providing a comprehensive overview of determinants of product care. This overview has been missing by now, because previous studies have only looked at elements of product care. By linking these determinants to motivation, ability, and triggers, researchers and practitioners can use them as well when designing for behaviour change in product care.

3.2 Method

In order to understand the motivation, ability, and triggers of people to take care of their products, fifteen in-depth interviews were conducted at the participants' homes. After a pilot test with two participants whose data were not used for analysis, we continued the study with 15 people (8 male, 7 female).

Their mean age was 33.4 years ($SD = 12$). Participants were selected from the personal environment of the researchers, aiming at a large variety in gender, age, occupation, and housing situation (alone, with family or room mates).

3.2.1 Procedure

The study was conducted via semi-structured, face-to-face interviews, in which the respondents were encouraged to explain their answers in detail. This ensured that all relevant topics were included and allowed us to ask additional questions. Interviews lasted around 25 minutes on average. We visited the participants at their home so it was easier for them to find examples for the products we asked them about. Before the interview, participants signed an informed consent form and possible questions were answered by the researcher. We also explained the concept of product care by emphasising that it does not only include repair activities, but all activities that can prolong the product's lifetime.

Research in the field of repair and maintenance has often focused on electronic products, such as smartphones or laptops (see e.g., Flipsen et al., 2016; Mashhadi et al., 2016). It has been shown that consumers' attitudes vary greatly between different product categories (Edbring et al., 2015) and thus different design strategies are needed (Bakker et al., 2014). Therefore, our interviews covered a broad range of everyday products to identify not only general phenomena, but also aspects that are specific for certain product categories. This would allow developing strategies that make the Design for Repair & Maintenance principle relevant for society. At the same time, the amount of different topics had to be workable, so we included product categories for which most people should own at least one product. We selected the product categories to cover different ends of scales, such as products of high (e.g., communication devices) and low (e.g., clothes) complexity or utilitarian (e.g., tools) and hedonic (e.g., shoes) products. We also included products for which a service for repair and maintenance is often used, such as cars. These decisions were based on a pre-existing list, which included the most frequently owned products of 1386 Dutch households. As a result, the following six product categories were selected:

- household appliances and tools (e.g., drilling machine, coffee maker, vacuum cleaner)

- consumer electronics and communication devices (e.g., laptop, smartphone, tv)
- means of transport (e.g., car, bike, motorbike)
- furniture and interior design items (e.g., table, curtains, bed)
- clothes, shoes and fashion accessories (e.g., shirts, handbags, scarves)
- sport equipment, accessories for hobbies and leisure (e.g., ski, sport shoes, fishing rod)

For each group of products, the participant was asked to name a product that he/she takes care of, that is he/she devotes effort and/or attention to, so it remains usable for a longer period of time. Depending on the answer, further questions included the reason (as insights into motivation) and the process of taking care as well as possible problems (as insights into ability) by doing so. Subsequently, we asked participants to specify a product that he/she does not devote effort and/or time to, even if that means that he/she cannot use it for a long period of time. Again, reasons and barriers for this behaviour were requested. We used this approach of positive and negative examples as we aimed to get real experiences on the dimension taking care/not taking care. Finally, sociodemographic data were collected (age, gender, profession and household composition).

3.2.2 Analysis

All interviews were audio recorded and fully transcribed. After a verbatim transcription of the interview recordings, a qualitative content analysis was conducted making use of the software f4/f5 [1]. The coding process started by a full coding of two interviews by the main researcher, which resulted in 97 codes. The three factors of the Fogg behaviour model – motivation, ability, and triggers – served as a basis for this coding, but it became clear that more codes and subcodes would be needed to cover all relevant aspects. Hence, after a discussion among the three members of the research team, more relevant codes were added. This led to a coding scheme of 154 codes, which was then applied to all 15 interview transcripts. During a further coding session, two researchers refined and merged these codes. We examined the point of saturation, after which new data produces little or no change to the codes (Guest et al., 2006). Saturation had been reached after interview 12, as the remaining interviews mostly

[1] https://audiotranskription.de

confirmed previous insights. We therefore concluded that 15 interviews were a sufficient sample size for this study.

3.3 Findings and Implications for Practice

Based on the analysis of our interviews, we clustered the findings into general insights on product care as well as into motivation, ability, and triggers. We will also discuss ideas how these aspects can be addressed by companies.

3.3.1 General Insights on Product Care

Activities of product care identified in our study were repair, maintenance and keeping the product clean. Furthermore, product care activities included improvements, the purchase of adequate accessories and protective tools as well as a generally careful and thoughtful handling. Improvements can be actions of personalization, such as changing parts of clothes for a better fit. Examples of adequate accessories are care products, such as a descaler:

> *I use these descalers to avoid the [washing] machine being damaged by the water, so that the machine does not get broken so fast. (P11)*

Thoughtful handling was realized by using the product only for the intended use, regular controlling of the product and avoiding to overstress the product:

> *You just don't want to overstrain it [kitchen machine]. (P06)*

Services are mainly used for repair and maintenance in the transport category (cars, bikes), but in some cases also for household items (e.g., washing machine) or consumer electronics (e.g., laptops).

We identified different degrees of product care intensity among our participants. This factor describes the amount of time and effort people spend on care activities. Participants with a low degree of care intensity do not take care of a certain product, often because they do not really need it. They would also not replace it when it is broken. A medium degree of care intensity relates to care activities for which as little effort and time as possible is invested. Consequently, product care is not done on a regular basis, but a trigger, such as

a broken product, is needed. Even then, there is often no urgency to repair it. This degree of care intensity also includes care activities that have to be done to avoid negative effects in the long term. The products with this degree of care intensity are needed or valued, which leads to their owners' interest in prolonging their lifetimes. The highest degree of care intensity describes a strong care towards the product, which is also done on a regular basis. The underlying reasons can be cognitive ones, like financial aspects, or affective aspects, such as an emotional attachment towards the product. Both result in an explicit wish to keep the product usable as long as possible.

We also identified different stages of care determination. Care determination describes the extent to which the participants are convinced that their executed care activities are appropriate. It is high for participants who take good care of their products, often due to their intrinsic motivation and a general attitude towards longevity of products:

> *Generally…if I buy myself household appliances, for example a mixer or whatever…we don't have one, but it would be the same for a Thermomix: If I spend the money, then I will take care of the product and I won't buy a new one after two years. (P7)*

But it can also be high for people who have no intention to take care of their products as long as they strongly believe that this behaviour is right, for example, because they think it is part of their personality to change products often. On the contrary, a low care determination means that people are not sure if taking care of their products makes sense at all and should be done in the future:

> *And then with sneakers…you cannot really take care of them. They will get broken anyway somehow. (P15)*

Many consumers are doubtful whether they should take care of their products, resulting in a low care determination. These people often base their decisions on rational reasons, such as the money or effort needed for repair. Addressing these rational reasons and enhancing the consumers' motivation can therefore be an important strategy for companies to increase consumers' likelihood to take care of their products.

3.3.2 Motivation to Take Care

Although motivation alone will not lead to product care behaviour, its absence prevents people from performing it. Our findings indicate that at least a strong interest in topics such as obsolescence and sustainable consumption is common in our society. The 11 motivators found in our study are based on either the product (financial aspects, pleasure, functionality, aesthetics), the person itself (intrinsic motivation, previous care experiences, product care as a challenge, rebellion against brand policy), or the relationship between person and product (irreplaceability, fit with the participant's identity, shared ownership).

Product-Related Sources of Motivation

There are four product-related motivators:

First, *financial aspects* play an important role for participants' motivation to take care of their products. A high price of a product leads to consumers expecting a better quality, similar to investment products (Cox et al., 2013). As a long lifetime is expected from high-quality products, consumers are willing to do their part by investing money and effort in product care activities:

> *I take care of an expensive product [more than of a cheaper one], so I can keep it for a longer period of time. [talking about household items in general] (P7)*

On the other hand, high prices for spare parts or a service keep some consumers from taking care. For companies, these insights suggest that a combination has to be found between a high selling price of the product, but also moderate prices for product care activities, either done by the consumers or by a service. An online tool that calculates if it is feasible to repair the product or if it should be disposed of could support consumers in their decisions. Companies could also offer a 'no worries-time' after purchasing a product. Within this time, the consumer could bring the product back and all necessary care activities would be conducted for free. Another possibility is a service flat-rate, which can be understood as an extension of the already existing insurances for laptops, smartphones etc. By paying a fee, care activities as well as theft or destruction would be covered.

Second, participants are motivated to take care of products that are associated with activities of *pleasure*, for example, because they represent a hobby or provide social experiences (e.g. a kettle used for drinking tea with friends). On the other hand, products that are annoying or do not provide fun are usually taken care of less. When consumers associate fun and pleasure with the product, they tend to take more care of it:

> *And Paulchen [a camper] has [...] a kind of fun factor, I associate travelling with it...and we invested a lot of love and time to make it pretty and make it nice for us. (P 17)*

Consequently, household appliances or tools are only seldom taken care of. To enhance consumers' product care behaviour, it is therefore important for companies to connect the usage of a product to more positive feelings, such as fun, or pride.

Third, the *functionality* of a product seems to play an important role for the participants' motivation. This includes the product's quality as well as the features it offers. Aside from the general quality of a product, participants often mentioned functional product characteristics that are (or were at the time of purchase) relevant for their decision. The high functionality then leads to a regular use of the product and, as a result, to regular product care:

> *I really use it [the laptop] every day. I always pay attention for these kind of products, so they really work well. (P13)*

A high functionality also leads to a fear of negative effects such as a premature breakdown of the product due to missing care activities, such as the calcification of a washing machine. While a product that is often used is usually taken care of, a product that is only regarded as a temporary solution or whose lifetime seems to be limited by external factors will not get this amount of attention. The functionality aspect is also relevant for products that consumers are legally obligated to take care of, such as the regular inspection of a car:

> *If bringing your car to a regular service is regarded as taking care, then my car is taken care of necessarily, just due to the legal situation. (P17)*

Products that are technically out-dated, such as older mobile phones, are likely to be replaced by a newer version. A low product care degree is also relevant for products that are generally needed, but are not cherished by the participants on an emotional or personal level. This often applies to very functional products, such as a vacuum cleaner or tools, thereby confirming research on so-called workhorse products (Cox et al., 2013). The participants often reported that they do not take care of them and described these products as *'It is just there'*. (P11)

Another factor that affects motivation are the product's *aesthetics*. This factor concerns very aesthetically appealing products that are often taken care of:

> *Yes [I would bring it definitely to a repair service]. If I regard it as being nice, I don't care if it is custom jewellery or expensive jewellery. (P10)*

Especially within the clothes category, participants prefer to take care for pieces that can be used over a longer period of time and are not dependent on fashion trends.

Person-Related Sources of Motivation

With regard to the person himself/herself, *intrinsic motivation* was found to influence product care activities. This includes a general attitude towards longevity, which motivates the participant to take care of products:

> *I do not want to throw away things generally. (P03)*

This general positive attitude towards product longevity motivates some participants to take care of all of their products, while others differentiated more, either between different product categories or between different products within one product category. On the other hand, there are participants who do not want to take care of their products and prefer to buy new products regularly instead. This behaviour is often independent from the product category:

> *I am the type of person who always buys everything new. (P08)*

These persons always strive to own the latest products, even when the current ones are still of good quality and functionality.

Previous care experiences relate to the former experiences of taking care. They describe how the care activity, either done by the participant himself/herself or by a service provider, was perceived and how it affects the motivation for future care activities. A positive experience is granting the participant for example pride and pleasure:

> *I always recognize that the bike works better afterwards, that you can drive with it in a better way. I am happy that it works better again and mostly the driving experience is also better than before. (P04)*

Some participants seem to be motivated because they see *product care as a challenge*. They want to try out what they can do by themselves and where their personal boundaries are:

> *Simply to find out if I can do it. And because I put the demand on myself to try it by myself first without seeking help immediately. Because I like to figure out if something will work. (P13)*

Challenging themselves increases the participants' motivation to take care of the product, and it can additionally improve their ability: If they are lacking some skills or knowledge, they may gain it to 'overcome the challenge'.

A more specific motivator is the *rebellion against the brand policy* that enhances the motivation to repair products. It describes the attitude of participants who are generally satisfied with a certain product, but become annoyed if their product needs to be repaired or if they need spare parts. The only solution is often to contact the brand's service provider and pay high prices for the repair. This is mainly frustrating for participants who are motivated to repair products on their own, but who are declined the possibility to do so by the brand policy:

> *And I do not want to be part of that game. Apple does that... I fancy Apple products. I think Apple produces good products... but it is disgusting, that the products are closed... in every sense. (P03)*

Sources of Motivation Related to the Person-Product Relationship

Three motivators are linked to the relationship between the consumer and the product.

The first motivator is the product's *(ir)replaceability*. Often a product is regarded as irreplaceable because the participant is emotionally attached to it, for example, because it is an heirloom, an own creation or because it reminds the owner of an event:

> *It [the dress I wore for my graduation ceremony] has also an emotional value. (P04)*

In contrast to these cherished products, there are products that are easy to replace. This often applies to certain clothing items, such as socks or underwear, which are so cheap and easy to be replaced that it is not worth to take care of them:

> *Underwear is not something that could not be replaced very easy. (P12)*

Second, people are motivated to take care of products that *fit with the participant's identity*. If the person has the feeling that the product does not represent his/her lifestyle or represents an unsustainable way of consumption, it may cause a decreasing amount of care, because the person is not interested in using the product as long as possible:

> *It did not really fit into my way of life. It was neither a city car nor a camper. [...] I never stood by it, it never suited me. (P03)*

Last, the *shared ownership* of some products is a reason for low product care. The fact that other people own the product seems to lead to a decreased responsibility to take care of the product. This effect is also described in shared flats, where flatmates do not seem to invest as much time and effort in taking care for the product than the owner:

> *There are flatmates who use it [the kitchen machine] every day and who do not [clean it afterwards]. (P13)*

Motivation is an important aspect to consider when designing for product care, as people will not change their product care behaviour without being motivated to do so. There always has to be a reason for consumers to take care. The product-related motivators pleasure, functionality, and aesthetics can be

directly influenced to enhance consumers' product care behaviour. The person-related motivation can be enhanced by improving the care experience and/or the outcome of care. These positive previous care experiences can serve as a source of motivation for future care activities.

The application of Slow Design (see also Figure 3.1) on mass consumer products may be a promising approach for a prolonged use of products (Grosse-Hering et al., 2013). Figure 3.1 shows a jar that has been designed based on Slow Design principles: It requires the consumer to use both hands to lift and is made of white glass, encouraging careful handling. Slow Design stimulates the user to spend more time on the meaningful parts of the interaction with the product. Meaningful interactions could also be related to product care, for example if care equipment in designed in way that it enables a engaged and reflective process, maybe even leading to a ritual-like experience.

Figure 3.1: Slow Design Jar (Grosse-Hering et al., 2013, p. 3438)

Product care could thereby be encouraged in two ways: On the one hand, the careful handling keeps the product usable for a longer period of time and contributes to more appealing aesthetics, which can in turn enhance the motivation to take care of it. On the other hand, the underlying activities lead to a positive involvement of the consumer (Fuad-Luke, 2002) and can enhance the personal relevance of a product (Zijlema et al., 2017), which results in the consumer's wish to extend the product's lifetime. Additionally, it is important to explain to the consumer that the product is not only of high quality, but that its lifetime can be extended by the consumer himself/herself easily. This results in the acceptance of a higher price at the time of purchase, which in turn enhances the motivation to take care of the product (see financial aspects).

3.3.3 Ability to Take Care

The ability factors presented in this section should be understood as the perceived ability of the participants. For example, it describes how difficult the care activities are judged by the interviewees. Four factors seem to affect participants' perception of their ability to take care of their products: knowledge and skills, time and effort, lack of tools and general repairability.

The first one, *knowledge and skills*, ranges from participants who think they are able to take care of the product to those who either do not have enough knowledge and skills or at least think so. Not enough knowledge and skills are often mentioned for electronic or technical products:

> *Well, because I am not a master of technical things anyway. I have always fears and reservation that I might damage something by handling it in a wrong way. (P05)*

Some of the participants indicated an interest in gaining (more) knowledge or skills, although in the majority of the cases they did not have enough time to learn it until now. Also, participants may have tried to take care of their products, but failed:

> *I tried [to fix it]. I searched online for Mac cleaning programmes and was quite convinced. But then I did not know what files I could throw away... no, I would outsource this in the future. (P03)*

Participants' perceived knowledge and skills vary strongly between the reported care activities: Care activities such as keeping clean do not seem to be problematic for the participants, regardless of the product category. On the other hand, repair is often regarded as demanding, depending strongly on the particular group of product categories. For example, participants seldom repair their technical products, especially those with electronic components or software, such as laptops or mobile phones. They often report of their fear to damage the product further or to hurt themselves. It became clear that participants without technical knowledge are scared of repairing these products without any help. Even other products challenge the participants: Especially in the clothes category they often reported that they do not know how to sew, darn or otherwise work on tissues. Their solution is often to bring the products

to professionals or family members, mostly their mother, who will do this handiwork for them.

The second aspect is the *time and effort* required for the care activity. Participants mentioned that they either do not have enough time to take care of their products or do not want to spend the required effort:

> *But at one point you do not have the time anymore. This is the second aspect…the first one is the money; the second one is the time. And then you think: Is it worth the effort to bring it to the service or spend my own time? Because I do not have this time, especially because of the kids. (P07)*

Third, the participants mentioned a *lack of tools*. This factor relates to tools that are necessary for the care activity or tools to enhance their knowledge or skills such as tutorials:

> *It is not possible [to repair it], because there is a hole in the tire and I do not have the appropriate tools. (P16)*

The last factor that influences the ability to take care is the *general lack of reparability* of a product. It describes the fact or the assumption that a product cannot be repaired in principle. This is often the case for technical products or products with electronic components, which are designed deliberately in a way so that consumers cannot open them:

> *I think you cannot open it [kitchen machine] generally, to be honest. (P08)*

This factor also applies to products that can be repaired, but will not be as nice or practical as before:

> *But it [a pair of winter shoes] is not worth to repair, because it will never be as before. (P07)*

In addition to insights about self-care activities, participants provided comments concerning the usage of services for product care. Participants reported to use a service for difficult or annoying tasks, often regarding technical products, such as a car, a bike or a laptop. Some participants use services not only for tasks they cannot perform themselves, but also because they really enjoy the experience and are happy with the results:

> *It is a very good feeling. That [a cobbler shop] is a service I appreciate a lot. (P03)*

To enhance people's ability to repair a product, various strategies that focus on the consumer could be implemented: Generally, knowledge and skills could be enhanced. As participants reported a general willingness to learn more about care activities for their products, this may be a good strategy. It could be realised by free video tutorials or better instructions, which lead to more advanced knowledge on how to take care of the products. Repair and maintenance workshops offered by the producer could also address this problem and additionally solve the problem of missing tools. To make sure that product care activities do not require too much time or effort, companies could also offer accompanying services to support their customers. Repair and maintenance services are well accepted by participants. Some participants even stated that a service offer for repair etc. is an important aspect of their buying decision.

3.3.4 Triggers to Take Care

Three different triggers – stimuli that push people to perform a certain behaviour immediately – were found by analysing the interviews: appearance triggers, time triggers, and social triggers.

First, the participants' motivation can be increased by *appearance triggers* when the product does not look nice anymore. This can for example be due to traces of a longer period of use:

> *Yes, [I painted my piano] simply black. Because you realise after some time that this black does not look so nice anymore. (P10)*

This trigger applies to the fact that the product's aesthetics can serve as a motivator for product care: When products that looked fine before loose their 'per-

fect' appearance, this trigger enhances the owner's motivation to take care of it and to re-establish its aesthetics.

Another category of triggers are *time triggers*. For example, care activity may be carried out regularly, independent from the actual state of the product.

> *It [the car] is cleaned twice a year. (P17)*

This trigger is also relevant for activities that have to be done on a regular basis due to regulations, such as an annual vehicle inspection.

The third kind of triggers are *social triggers*. They relate to the influence of the social environment, such as family or friends. Their influence can work in both directions by either decreasing or increasing the motivation to take care.

> *My wife sometimes even mocks me, because she thinks it is so nerdy [to take care of my shoes in that way]. (P03)*

Companies can use triggers in order to push consumer towards the desired behaviour. Time triggers range from simple measures such as a reminder for an annual check-up to more complex ones such as a signal that is integrated in the product and attracts attention to itself after a certain time of usage. Appearance triggers can be realised so that a look at the product triggers the consumer to conduct a product care activity. An example is a surface of the product that changes over time. This may work well for furniture, but can also be used for other product categories, such as electronic devices. Social triggers work if people take care of their product, because they do not want other people to look down at them, but also if people want to be admired for taking care of their products. A product that emanates its care state, for example by a small display, so that it is also visible for other people, could therefore be a social trigger.

Table 3.1 provides an overview of the factors related to motivation, ability, and triggers. The table presents each factor, its definition as well as its expected effect on product care. For example, with respect to financial aspects, we propose that the higher the price of the product is, the more likely consumers are to take care of this product. However, the more expensive spare parts of a product are, the less likely consumers are to take care of this product.

Table 3.1: Determinants of Product Care

	factor	definition	effect on product care
SOURCES OF MOTIVATION	financial aspects	high price of the product	⊕
		high price of spare parts	⊖
	pleasure	fun or joy provided by the product	⊕
	functionality	high functionality and therefore regular use of the product	⊕
	aesthetics	concerns very aesthetically appealing products	⊕
	intrinsic motivation	general attitude towards longevity	⊕
	previous care activity experiences	previous positive care activity	⊕
	challenge-based approach	consumers want to try out what they can do by themselves and where their personal boundaries are	⊕
	rebellion against the brand policy	consumers' reaction as the brand tries to prohibit them from repairing their products	⊕
	irreplaceability	emotional attachment towards the product	⊕
	fit with participant's identity	product represents consumer's lifestyle	⊕
	shared ownership	other people owning the product leads to a decreased feeling of responsibility for the product	⊖
ABILITY	knowledge & skills	consumer knows how to take care of the product	⊕
	time & effort	consumer has enough time for taking care	⊕
	lack of tools	consumer has no access to suitable tools	⊖
	general lack of repairability	the fact or the assumption that a product cannot be repaired in general	⊖
TRIGGERS	appearance triggers	product does not look nice anymore	⊕
	time triggers	care activity after a certain amount of time, independent from the actual state of the product	⊕
	social triggers	influence of the social environment, such as a family or friends	⊕ ⊖

3.4 Discussion

In general, our findings support previous studies on repair and maintenance (see Chapter 2) that identified sources of motivation, such as attachment, financial considerations, assumptions about the product's lifetime and previous

care activities. Previously known ability factors of repair and maintenance, such as knowledge, skills, and resources, could also be found as relevant determinants for product care. Triggers for repair and maintenance were not known in literature by now, but are crucial to consider in design for behaviour change (see Fogg, 2009). We were able to identify three different triggers that are relevant for product care: appearance triggers, time triggers and social triggers. The findings of this study helped us to understand product care in more depth and serve as an important background for the development of design strategies for product care.

As described in Chapter 2, Fogg (2009) identified the three positive motivators pleasure, hope, or social acceptance – as well as their negative counterparts – pain, fear, and social rejection. The 11 sources of motivation identified in our study can be linked to Fogg's findings: Our product-related motivators pleasure, functionality and aesthetics as well as previous care activities and the challenge-based approach as person-related sources of motivation refer to Fogg's pleasure, as they all represent a positive experience with the product. The irreplaceability of a product can be seen as the consumer's fear of losing memories connected with the product. The wish to be accepted in society corresponds with a general interest in sustainability, and the fit between the product and one's own identity: People do not want to care for products if they do not match with their own personality. Participants also sometimes mentioned that they take care of some products because they are legally obligated to do so. This means that not taking care could be considered as social deviance, which people try to avoid according to Fogg.

Participants reported of having not enough time to take care of their products, mentioned the high prices for spare parts or services and their cognitive or physical struggle with some tasks. These statements support Fogg's ability factors time, money, physical effort, brain cycles, and non-routine. Additionally, we identified the access to tools and equipment as well as the general reparability of a product as ability factors.

Our interview questions focused on motivators and ability factors to take care or to not take care of products. The observed gap between attitude – a high interest in longevity of products – and action – a general low level of product care – is likely caused by the absence of triggers. Missing triggers represent missing stimuli that provoke immediate care activities. Fogg (2009) also identi-

fied a bad timing of triggers as the most frequent missing element in behaviour change. Unfortunately, consumers are often not consciously aware that certain triggers are absent. More research is needed to explore how these triggers can be designed in order to encourage product care.

While Fogg's model was developed for a different purpose, it helped us to explain the specific phenomenon of product care behaviour. Figure 3.2 shows a specified version of Fogg's model based on our findings.

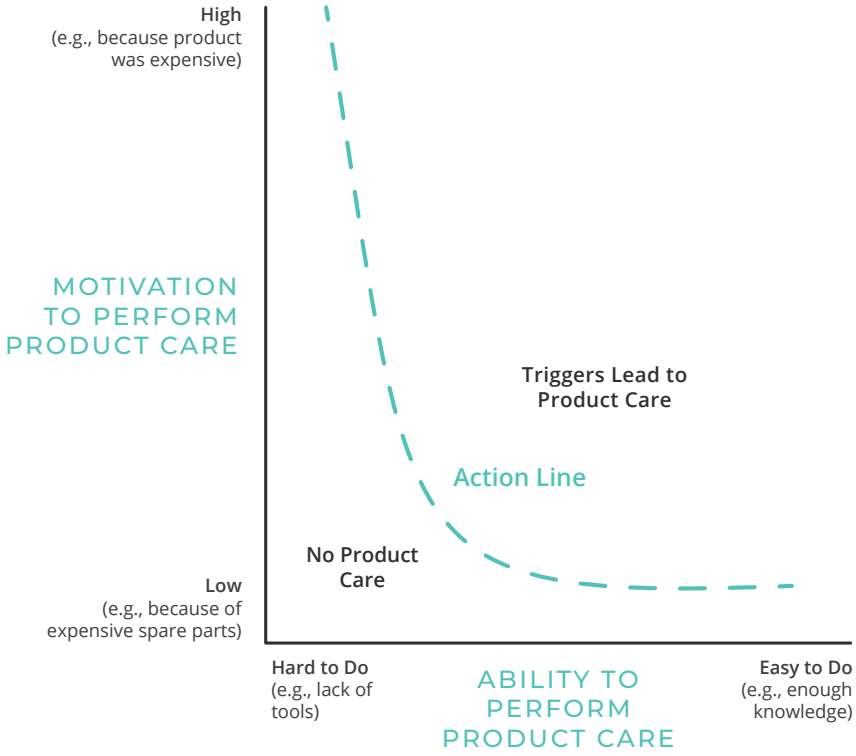

Figure 3.2: Specified Fogg's Model Based on the Uncovered Factors of Motivation, Ability and Triggers for Product Care

For each factor, suggestions for practical implications for companies were given. In general, companies have to start to take care of their products together with their consumers – it is a shared responsibility that has to be addressed. Companies can also benefit from product care: Factors, such as the usefulness of repair information and complexity of repair, do not only affect current care activities: They were also identified as determinants on future purchase decisions as well as on recommendations of the brand (Sabbaghi et al., 2016). This means

that companies cannot only earn money by offering spare parts or services for repair and maintenance, but that a more product care-friendly strategy may increase future sales and affects the company's image in a positive way.

An interesting aspect in this context is the rebellion against brand policy that emerged as a source of motivation from our interviews. During the last years, products became more difficult if even impossible to repair for the consumer (The Economist, 2017a). This applies for example to products, such as smartphones, whose parts are often glued together or whose repair requires special tools. Also, digital ownership has become more 'slippery', as companies, such as Tesla, control via software how their products are used (The Economist, 2017b). Though, recent developments such as the Repair Association[2], that wants US states to pass 'right to repair' laws, or the French law to prohibit planned obsolescence, show that a lot of consumers are interested in taking care of their products and that they are not willing to accept these restrictions.

The shift towards a Circular Economy also bears some challenges for companies: One necessary step is a shift from current business models towards new approaches that do not primarily focus on selling products, but also consider accompanying services (see e.g., Bocken et al., 2016). Therefore, the relationship with the consumer has to be considered throughout the lifetime of a product to be able to take care of it. Another aspect for future research is the communication of product care-related features of a product or a service. Often people do not seem to know if or how a product can be repaired at all, which decreases their motivation to take care of it.

One limitation of this study was the small sample size. Although we determined the point of saturation (Guest et al., 2006) after twelve interviews, quantitative studies with large sample sizes would help to study product care in a more generalisable way. This would allow identifying the most relevant motivators, ability factors and triggers for different consumers, different product categories and different situational contexts. It would also allow the development and testing of design interventions for product care, for example by comparing the level of product care for different versions of a product. Large sample sizes are only possible if we have a valid, reliable and efficient instrument to measure product care. Consequently, we developed a scale for the assessment of product care as a next step (see Chapter 4).

[2] https://repair.org

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4

Development and Validation of the Product Care Scale

In order to be able to assess product care quantitatively in future studies, a product care scale was developed and validated in a set of four related studies. In Study 2.1, we asked experts to examine the face validity of a set of 35 items. In Study 2.2, we reduced the initial set of items to 10 items using exploratory factor analysis. A subsequent confirmatory factor analysis supported a three-factor solution. Study 2.3, a nomological network study, demonstrated that the construct measured by our scale is related but still distinguishable from existing concepts, such as frugality, use innovativeness and attachment towards the product. Study 2.4 was a known-groups test with participants from two different countries and with various previous experiences in visiting repair cafés. The final 10-item product care scale includes three factors: relevance, easiness and positive experience. The developed product care scale enables a deeper understanding of product care and offers a valid approach to quantify the effect of different interventions to stimulate product care.

4.1 Introduction

Previous research related to product care has identified some aspects that can stimulate or hinder product care (see also Chapter 2). While these studies identified some determinants that are relevant for product care, such as attributes of the product or consumers' knowledge and skills, it remains unclear how product care can be fostered. From a sustainability perspective, it is important to understand the determinants of product care in depth in order to be able to stimulate this behaviour.

Measuring product care is related to three challenges: First, product care has often been explored through qualitative studies, such as interviews or focus groups (see Cox et al., 2013; Young, 2017; Chapter 3). Quantitative studies, that would allow for testing and generalization of these previous qualitative findings, are not yet possible, because no scale that can measure product care behaviour in a reliable and valid manner has been developed.

Second, product care cannot be measured directly; instead, it is a latent construct that has to be inferred from other, measurable variables. As part of the scale development, we expect to identify different dimensions that, taken together, allow the assessment of product care.

Third, prior research has shown that consumers are not consistent in their pro-environmental behaviour (Kaiser, 1998; Gatersleben et al., 2002; Steg & Vlek, 2009): For example, while they recycle their waste, they might still prefer their car over public transport, thus choosing a less environmentally friendly alternative for some areas of life. This means that general scales on pro-environmental behaviour, such as the scale by Markle (2013), cannot provide reliable information on product care behaviour, which makes a specific scale to assess product care necessary.

Our scale contributes to research on product care behaviour but also offers benefits for practitioners. The scale will deepen the theoretical knowledge about product care as a specific kind of sustainable consumer behaviour. A reliable and valid product care scale enables researchers to understand differences in behaviours between people and thus to explore determinants of product care. Understanding determinants, such as perceived costs and benefits, contextual factors, or habits of a certain behaviour is a necessary step before interventions for encouraging pro-environmental behaviour, such as information or persua-

sion can be developed (Steg & Vlek, 2009). In addition, the scale enables practitioners to measure the effects of newly designed interventions on consumers' product care behaviour in an efficient and manageable way.

4.2 Overview of Studies

The aim of the current study is the development and validation of a scale to measure product care of individuals: We want to assess if a person takes care of his/her product(s) in a reliable, valid and efficient way. Four related studies were conducted to develop the scale to measure product care: First, we generated items based on previous research on product care and validated them with experts from the fields of circular economy and consumer behaviour (Study 2.1). In Study 2.2, we used an online survey to gather consumer responses on potential items for our scale. After conducting an exploratory and a confirmatory factor analysis, we ended up with a 10-item product care scale, consisting of three factors. We compared our product care scale with existing, related scales to assess the nomological validity in Study 2.3. Study 2.4 was a known-groups test in which we analysed the responses of specific groups of participants for which we expected different levels of product care.

4.3 Item Generation and Initial Validation (Study 2.1)

The aim of this first study was the generation of a first set of items as well as the evaluation of their face validity by experts (see also Hardesty & Bearden, 2004). We developed a broad set of more than 60 items that included different aspects related to product care. These items were based on the Fogg behaviour model (2009) and its application to product care (Chapter 3): We expected motivation and ability to play an important role for product care. Therefore the items refer to financial considerations (e.g., 'One reason why I take care of my products is to save money.'), emotions associated with product care (e.g., '*Taking care of my products is something I enjoy.*') and the perceived ability to take care of products (e.g., '*I am capable of looking after my products.*').

At this stage, items were highly oversampled to allow the selection of the best items during the next steps. For a feedback on face validity, we sent these ini-

tial items to 13 experts, such as scholars in the field of circular economy and consumer behaviour. The main part of this questionnaire were open questions, in which we asked them to give us feedback on the scale and on the items. In addition to this qualitative part, the experts were asked to evaluate each of the 60 items for its fit with the construct on a 3-point Likert scale (1 = '*very representative*', 2 = '*somewhat representative*', 3 = '*not representative*'). Each item was presented in two different versions: First, a general one, referring to products in general, e.g., '*I look after my products regularly.*'. Second, we asked the participants to imagine a specific product and respond to the item based on this product. This version was presented, for example, as '*I look after my [product] regularly.*'. We received nine completed questionnaires.

In the qualitative results, experts mentioned that product care differs strongly between different products, even for the same person. As a consequence, it is difficult, if not impossible, to answer the items on a general level (e.g., '*I look after my products regularly.*'). Consequently, the experts preferred the items in the scale referring to a specific product instead to ensure face validity. In addition, the overall feedback of the experts on our product-focused items was generally positive and the different perspectives towards product care that were included in the items were considered relevant for the product care scale (see also Appendix A). Specifically, items that focus on the ability of the consumer, such as 'I know how to protect my [product] from possible damage.' or 'I am capable of looking after my [product].' were considered as relevant for the scale, as well as items describing the motivational aspects of product care (e.g., '*I keep my [product] in a good condition so I can use it for an extra-long period time.*'). This feedback again related product care to Fogg's behaviour model (2009), highlighting the relevance of ability as well as of motivation. In addition, the experts considered items that merely describe the care activities being conducted as representative for the scale (e.g., '*I look after my [product] regularly.*' or '*I clean my [product] regularly.*').

Based on the feedback of the experts, we decided to change the list of items in different ways to ensure face validity of the product care scale: First, as explained above, each item should refer to a specific product, because an assessment of product care for products in general did not result in a valid measurement. Second, based on the experts' responses regarding the differences between specific products, we questioned whether there would also be differences among various care activities, such as repair and maintenance for a spe-

cific product. To test this possibility, each item of the scale was revised so that it refers either to care, repair and maintenance for the next study. This would allow us to analyse if these aspects lead to independent factors or if they can be summarized under product care as a general factor. For example, the item '*I often postpone maintenance activities for my [product] as long as possible.*' was changed into three new items: (1) '*I often postpone care activities for my [product] as long as possible.*', (2) '*I often postpone repair activities for my [product] as long as possible.*' and (3) '*I often postpone maintenance activities for my [product] as long as possible.*'. Third, some items were rephrased slightly based on the experts' feedback (e.g., '*In general, looking after my [product] is a positive experience.*' instead of '*Taking care of my [product] is something I enjoy.*'), because 'enjoy' was judged as too enthusiastic, leading to little variation within a sample. These considerations led to a new set of 100 items, which was used for Study 2.2.

4.4 Exploratory and Confirmatory Factor Analysis (Study 2.2)

The goal of this study was to reduce these 100 items based on statistical analyses to get to a scale with a reasonable and applicable number of items. We therefore started with an Exploratory Factor Analysis (EFA), which aimed at identifying the latent factors of product care. It was followed by a Confirmatory Factor Analysis (CFA) to examine the construct validity of our underlying model.

4.4.1 Sample and Procedure

For the data collection, we contacted the members of an existing consumer panel (Tan, 2014) and asked them to answer the revised set of items as well as questions on demographic data via an online survey. Based on the experts' feedback from the previous study, we decided to refer to one specific product within all items. As all panel members were from the Netherlands, we chose a product that most Dutch people own: a bicycle. For example, the item '*It is important for me to take care of my [product].*' was changed to '*It is important for me to take care of my bicycle.*'. As described above, each item was presented as three versions: One relating to care in general, one relating to repair and one relating to maintenance. For each item, participants indicated their level of agreement on a 7-point scale, ranging from 1 = '*strongly disagree*' to 7 =

'*strongly agree*'. We contacted 600 people via e-mail. Based on the panel information, we selected these people with a high variance in gender and age to get a representative sample. As an incentive, they were offered € 4.15, which they could receive as stamps or donate to a charity organization. Two hundred and forty-nine participants (52 % female, M_{age} = 50 years, SD = 12) completed the questionnaire within two weeks. We analysed the data using the open-source software RStudio 1.1.463 (RStudio 2018).

4.4.2 Results

As a first step, we had a look at the descriptive statistics of the data and analysed the items related to care, repair and maintenance by comparing their scores. We observed very high correlations between these three set of items (care – repair: r = .93, care – maintenance: r = .93, maintenance – repair: r = .95). This may be due to the fact that consumers do not differentiate between different care activities: If they maintain their bicycle, they also repair it and they take care of it in general, for example by handling it carefully. In addition, some care activities cannot be categorized easily. As an example, tightening the bike chain can be seen as maintenance, because the bike can still be used at this time, but it can also be seen as repair, because a loose chain is a faulty chain. We therefore decided to develop a scale that assesses product care as a whole, including repair and maintenance, but also cleaning, careful handling etc. Consequently, all further analyses refer only to the 35 items (see Appendix B) that were referring to care in general, such as '*I can look after my bicycle well.*', but not to the corresponding item version related to repair ('*I can repair my bicycle well.*') and maintenance ('*I can maintain my bicycle well.*').

Exploratory Factor Analysis

The Kaiser–Meyer–Olkin (KMO) criterion of sampling adequacy (KMO = .90) as well as the Bartlett test of sphericity ($\chi^2(34) = 195.82$, $p < .001$) both indicated that the data was well used for conducting an EFA. An examination of the criteria of skewness and kurtosis (West et al., 1995) revealed that normality was not severely violated, as no item had a skewness value > 2 or a kurtosis value > 7. The Maximum Likelihood (ML) extraction method was used because it is assumed to produce the best results with a lot of indexes of the goodness of fit (Fabrigar et al., 1999; Costello & Osborne, 2005). Furthermore, ML is the

preferred method if a CFA with ML is planned afterwards (Bühner, 2011). An oblique rotation method, CF-varimax (Crawford & Ferguson, 1970), was chosen because we assumed that the different factors that we expected to contribute to product care, such as motivational factors and ability, influence each other. For example, the importance of product care can be based on rational considerations, but emotional aspects can also play an important role. As a consequence, we expected these factors to correlate to a certain degree.

In order to determine the number of factors to be extracted, a parallel analysis (Hayton et al., 2004) and a scree plot were conducted (see also Fabrigar et al., 1999). Both indicated that either three or six factors should be retained. Because the latter led to factors with less than three items per factor, which is considered to be too weak (Costello & Osborne, 2005), we went for a three-factor solution. During the EFA, only items with loadings > .32 and without cross-loadings (as defined by Tabachnick et al., 2007) were retained (see also Costello & Osborne, 2005), which reduced the number of items from 35 to 10.

Thus, the final output of the EFA was a three-factor solution with 10 items (see Table 4.1). The first factor, easiness, describes the perceived ability of the participants to take care of their bicycle. Factor loadings range from .46 to .96. It is based on former experiences ('*I am experienced in looking after my bicycle.*') and the general self-esteem of being capable to take care of the product ('*I can look after my bicycle well.*'). Another aspect of easiness is the availability of equipment that may be needed to repair or maintain the bicycle, such as special tools, spare parts etc. ('*I have the necessary equipment for care activities on my bicycle.*').

The second factor, relevance, describes the general care behaviour and its importance for the consumer. Factor loadings range from .47 to .73. This factor includes three care activities ('*I look after my bicycle.*', '*I try to prevent my bicycle from failure.*' and '*I clean my bicycle.*') as well as one item regarding the importance of care activities ('*It is important for me to take care of my bicycle.*').

The third factor, positive experience, refers to the emotional aspects of product care, such as the experience ('*In general, looking after my bicycle is a positive experience.*') and the feeling of taking care ('*Taking care of my bicycle gives me a good feeling.*', '*It makes me proud that I am able to take care of my bicycle.*'). Factor loadings range from .62 to .93. The three factors can also be explained based on the Fogg model (2009): Relevance and positive experience represent sources of motivation, whereas easiness is related to perceived ability.

Table 4.1: Remaining Items with Factor Loadings after EFA

	easiness	relevance	positive experience
I am experienced in looking after my bicycle.	0.964	−0.025	0.033
I can look after my bicycle well.	0.581	0.307	0.083
I have the necessary equipment for care activities on my bicycle.	0.463	0.009	0.020
It is important for me to take care of my bicycle.	0.029	0.735	0.076
I look after my bicycle.	0.138	0.731	0.056
I try to prevent my bicycle from failure.	0.117	0.709	0.051
I clean my bicycle.	0.037	0.474	0.236
Taking care of my bicycle gives me a good feeling.	0.001	0.019	0.928
It makes me proud that I am able to take care of my bicycle.	0.125	0.041	0.713
In general, looking after my bicycle is a positive experience.	0.181	0.090	0.624

Note: Highlighted numbers illustrate items with a strong loading on this factor.

Confirmatory Factor Analysis

To test the goodness of fit of this factor structure, we defined a model with product care as a general factor and the three factors easiness, relevance, and positive experience as latent factors within RStudio and ran a CFA. The fit statistics for this final three factor-solution with 10 items were on a good level (χ^2/df ratio = 1.597, $RMSEA$ = .049, CFI = .984, $SRMR$ = .040). To assess the convergent validity of our model, we analysed the average variance extracted (AVE). The AVE of each factor is above the cut-off of .50 defined by Fornell and Larcker (1981), see Table 4.2, while the total AVE is .57. Regarding the discriminant validity, we compared the squared correlations between two factors with their AVE. The AVE should always be greater than the squared correlations (Fornell & Larcker, 1981). All three factors fulfil the criterion; thus, discriminant validity between the three factors of the product care scale was confirmed. Scale inter-correlations were in general on a satisfactory level (relevance – easiness: .63, relevance – positive experience = .57, easiness – positive experience = .56), indicating that the factors are correlated, but at the same time not too similar.

To assess internal consistency of each factor, we calculated Cronbach's alpha (easiness: .74, relevance: .81, positive experience: .86) as well as the composite reliability (between .77 and .86, see Table 4.3 for Studies 2.2, 2.3 and 2.4).

Table 4.2: Analysis of the Convergent and the Discriminant Validity

	value
AVE easiness	.52
AVE relevance	.51
AVE positive experience	.68
total AVE	.57
squared correlation easiness – relevance	.36
squared correlation positive experience – relevance	.29
squared correlation easiness – positive experience	.31

4.5 Nomological Network Study (Study 2.3)

The next step was a validation of the 10-item product care scale through a nomological network study. We used other measures related to product care and compared the scores with the scores of our scale. Product care behaviour is related to characteristics of the consumer, the product itself, as well as the relationship between consumer and product. Based on our literature research, we thus selected several established and related scales from the field of environmental psychology and consumer research. Despite some similarity with these constructs, product care behaviour is also different, as it describes a certain behaviour towards a specific product. We expected the product care scale to correlate on a moderate level with these other scales, indicating that our product care scale assesses related, but not the same constructs as these scales (Evans, 1996). We first present characteristics of the consumer that might increase the proneness to conduct care activities.

The first construct is environmental concern (Weigel & Weigel, 1978) that describes the extent to which a person is concerned with sustainability issues, that is how much he or she cares about the environment. Previous research is not unambiguous about the role of environmental concern for pro-environmental behaviour: Fujii (2006) states that environmental concern may contribute to pro-environmental behaviour, whereas Evans and Cooper (2010) state that environmental concern is not a typical driver for lifetime optimising behaviour. In the context of product care behaviour, we expect that people with a high envir-

Table 4.3: Construct Measurement Summary: Factor Loadings from CFA and Reliability Scores (CR = composite reliability)

		Study 2.2		Study 2.3				Study 2.4			
		bicycle		coffee machine		leather shoes		bicycle		coffee machine	
	item	loading	reliability	loading	reliability	loading	reliability	loading	reliability	loading	reliability
EASINESS	I am experienced in looking after my [product].	.81	$\alpha = .74$ $CR = .77$	.89	$\alpha = .87$ $CR = .87$	.89	$\alpha = .87$ $CR = .88$	.09	$\alpha = .84$ $CR = .70$	.89	$\alpha = .89$ $CR = .90$
	I can look after my [product] well.	.78		.90		.87		.87		.92	
	I have the necessary equipment for care activities on my [product].	.45		.73		.72		.87		.79	
RELEVANCE	It is important for me to take care of my [product].	.73	$\alpha = .81$ $CR = .82$	.88	$\alpha = .90$ $CR = .91$	.83	$\alpha = .90$ $CR = .91$	.50	$\alpha = .78$ $CR = .83$	.77	$\alpha = .86$ $CR = .85$
	I look after my bicycle.	.82		.95		.89		.71		.89	
	I try to prevent my [product] from failure.	.76		.78		.84		.90		.68	
	I clean my [product].	.61		.75		.81		.81		.72	
POSITIVE EXPERIENCE	Taking care of my [product] gives me a good feeling.	.87	$\alpha = .86$ $CR = .86$	.96	$\alpha = .92$ $CR = .93$	.86	$\alpha = .89$ $CR = .89$	.81	$\alpha = .85$ $CR = .88$	.11	$\alpha = .85$ $CR = .72$
	It makes me proud that I am able to take care of my [product].	.87		.87		.79		.84		.87	
	In general, looking after my [product] is a positive experience.	.82		.87		.92		.87		.92	

onmental concern realize that it is important to take care of products to extend their lifetimes and are more aware of appropriate product care activities for their products. As an example, people with a high environmental concern may recognize the need of a kettle to be freed from calcium carbonate more often than people with a low degree of environmental concern. Based on Fogg's behaviour model (2009) we argue that environmental concern may enhance consumers' motivation to take care of their products, which may lead to a positive correlation with product care.

Frugality can be defined as the 'careful use of resources and avoidance of waste' (De Young, 1986, p. 285). As product care behaviour reduces the need to buy new products, and thus helps to save money and waste, we expect product care behaviour to positively correlate with frugality. Frugality is not only a personality trait, but it can also help to explain the usage of product and services by consumers (Lastovicka et al., 1999). Prior research indicated that frugality can be an effective means to stimulate pro-environmental behaviour (Fujii, 2006) and that it is positively related to repair propensity (Lefebvre et al., 2018).

Use innovativeness (Price & Ridgway, 1983; Girardi et al., 2005) explores a personality trait that refers to the innovative ways in which a person uses products. It applies not only to products new to the market, but also to old products and services. In the latter case, use innovativeness describes if a person uses the product in a new or innovative way. An example would be an old skateboard that is used as a shelf. As consumers with a high level of use innovativeness are often very hands-on, and experienced in craftsmanship, product care activities are easy to conduct for them. Use innovativeness was found to be a determinant of product lifetime extension (Price & Ridgway, 1983) and repair propensity (Scott & Weaver, 2014; Lefebvre et al., 2018), and as such we expect that it will positively correlate with the product care scale.

In addition to these consumer characteristics scales, we also expect scales that refer to attributes of the product or to the relationship between consumer and product to be related but still distinct from product care: For example, a strong connection or attachment between the product and its owner is likely to motivate product care behaviour (Kleine & Baker, 2004; Mugge et al., 2010). Involvement describes the personal meaning or relevance a consumer attributes to a product category (Antil, 1984). Involvement can lead to the perception of greater product importance (Howard & Sheth, 1969), which may sub-

sequently result into enhanced product care. Satisfaction (Crosby & Stephens, 1987; Spreng et al., 1996) concerning the product can also be an important driver for product care: The more satisfied the consumer is, the more he/she wants to keep the product for a longer time, and thus the more likely a person will be to perform care behaviours for this product. Closely related to satisfaction is the product's quality (Grewal et al., 1998) as well as its usefulness (Cox & Cox, 2002). The latter describes the extent to which a product is perceived to be practical by the consumer. In addition, the attitude towards an object scale (Ahluwalia & Burnkrant, 2004) asks for a more general evaluation of the product.

While these product-related constructs are all related to a positive attitude towards the product and are therefore stimulating product care, disposal tendency (Harrell & McConocha, 1992) refers to the fact that the consumer does not want to keep a product although it can still be used. Consequently, we expect product care and disposal tendency to correlate negatively.

4.5.1 Sample and Procedure

Two versions of the questionnaire were created, of which only one was presented to each participant: One in which the product care scale as well as the scales that are referring to a specific product (i.e., attitude, quality, satisfaction, attachment, disposal tendency, usefulness) were related to leather shoes, and one in which these items were related to a coffee machine. The consumer characteristics scales (environmental concern, frugality, use innovativeness) were the same in both versions.

We selected other products than in the previous studies to explore the applicability of the 10-item product care scale to different kinds of products. Coffee machines and leather shoes were chosen because 1) they are owned and used by most people, 2) they need to be taken care of, and 3) product care activities for these products are relatively easy to conduct. These considerations should assure that many people can relate to the products and the care activities needed.

At the beginning of each questionnaire, we made sure that the participants own and regularly use the product we wanted to ask them about. In addition to the 10 items from the product care scale which were assessed on a 7-point

Likert scale, 49 items from existing scales were used (for a complete list see Appendix C):

On a 7-point semantic differential:

- 4 items (as used in Bower & Landreth, 2001) from the involvement scale (Zaichkowsky, 1985)
- 5 items from the attitude scale by Ahluwalia and Burnkrant (2004)
- 3 items from the usefulness scale by Cox and Cox (2002)
- 3 items from the satisfaction scale (Crosby & Stephens, 1987)

On a 7-point Likert scale (from 1= strongly disagree to 7 = strongly agree)

- 6 items from the environmental concern scale (Kilbourne & Pickett, 2008)
- 8 items from the frugality scale (Lastovicka et al., 1999)
- 9 items from the use innovativeness scale (Girardi et al., 2005)
- 4 items from the attachment scale (Schifferstein & Zwartkruis-Pelgrim, 2008)
- 3 items from the quality scale (Grewal et al., 1998)
- 4 items from the disposal tendency scale (as used in Mugge, 2007)

Again, the questionnaire was sent out to participants via an existing consumer panel. As in the previous study, they were offered € 4.15, which they could receive as stamps or donate to a charity organization. Participants were randomly assigned to either the questionnaire version of the leather shoes or the coffee machine. If they did not own leather shoes or a coffee machine, they were forwarded to the other version, respectively. After 2 weeks, 117 participants had finished the questionnaire on the leather shoes (52 % female, M_{age} = 53 years, SD = 12) and 118 participants had completed the questionnaire on the coffee machine (53 % female, M_{age} = 56 years, SD = 10).

4.5.2 Results

The psychometric analysis of this study confirmed the scale structure found in Study 2.2: A CFA on the data provided a good model fit for a three-factor solution (coffee machine: χ^2/df ratio = 2.95, $RMSEA$ = .129, CFI = .939, $SRMR$ = .063; leather shoes: χ^2/df ratio = 2.40, $RMSEA$ = .109, CFI = .951, $SRMR$ = .050), with only the RMSEA value being higher than the recommended cut-off, which may be caused by the small sample size in our study (see Chen at al., 2008, for a discussion of this issue).

The total AVE was .71 for coffee machines and .74 for coffee machines. In addition, the three factors led again to good values for composite reliability (see Table 4.3). Our product care scale demonstrates good internal consistency (α = .93 for coffee machines, α = .94 for leather shoes).

To assess the construct validity of our scale, we calculated the correlations between the product care scale and the selected existing scales introduced in the previous section. As an analysis of skewness and kurtosis suggested that our data does not deviate strongly from normal distribution as defined by West et al. (1995), Pearson correlation coefficients were calculated (see Table 4.4).

Although there is no official cut-off for construct validity (DeVellis, 2017), the results of our study seem to be promising: Two product-related scales correlate on a significant level with product care for coffee machines as well as for leather shoes: Attachment ($r_{\text{coffeemachine}}$ = .46, p < .001; $r_{\text{leathershoes}}$ = .33, p < .001) and quality ($r_{\text{coffeemachine}}$ = .33, p < .001; $r_{\text{leathershoes}}$ = .35, p < .001). These moderate levels of correlation mean that these scales measure constructs are related to product care, but are still distinct.

Table 4.4: Correlations between the Product Care Scales and Selected Existing Scales

	Coffee Machine		Leather Shoes	
	cronbach's alpha	correlation with product care scale	cronbach's alpha	correlation with product care scale
Involvement	α = .91	0.41*	α = .92	0.24
Attitude	α = .96	0.29*	α = .98	0.14
Usefulness	α = .96	0.19	α = .99	0.09
Satisfaction	α = .93	0.29*	α = .90	0.17
Attachment	α = .88	0.42**	α = .84	0.33**
Quality	α = .88	0.33**	α = .86	0.35**
Disposal	α = .82	−0.15	α = .70	−0.04
Environmental Concern	α = .88	0.12	α = .89	0.10
Frugality	α = .82	0.26*	α = .84	0.35**
Use Innovativeness	α = .79	0.37**	α = .82	0.09

Note: * significant at .01 level, ** significant at .001 level

For coffee machines, but not for leather shoes, three additional scales correlate on a moderate level with the product care scale: involvement ($r_{\text{coffeemachine}}$ = .41, p < .001), attitude ($r_{\text{coffeemachine}}$ = .29, p < .001), and satisfaction ($r_{\text{coffeemachine}}$ = .29, p = .002). Again, these correlations are on a moderate level, indicating a related but still distinct relation to product care.

The other product-related scales (usefulness and disposal) do not significantly correlate with product care. They can therefore be interpreted as distinct from the construct of product care; just because a product is seen as useful does not mean that consumers take care of it and taking care of their product does not necessarily reduce the chance that individuals dispose of their product. From the consumer-related scales, frugality was significantly related to product care ($r_{\text{coffeemachine}} = .26$, $p = .004$; $r_{\text{leathershoes}} = .35$, $p < .001$). Use innovativeness only had a significant correlation with product care for coffee machines ($r_{\text{coffeemachine}} = .37$, $p < .001$), and environmental concern was not significantly related. This means that product care is higher for products that people are emotionally attached to and that are regarded as high quality. Frugality is also related to product care, which could mean that saving money is a motivational source for product care. Use innovativeness was only significantly related to taking care of coffee machines, but not of leather shoes. The higher complexity of coffee machines requires more technical knowledge and skills, which might be related to use innovativeness.

The results do not only confirm our three-factor solution from Study 2.2, but also demonstrate that our scale is able to measure product care for different kinds of products, thus proving its usefulness for practitioners. The findings confirm previous research that proposed that characteristics of the consumer (e.g., frugality, use innovativeness) as well as product attributes (quality, satisfaction) and the emotional attachment towards a product are related to product care (Schifferstein & Zwartkruis-Pelgrim, 2008; Lefebvre et al., 2018; Ackermann & Tunn, 2020), but also shows that all these constructs are still distinct from product care. In addition, the study demonstrated that scales such as involvement (with the product category) and attitude are at least for certain product categories related to product care. Higher scores on all these scales result also in higher levels of product care. In conclusion, the product care scale measures a construct that is related to but still distinct from other scales. It has therefore the potential to explore a behaviour that cannot be assessed through already existing scales, proving its unique contribution to research of pro-environmental behaviour.

4.6 Known-Groups Test (Study 2.4)

The final study was a known-group comparison to assess the construct validity of our product care scale. According to Hattie and Cooksey (1984), proving a scale to be valid requires scale scores to discriminate across groups that are expected to differ based on a priori considerations. We therefore defined a priori groups of participants for which we expected differences in product care behaviour. One pair of groups was formed based on previous visits to a repair café. We expected previous visitors of repair cafés (at least one visit) to have a higher product care score, because they have already demonstrated a certain interest in repair activities before. For the second pair of groups, we decided to compare two different products over two countries, assuming that these products are not equally relevant for the respective residents. We assumed that people from the Netherlands score higher on product care for their bicycles than people from Austria, because they are in general using their bicycles more often in daily life and are thus more dependent on them staying in a functional state. We did not expect a similar effect for coffee machines, as this product is equally important in both countries.

4.6.1 Sample and Procedure

The study was conducted by approaching people in person and asking them to fill in the paper-based questionnaire (see Appendix D). For this study, we used a convenience sample: We approached students in Austria and the Netherlands, as well as people from the street in Austria to cover a broad range of the population. In addition, we distributed the questionnaire in an Austrian fab lab because we expected high expertise in repairing products for its visitors. A candy bar was offered as an incentive. Each participant answered the product care scale for his/her bicycle and for his/her coffee machine. We selected these products because they are owned by most people, and people use them regularly. In addition, these products differ strongly in complexity, with product care for a bicycle being easier and requiring less technical skills than product care for a coffee machine. In addition to the product care scale, we asked the participants if they had ever visited a repair café, which they could indicate on a 3-point scale from '*yes, regularly*' over '*once or twice*' to '*never*'. We collected questionnaires from 189 participants (48 % female, M_{age} = 27 years, SD = 11).

4.6.2 Results

A t-test revealed that participants who had at least once visited a repair café demonstrated a significantly higher level of product care for both products than participants who had never visited a repair café before ($M_{\text{previous}} = 3.39$, $M_{\text{never}} = 2.93$, $t = 3.00$, $df = 113$, $p = .003$, $d = 0.47$). Because only two participants had visited a repair café more than once, it was not possible to calculate an effect of the number of visits on product care. A Mann-Whitney-U test showed a significant difference in product care for bicycles between participants from the Netherlands and from Austria ($M_{\text{Austria}} = 2.77$, $M_{\text{Netherlands}} = 3.09$, $W = 3172$, $p = .043$) In conclusion, the known-groups study demonstrated that our product care scale can discriminate between groups of participants for which we expected these differences a priori. In addition, we again tested the internal consistency and model fit of our scale. In conformity with the findings of the other studies, the product care scale demonstrated good internal consistency ($\alpha = .90$ for bicycles, $\alpha = .92$ for coffee machines), and a subsequent CFA of the data on the three-factor model provided a good model fit (bicycle: χ^2/df ratio = 1.77, $RMSEA = .065$, $CFI = .980$, $SRMR = .043$; coffee machine: χ^2/df ratio = 3.15, $RMSEA = .108$, $CFI = .958$, $SRMR = .050$). The total AVE was .62 for bicycles and .70 for coffee machines. The factor loadings as well as the reliability values for the three factors of the scale were again on a good level (see Table 4.3).

4.7 Discussion

Research by now has shown that people differ greatly in their pro-environmental behaviour (Kaiser, 1998; Gatersleben et al., 2002; Steg & Vlek, 2009). Therefore, researchers cannot infer from the presence of a specific pro-environmental behaviour, such as recycling, that the same individuals would also show another pro-environmental behaviour (e.g., choice of transport means), which makes a specific scale for product care necessary.

Product care usually takes place in a private setting, researchers are dependent on information provided by the consumers themselves. It has been argued that self-reported behaviour would be influenced by social desirability (Tam & Chan, 2017), leading to an over-reporting of pro-environmental behaviour (Huffman et al., 2014). However, a recent meta-analysis (Kormos & Gifford, 2014) re-

vealed that a systematic bias is unlikely, as social desirability is not or only on a low level correlated with self-reported pro-environmental behaviour. We therefore decided to develop a scale that can be filled in by consumers themselves.

We conducted four related studies. The first one was an initial item evaluation through experts, which contributed to the decision to develop a product-specific scale instead of a scale that measures individuals' care behaviour in general. The second study was an online survey that allowed us to conduct an exploratory and a confirmatory factor analysis, resulting in a three-factor scale with 10 items. These factors were relevance (general care behaviour and its importance for the consumer), easiness (perceived ability of the consumer to take care of his/her product) and positive experience (emotional aspects of product care). The nomological network study (Study 2.3) demonstrated that the product care scale is related, but still distinct from well-established scales such as environmental concern, frugality or use innovativeness. Study 2.4 then revealed that the scale is able to differentiate between groups of participants for which different levels of product care can be expected.

The psychometric analyses of our scale were promising: Results are indicating that our scale is a valid measure for care of products within different categories (leather shoes, coffee machine, bicycles). Independent from the fact that these products differ in their technical complexity as well as in their importance for consumers in daily life, the care behaviour for these products can be assessed in a valid way. The three-factor structure of the scale which was developed in Study 2.2 was confirmed in Studies 2.3 and 2.4, with good reliability measures as well as factor loadings (see Table 4.3). The three factors represent sources of motivation (relevance, positive experience) as well as perceived ability (easiness). This scale structure is in accordance with previous research findings, such as Fogg's behaviour model 2009 as well as studies in the field of pro-environmental behaviour based on this model (Scurati et al., 2020), that also highlight the need for motivation and ability as determinants of a certain behaviour. It makes sense that triggers are not included in this scale, as the scale assesses product care towards a specific product over a longer time period, and not in a particular situation.

By nature, the scale is no appropriate instrument to explore sources of motivation or other underlying reasons for product care in depth, because it consists of 10 items only. At the same time, 10 items make the scale useful for both

scientific and practical design research that aims to test specific interventions. Another limitation of our research may be the limited representativeness of our convenience sample in Study 2.4. We believe that this does not undermine the value of our scale. In fact, our product care scale has been used in Chapter 6 in which further support is given for the scale's likelihood to differentiate between groups on their tendency to take care of products. Despite these limitations, we believe that our scale provides a valid and helpful instrument for future research in the field of pro-environmental behaviour.

Based on previous studies (see also Chapter 3) and the experts' feedback (Section 4.3), we developed a scale that is always referring to one specific product, such as a bicycle, a coffee machine or leather shoes. We were able to show that the scale works for products from different product categories by simply inserting the product of interest in our items. For future studies, we encourage researchers to use our scale for various kinds of products across different levels of complexity, price and emotional attachment in order to understand the determinants of pro-environmental behaviour of product care in more detail. These insights facilitate the development of interventions to stimulate product care.

Because the scale consists of only 10 items, the scale enables the efficient assessment of product care, for example by measuring it before and after interventions. It can easily be included in online surveys or distributed as a paper-pencil questionnaire (as done in Section 4.6). In quantitative studies, the scale can assess the status quo of product care among a large number of individuals.

For future studies, we also want to point out the necessity to translate the items carefully when using the scale in other languages. For example, the German translation of 'taking care' ('kümmern') led to some confusion among our participants in Study 2.4, because it is an uncommon word in this context. This did not influence our study because participants filled the questionnaires in while we were present, but it may be worth to be considered in future studies.

As mentioned above, one field of application for the scale is the testing of strategies for product care. The development and evaluation of design strategies for product care will be presented in the following Chapter 5.

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5

Design Strategies for Product Care

Design has the potential to increase product care activities, but designers need to know how to evoke product care among consumers. By the means of individual and group brainstorming sessions as well as an analysis of existing solutions we created a large amount of ideas on how to stimulate product care in Study 3.1. We were able to summarize these ideas into eight strategies and 24 sub-strategies that can foster product care through design. These eight strategies are: informing, awareness, antecedents & consequences, social connections, enabling, appropriation, reflecting, and control. In Study 3.2, we conducted interviews with 15 consumers to evaluate these strategies, which helped us to understand the suitability of different strategies dependent on the product and the context. To support designers in the implementation of these strategies, we developed and tested a toolkit that can be used in the product development process of different product categories (Study 3.3).

Parts of this chapter have been published in Ackermann et al. (2019). The development of the strategies and the toolkit have been part of the master project of Mahana Tuimaka (2019) that was co-mentored by the author of this thesis. She also designed the illustrations used in this chapter.

5.1 Introduction

Prior research has shown that the design of products and services can be a valid approach to achieve more sustainable behaviour change (e.g., Bhamra et al., 2011; Daae et al., 2017; Lilley et al., 2017). Research has also revealed possible (design) strategies for repair and maintenance (e.g., Cooper, 1994; Van Nes & Cramer, 2005), that may also be relevant for product care. However, these strategies have focused mostly on product design that facilitates product care, for example by enabling repair with standard tools. Ability alone does not lead to product care, motivation and triggers are needed as well (see Chapter 2, Chapter 3). This missing perspective on consumers of these approaches leads to a value-action gap: Consumers report that they are in general motivated to take care but struggle to take care of their products in everyday life (see also Chapter 3).

We argue that design strategies for product care should focus not only on the facilitation of product care but also on the necessary sources of motivation as well as on possible triggers in order to influence consumers' behaviour. Today's designers and manufacturers are aware of the need for products and services that support sustainable consumption and have the potential to support a shift away from a linear towards a Circular Economy. In addition, human-centred design processes are part of the design education and are applied in design practice by integrating consumers at different stages of the product development process. However, consumers' motivation and possible triggers to stimulate product care often to not play a prominent role in recommendations for design for repair and maintenance (see also Chapter 2).

Fogg's behaviour model (2009) was again used as a background theory for the development of design strategies described in this chapter. This integration allowed us to develop design strategies that extend the current design strategies for repair and maintenance by 1) also considering care activities that go beyond repair and maintenance, such as careful handling or preventive measures, and 2) integrating the consumer perspective by focusing not only on the facilitation of product care but also on ways to enhance consumers' motivation and create triggers for them.

This chapter describes three related studies: In Study 3.1, we developed the design strategies, using a multi-method approach of brainstorm sessions and

desk research. In Study 3.2, we evaluated the design strategies in an interview study with 15 participants in order to gain further insights into their thoughts on how design can stimulate product care. During the interviews, we presented the strategies and discussed products and situations in which the particular strategy would help them to take better care of their products. This integration of the consumer into our research process ensured that the design strategies consider the consumers' perspective and actually have the potential to change their behaviour. It also helped us understand in which situations the strategies are seen as more or less suitable to promote product care. In order to bring this knowledge into practice, we then developed the Product Care Kit based on the identified design strategies. This toolkit can be used to stimulate designers during the ideation phase, making them aware of possibilities on how to foster product care through design. It can also be used during brainstorming sessions within the design team, or to facilitate communication between designers and other stakeholders. Study 3.3 describes the development as well as the testing of this toolkit.

5.2 Development of Design Strategies for Product Care (Study 3.1)

As a first step in this first study, we aimed to collect a large number of existing products, services or product concepts that stimulate consumers to perform product care activities. This would allow us to look for patterns or overarching themes which would then used to define concrete design strategies.

5.2.1 Procedure

For the collection of products, services and concepts for product care we chose a multi-method approach because we wanted to combine existing knowledge and strategies with new ideas and concepts. We thereby aimed for strategies and examples that have a theoretical background, for example, from research on repair and maintenance, and are relevant for design practice. During all process steps, the focus was on existing and conceptual product and services that stimulate product care among consumers. Three different methods were used to gather a large variety of products, services and concepts: 1) a brainstorm session with designers, 2) an individual brainstorm session by one designer from the research team and 3) performing desk research into existing products and

services that stimulate product care. This approach ensured that novel ideas were combined with existing knowledge, and that ideas from practice as well as from research were considered.

For the collection of products, services and concepts, we referred to seven different product care activities that we defined based on the findings in Chapter 3: repair, preventive measures, product revival, creating something new/different, small care, instructed & mindful handling, and routine acts (see Table 5.1). We believe that there may be some overlap between these different product care activities: For example, product revival and repair can contain similar activities for certain products: Replacing parts of a bicycle because it is not pleasant to cycle could be seen as either repair, because the product doesn't function properly anymore, but also as product revival because product care is executed to make it perform better. However, the main aim was to have a comprehensive overview of different product care activities, due to which overlap between the different product care activities was not seen as an issue.

Table 5.1: Product Care Activities

product care activity	description
repair	Repair consists of activities that will make the product function properly again. This can be the repair or the replacement of broken parts. The product or a part of the product is usually broken. This prevents the product from performing its primary function, performing a specific function or performing satisfactorily. Example: *Changing the tire of a bike when it is punctured, or glueing the ear back on a coffee mug after it fell and broke.*
preventive measures	Preventive measures that are taken to make sure a product breaks or deteriorates slower than usual. These measures often consist of external products or services that equip or protect the product against its environment. Example: *Putting a phone case on a phone or spraying hiking boots with a water-resistant spray.*
product revival	Product revival consists of activities that revive a product to a certain standard. This means that product care is performed in order to make the product work more fluently/better/faster. It can also imply that after these care activities the product obtains a more appealing appearance. Example: *Cleaning and greasing the chains of a lawnmower, or sanding and varnishing a scratched up table.*
creating something new/different	Creating something new/different consists of activities that result in an end product that is new or different from the original product. It can consist of one or more products, where the existing products are remodelled/rebuilt/reformed so it feels like a new, different or personalized product to the user. This means that instead of replacing or throwing out the old product, the old product or its materials are used to make a new/different product. Example: *Painting an old IKEA kitchen cabinet and adding legs to create a nightstand, or using the fabric of an old pair of jeans to make a handbag.*

Table 5.1: Product Care Activities, cont.

product care activity	description
small care	Small care consists of activities that are done to freshen up the product, to maintain the quality of its aesthetics and/or its performance. These are activities that are usually low in effort and/or time. Example: *Polishing silver earrings, or pumping the tires of a bike when they feel a little soft.*
instructed & mindful handling	Instructed & mindful handling implies that the user actively aims to treat and take care of the product in a good way. The product is kept in a good state because the user consciously refrains from behaviours or actions that negatively influence the state/lifetime of the product and only perform acceptable behaviours or actions. Example: *Not using metal cutlery in pans to prevent the non-stick coating from getting damaged, or rolling up the charger for a laptop carefully before storing it in a bag.*
routine acts	Routine acts consist of activities that the user performs unconsciously. The consumer learned to do this behaviour and has never thought about doing it differently. These habits are often short or small activities that are done regularly and have become part of people's routine. Example: *Cleaning cast iron pans by hand instead of putting it in the dishwasher because this is how your caregivers did it, or brushing of the mud of a pair of rugby shoes after each rugby training because everyone else does so after leaving the training.*

Brainstorm Session with Designers

The first brainstorm session was conducted with four design students who had a bachelor in design and one UX designer with a master in design. None of the participants had experience with designing for product care specifically or were consciously aware of design strategies for product care. In the week before the brainstorm session, participants were sensitized to the topic of product care. They received a short written introduction including the definition of product care and the description of the seven different product care activities. Participants were also asked to think of one product that they take care of and one product that they do not take care of and think through why this is the case.

At the start of the brainstorm session that lasted approximately 2,5 hours, participants were briefed about the purpose of the research, and about the goal of the session. A short discussion was held about the preparation assignment. The group talked about the products that they repaired or maintained and why they believed they were successful in this. Next, they discussed why they failed to maintain or repair their second product. By discussing their own experiences and motivation to perform product care, they were sensitized to consider the consumer who needs to be motivated or supported in order to perform product

care activities. Participants were then asked to write down and tell their initial ideas and thoughts about product care on sticky notes to encourage the flow of writing and talking about their thoughts and ideas with the group.

Three rounds of brainstorming took place. In the first round, participants were asked to write down product/service solutions for product care activity that they could come up with. In the second round, participants were asked to write down product/service solutions for the products that the participants did not maintain or repair. In the third round, participants were asked to write down product/service solutions for six different product categories (as used in Chapter 3) to get ideas for a broad set of products. These categories were: household appliances and tools, consumer electronics and communication devices, means of transport, furniture and interior design items, clothes, shoes and fashion items, sports equipment, and accessories for hobbies and leisure. For this round, the researcher prepared a set of possible products beforehand, to ensure that the products differed from the ones chosen by the participants for the second round. All ideas and solutions during the session were written down on sticky notes and stuck to the wall where everyone could see them. Participants were encouraged to write down their solutions themselves or say the idea out loud, so it would evoke discussion or inspiration within the group. The brainstorm session resulted in 140 product/service solutions and ideas.

Individual Brainstorm Session

During this individual brainstorm session, one member of the research team ideated additional product/service solutions. The aim of this step was to find as many solutions as possible. The brainstorm was executed by brainstorming/drawing through associating (Buijs & van der Meer, 2012). To ensure variety in the type of solutions that would be created during this step, the researcher switched her focus continuously between the different product care activities and the different product categories. She also used the human senses (sight, smell, touch, hearing, taste) as an inspirational trigger to widen the solution space even further. By using human sense as a trigger, different ways of approaching the consumer were ensured. A Forced Fit method (Tassoul, 2009) was used for the ideation. During the Forced Fit method, the researcher randomly picked one of each aspects to focus on: one of the six product categories, one of the seven product care activities and one of the five human senses. This way she forced herself to consider solutions that she would otherwise not have

thought of. If one idea triggered the next one without picking a new set of triggers, that idea was also documented. If no more new ideas came up, a new combination of aspects was chosen for the next ideation round. All product solutions consisted of a simple drawing with an explanation of how it would work. The brainstorm session resulted in 63 solutions for product care. These product/service solutions are additional solutions, which target product care in more unexpected angles due to the Forced Fit method and therefore help cover a larger field of product care solutions and minimize the chances of undetected strategies.

Research into Existing Products and Services

An extensive inquiry was conducted via searching on the internet, asking colleagues and acquaintances and by looking into prior experiences (Xue & Desmet, 2019). By asking colleagues and acquaintances to share their care experiences, we received more insights in what motivates and pushes consumers to perform product care. The aim of the search was to look for existing products and services that stimulate product care behaviour. For example, the municipality of Rotterdam placed bike repair poles near bicycle paths providing cyclists with the right tools to pump or repair their bikes. There are also products and services that can lead to enhanced product care behaviour due to a clever design feature. An example is the Dopper bottle[1], that can be screwed open to transform the bottle into a cup. Additionally, this makes it possible for the consumer to properly clean the bottle on the inside and reuse it. This desk research led to further 76 solutions, that were all documented in the form of a picture of the product/service and a short description of how it may promote product care behaviour.

Clustering of the Product Solutions and Ideas

The collection of products and product concepts resulted in 279 solutions that stimulate product care through their design. The ideas and concepts were first clustered individually by two researchers. The aim was to identify different strategies and sub-strategies that foster product care through means of design. To ensure a profound understanding of the solutions as well as of the aim of the strategies, these two researchers both had a background in design, one in

[1] https://dopper.com

industrial design engineering and the other in interaction design. During this clustering process, they looked at similarities between the different solutions with respect to the way in which a product or service stimulated or evoked product care among consumers, for example by enhancing their motivation or by serving as a trigger. Afterwards, both researchers discussed the created clusters in detail with each other. As their clustering mainly differed in the naming of the strategies, consensus could be found within one session of around 45 minutes.

5.2.2 Results and Discussion

The clustering resulted in eight design strategies to stimulate product care, and 24 sub-strategies (see Table 5.2). In the following section, we explain the strategies and compare them to Fogg's behaviour model (2009), to the design intervention strategies by Bhamra et al. (2011) that were introduced in Chapter 2, and to additional concepts and theories related to product care.

Table 5.2: Design Strategies and Sub-Strategies to Stimulate Product Care

strategy	sub-strategy	explanation
informing	static information	The consumer is informed about product care through static manuals or tutorials, e.g., written paper manuals.
	interactive information	The consumer is informed about product care through interactive platforms, e.g., interactive websites, workshops or online tutorials.
	physical information	The consumer receives information or clues about product care through affordances and through the design, e.g., material.
awareness	push messages	The consumer's awareness about the need for product care is increased via specific messages, e.g., notifications on the smartphone or notification lights in the car dashboard.
	product changes in appearance	The consumer's awareness about the need for product care is increased via changes in the product appearance, e.g., seeing the greyness of a wooden table.
	product changes in functionality or performance	The consumer's awareness about the need for product care is increased via changes in the product's behaviour, e.g., a bike chain that makes a rattling noise.
antecedents & consequences	anticipating effects	The product creates associations between negative effects and non-care or positive effects and product care, making the user think of the consequences of non-care and product care, e.g., a warning message on washing labels of a wool sweater or an app where you can post about your product care activities and you can receive rewards or 'likes' from other consumers.

Table 5.2: Design Strategies and Sub-Strategies to Stimulate Product Care, cont.

strategy	sub-strategy	explanation
antecedents & consequences	after-effects	The consumer can see the effects of product care, because it is made (extra) apparent through the product, e.g., a table that looks shiny after varnishing it.
social connections	social connections as facilitators for product care	Product care activities are supported by other consumers or people, transforming product care into a social activity e.g., a DIY repair shop where consumers get help from other consumers or an expert.
	social connections as a result of product care	By making product care result in social contact with others, product care can be seen as the step to having more social interactions with other consumers or people, e.g., a club of old-timer owners who share their tips on product care for their cars.
	shared ownership	The consumer shares and takes care of a product together with other consumers, which may lead to a sense of solidarity and shared responsibility, e.g., a car-sharing system.
enabling	providing flexibility	Through the compatibility with standard tools or easy accessibility of necessary tools, consumers receive more flexibility to be able to perform product care, e.g., the use of standardized screws.
	providing necessary means	The necessary tools and other product care means come together with the product and thereby provide the consumer with all the necessary means for product care, e.g., a spare button on the inside of a blouse.
	providing a service	Through product care services the consumer can let a service handle product care, e.g., a bike repair service.
appropriation	personalization	The product is adapted to the consumer's specific needs or preferences, thus heightening the chance of making the consumer feel more attached to this specific product, e.g., a custom-made bed frame or customized sneakers.
	ever-changeable products	By enabling the adaptation of the product during its time of usage the consumer can remodel the product according to the consumer's current needs, thus making the consumer steer away from the need for or desire of a new product, e.g., a modular phone that lets the user upgrade and adapt the same phone over and over.
	creative change	By facilitating individual creative approaches, the consumer is likely to keep and upcycle the product and refrain from disposing of it, e.g., IKEA hackers guides or DIY activities.
reflecting	meaningful memories	An emotional bond is created between consumer and product through shared experiences or a specific meaning, making it difficult for a consumer to neglect or throw away the product, e.g., a lamp in which the height of your child can be recorded by scratching it as people would do on a doorpost or wall.

Table 5.2: Design Strategies and Sub-Strategies to Stimulate Product Care, cont.

strategy	sub-strategy	explanation
reflecting	showing traces	The product reflects previous interaction with the consumer, thus telling a story, e.g., a rug that reveals a different colour, texture or pattern after wear and where the gradual erosion heightens is attractiveness or kintsugi, the Japanese art of repairing broken ceramics with gold glue.
	experience of the product care activity	Product care is made into a pleasurable care activity, e.g., cleaning of a pair of shoes is made relaxing through the use of soft and precise cleaning tools or gamification.
control	product takes initiative	The consumer is pressured into performing product care because the product initiates (the first part of) a product care activity, e.g., a coffee machine that opens up to be cleaned.
	product handles product care itself	Through products that perform product care themselves, the consumer does not have to perform product care anymore, e.g., self-healing materials.
	unconscious take-over	Product care is made part of other routines in people's daily life, e.g., a tool rack that is incorporated into the keyrack near the front door, so the user will always see the tools when leaving or coming home.
	forcing product care	The consumer is forced to perform product care because the product stops working until it is being cared for, e.g., a coffee machine that refuses to work until it is decalcified.

Informing is related to providing consumers with different kinds of information. Besides well-known means of *static information*, such as written manuals and instructions, this strategy can be implemented through *interactive information*, such as online tutorials, workshops for consumers etc., that are offered as a service by the producer. In addition, the product itself can already include affordances for product care through its design (e.g., via the material or the shape). An example of this sub-strategy, which we describe as *physical information*, are Miele dryers that indicate the possibility to remove and clean the fluff filter by an orange dial.

The overall aim of this strategy is to heighten consumers' knowledge of product care to facilitate care activities. *Informing* enhances consumers' knowledge about product care and therefore their perceived ability according to Fogg's behaviour model (2009). In the case of the Miele dryers, the indicator serves as a trigger that enhances the ability for this situation, whereas tutorials can foster knowledge and skills in the long term.

This strategy can also help to provide information about how a product works and how it can be taken care of. With this strategy, control stays with the consumer and not the product, because the consumer still has to take initiative.

Hence, it is related to the eco-information strategy suggested by Bhamra et al. (2011). As information about product care takes the consumer's interaction and his/her possibilities to influence the product's lifetime into account, the eco-feedback strategy (ibid.) might also apply. *Informing* is in accordance with previous research that suggests that it already helps to provide the consumer with useful repair (Sabbaghi et al., 2016) or care information (Cox et al., 2013; Bovea et al., 2018) to foster product care. It is also related to the website iFixit.com (see also Chapter 2).

Awareness aims to remind the consumer of the fact that he/she should take care of the product. It is especially relevant for products that consumers often forget to take care of. Simple reminders, such as a *push message* on the smartphone or an e-mail by the service provider, can already enhance consumers' awareness in a specific situation. Examples for this strategy are dishwashers that signal the need of rinse aid or car garages that remind consumers of the next car service. Furthermore, the *product's appearance* may change to encourage consumers to take care, such as a surface that looks unappealing when it is not being cared for, such as leather shoes that look unaesthetic if they are not cleaned and waxed regularly. Also, a decrease in the *product's functionality* can raise awareness. This is especially relevant for technical products such as a bicycle that is harder to pedal if the chain is not oiled properly or the tires are not pumped.

Awareness concerns small hints and cues that prompt an immediate reaction. By making the consumer aware of the need for product care, they serve as triggers, as defined by Fogg (2009) in his behaviour model. If motivation and perceived ability are present at this time, triggers should thus stimulate care activities. This strategy is related to eco-feedback (Bhamra et al., 2011), which refers to tangible aural, visual, or tactile cues that remind the consumer of his current behaviour.

Antecedents & Consequences of product care – but also of non-care – can be communicated to the consumer to encourage him/her to execute care activities. For example, if the consumer learns about the *anticipated effects* of a well-maintained bicycle, such as less effort while cycling, it can motivate him/her to conduct these care activities. *After-effects*, such as a product being especially shiny or well working after product care, may motivate the consumer for future care activities.

Antecedents & Consequences is strongly related to motivational factors of product care, which either have to be present before the care activity takes place or which are expected to occur after the care activity. This strategy is therefore strongly similar to Fogg's (2009) dimensions of motivation, such as pleasure/pain, hope/fear and social acceptance/rejection. The eco-spur design strategy (Bhamra et al., 2011) is based on rewards and punishment for sustainable behaviour, which is related to making the consumer aware of consequences of his/her behaviour, as described in this strategy.

Social Connections describes the facilitation of product care through the consumer's social interactions. Specific communities can support consumers in their care activities, such as repair cafés or shared private garages to work on cars. Conducting care activities in these settings on the one hand *facilitates* repair and maintenance because equipment, as well as knowledge and skills, can be shared with other people. In addition, shared garages offer enough space for care activities which is often not given at home. Another aspect is that *Social Connections* can be seen as the *result of product care activities* when interactions among people are created through product care. The motivation for product care is enhanced through social interactions, and it is facilitated by offering access to tools and space. As such, it is related to motivation as well as ability in Fogg's (2009) behaviour model.

Another sub-strategy is *shared ownership*, which means that a product is used by several consumers. This is often the case in shared apartments, but also in offices or other workplaces. In these settings, products are often not owned by a single person. Because people know that the same product is used by their housemates or colleagues, they can feel more obligated to take care of it. One reason for this behaviour is that they fear social rejection (as described in Fogg's model as a driver for motivation) if they handle the product carelessly. The effectiveness of this sub-strategy may be limited in anonymous settings where others would not know who is responsible for a lack of product care.

The strategy *Social Connections* is barely part of existing models and strategies in the field of sustainable design. However, this strategy is well established in practice: The rise of repair cafés, where people meet and repair their products together demonstrates the relevance of the social environment for repair (see e.g., Keiller & Charter, 2016; Cole & Gnanapragasam, 2017).

Enabling refers to facilitating consumers to perform product care activities in a more practical way by offering the right *tools* together with the product, ideally already at the time of purchase. As an example, sewing machines are often delivered together with tools to open the machine, with a small bottle of motor oil as well as with brushes to remove dust. This makes it convenient for consumers to take care of them. Another part of this strategy is to enhance the *flexibility* for repair and maintenance by designing the product in a way that standard tools and materials that are available in most households can be used. A negative example for this strategy are products by Apple that require special screwdrivers to open them. The establishment of a network of *service providers* that help consumers to repair and maintain the product is another example of the design strategy *Enabling*.

This strategy is linked to the ability dimension of Fogg's behaviour model (2009), as it facilitates product care by different means. The strategy is related to product lifetime extension strategies, such as Design for Reparability (Bakker et al., 2014), as well as to strategies to postpone replacement, such as Design for Repair & Maintenance as proposed by Van Nes and Cramer (2005).

Making product care easier provides the consumer with a sustainable option for his/her consumption and can be seen as part of the eco-choice strategy by Bhamra et al. (2011). The *Enabling* strategy is supported by several initiatives outside the field of research, such as the Right to Repair movement (see also Chapter 2).

Appropriation describes the adaptation and/or *personalization* of a product through the consumer. This can be achieved by modular, *ever-changeable products* that allow the replacement of certain parts when an upgrade or repair is desired. Appropriation also describes a product design that encourages the consumer to *change the product in a creative way*, such as upcycling and do-it-yourself activities. As a consequence of these creative activities, the consumer can feel more attached to this product and is more likely to take care of it.

By creating a pleasurable experience with the product, this strategy is related to Fogg's (2009) concept of motivation. Personalization has been identified as a determinant of product attachment by Mugge et al. (2009), which in turn can foster product care (e.g., Schifferstein & Zwartkruis-Pelgrim, 2008). Investing time in a product and thereby increasing the personal value of this product can be seen as part of the Slow Design approach (Fuad-Luke, 2002; Strauss &

Fuad-Luke, 2008). The sub-strategy of ever-changeable products is related to Bakker & den Hollander's (2014) Design for Adaptability & Upgradeability that focuses on the possibility to adjust products to the consumer's changing needs. The final sub-strategy, creative change, matches the upcycling approach (e.g., Sung et al., 2014; Wilson, 2016), where products are improved by means of renovating, or by adding or changing components.

Reflecting refers to *meaningful memories* and *traces* that are created through the interaction of the consumer with the product. By creating a special meaning for the consumer, the motivation to take care this product increases. An example is a skateboard with scratches as a result of its usage. The consumer may want to preserve these reminders of past adventures with the skateboard, and will consequently take better care of it. This valuable memory can be created through the interaction with the product or through the *experience of the product care activity* itself. For example, painting a wooden piece of furniture can generate a unique value for the consumer, because he/she remembers that activity in a positive way. Another corresponding aspect of reflecting is the gamification approach: Gamification connects the care activity with fun and pride, which can serve as a trigger according to Fogg (2009) and stimulate consumers to perform product care activities in the future.

This strategy can be linked to many existing design strategies and models. In general, it addresses the motivation to take care of the product, because it creates relevant and positive emotions as mentioned by Fogg (2009). The relevance of meaningful memories is part of the Design for Attachment & Trust principle (Mugge et al., 2006; Bakker et al., 2014) and Emotionally Durable Design (e.g., Chapman, 2015). It can be found within the Slow Design approach that suggests that the traces of the relation between consumer and product should be made visible (Strauss & Fuad-Luke, 2008). This strategy does not necessarily focus on creating pleasurable experiences, but more on the appreciation of experiences.

Control refers to how much control over the product care behaviour is given to the consumer. Control can be applied with different intensities: One option are *products that take over the initiative* for product care themselves. An example is a coffee machine that not only informs the consumer on the display when maintenance is needed but even opens the parts that should be cleaned. Taking over the initiative or starting the product care process can be seen as a trigger

that enhances the consumer's motivation as well as his/her ability to conduct the care activity immediately. For other cases, the product encourages the consumer to take care of it regularly, so it can be seen as an *unconscious take-over* of control, as product care becomes a habit. An example is a reflex camera that keeps on reminding the user to put the cover back on the lens when turning the camera off. After some time, this action becomes a habit and the lens is always protected. Self-healing materials can be seen as part of this strategy because they contribute to the product being repaired without any intervention or action conducted by the consumer. The products, therefore, *handle product care themselves* as a result of their (novel) materials. The application of self-healing materials in product design can enhance physical durability and reliability, and thereby reduce cost and risk of future repair (Haines-Gadd et al., 2019). The most controlling version of this strategy is a product that refuses to work if it is not being cared for. The consumer is thereby *forced to perform a product care activity*. For example, a kettle can stop boiling water until it is decalcified.

Control can be linked to Fogg's (2009) concept of triggers because it prompts a certain behaviour more or less strongly. It is closely related to some of the design strategies proposed by Bhamra et al. (2011) whose strategies eco-steer and eco-technical intervention also represent different levels of control being taken over by the product, ranging from integrating constraints and affordances into the product's design to technology that controls consumer behaviour. Clever design describes the strategy by Bhamra et al. (2011) with the most control for the product and the least control for the consumer, which decreases consumer's behaviour without even raising awareness. This equals our sub-strategy of unconscious takeover, where product care eventually becomes a habit in daily life.

5.3 Evaluation of the Design Strategies with Consumers (Study 3.2)

The aim of this study was to evaluate the design strategies from Study 3.1 together with consumers. We wanted to see if they think that these strategies would help them to take better care of their products. Recognizing the effectiveness of the strategies would be a first step for a general acceptance of products designed to foster product care. We decided to conduct a study with semi-

structured interviews to assess consumers' reactions regarding our strategies. The face-to-face situation enabled us to explain the strategies that may be quite abstract and therefore difficult to understand for consumers, in more detail. Additionally, it allowed us to ask in-depth questions that encouraged the participants to elaborate on their answers if necessary.

Similar to Study 1 (Chapter 3), participants were selected from the personal environment of the researchers. This facilitated the selection of participants with a large variety in gender, age, and occupation. We interviewed 15 participants (8 male, 7 female). Their mean age was 38.5 years (SD = 13). Interviews lasted around 35 minutes on average.

5.3.1 Procedure & Analysis

We contacted the participants either in person or by e-mail. We briefly explained the concept of product care and that we wanted to discuss design strategies for product care with them. If they agreed to join our interview study, we fixed an interview date and provided a small task as a preparation: We sent them the six product categories as used in Study 1 (Chapter 3): household appliances and tools; consumer electronics and communication devices; means of transport; furniture and interior design items; clothes, shoes and fashion accessories; sport equipment and accessories for hobbies and leisure) to cover a broad range of products. The participants were asked to think about examples of a product that they do not take care of for each product category. This procedure should allow them to already think about product care, thus making it easier for them to relate the different design strategies to their daily life.

Most of the interviews were conducted at the participants' homes, and a few in public places such as a café or a university building. At the beginning of each interview, the participants signed an informed consent form and the researcher answered possible questions. Demographic data (age, gender, occupation) was collected. During the interviews, we first explained product care in more detail to make sure that the participants were aware of all the aspects of product care and did not limit it to repair only. Then we talked about each of their examples: We asked them to explain what hinders them in taking care of these products. This helped us to understand their reflection on the strategies better. We also asked them to write these products on separate sticky notes in order to assign them to the design strategies later. Subsequently, we explained

the design strategies one after another, and also told them the corresponding sub-strategies. We showed them small cards with the strategies and the sub-strategies to make it easier for them to remember. After each new strategy, we asked them if they think that this strategy could help them to take better care of their products, and for which of their products this strategy may be most effective. We asked them to give reasons for their answer and encouraged them to put the sticky notes with the products next to the strategy cards. It was possible to assign several products to one strategy or several strategies to one product. Towards the end of the interview, we asked them to name their favourite strategy, that is, the strategy that would help them most to take better care of their products. We then provided them with a € 10.00 voucher for a supermarket as a reward.

With the permission of the participants, the interviews were audio recorded and fully transcribed afterwards. The qualitative content analysis was based on the eight different design strategies. For each strategy, we tried to identify insights on specific product categories (e.g., 'I *could imagine this strategy for electronic products.*') or contexts of use (e.g., '*I think this works for products that you use regularly.*') in which the strategy would help the participants to take better care of their products. In the same way, we looked for product categories and contexts of use that were mentioned as not suitable for this strategy. We first analysed these insights for each participant separately, and then combined them in order to gain a comprehensive overview of the suitability of our design strategies.

We realized that the final three interviews did not provide any additional insights and concluded that 15 interviews were a sufficient sample size for our study (see also Guest et al., 2006).

5.3.2 Results

The following section describes the insights on each category separately. The strategies are presented in the same order as in Section 5.2.

Informing

Providing additional information on how to take care of the product was seen as especially helpful for relatively easy product care activities, such as cleaning printers, or exchanging the filter from vacuum cleaners or washing machines.

At the same time, participants admitted that for such easy tasks, it is often not a matter of missing information that stops them from taking care of their product, but they still struggle to integrate the product care activities into their everyday life. They also suggested improvements for existing instructions: The documents should contain an overview of the most important product care tasks for the product, together with an indication of how often these tasks should be conducted. Too lengthy and too technical instructions, on the other hand, are seldom used. Regarding the medium for providing the information, participants differed in their opinion: Some of the preferred a classic, printed instructions handbook because this allows them to stop reading at any time and jump back and forward within the book. Others liked video tutorials more, because they can take play them on their smartphone at any time and any place. One participant mentioned that instructions always should be part of the product, because otherwise one already needs to take action to get the handbook.

Awareness

Creating awareness through push messages was criticized by many participants. They stated that they would be annoyed to get these messages. It would only be accepted for products for which they use a service, such as cars or bicycles, in order to arrange appointments. Making the consumer aware through changing appearance or performance of the product was better accepted. However, participants often failed to imagine this strategy for different products because they said that the product automatically functions worse (e.g., the tube sounds worse) or makes strange sounds (car, bicycle) if you do not take care of it. They did not see this effect as a design strategy but more as a natural consequence of missing product care.

In any case, they said that the knowledge, skills and equipment have to be present first in order for this strategy to have an effect. However, creating awareness was often also discussed in a broader sense, with participants mentioning how important it is that consumers are in general aware of their power to prolong products' lifetimes and that they have to learn to use this power. In their opinion, it is crucial to already teach children how many resources are needed to produce a product and how important it is to value these resources by taking care of the product as good as possible. One participant told us that he thinks that product care differs strongly between generations: While his parents tend to replace products fast, maybe because they grew up during the time

of the economic miracle, his generation (around 30 years old) starts to question consumerism and tries to live more sustainable.

Antecedents & Consequences

Participants would prefer this strategy to focus on positive consequences of product care; they said that they are only interested in negative consequences if the product is either safety-relevant (such as a car) or if negative consequences for their own health can be anticipated due to a lack of product care (e.g., moulding of a mattress). In these cases, they considered this strategy as very effective – one participant even said '*If it comes to hygiene-related consequences, this strategy does wonders!*'. Apart from these examples, participants preferred positive consequences. These can not only be relevant for the consumer (such as a good feeling when using a cleaned car) but also for the environment. For example, participants said they would like to know if they contributed to a better environment by taking care of their product (e.g., '*because you renewed the filter of your car, the exhaust gases are less toxic now*').

Social Connections

Most participants said that they see this as an effective strategy in order to foster product care. Most of them immediately referred to repair cafés, which they often knew but never visited before. One participant said that repair cafés are good for singles and elderly people who even struggle to conduct easy product care tasks. Another participant said that a certain level of openness is needed to join repair cafés. Many participants, especially the ones living in rural areas, stated that they often help neighbours and friends and that these people also help them in return. In addition, they are open to share products with other people, especially things they do not need often, such as tools or music equipment. However, they also mentioned that it is important that everyone shares the same understanding and relevance for product care. They do not want to share their products with people who do not handle them carefully or who are not aware of the need to clean them properly. If you do not know the people well (e.g., a shared washing machine in an apartment building), chances are high that nobody feels responsible to take care. Family members were also often mentioned as partners for product care; however, this often led to the product only being taken care of by the family member, which does not result in a shared experience.

Enabling

Offering matching tools or other care equipment was preferred for products that are not too complex but still require special tools. Shoes were mentioned as an appropriate product several times: Participants mentioned that leather grease or impregnation products that are sold together with the product would help them to take care of their shoes. Participants think that it is convenient if the right products are immediately available; they enjoy the fact that they do not have to find out which additional product is needed and where to get it. A few participants also mentioned that they do not want to get the right tools and other care products together with the product; they prefer to select these products themselves and mentioned that different consumers might have different standards regarding tools. This means that some consumers prefer spending much money on their tools while others prefer the cheapest version. However, the same participants said that they would appreciate it if the manufacturer at least offers to add care products during the buying process so that they can select the products they really want and need.

Tools and equipment that are directly attached to the product were judged as especially helpful. An example would be the small compartment sewing machines often have for oil, a brush and a small screwdriver. A service for product care tasks was only seen relevant for complex products, which is often equal to products with electrical and/or safety-relevant components such as a washing machine, a laptop and a car. Participants claimed that they are afraid to open and repair these products, even if they have the right tools. Consequently, their product care is often limited to simple tasks such as dusting off; for other tasks, they appreciate a service provider.

Appropriation

Most participants were sceptical about aesthetical ways of personalization, such as adding stickers to your car or selecting specific colour combinations for your sneakers. They said while personalization was more important when they were younger, they are not interested in these things anymore. When making them aware that personalization can also refer to functional aspects, such as selecting specific modules for your smartphone according to your needs, they were more interested and positive. Many agreed that a product that works well because it fulfils your individual needs enables a positive experience and

this in turn leads to consumers taking better care of their products. A similar effect was observed for the creation of new products: Participants mentioned that they are proud of the things they made or adapted themselves and are thus taking care of them.

Reflecting

All participants agreed that they take better care of products they cherish. Reasons for emotional attachment towards the product were positive memories associated with the interaction with products, such as working shoes that remind the participant of his first job or dinnerware that has been used for a long time. Participants also reported that traces of use, such as small scratches on a vacuum cleaner or little dents at the car remind them of the fact that they own the product for some years. This often leads to enhanced motivation to keep it also for the upcoming years, thus stimulating product care. One participant also reported that she often receives compliments for her bike that she painted herself and is even asked to help other people painting their bikes. Despite of this positive experience, she said that these reactions do not enhance her own care activities.

Control

Control was the strategy that caused most controversy. Spontaneously, some participants claimed '*oh no*' or '*never ever*' when the strategy was explained to them. They often had the feeling that this strategy is quite unrealistic and can only be implemented in the future. However, when we explained that many products already refuse to work until product care is conducted (e.g., coffee machines, laptops, smartphones), participants admitted that this strategy may indeed foster product care. One participant summed it up as '*This strategy is really no fun, but can be very effective.*'. All participants agreed that this strategy only makes sense for products that already have an electronical component included that can then be used to also control product care, such as vacuum cleaners or other household appliances. Most participants could not imagine including this feature to analogue products, but one participant even brought up the ideas of shoes that stick to the ground if you do not take care of them. Especially for safety-relevant products, the acceptance of this strategy would be high: Participants mentioned that a car that refuses to drive as long as you did not take care of relevant parts, would be a reasonable approach. Other

examples would be the brakes of a bike, a saw, or ski bindings. One participant explained that control could lead to a strong learning process when consumers realize after a while that product care is really necessary to conduct.

The Most Preferred Design Strategy

As explained above, we asked each participant to name his/her favourite strategy for all product categories. We realized that there was no general preference for one or the other strategy when taking multiple answers by all participants into account. Except from *Control*, every strategy was at least twice mentioned as one of the best strategies. *Informing* was named five times, and *Enabling* and *Reflecting* four times, respectively.

Many participants could not decide for one specific strategy but rather chose a combination, such as *Informing* and *Enabling* or *Appropriation* and *Reflecting*.

In addition, we observed that participants found it hard to distinguish between the different design strategies, especially between the more practical ones (*Awareness*, *Informing*, *Enabling*, *Control*, *Antecedents & Consequences*) and the more emotional ones (*Appropriation*, *Reflecting*, *Social Connections*). For example, participants mentioned that taking care together with others also concerns the *Reflecting* strategy, because they then remember the product care experience as positive and fun.

5.3.3 Discussion

Overall, we received positive feedback on our strategies. When looking at the different products or product categories that were mentioned for each strategy, it is difficult to identify overall patterns. Complex products with electronical components are often only be cared for on a simple level, such as dusting off. Even if the participants would have more information or the right equipment, they would still refuse to open these products, for example in order to replace or repair parts of it, because they are afraid of doing so due to safety reasons. Safety seems to be an important aspect also for the *Control* strategy which is especially well accepted for safety-relevant features such as bike brakes.

Notably, the most favourite strategies of the participants are also the ones that are most common for products: *Informing*, *Enabling*, and *Reflecting*. Still, these strategies do not seem to be effective, as Chapter 3 has shown that consumers

struggle to include product care into their everyday life. This may be caused by missing triggers for these strategies: *Informing*, *Enabling* and *Reflecting* are strategies that do not heighten motivation and ability in a specific situation but over a period of time. It may therefore be reasonable to combine different strategies in order to foster product care. For example, the *Awareness* strategy is mainly related to triggers, as it is the *Control* strategy. Both strategies take effect in a specific situation, for example by providing a reminder or by initiating product care. A combination of these strategies with other ones, such as *Informing* and *Enabling*, may lead to the intended behaviour. For example, *Awareness*, *Informing* and *Social Connections* could be realized together by providing a smartphone app that contains information about product care and the possibility to share tips on product care within an online community. In addition, the app can remind the consumer when it is time to conduct certain product care activities, thereby serving as a trigger.

One limitation of this study is that it is harder for consumers to imagine how these strategies could work, as compared to designers. Some sub-strategies were hard to understand or imagine for the participants. Many participants had never heard of self-healing materials and could barely believe that they exist. Also, a product that stops functioning if it is not being taken care of was a novel idea for many of them, although some coffee machines, printers etc. already use this strategy.

The findings show again that product care is never only dependent from the product, but also from the consumer and its environment. For example, it seems to be easier to use *Social Connections* as a strategy to foster product care in a rural area, where people usually know their neighbours, than in a city. Although these aspects can hardly be directly influenced through design, these insights are still interesting in order to develop appropriate design strategies for different consumers, but also different social and physical contexts.

5.4 Development and Testing of a Toolkit for Designers (Study 3.3)

In Study 3.1, eight design strategies and 24 sub-strategies to stimulate product care were uncovered and presented in written text. Even though these design strategies can help designers in providing inspiring, new ways to consider care

activities in the design of products and services, the textual presentation form may not provide an optimal fit with the design audience and the purpose of the strategies. Many designers are used to working visually, work with interactive or physical design tools and/or are in need of quick information. We therefore developed a toolkit to foster product care, the Product Care Kit. A fun, visual and easy to use design tool is more likely to inspire and enthuse people about product care than a piece of text can. This means that the design tool should explain the strategies in a concise and a visually pleasing way.

The tool is intended to be usable in ideation with multiple people and creative sessions, because in (design) companies creative sessions with teams or multiple parties are often used to reach a solution for a customer's or company's problem, to create a vision for the company or to create a new product/service. The aim of this toolkit is to teach designers about product care and provide inspiration on how to design for it. In order to confirm that designers are able to use the toolkit for the standard design cycle (Eger et al., 2010; Van Boeijen et al., 2013), the Product Care Kit was tested multiple times with designers.

5.4.1 Method

The development process started with a preliminary version that was improved during two iteration cycles. The preliminary version consisted of cards that explained the different strategies for product care and example cards with products and services related to those strategies. Next to that, the process of designing was explained on a four-pages template that people could write on. The template posed questions which were to be answered by the designer, and would help to elaborate on the context and product that the designer was designing for. This version was printed out as a first prototype and evaluated by the rest of the research team and by four design students. They were asked to explain how they thought the template was to be used, how they would prefer to use it, and in what way they usually use design tools in their design projects. The main results of this first round of testing were that the process of using the template was too linear for designers since a design process is almost never linear and designers tend to go back and forth in their process. In addition, the tool could not be used by multiple designers at the same time, for example during group discussions.

The second prototype was a card set with:

- 8 cards with the different design strategies and the corresponding sub-strategies (see Table 5.2)
- 7 cards with the different product care activities
- 6 cards with different products as examples to focus on, plus one card with a question mark as a place holder for any other product
- 8 persona cards that describe fictitious consumers and invite designers to define their target group
- 48 cards with examples of product/service solutions matching the different design strategies

We included not only the design strategies, but also the care activities and persona as well as product cards in order to support designers in getting a comprehensive overview of their project. Additionally, the set contained an explanatory leaflet about how the card set could possibly be used. The card set was magnetic and could be used to brainstorm on whiteboards.

The testing of this iteration was conducted with four design students with a bachelor in design and two UX designers. None of the participants had experience with designing for product care specifically or were consciously aware of design strategies for product care. Testing took place in pairs, i.e., two designers used the toolkit together. In the week before testing the prototype, the participants were sensitized in order to get acquainted with the topic of product care: They all received a short written introduction including the definition of product care and the seven different product care activities. Each product care activity had a small illustration that served as an example. The participants worked in pairs and were asked to use the card set to create one or more product solutions that stimulated or motivated people to perform product care for one of their products. Participants received the card set and the instruction booklet and did not receive extra information from the researcher on how to use the card set. They were asked to talk out loud, so the researcher would know what they thought while using the card set for the first time. The whole session lasted one hour per pair, including a short evaluation session at the end. During this, they were asked to explain how they thought the card set was to be used and how they would prefer to use it.

An analysis of their responses showed that this version of the toolkit was practical and inspirational. It became apparent that the application opportunities

of the toolkit are quite diverse: They ranged from conceptual product ideas to a visual map that visualizes the context in order to deepen discussions and generate new insights and knowledge about product care.

5.4.2 The Product Care Kit

For the final version of the toolkit (Figure 5.1), minor changes and alterations were made related to the graphic design and the text. The number and kind of cards remained the same as described in the previous section. These changes were related to making the different categories of cards more pronounced, and making the text easier to read. To some of the participants, it had been difficult to see which cards belonged to which category (product care activities, design strategies, persona, products), because they had similar colours. To clarify this, each type of card got their own distinct coloured backside and coloured border on the front. Also, the text was written more concisely, with clearer typography to make it easier to read. Furthermore, the instruction booklet was rewritten slightly, as some sentences were not clear or concise enough according to the participants.

Figure 5.1: The Product Care Kit

For easy recognition, each card has an illustration corresponding with the card. The cards are magnetic, which makes it possible to use them on whiteboards and easily hold brainstorm sessions around them.

The hexagonal shape of the cards invites designers to place relevant cards next to each other and therefore gain a comprehensive overview of their project. For example, designers can first think about the product and its context by selecting a product card and a persona card that describes potential consumers for the product. They can then think about care activities that are relevant for this product by selecting one or multiple product care activity cards. The design strategy cards can be used to develop suitable ideas and concepts that stimulate the intended care activities for the selected product among the defined consumers. The example cards serve as inspiration and provide an understanding of how the strategies can be applied to products and services.

Each card presents questions that trigger the designer to think about how to target product care with their design. The different types of cards pose different types of questions. Figure 5.2 shows the design strategy card *Social Connections*. Each strategy is presented with a short explanatory text and an illustration on the front side. On the back side, we present the sub-strategies together with inspiring questions to consider. The same principle was applied to the cards for product care activities.

Figure 5.2: Design Strategy Card *Social Connections*

The product cards (laptop, car, backpack, hiking boots, desk chair, 'your design') show an illustration on the front side and the following text on each back side:

> Think about this product: What is it intended use? Why do you use it? Where and when do you use it?
> Think about how it is treated: What interactions does the user have with it (from pre-purchase to disposal)? In what non-intended ways is it also used? Which forms of product care can be applied to this product?

The persona cards invite the designer to define their target group. Their front side shows the name and an illustration of an fictitious consumer, and the back side contains the following text:

> Think about who this person is:Describe a day from their life! What is their home situation like? What do they like/dislike doing?
> Think about their behaviour: What motivates or stimulates them to change their behaviour? And what stops them or makes it hard? What skills/knowledge do they have or lack when it comes to product care?

The example cards (Figure 5.3) show the design strategy on the front side and a description as well as a photo of the existing product/service solution for this strategy on the back side.

Figure 5.3: Example Cards of the Product Care Kit

The toolkit can be used by an individual designer within the ideation phase in order to stimulate ideas for product care-friendly products and services, as well as during brainstorming sessions and discussions in a team setting.

5.4.3 Evaluation of the Product Care Kit

Ten toolkits were produced and used for a workshop at the PLATE (Product Lifetimes And The Environment) 2019 conference in Berlin, Germany (see also Figure 5.4). We did not only want to test the toolkit in practice but also aimed to learn more about its relevance for design practice. After a short presentation of the background and the theory behind the toolkit, 25 participants worked with the toolkit in groups of five people. We asked them to select a product based on their own care experiences or from examples provided in the toolkit and to create ideas on how to stimulate product care for this product. All five groups were able to use the toolkit after a short amount of time to develop ideas to stimulate product care. After approximately 45 minutes, the groups presented their concepts. At the end of the workshop, we handed out a short paper-based questionnaire asking them for general feedback, how the toolkit influenced their design process and possible fields of future application for the toolkit through open questions.

Figure 5.4: Testing of the Product Care Kit during the PLATE Workshop

We received feedback sheets from 21 workshop participants, with the majority working in design education, design research or design practice. All participants indicated that the toolkit helped them create new ideas, think outside the box and provided them with new insights into product care. As an example, they mentioned that they would have focused only on repair before, because they never thought about other aspects of product care, such as careful handling, or sometimes even maintenance. The toolkit facilitated group discussions and communication and structured their design processes. When asked about possible fields of application, many participants suggested design education, as well as design in practice. Some participants also mentioned other application areas such as using the toolkit to discuss with other stakeholders about ecodesign. Ideas for improvement concerned better instructions, especially for the first phase of the design process, and a more elaborate description of the persona cards.

5.5 General Discussion

We developed design strategies for product care that consider the consumers' perspective on product care – a perspective that has often been neglected by now, leading to a limited impact on actual consumer behaviour (Section 5.2). These design strategies were evaluated with consumers (Section 5.3) and translated into a design toolkit (Section 5.4).

We identified existing product/service solutions that stimulate product care among consumers and added further ideas that we developed together with designers and within the research team. This led to 279 solutions and ideas. One important step was the clustering of these solutions and ideas, because it enabled us to identify design strategies that represent directions to consider during the design process. These design strategies are: *Informing*, *Awareness*, *Antecedents & Consequences*, *Social Connections*, *Enabling*, *Appropriation*, *Reflecting*, *Control*. They represent the three factors of Fogg's (2009) behaviour model: motivation (*Appropriation*, *Reflecting*), ability (*Informing*, *Enabling*, *Antecedents & Consequences*) and triggers (*Awareness*, *Control*). *Social Connections* can enhance motivation and ability. The design strategies were split into 24 sub-strategies that represent different aspects of how the strategy can be used for product and service design, and therefore, facilitate the implementation of the superordinate strategies.

The strategies were then presented to consumers who rated them overall in a positive way. The insights from this interview study revealed that it may be reasonable to combine design strategies in order to foster product care. One strategy that enhances consumers' motivation (such as *Reflecting*) with one that facilitates product care (such as *Enabling*) and one that serves as a trigger (such as *Awareness*) may be an effective combination of strategies. Additionally, the social and physical environment should be considered: *Social Connections*, for example, is easier to realize in communities where people know each other well.

The design strategies as well as the sub-strategies were transferred into the Product Care Kit. The toolkit is a cardset that can be used during the ideation phase of the product/service development processes. Besides the strategies, the toolkit includes cards that show examples of existing solutions for product care, cards that show different product care activities and cards to consider the context of product care, i.e., persona cards and product cards. The toolkit has been developed in an iterative process, and the final version was tested during a conference workshop. The results of the testing of our toolkit are promising: The participants were able to use the toolkit during their ideation phase and recognized its additional potential for discussions or communication with stakeholders.

Our study contributes to the literature by providing specific design strategies to foster product care. Past research has either focused on behaviour change in general (see e.g., Fogg, 2009) or on other more general ways of stimulating sustainable behaviour through design (see e.g., Bhamra et al., 2011). Our research builds on these theories as our strategies relate to the general constructs described, such as motivation, ability and triggers in Fogg's behaviour model (2009), but also provides more detailed insights. In addition, we took the consumers' perspective explicitly into account: While previous research, such as the Design for Repair & Maintenance principle (Van Nes & Cramer, 2005), has focused on the facilitation of repair and maintenance by changing the design of a product, we also considered consumers' motivation to take care of their products and the trigger(s) that pushes them to do so.

Another important goal of our study was to ensure that the design strategies for product care can actually be applied by designers and design students in practice. Practitioners should be able to consider product care aspects for their

products and services in order to create an impact of this research on sustainability. Only if the design strategies are actually used in design practice, they can contribute to more sustainable products and services and thereby support the shift towards a Circular Economy. As a consequence, we integrated designers and design students into the development of the strategies and the toolkit as much as possible. While the overall feedback was positive, we strongly believe that future research is needed to understand how the toolkit can be used in daily design practice, such as in design agencies, because it has only been tested in a research setting. Testing the strategies in design practice would help us understand if certain design strategies are more difficult to implement, and how these challenges can be approached.

We encourage the usage of our toolkit in educational settings, such as for study projects of design programmes at universities. Integrating the toolkit in education would teach design students about the relevance of product care and how this aspect can be integrated in a product or service. We, therefore, provide a free download of the toolkit in order to encourage use in research and practice and contribute to its further development.

The toolkit can be downloaded at https://designforproduct.care.

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6

The Influence of Ownership on Product Care

In access-based product-service systems (AB-PSS), such as long-term renting, consumers pay a fee in order to get access to a product, but ownership of the product remains with the provider company. These business models have often been promoted as a more sustainable alternative compared to traditional sales models, because products are only kept as long as they are needed and can then be used by another consumer. However, it remains unclear if consumers take care of accessed products equally to owned products. In this chapter, we explore product care of newly bought, second-hand, and long-term accessed bicycles and washing machines through an online survey (n = 212). Our analysis demonstrates lower product care for AB-PSS products compared to owned products. Based on the findings, we argue that the sustainability potential of AB-PSS is limited because consumers do not take care of the products properly, and that these business models can, in fact, be less sustainable than ownership.

Parts of this chapter have been published in Ackermann and Tunn (2020), to which both authors contributed equally

6.1 Introduction

Research in this thesis has focused on products owned by the consumers. This chapter will present a study that compares owned products to AB-PSS products that can be used by consumers but are owned by a service provider. Examples of AB-PSS are leasing, renting, and commercial sharing services (Roy, 2000; Mont, 2002; Tukker, 2004). In this study, we focus on long-term AB-PSS, which grant consumers exclusive access to a product for several months or years. As product care falls into the usage phase of products, long-term AB-PSS are more relevant to study than short-term solutions, such as renting a bicycle for one day in a new city. In the latter case, it will not be necessary for the consumer to take care of the bicycle. Despite being noted as an important consideration in previous literature (e.g., Tukker, 2004; Bardhi & Eckhardt, 2012), it is still unclear if the lack of ownership in long-term AB-PSS influences consumers' product care.

Circular business models, such as AB-PSS, have been developed to help implement circular economy principles in companies and incorporate resource efficiency strategies to slow, close, and narrow resource loops (Bocken et al., 2016). Specifically, circular business models are designed to enable the reuse, repair, refurbishment, and remanufacturing of products thereby maintaining them at their highest value for as long as possible (Nußholz, 2017; Geissdoerfer et al., 2018).

The sustainability potential of AB-PSS has been intensely discussed and researched (e.g., Roy, 2000; Cook, 2004; Tukker, 2004; Matschewsky, 2019). Their potential hinges on the assumption that the providing organisation maintains and repairs the products, thereby prolonging product lifetimes (Mont, 2002; Cooper, 2005). Agrawal et al. (2012) argued that leasing of durable products, such as washing machines, only contributes to sustainability if product longevity is improved compared to ownership. Tukker (2004) largely followed this line of argumentation and emphasised that consumers' careless use of non-owned products may outstrip the benefits of professional maintenance and repair in AB-PSS. A frequently mentioned example in this context is bicycle sharing: Although it could in theory reduce the need for cars and encourage use of public transport by solving the last mile problem, in practice these systems might increase impacts if they substitute walking and use of public transport (Fishman, 2016). In addition, shared bicycles are frequently abused by users

as well as non-users. This can result in extremely short product lifetimes and thus reduce sustainability compared to ownership. Overall, it is now widely agreed that AB-PSS have a sustainability potential but need to be purposefully designed, assessed, and adjusted to realise their sustainability potential (Mont, 2004; Kjaer et al., 2019).

Standard maintenance and repair are generally part of the service of the AB-PSS provider, but AB-PSS users are usually expected to take a reasonable level of care of the accessed products themselves. For example, the Dutch companies Swapfiets[1] and Homie[2] offer long-term access to bicycles and washing machines respectively. Both offer renting schemes where the consumer pays either a monthly fee in order to use the product or pays per use. The Swapfiets (2019) terms and conditions state the expectation that 'the Rental Customer makes normal use of the Bicycle and takes due care of the Bicycle' and the service contract of Homie (2019) demands customers 'to take good care of the washing machine'. Baxter and Childs (2017) argued that the frequent dispossessing of products in short-term AB-PSS hinders consumers to perceive the same stewardship as for owned products and prevents product care but it is unclear if this also holds true for long-term AB-PSS. In contrast, a few studies suggest that consumers treat accessed products more carefully than owned ones (e.g., Ozanne & Ozanne, 2011; Baumeister & Wangenheim, 2014; Lidenhammar, 2015; Catulli et al., 2017a; Cherry & Pidgeon, 2018). Product care in AB-PSS has been largely explored through qualitative studies, and literature so far is inconclusive about actual levels of product care.

This study aimed to understand the effects of non-ownership (vs. ownership) on consumers' product care activities. We therefore compared product care for products that consumers own with products that consumers use through long-term AB-PSS. Owned products were further differentiated based on the question if they were bought in a new state or second-hand. Second-hand products fall into the reuse approach of the Circular Economy (Lewandowski, 2016) and thereby have the potential to save resources. Similar to AB-PSS, second-hand products can only make full use of their sustainability potential if they are taken care of properly. Otherwise, their lifetimes are too short to have a relevant impact on the environment. However, it remains unclear if consumers take care less of second-hand products than newly products. Based

[1] https://swapfiets.nl/
[2] https://www.homiepayperuse.com/

on the determinants for product care presented in Chapter 2, a positive as well as a negative effect can be expected: On the one hand, second-hand products are usually cheaper than the same new product, and based on financial considerations, second-hand products may often not be seen as worth being repaired anymore. Additionally, they may be seen as closer to the end of their lifespan than new products, which could also decrease consumers' motivation to take care of them. On the other hand, consumers may be more attached to second-hand products in comparison to newly bought products because acquisition was more memorable or because the product was harder to find. We assume that consumers take most care of products they bought newly, less care of second-hand products and least care of AB-PSS products, leading to the first hypothesis:

H1: Consumers take care of owned products more than of long-term AB-PSS products.

We expected owned products to be evaluated more positively than long-term AB-PSS because previous research has shown that using products through AB-PSS does not lead to product attachment (Catulli et al., 2017b) and that owned products are more highly valued (see Baxter, 2017). For the evaluation of the products, we selected the same variables as in Section 4.5. This led to the following hypothesis:

H2: Owned products are evaluated more positively than long-term AB-PSS products.

In addition, previous research has shown that product attachment has a positive effect on product cared (Belk, 1991; Van Hinte, 1997; Chapman, 2005; Walker, 2006; Mugge, 2007; Niinimäki & Koskinen, 2011; Page, 2014) and Section 4.5. It can therefore be assumed that attachment may serve as a mediator on the relationship between ownership and product care, i.e., that the differences in product care between newly bought, second-hand and AB-PSS products can be explained by different levels of attachment for these products:

H3: The influence of ownership on product care is mediated by attachment towards the product.

While we know from Section 4.5 that frugality and use innovativeness correlate positively with product care, we do not know how consumer characteristics influence the decision to either buy a new product or a second-hand product, or to use an AB-PSS. We decided to explore this relationship in more depth. In ad-

dition to the consumer characteristics from Section 4.5, we included long-term orientation as a further consumer characteristic. Long-term orientation (see also Hofstede, 2011) may explain why consumers invest resources now in order to be rewarded at a later point in time. It may also be linked to choosing more sustainable alternatives now in order to preserve the environment for future generations. Based on these considerations, our final hypothesis was:

H4: Depending on their characteristics, consumers decide to buy a new product or a second-hand product, or use an AB-PSS.

6.2 Method

In order to explore the influence of ownership on product care, an online survey was conducted to collect data from consumers that either own the product (and bought it new or second-hand) or use an access-based PSS in which they only use the product but do not own it. The implementation and adoption of AB-PSS is still rare (e.g., Tukker, 2015; Tunn et al., 2019b) which makes it difficult to reach a large number of users. Consequently, we decided to focus not only on one product, but on bicycles and washing machines as these two products can be accessed through long-term AB-PSS in the Netherlands, where our study took place. We created one survey with two versions focussing on respondents' everyday bicycle or washing machine. In addition to their availability through long-term AB-PSS, these two products both have a high functional value and were selected because product care can extend their lifetimes.

6.2.1 Survey

First, respondents were asked about their mode of consumption of that product; whether they bought it new, second-hand, or use it through an AB-PSS. If none of these options applied, we thanked the participants for their interest in our study and invited them to join our other survey about bicycles or washing machines, respectively.

We then asked them how often they conduct certain product care activities. For washing machines, we asked them to judge the frequency of the following care activities (from 1 = '*never*' to 9 = '*once a day*'): inspect the hoses, not overload the machine, use the right type of detergent, use the right amount of detergent,

clean the interior and dispensers, wipe down the drum and door, leave the door ajar after a load, transfer clean laundry to the dryer as soon as it is done, clean filters, make sure the washing machine is level. For bicycles, we used the following care activities (again from 1 = '*never*' to 9 = '*once a day*'): check air pressure of the tires, pump the tires, oil the chain, cycle over high pavement edges, check brakes, check screws, double lock the bicycle, clean the bicycle, have the bicycle professionally checked/serviced. For further analyses, we used the average value of the responses. This was the only question that differed between the two versions (bicycle and washing machine) of our survey.

We also included the product care scale (see Chapter 4) for washing machines and bicycles, respectively (α = .92). While the product care scale uncovers a general care behaviour towards the product, the questions about the care activities helped us to explore the frequency of product care activities.

In addition, several established scales were used to measure respondents' characteristics as well as the product-related variables:

- 6 items from the environmental concern scale (Kilbourne & Pickett, 2008), α = .87
- 8 items from the frugality scale (Lastovicka et al., 1999), α = .85
- 9 items from the use innovativeness scale (Girardi et al., 2005), α = .77
- 8 items from the long-term orientation scale (Bearden et al., 2006), α = .82
- 5 items from the attitude scale (Ahluwalia & Burnkrant, 2004), α = .92
- 3 items from the usefulness scale (Cox & Cox, 2002), α = .93
- 3 items from the satisfaction scale (Crosby & Stephens, 1987), α = .94
- 4 items from the attachment scale (Schifferstein & Zwartkruis-Pelgrim, 2008), α = .81
- 3 items from the quality scale (Grewal et al., 1998), α = .87
- 4 items from the disposal tendency scale (Mugge, 2007), α = .77

For the attitude, usefulness and satisfaction scales, a 7-point semantic differential was applied. All other variables were assessed with 7-point scales (from 1 = '*strongly disagree*' to 7 = '*strongly agree*').

Finally, we asked for the demographic data of the participants as background variables for our study. Age was assessed using age ranges (16-20, 21-25, 26-30, ..., 66-70, older than 70 years). For current occupation, we asked the participants to select one of the following items: *full time employment*,

part time employment, *unemployed*, *student*, *retired*. The possible answers for level of education were: *Lager onderwijs*, *basisonderwijs (elementary school)*, *LBO/VMBO/MAVO/HAVO/VWO (high school)*, *MBO (vocational school)*, *HBO/WO (university/university of applied sciences)*, and *PhD or higher*.

The collected data was analysed using the open-source statistics software Jamovi (version 1.1.9.0).

6.2.2 Participants

Links to the survey were posted in social media groups for housing, second-hand furniture, and second-hand bicycles. The sample comprises Dutch respondents and expats living in the Netherlands. Of the 306 started surveys, 166 were completed (54 %) and 212 surveys were sufficiently completed to be included in the analysis, which means that participants filled in at least the questions on product care, frequency of product care activities and if they bought the product new or second hand, or use a long-term AB-PSS. Of the respondents, 58 % are female. Seventy-five percent were between 16 and 30, and 19 % between 31 and 45 years old; the rest was above 46 years old. Respondents could enter a prize draw to win a € 10.00 gift voucher.

6.3 Analysis

As explained above, we were not interested in differences between washing machines and bicycles but only selected these two products to reach a sufficient number of participants, especially for long-term AB-PSS. Indeed, a Wilcoxon rank sum test revealed that product care for bicycles and washing machines does not differ significantly ($W = 5669$, $p = .57$). Thus, we decided to combine the data of bicycles and washing machines for the subsequent analyses. For the analysis of the product-related and the person-related variables, we calculated the means for each scale, with disposal tendency being recoded so that a high value represents a low tendency to dispose of the product. Ownership was defined as bought new ($n = 52$), second-hand ($n = 94$) and long-term AB-PSS ($n = 66$).

6.4 Findings

We examined the relationship of background variables with the decision to either buy a new or a second-hand product, or use an AB-PSS. We refrained from analysing the level of education in depth because 83 % of our participants had a university degree or higher. Neither gender ($\chi^2(2) = 0.58$, $p = .749$) nor current occupation ($p = .521$, Fisher's exact test) nor age ranges ($H(2) = 4.55$, $p = .103$) differed significantly between consumers/users of newly bought products, second-hand products and AB-PSS products.

In a similar way, we analysed the background variables with regard to product care. We did not find any significant differences in the level of product care for gender ($t(164) = 1.41$, $p = .161$) or current occupation ($F(5, 16) = 1.36$, $p = .292$). Age did not correlate with care (Spearman's $\rho = .12$, $p = .060$).

H1: Consumers take care of owned products more than of long-term AB-PSS products

We subsequently tested the hypotheses presented above. An ANOVA revealed that ownership has a significant influence on product care ($F(2, 121) = 6.59$, $p = .002$). Subsequent post-hoc tests with Tukey correction demonstrated that product care for AB-PSS products ($M_{\mathrm{AB-PSS}} = 3.76$, $SD = 1.4$) was significantly lower ($t(209) = 3.20$, $p = .004$) than for newly bought products ($M_{\mathrm{new}} = 4.56$, $SD = 1.3$) as well as for second-hand products ($M_{\mathrm{second-hand}} = 4.43$, $SD = 1.3$, $t(209) = 3.10$ $p = .006$). Product care did not differ significantly between newly bought products and second-hand products ($t(209) = 0.55$, $p = .845$). When we looked at the frequency of care activities, we could not examine significant differences between newly bought, second-hand and AB-PSS products ($F(126) = 2.54$, $p = .083$). The findings support our hypothesis that product care is higher for owned products than for AB-PSS products. This holds true for newly bought and second-hand products. However, this does not necessarily mean that consumers take care more frequently.

H2: Owned products are evaluated more positively than long-term AB-PSS products

There were no significant differences between new, second-hand and AB-PSS products for attitude ($F(2, 167) = 0.07$, $p = .930$), usefulness ($F(2, 167) = 0.73$, $p = .484$), satisfaction ($F(2, 167) = 0.09$, $p = .916$), quality ($F(2, 164) = 1.58$, $p = .210$) or disposal tendency ($F(2, 164) = 2.46$, $p = .089$). We uncovered significant differences for attachment ($F(2, 164) = 13.0$, $p < .001$). Attachment for AB-

PSS products ($M_{\text{AB-PSS}} = 3.16$, $SD = 1.0$) was significantly lower ($t(164) = 2.47$, $p = .038$) than for newly bought products ($M_{\text{new}} = 3.66$, $SD = 1.0$) as well as for second-hand products ($M_{\text{second-hand}} = 4.05$, $SD = 1.0$, $t(164) = 5.10$, $p < .001$). Attachment for owned products does not differ significantly from attachment for second-hand products ($t(164) = -2.07$, $p = .098$). H2 can be confirmed for attachment, but not for the other product-related variables attitude, usefulness, satisfaction, quality and disposal tendency.

H3: The influence of ownership on product care is mediated by attachment towards the product.

This hypothesis was based on theoretical considerations (see also Section 6.1), but was also derived from our data, because attachment was the only product-related variable that differed significantly between new, second-hand and AB-PSS products. This significant difference is a necessary condition in order to test its relevance as a mediator (Baron & Kenny, 1986). Indeed, the data shows a partial mediation of attachment on the effect of ownership (new, second-hand, AB-PSS) on product care. The indirect effect estimates ($beta = 0.053$ $p = .019$) accounts for 50.6 % of the total effect ($beta = 0.137$ $p = .070$), indicating that about half of the influence of ownership on product care can be explained through the additional consideration of attachment.

H4: Depending on their characteristics, consumers decide to buy a new product or a second-hand product, or use an AB-PSS.

Subsequently, we examined differences in consumer characteristics with regard to the choice to buy a product either new or second-hand, or to use a long-term AB-PSS. An ANOVA revealed that there are only significant differences between the three groups of ownership (newly bought, second-hand, AB-PSS) for environmental concern ($F(2, 186) = 4.67$, $p = .010$) and frugality ($F(2, 171) = 3.09$, $p = .048$), but not for use innovativeness ($F(2, 171) = 2.97$, $p = .054$) and tradition ($F(2, 186) = 1.06$, $p = .349$). Subsequent post-hoc tests with Tukey correction uncovered that environmental concern differs significantly between buying new products and using AB-PSS ($t(186) = -2.99$, $p = .009$, $M_{\text{new}} = 5.88$, $SD = 0.9$, $M_{\text{second-hand}} = 6.07$, $SD = 1.0$, $M_{\text{AB-PSS}} = 6.39$, $SD = 0.6$), but not between buying new products or second-hand products ($t(186) = -1.19$, $p = .462$) or between buying second-hand products and using AB-PSS products ($t(186) = -2.16$, $p = .080$). With regard to frugality, post-hoc tests with Tukey correction did not uncover significant differences between the groups ($M_{\text{new}} = 5.50$, $SD = 0.8$, $M_{\text{second-hand}} = 5.88$, $SD = 0.9$, $M_{\text{AB-PSS}} = 5.89$, $SD = 0.9$). In conclusion,

only environmental concern differs significantly between consumers who buy products new and those who use AB-PSS.

In addition to testing the hypotheses, we also analysed the care activities conducted by the consumers. The frequencies of care activities correlate with product care measured through the product care scale on a medium level (r = .51, p <.001), which indicates that frequency of care activities are related to product care in general. Although we only asked participants about specific care activities, and not – as within the product care scale – about aspects such as positive feelings associated with product care, we could still observe a linear relationship between both variables.

6.5 Discussion

We are contributing a quantitative study on the influence of ownership on product care. Our findings demonstrate that product care varies among newly bought, second-hand and AB-PSS products; being highest for products that consumers obtained new and lowest for long-term AB-PSS products. Therewith, these results quantitatively confirm what Tukker (2004) theorised and Bardhi and Eckhardt (2012) found qualitatively.

In addition, we were able to show that attachment plays an important role for product care, and that it is also highly dependent from the fact if consumers bought the product newly, second-hand or use a long-term AB-PSS. This might be explained through a memorable acquisition of second-hand products, which were maybe previously owned by relatives or friends or were bought in a more interesting setting than a normal (online) shop for new products. We were also able to show that consumers with a high environmental concern tend to use long-term AB-PSS more often than consumers with low scores on that scale.

At the same time, users of long-term AB-PSS treat their products less carefully. This means that resources needed by service providers to repair and maintain AB-PSS products may outweigh potential sustainability benefits of AB-PSS, although consumers choose AB-PSS because of environmental concerns. One reason may be that these consumers are not aware of the need for product care so they do not take care of their AB-PSS products. Another possible reason is that they already feel that they are contributing to a more sustainable way of consumption by choosing AB-PSS. As a consequence, they are not motivated to take care of the product anymore.

One limitation of our study is the sample. The implementation of AB-PSS is still rare (e.g., Tukker, 2015; Tunn et al., 2019a) which makes it difficult to reach a large number of users. We thus resorted to recruiting a non-probability sample through social media, which resulted in a high percentage of participants with at least a university degree in our sample. Because AB-PSS are not very common at the moment, it could be assumed that these participants are more aware of AB-PSS and consider them as a sustainable alternative to sales models. For future studies, we recommend larger and more representative samples which would also allow the exploration of further constructs that might influence product care, such as awareness of the need for product care, and how these can be stimulated in AB-PSS.

6.5.1 Implications for Theory

This study supports findings from the literature (DEFRA, 2011) indicating that workhorse products, in other words products that mainly serve a functional purpose, are not taken care of well, especially in comparison to investment products that are either expensive or valuable to the consumer (e.g., because financial reasons or because of a feeling of emotional attachment). Washing machines and bicycles are typical examples of workhorse products (see also Chapter 2), while investment products could be large furniture or high-quality electronic products. Further, product care did not significantly differ between washing machines and bicycles. Both products are durable, provide primarily functional value, and product care is not complex; the findings may thus be generalisable for products with similar properties, such as dishwashers.

Based on our findings, we argue that product care is likely to be even lower in short-term AB-PSS because damages are harder to retrace and can also be the result of vandalism by non-users. On top of that, consumers do not rely on one specific product to obtain the desired functionality when using short-term AB-PSS; if one product is broken, consumers can easily access another one (see Schaefers et al., 2016, for more insights into product care in short-term AB-PSS). Hence, consumers may take even less care of products used through short-term AB-PSS than of those used through long-term AB-PSS. If AB-PSS encourage consumers to use the service more or stimulate frequent product replacement, the additional impacts of logistics and resources needed by the service provider may reduce or even nullify the sustainability potential of these business models.

Further research on short-term and long-term AB-PSS is needed in order to understand the implications of different business models for sustainability.

6.5.2 Implications for Practice

Based on our findings, we proposed the following recommendations for the design of long-term AB-PSS: First, design strategies from Chapter 5 that were developed for owned products should be applied and tested for long-term AB-PSS. Our results suggest that the 'soft benefits' of ownership that enhance product care, such as product attachment, are lacking in AB-PSS thus confirming research by Baxter (2017).

The relevance of personalization for long-term AB-PSS has been researched before (see e.g., Tunn et al., 2019a), and personalization is also a sub-strategy of the design strategy *Appropriation* (see Chapter 5). In general, the design strategies *Appropriation* and *Reflecting* may create an emotional attachment between consumers and product and should therefore be considered in AB-PSS. In addition, one could provide the consumer with more information and the required tools and equipment for product care, thereby referring to the strategies *Informing* and *Enabling*. This may enhance product care among consumers who decide to use AB-PSS due to environmental considerations but still struggle to take care of their products. The application of these strategies could increase product care and may also discourage frequent replacement of accessed products, thereby supporting the full potential of long-term AB-PSS as well as helping AB-PSS providers to ensure that these services are financially viable.

Second, products for long-term AB-PSS should be especially durable, easy to repair and maintain (see e.g., Van Nes & Cramer, 2005). They should also be designed to be of high quality, sturdy, and long-lasting to withstand poor care. Thereby, designers can ensure that AB-PSS actually improve sustainability (see Agrawal et al., 2012; Kjaer et al., 2019). Similarly, products that are designed in this way for traditional sales models are more likely to last and be eventually sold through second-hand sales. Because high quality often also means that more resources are needed, the effectiveness of this approach should be determined thoroughly.

Third, product care should be considered not only during the product design, but also when planning the business model. Business models can be implemented and designed to encourage consumers to take care of the products, for example, by offering incentives such as a financial refund if he/she returns the product in a good state. This approach would also refer to the design strategy *Antecedents & Consequences*, which we introduced in Chapter 5. Alternatively, in AB-PSS the expected level of product care can be specified in the contract between the AB-PSS provider and the users, penalising users if they do not take sufficient care of the products. Although penalties are not always useful in order to support behaviour change, they could still work in this context if they do not suppress consumers' moral obligation to take care of the products (Bolderdijk et al., 2018). This again needs to be clearly communicated to consumers in order to encourage product care and to prevent consumers from being surprised by fines.

In any case, providers of AB-PSS should be aware of the challenges that a lack of ownership causes for the sustainability of their services and take effective countermeasures.

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7

Discussion

The aim of this thesis was to understand how design can encourage consumers to take care of their products. Taking care of products is one approach to prolong products' lifetimes, which in turn is a necessary step within the transition towards a Circular Economy: The longer products can be used, the less material and resources are needed. By now, research has mostly focused on repair and maintenance, the latter often in a quite technical sense, i.e., exchanging parts of a product after a certain time. However, product care goes beyond repair and maintenance and also includes careful handling of products or the prevention of damage by using covers etc. In order to foster product care, we aimed for a change in consumers' current behaviour and used Fogg's behaviour model (2009) as a theoretical background for our studies. This final chapter summarises the main findings of this thesis together with their implications for theory and practice. It also presents limitations as well as avenues for future research and discusses the impact of recent developments on the future of product care.

The main research question of this thesis was:

How can design foster product care among consumers?

We defined product care as *all activities initiated by the consumer that lead to the extension of a product's lifetime*, a definition that goes clearly beyond repair and maintenance and includes also consumers' daily interaction with product, such as careful handling.

7.1 Main Findings

The following section discusses the main findings of this thesis and is structured according to the research questions presented in Chapter 1.

Why do consumers (not) take care of their products?

Fogg's behaviour model (2009) served as a theoretical background for a deeper understanding of product care. The model claims that motivation, ability, and trigger have to be present at the same time, i.e., that consumers want to conduct the desired behaviour and are able to do it. In our case, this means that consumers should want to take care of their products and are also capable of doing so.

We were able to identify different sources of motivation for product care that are either dependent on the product, the consumer or the relationship between them (Chapter 3), such as the initial price, the attitude towards longevity or emotional attachment. In addition, we examined factors that facilitate product care, thus enhancing consumers' ability to take care of the product. Ability factors are for example knowledge & skills, time & effort, and the availability of tools. Motivation and ability together have to be present in order to enable triggers to work. In the case of product care, triggers can be for example a smartphone notification or a change in the appearance of the product. Chapter 3 uncovered the need to enhance motivation and ability, and to develop triggers for product care.

How can we measure the degree to which consumers take care of their products?

We developed a scale that enables the assessment of product care using 10 items in order to measure product care in a reliable and efficient way. As previous studies (see also Chapter 3) and the experts' feedback (Section 4.3) have shown, product care is dependent from the consumer as well as from the product itself. We therefore developed a scale that is always referring to a specific product, such as a bicycle or a washing machine. Within four related studies, we checked the scale for face validity, construct validity, nomological validity, and reliability (see Chapter 4).

The scale contains three factors: easiness, relevance and positive experience. *Easiness* describes the perceived ability of consumers to take care of their product. It is thereby strongly related to the ability factor in Fogg's behaviour model (2009). *Relevance* describes the general care behaviour and its importance for the consumer. This factor is referring to the integration of product care into the daily life of consumers. *Positive experience* describes the emotional aspects of product care, such as the experience and the feeling of taking care. Relevance and positive experience can both enhance consumers' motivation.

While motivation and ability are assessed through the scale, triggers are not included, because they activate a certain behaviour in a specific situation, whereas our scale measures product care over a longer time period. The scale was applied in Study 4 on the influence of ownership on product care (see Chapter 6). It was able to uncover different levels of product care for bicycles and washing machines owned by the participants versus product care for bicycles or washing machines that were used via AB-PSS.

We believe that the scale provides a helpful instrument for further research in the field of sustainable consumer behaviour, because it enables an efficient and valid way of measuring product care.

What are possible design strategies to stimulate product care among consumers?

In Chapter 5, we developed eight design strategies for product care:

- *Informing*: providing information about product care

- *Awareness*: reminder or a change in the product's appearance or functionality
- *Antecedents & Consequences* of product care
- *Social Connections* as a facilitator or as an outcome of product care
- *Enabling*: facilitating product care by offering right tools or a service
- *Appropriation*: adaptation/personalization of a product
- *Reflecting*: creating meaningful memories for the consumer
- *Control*: ranging from a product that takes over the initiative for product care to self-healing materials

These strategies are related to the three factors of Fogg's behaviour model (2009), thus addressing consumers' motivation and ability, and also providing triggers for product care. The design strategies aim to transfer the theoretical knowledge on product care into its application in practice and present directions how products and services should be designed in order to foster product care. The corresponding sub-strategies provide further inspiration on how the strategies could be applied in design practice. For example, the informing strategy consists of the three sub-strategies static information, interactive information, and physical information in order to demonstrate the different possible approaches for this strategy.

How do consumers consider the suitability of these design strategies?

The best design strategies to foster product care are useless if they are not accepted by consumers. We talked to consumers about our design strategies, asking them if they consider the strategies as useful in fostering product care (Chapter 5). The overall reaction of our participants was quite positive, but it was also suggested that certain strategies only work for specific products and specific consumers. For example, the *control* strategy was only seen as useful for products that already have an electronic component, whereas *informing* only supports care activities that are relatively easy to conduct.

Some participants mentioned that a general awareness of consumers about product care should be created. The interviews also uncovered that a combination of design strategies, for example one that fosters motivation and one

that enhances ability, may often be the best approach to stimulate product care through design.

How can these design strategies be transferred into design practice?

The design strategies are formulated in a way that enables their application in design practice. In order to further facilitate the transition from theory into practice, we developed and tested the Product Care Kit that consists of several types of cards. There are product cards that stimulate questions about the product that is going to be (re)designed and persona cards that help to define the target group. These cards help designers to determine the context of their project. The toolkit also includes different card with product care activities, such as repair or careful handling that designers may want to focus on. In addition, it provides the design strategies for product care as well as examples of products and services that foster product care among consumers.

What are the effects of non-ownership (vs. ownership) on consumers' product care activities?

Chapter 6 examined the influence of ownership as opposed to access-based consumption such as long-term renting. AB-PSS have been promoted as one approach for a shift towards a Circular Economy. However, it is still unclear how the lack of ownership in long-term AB-PSS influences consumers' product care. Study 4 was able to show that there is indeed an effect of ownership on product care: Consumers took better care of products they owned, independent of the fact if they bought the product newly or second-hand. Products that were used via AB-PSS were taken care of less. Based on the findings, we argue that the sustainability potential of AB-PSS may be limited because consumers do not take care of the products properly, and that these business models can even be less sustainable than sales models.

7.2 Implications for Theory

7.2.1 Contribution to Theory

Our findings indicate that the Fogg behaviour model is a useful theoretical background in order to understand human behaviour and to develop design interventions to change this behaviour. We were able to show that sources of motivation, such as attachment, financial considerations, assumptions about the product's lifetime and previous care activities are relevant for product care (see Chapter 3), thereby confirming determinants for repair and maintenance that were identified in previous studies (see Chapter 2).

In addition, we uncovered the effect of ownership (vs. non-ownership) on product care (Chapter 6) and highlighted the relevance of social factors that can enhance the motivation as well as the ability to conduct product care (see Chapter 5). Our research further confirms the relevance of previously known ability factors of repair and maintenance (knowledge, skills, resources) for product care. In addition, we were able to uncover the relevance of triggers for product care: If consumers are motivated and have the necessary ability to take care of their products, they still need a push into the right direction in order to start.

Past research has either focused on behaviour change in general (see e.g., Fogg, 2009) or on other more general ways of stimulating sustainable behaviour through design (see e.g., Bhamra et al., 2011). Our research contributes to the literature by providing specific design strategies that are necessary to foster a specific sustainable behaviour, such as product care. Our design strategies build on these theories by considering motivation (*Appropriation*, *Reflecting*, *Social Connections*), ability (*Informing*, *Enabling*, *Antecedents & Consequences*, *Social Connections*) and triggers (*Awareness*, *Control*) as relevant elements of the consumer perspective on product care.

The product care scale that we developed in Chapter 4 is the first instrument to assess product care in an efficient and reliable way. It thereby contributes to research in the field of sustainable consumer behaviour. In contrast to measuring pro-environmental behaviour in general (see e.g., Markle, 2013), our scale enables the assessment of a specific behaviour related to a certain product. Because the scale consists of only 10 items, it can be easily combined with other

existing scales in order to explore relationships with further attitudes or behaviours. It can also be applied in order to assess product care behaviour of one consumer for different products. Analysing intra-individual differences in product care can lead to a better understanding of the determinants of product care, thus facilitating further research in this field.

7.2.2 Limitations and Avenues for Future Research

Based on the determinants of product care that we uncovered and the insights from our scale development, we propose a few suggestions for future research on product care.

One avenue for future research is the quantification of our assumption that product care leads to an extension of products' lifetimes. While it is reasonable to assume that regular maintenance and repair will lead to longer product lifetimes, it remains unclear how much longer products can be used if they are taken care of and which amount of resources can be saved through product care. In addition, product care itself also requires resources, such as material, energy etc., which should be considered in these calculations.

These calculations could be supported by big data analytics that consider various variables and their influence on the lifetime of products. This would also allow for the calculation of specific recommendations such as '*If consumers decalcify their kettle every two weeks, it will remain usable two years longer*' that may support consumers who do not know how often they should conduct different care activities for their products.

A second avenue for future research is an exploration of further determinants on product care. One interesting example may be social connections: Study 1 (Chapter 3) has shown that family members and friends can trigger more product care if they are supportive and/or help with product care. On the other hand, negative comments can reduce the motivation to take care. During the development of our design strategies (Chapter 5), we realized that help from other people can indeed foster the motivation and ability for product care, but that shared ownership may only have a positive effect on product care if the other user(s) of the product is/are known. For example, using a coffee machine together in a shared apartment could enhance product care, but using it together in a big office building may result in a diffusion of responsibility.

Another example is the impact of consumers' cultural background on product care. Kaiser (1998) suggests that social and cultural aspects may determine if a behaviour is seen as easy, and ability seems to be an important determinant of product care (see Chapter 2). For example, in Section 4.6 we demonstrate that product care for bicycles differs between Austria and the Netherlands. Our assumption is that this is because bicycles are more part of the Dutch than of the Austrian culture. Therefore, knowledge and skills about repairing and maintaining bicycles is higher in the Netherlands. In addition, more bicycle shops exist, making it easier for consumers to get spare parts and tools or to use the repair and maintenance service offered there. It might be interesting to explore further consequences of such differences, and also the effect of cultural dimensions such as long-term orientation (see also Hofstede, 2011) on consumers' motivation to take care of their products. High scores on long-term orientation could explain why consumers invest resources (such as time, effort and money for product care) now in order to be rewarded at a later point in time (by prolonging the product's lifetime).

A third avenue for future research is the application of the design strategies in practice. By now, the strategies have only been discussed with consumers, but it would be interesting to actually apply the strategies to different products. One could compare product care for a conventional product with a similar product that was designed based on our strategies, using our product care scale. For many products, care activities are only necessary after several weeks or months, and these time spans vary between products. For example, for most people it is enough to oil wooden garden furniture once a year, whereas a decalcification of a kettle might be reasonable after some weeks. Longitudinal studies would enable an assessment of care activities when they are actually necessary, which may lead to an understanding how the design strategies can influence motivation and ability, or create triggers for product care. It would also be interesting to see if the strategies can easily be applied to various products, or if designers struggle to use them in practice.

Finally, an avenue for future research could be the role of service providers for product care. Our research focused on the role of consumers for product care, which does not necessarily mean that the care activities are also conducted by the consumers themselves. As defined in Chapter 1, product care includes all activities *initiated by the consumer* that lead to the extension of a product's lifetime. Consequently, we also talked about repair and maintenance services

in Chapter 3, and the design strategies in Chapter 5 can also result in asking a service provider for help. However, the role of service providers seems to be limited at the moment: Maintenance activities, such as careful handling and cleaning, are usually done at home, because it takes less time conducting these activities than asking a service provider for help. Additional attributes of the service, such as its price, availability or trustworthiness may also encourage consumers to either take care themselves or to not take care of their products at all.

Product care should also be further explored in the context of circular business models (see e.g., Bocken et al., 2016). One example are AB-PSS, in which consumers only use the product, but the ownership remains with the service provider. Chapter 6 has shown that the sustainability potential of AB-PSS may be outweighed by the fact that consumers do not take proper care of products they do not own. This may be caused by the fact that the sources of motivation for product care that we identified for owned products are not relevant for rented or shared products. For example, emotional attachment towards the product is probably less important, whereas financial repercussions for the consumer if the product is not treated properly may play a more prominent role. Future studies may explore product care for products in circular business models, which would also include short-term renting or sharing, and present strategies that enable these models to reach their sustainability potential.

7.3 Implications for Practice

7.3.1 Contribution to Practice

Our research has shown that product care is relevant for various product categories, because most products of our everyday life need to be taken care of. Aside from convenience goods such as groceries or drugstore products, products of our everyday life, such as clothes, furniture, household appliances etc. usually need product care from time to time in order to prolong their lifetime. This means that product care is relevant in many industries, and that knowledge on product care should be spread across practitioners in these industries.

With our design strategies, designers can pay extra attention to the role of consumers for product care. While previous strategies were targeting sustainable

behaviour in general, our strategies are specifically related to product care. In addition to the design strategies, we present a toolkit that supports the application of the design strategies in practice. The toolkit will be available for free on our website, https://designforproduct.care, in order to reach as many people working in design practice, in design education, and in design research as possible. We hope that the toolkit will not only be used by designers for the development of new products and services, but that it also facilitates communication with other stakeholders, such as policymakers or manufacturers.

7.3.2 Avenues for Developments in Practice

Manufacturers and Service Providers

Companies currently address product care in different ways: On the one side, there are manufacturers that encourage consumers to take care of their products and offer the right equipment to do so (see Figure 7.1). This is often the case for high-quality products that are designed to last for a long time. The corresponding business model is a classic long-life model that considers products' durability and reparability (Bocken et al., 2016).

On the other side, there are many manufacturers that currently do not support consumers in taking care of their products. Quite the contrary, they even encourage them to not take care (see Figure 7.2), suggesting that these products should show wear and tear. Another way of making product care obsolete is to offer new versions of a product within short time frames. Upgrades often lead to consumers treating these products in a careless way, thereby justifying the purchase of the newer version (Bellezza et al., 2017). Finally, there are manufacturers that make it difficult for consumer to take care of their products, because they require them to bring their products to certified technicians. These manufacturers are following business models in which profit is made by selling more and more products because consumers are lacking the ability to take care of their current ones. Especially cheap products are often not seen as worth to be repaired, and the temptation to simply order a new product is high (DEFRA, 2011; Dewberry et al., 2017).

Consumers' purchase decisions are influenced by the sustainability claim of products (Cho, 2015) and values such as responsibility for the environment have to be considered in future business models. From a business perspective,

a current barrier for this shift towards more sustainable business models is the focus on profit maximization and subsequent short-termism and uncertainty avoidance (Bocken & Geradts, 2020). These business models do not only create a negative environmental impact because consumers do not make optimal use of their potential lifetimes, but they also often have negative social-economical consequences, such as poor labour standards (Reinecke et al., 2019).

Figure 7.1: Shoe Care Kit by Dr. Martens (https://www.drmartens.com)

One possibility for manufacturers to earn money while still promoting product care are AB-PSS. In AB-PSS, ownership remains with the manufacturer or service providers, and repair as well as maintenance are part of the contract or offered as an additional service (Bocken et al., 2016). The role of the service provider for product care will therefore become more prominent: Consumers will decide for a service provider based on different features of the service, i.e., if products are repaired or exchanged quickly when broken, or if they can bring and pick up their products for maintenance in a convenient way. For the

everyday product care, such as careful handling, service providers could offer products that are robust and resistant to traces of wear and tear so that they can be used by multiple consumers consecutively. Products that can withstand renting well are also more profitable for service providers because they can rent them out for a longer time without the need for major repair or refurbishment. Companies can also benefit indirectly if they consider product care for their products: Products that can be easily repaired and maintained contribute to a higher brand loyalty and to an increased probability of future purchases by consumers (Mashhadi et al., 2016; Sabbaghi et al., 2016).

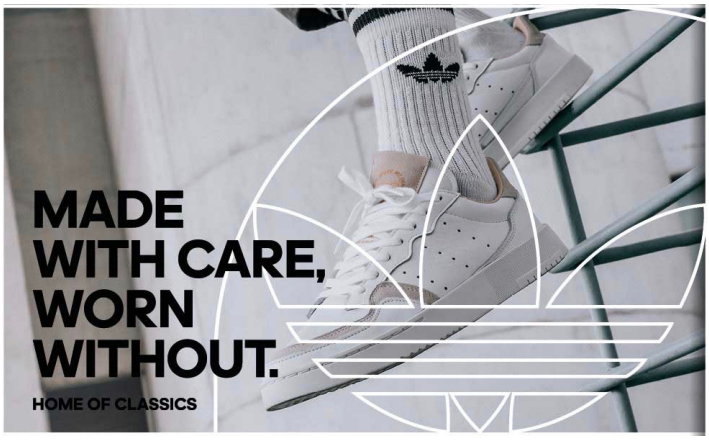

Figure 7.2: Adidas Commercial "Made with Care, Worn Without" (https://www.adidas.com.sg/supercourt)

Design

For the future design for product care, the development of innovative materials can lead to products that need less care by their consumers, because they can take care of themselves. A first step into that direction are products with a lotus effect, which means that water droplets roll off the surface, even taking dirt particles with them (Harmon, 2012). The lotus effect is already used for bathroom and kitchen surfaces, cars etc. In addition, self-healing materials, which can restore their aesthetics or their structure when being damaged, can play an important role for the shift towards a Circular Economy: As stated by Haines-Gadd et al. (2019), self-healing materials have the potential to reduce the cost and risk of future repair; however, they are currently barely tested in real-life settings but only in the laboratory.

In addition, design should focus on products that are worth being taken care of. High-quality products with good energy efficiency and high functional value for their owners should be preferred over products with short lifespans. For these products, lifetime extension is the preferred strategy (see also Bakker et al., 2014). One element of lifetime extension is product care, and the higher quality and functionality of these products will also enhance consumers' motivation to take care of them.

Consumers

Most people in industrial countries can afford a new version of their products if the old one broke down earlier than necessary due to a lack of product care. However, in less developed countries, people are often dependent on their products working properly. They cannot simply buy a new product, either due to financial reasons or even because new products are not immediately available. Product care in these countries is not a matter of motivation, but a necessity. Participants in our studies mentioned that many people are lacking a general awareness of the value of products. They also argued that children should be taught about the materials, energy, time and effort needed to produce and deliver a product. This information could make them aware that all products are worth to be taken care of, even if one could easily afford a new version.

Another aspect are the social connections that support product care. Participant in our studies often mentioned that they help their friends, family members, or neighbours with product care, or that they receive help by them. Repair cafés, especially if they only take place every few months like in Austria, can only support product care in certain situations. For many products, help is needed immediately or within a few days because the product's functionality cannot be missed. If social networks are missing, digital networks may be one approach to connect people who can help with a product care task with desperate consumers. Apps, websites and other online communities may be one approach to address this issue.

Policymakers

Similar to design interventions in public health (see Michie et al., 2014), behaviour change needs to be supported by policymakers. Even small measures can have an impact: In December 2019, the government in Salzburg (Austria) intro-

duced a so-called 'repair bonus' (Land Salzburg, 2020). Consumers can now get up to 100€ if they show the invoice of a service provider who repaired their product. Within six months, 2328 electric household appliances were repaired, financially supported with this bonus (Salzburg24, 2020). Based on the success of this initiative, the goverment is now planning to reduce the VAT for repair services in fall 2020 (Salzburger Nachrichten, 2020). Policy has the power to foster product care, for example by introducing lower taxes on spare parts or by penalising manufacturers for producing products that cannot be repaired or for which spare parts and updates are not available anymore after a few years.

7.4 Concluding Thoughts

Since starting this PhD, two developments that support the aim of this thesis took place. First, climate change and its implications for mankind became more prominent. While environmental concerns have been raised since decades, the Fridays for Future movement managed to bring thousands of people on the street each week, creating a public awareness for the challenges caused by climate change. People started joining the movement and began thinking about ways to live and consume in a more sustainable way.

In addition, civil initiatives, such as the Right to Repair movement[1] (see Figure 7.3) or the Repair Association[2], who are fighting for legal actions by the government to ease repair for consumers, succeeded in several countries: The Motor Vehicle Owners' Right to Repair Act in Massachusetts, USA (2012), the Consumer Rights Act in the UK (2015) and initiatives against planned obsolescence in the EU (Michel, 2017) all support consumers in their ability to take care of their products.

As a consequence, the European Union launched a 'right to repair' directive in October 2019 (European Commission, 2019; Hernandez et al., 2020). By 2021, the directive will empower consumers by facilitating the repair of their products by requiring manufacturers to design products for longer life and by making spare parts available for up to 10 years.

Second, the COVID-19 pandemic influenced people's perception on sustainable consumption: On the one hand, consumers barely ever had that much time to take care of their products as during the lockdown periods, that took place in

[1] https://repair.eu
[2] https://repair.org

most European countries and forced people to stay at home for several weeks. In order to prevent people from being bored, product care was even suggested as an occupation during that time (see e.g., Carpe Media, 2020). But even without being bored, consumers were more dependent on their products functioning, as many shops were closed and delivery times from online shops were long.

Figure 7.3: Right to Repair Movement (https://eeb.org/europe-paves-way-for-right-to-repair/)

Both developments support product care in different ways: The first one increases people's motivation to live more sustainable and product care can be one part of that movement. The second development emphasized the necessity of product care in certain situations. It made us aware that even in industralized nations, the availability of products can decrease quite fast and that the ability to take care of one's products can help during these times.

Based on these developments, we argue that the point of departure for product care is now better than ever. However, product care is an aim that requires the collaboration of various stakeholders. It is too easy to only ask designers and manufacturers to offer products that are easy to take care of and to demand consumers to take care of their products. In addition, the right social and political environment that supports these efforts is needed.

We therefore hope that the insights of this thesis are not only used by designers in research and practice, but that they are also appreciated and considered by policymakers.

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A

First Set of Product-Specific Items and Their Evaluation (Study 2.1)

Table A.1: First Set of Product-Specific Items and Their Evaluation by Nine Experts (rated from 1 = very representative to 3 = not representative) in Study 2.1

item	mean	sd
It is important for me to take care of my [product].	1.22	0.44
I have the tendency to look after my [product] more than other people.	1.56	0.73
I look after my [product] regularly.	1.44	0.53
I try to prevent my [product] from failure.	1.56	0.73
I use my [product] only as long as it does not require any care.	2.33	0.87
I often postpone maintenance activities for my [product] as long as possible.	2.00	0.71
I know how to protect my [product] from possible damage.	1.56	0.53
If I do not know how to take care of my [product], I will look for information.	1.67	0.71
I am capable of looking after my [product].	1.33	0.50
I am confident I can protect my [product] from damage.	1.78	0.44
I am afraid I will damage my [product] while taking care of it.	2.44	0.73
If I treat my [product] in a bad way, it gives me a bad conscience.	2.11	0.78
I have a bad conscience when I do not protect my [product] good enough from damage.	2.11	0.78
It is ok for me to spend my time maintaining my [product].	2.00	0.50
Taking care of my [product] is too much effort for me.	2.11	0.78
In general, looking after my [product] is a positive experience.	2.00	0.87

Table A.1: First Set of product-specific Items and their Evaluation by Nine Experts (rated from 1 = very representative to 3 = not representative) in Study 2.1, cont.

item	mean	sd
Taking care of my [product] is something I enjoy.	2.33	0.87
It makes me proud that I take care of my [product].	2.00	0.87
I keep my [product] in a good condition so I can use it for an extra-long period time.	1.22	0.44
I treat my [product] in a way so it is usable for an extended time.	1.33	0.50
Because of my careful handling, I can use my [product] for a longer period of time.	1.33	0.50
One reason why I take care of my [product] is to save money.	1.78	0.67
By preventing my [product] from breaking down, I save money.	1.44	0.73
When I buy a new [product], I check how it should be taken care of.	2.00	0.71
I do my best to protect my [product] from damage.	1.33	0.50
I conduct different activities that extend the lifetime of my [product].	2.00	0.71
If special care equipment is needed for my [product], I will buy it.	1.67	0.71
Family members or friends increase my motivation to look after my [product].	2.33	0.71
Repairing my [product] is an important activity for me.	1.89	0.93
I own a [product] that I repair, even if that requires a lot of time.	2.00	0.87
I repair my [product] regularly.	2.33	0.71
I repair my [product] only if I need it urgently.	2.00	0.71
I repair my [product] promptly when it is broken.	1.78	0.67
I am experienced in repairing my [product].	2.11	0.78
I do not repair my [product] even though I know how to do it.	2.22	0.83
I look for information to understand how I can fix my [product].	1.44	0.53
I enjoy gaining the knowledge that I need to restore my [product].	1.56	0.73
I can restore my [product] well.	1.89	0.60
I am sure I can fix my [product].	2.11	0.78
I fear making things worse when I repair my [product].	2.33	0.71
I am willing to reduce overall waste by repairing my broken [product].	1.44	0.53
When I have enough time, I repair my broken [product].	1.33	0.50
Fixing my [product] is too much effort for me.	2.33	0.71
It is embarrassing to have my [product] repaired.	2.78	0.44
I remember my prior repair experience on my [product] as negative.	2.56	0.73
Fixing my [product] gives me a good feeling.	1.33	0.50
It makes me proud that I am able to repair my [product].	1.56	0.73
If my [product] breaks down, I generally replace it by a new one.	2.11	0.78
I fix my broken [product] because I do not want to buy (a new one).	1.22	0.44
I extend the lifetime of my [product] by repair activities.	1.78	0.67
I repair my broken [product] because I do not want to spend money on a new one.	1.33	0.50
I fix my broken [product] because it is cheaper than buying a new one.	1.56	0.73
When I buy a new [product], it is important for me that it can be repaired easily.	1.89	0.60
The repairability of a [product] is important for my purchase decision.	1.89	0.78
I do my best to restore my [product] to a sound state.	1.56	0.53
Comments from family members or friends push me to repair my products.	2.33	0.71
I enjoy gaining new skills for the care of my [product].	1.67	0.71
I improve my [product] regularly.	2.22	0.67
I clean my [product] regularly.	1.56	0.88
I look after my [product] regularly.	2.11	0.60
I invest time into the care of my [product].	1.78	0.67
I put a lot of effort into the care of my [product].	2.11	0.93
I have enough space for repair activities on my [product].	2.22	0.67

B

Items for the EFA and CFA (Study 2.2)

- It is important for me to take care of my bicycle.
- I have the tendency to look after my bicycle more than other people.
- I look after my bicycle.
- I clean my bicycle.
- I try to prevent my bicycle from failure.
- I do my best to protect my bicycle from damage.
- I often postpone care activities for my bicycle as long as possible.
- If I do not know how to take care of my bicycle, I will look for information.
- I enjoy gaining the knowledge that I need to take care of my bicycle.
- I enjoy gaining new skills for the care of my bicycle.
- I can look after my bicycle well.
- I am experienced in looking after my bicycle.
- I do not keep my bicycle in a good state, even though I know how to do it.
- In general, looking after my bicycle is a positive experience.
- It makes me proud when I take care of my bicycle.
- It makes me proud that I am able to take care of my bicycle.
- I am confident I can protect my bicycle from damage.

- I am afraid I will damage my bicycle while taking care of it.
- Taking care of my bicycle gives me a good feeling.
- It is ok for me to spend my time taking care of my bicycle.
- Taking care of my bicycle is not too much effort for me.
- Taking care of my bicycle does not take too much time.
- I invest time into the care of my bicycle.
- I put effort into the care of my bicycle.
- I treat my bicycle in a way so it is usable for an extended period of time.
- Because of my careful handling, I can use my bicycle for a longer period of time.
- I am motivated to keep my bicycle in a good condition, because that reduces waste.
- By preventing my bicycle from breaking down, I save money.
- I take care of my bicycle because it is cheaper than buying a new one.
- When I buy a new bicycle, it is important for me that I can look after it easily.
- If special care equipment is needed for my bicycle, I will buy it.
- I take care of my bicycle early enough so it is usable when I need it.
- I look after my bicycle after a certain amount of time has passed.
- I have enough space for care activities on my bicycle.
- I have the necessary equipment for care activities on my bicycle.

C

Items Used for the Nomological Network Study (Study 2.3)

Product Care Scale (coffee machine/leather shoes)

1. It is important for me to take care of my coffee machine / my pair of leather shoes.
2. I look after my coffee machine / my pair of leather shoes.
3. I try to prevent my coffee machine / my pair of leather shoes from damage.
4. I clean my coffee machine / my pair of leather shoes.
5. I have the necessary equipment for care activities on my coffee machine / my pair of leather shoes.
6. I am experienced in looking after my coffee machine / my pair of leather shoes.
7. I can look after my coffee machine / my pair of leather shoes well.
8. In general, looking after my coffee machine / my pair of leather shoes is a positive experience.
9. Taking care of my coffee machine / my pair of leather shoes gives me a good

feeling.

10. It makes me proud that I am able to take care of my coffee machine / my pair of leather shoes.

Consumer Characteristics Scales

- Subscale "Environmental concern" (Kilbourne & Pickett, 2008)
  1. I am very concerned about the environment.
  2. Humans are severely abusing the environment.
  3. I would be willing to reduce my consumption to help protect the environment.
  4. Major political change is necessary to protect the natural environment.
  5. Major social changes are necessary to protect the natural environment.
  6. Anti-pollution laws should be enforced more strongly.

- Frugality (Lastovicka et al., 1999)
  1. If you take good care of your possessions, you will definitely save money in the long run.
  2. There are many things that are normally thrown away that are still quite useful.
  3. Making better use of my resources makes me feel good.
  4. If you can re-use an item you already have, there's no sense in buying something new.
  5. I believe in being careful in how I spend my money.
  6. I discipline myself to get the most from my money.
  7. I am willing to wait on a purchase I want so that I can save money.
  8. There are things I resist buying today so I can save for tomorrow.

- Use innovativeness scale (Girardi et al., 2005)
  1. Even if I don't have the right tool for the job, I can usually improvise.
  2. I never throw something away that I might use later.
  3. In general, I would rather alter an old product to work in a new situation than purchase a new product specifically for that purpose.
  4. After the useful life of a product, I can often think of ways to use its parts for other purposes.
  5. I do not enjoy a product unless I can use it to its fullest capacity.
  6. I use products in more ways than most people.

7. It's always impossible to improve on a project by adding new features.
8. After purchase of a product, I try to keep track of new accessories that come out in the market.
9. I enjoy reading and adding on to projects in which I'm involved on a continuing basis.

Scales Related to the Specific Product or the Product Category

- Attachment (Schifferstein & Zwartkruis-Pelgrim, 2008)
  1. I am very attached to my coffee machine / my pair of leather shoes.
  2. My coffee machine / my pair of leather shoes has / have no special meaning for me*.
  3. My coffee machine / my pair of leather shoes is / are very dear to me.
  4. I have a bond with my coffee machine / my pair of leather shoes.

- Attitude towards coffee machine / pair of leather shoes (Ahluwalia & Burnkrant, 2004)
  1. good/bad
  2. pleasant/unpleasant
  3. positive/negative
  4. useful/useless
  5. excellent quality/poor quality

- Disposal Tendency (Mugge, 2007)
  1. I would like to get rid of my coffee machine / my pair of leather shoes.
  2. If it was possible, I would sell my coffee machine / my pair of leather shoes.
  3. I expect to have my coffee machine / my pair of leather shoes in possession for a long time.
  4. I will soon discard my coffee machine / my pair of leather shoes.

- Involvement (Bower & Landreth, 2001; Zaichkowsky, 1985)
  To me, my coffee machine / my pair of leather shoes is:
  1. unimportant – important
  2. of no concern – of concern to me

3. irrelevant – relevant
4. does / do not matter – matters / matter to me

- Quality (Grewal et al., 1998)
  1. My coffee machine / my pair of leather shoes appears / appear to be of good quality.
  2. My coffee machine / my pair of leather shoes appears / appear to be durable.
  3. My coffee machine / my pair of leather shoes appears / appear to be reliable.

- Satisfaction (Crosby & Stephens, 1987)
  1. satisfied – dissatisfied
  2. pleased – displeased
  3. favourable – unfavourable

- Usefulness (Cox & Cox, 2002)
  1. not useful – useful
  2. not functional – functional
  3. not practical – practical

D

Items Used for the Known-Groups Test (Study 2.4)

A. Own scale (bicycle / coffee machine): see Appendix C, from 1 = strongly disagree to 5 = strongly agree

B. Environmental attitude (based on environmental concern subscale by Kilbourne & Pickett, 2008) from 1 = strongly disagree to 5 = strongly agree
   1. I am very concerned about the environment.
   2. Humans are severely abusing the environment.

C. Have you ever visited a repair café? (1 = yes, regularly, 2 = once or twice, 3 = never)

D. How would you judge your level of expertise... (from 1 = low to 5 = high)
   1. ...in repairing complex technical products, such as a coffee maker?
   2. ...in repairing clothes?
   3. ...in repairing simple products such as a bicycle?

Curriculum Vitæ

Illustration by Mahana Tuimaka

Laura Ackermann was born in Aschaffenburg, Germany, in 1985. After completing her secondary education at the Kronberg-Gymnasium in Aschaffenburg, she studied industrial engineering at the Aschaffenburg University of Applied Sciences (2007-2011). During this time, she interned at Daimler AG, Stuttgart, where she was responsible for collecting and analyzing drivers' feedback on vehicles. This experience made her aware of the importance of considering users' needs in the design process. Therefore, she focused on industrial and organizational psychology as well as human-machine interaction during her master's studies in industrial engineering (2011-2012, Kassel University).

After completing her master's degree, Laura worked as a researcher at the Department of Human-machine Systems Engineering at Kassel University. In 2013, she started working as a researcher and lecturer at the Department of Design & Product Management at the Salzburg University of Applied Sciences where she was offered the opportunity to integrate her research work with an external PhD at the Delft University of Technology. She has since completed her bachelor's degree in psychology part-time at the FernUniversität in Hagen (2013-2019) and started the master's program at the University of Salzburg in 2019. After her PhD, Laura will continue doing research and teaching future designers about the relevance of sustainability.

List of Publications

Journal Papers

Ackermann, L. (2018). Design for Product Care: Enhancing Consumers' Repair and Maintenance Activities. *The Design Journal*, *21*(4), 543–551.

Ackermann, L., Mugge, R. & Schoormans, J. P. (2018). Consumers' Perspective on Product Care: An Exploratory Study of Motivators, Ability Factors, and Triggers. *Journal of Cleaner Production*, *183*, 380–391. https://doi.org/10.1016/j.jclepro.2018.02.099

Conference Papers

Ackermann, L. & Tunn, V. S. (2020). Comparing Consumers' Product Care in Product-Service Systems and Ownership Models [Note: both authors contributed equally]. *Proceedings of the Design Society: DESIGN Conference* (pp. 2167–2176). Cambridge University Press. https://doi.org/10.1017/dsd.2020.80

Ackermann, L., Tuimaka, M., Pohlmeyer, A. E. & Mugge, R. (2019). How to Stimulate People to Take Care of Products? – The Development of a Toolkit for Designers. In N. F. Nissen & M. Jaeger-Erben (Eds.), *PLATE: Product Lifetimes And The Environment*. TU Berlin University Press.

Ackermann, L., Mugge, R. & Schoormans, J. P. (2017). Consumers' attitudes towards product care: an exploratory study of motivators, ability factors and triggers. In C. Bakker & R. Mugge (Eds.), *PLATE: Product Lifetimes And The Environment* (pp. 1–4). IOS Press. https://doi.org/10.3233/978-1-61499-820-4-1

Publications in Progress

Ackermann, L., Schoormans, J. P. & Mugge, R. (under revision). Measuring Product Care: Scale Development and Validation. *Journal of Cleaner Production*.

Ackermann, L., Tuimaka, M., Pohlmeyer, A. E. & Mugge, R. (under review-a). Design for Product Care – Development of Design Strategies and a Toolkit for Sustainable Consumer Behaviour. *Journal of Sustainability Research*.

Ackermann, L., Mugge, R. & Schoormans, J. P. (under review-b). 'No Fun, but Very Effective': Consumers' Evaluation of Design Strategies for Product Care. In C. Fitzpatrick (Ed.), *PLATE: Product Lifetimes And The Environment*.

Tunn, V. S. C. & Ackermann, L. (under preparation). Don't be gentle, it's a rental? Product Care in Circular Business Models.

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When I first visited Delft during a holiday in 2013, I already knew about the excellent scientific reputation of TU Delft. What I did not expect was that I immediately fell in love with this town – even though it was raining throughout our stay.

Almost three years later, I was able to start as an external PhD student at TU Delft while still living and working in Austria. This experience allowed me to improve my scientific knowledge and skills, but also to grow personally.

This section is dedicated to all the people who supported me on this adventure, including the many, such as the study participants, who cannot be addressed here specifically.

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Finn, in den letzten Jahren habe ich mehrfach gehört, dass Product Care vergleichbar damit sei, sich um ein Haustier zu kümmern. Solange uns Produkte jedoch nicht so viel Freude, Glück und Entspannung geben wie du es tust, wird dieser Vergleich immer hinken.

Product care is defined as all activities initiated by the consumer that lead to the extension of a product's lifetime. It includes repair and maintenance, as well as preventive measures or general careful handling of a product. Product care is one way to extend a product's lifetime, as it keeps the product in a usable and maintained state for a longer period of time, thereby postponing its replacement. An issue with product care is that it heavily relies on consumers' behaviour once the product is in use. Therefore, the main research question of this thesis is:

How can design foster product care among consumers?

We present the current state of product care among consumers, a scale to measure product care, and design strategies to foster product care. In addition, we explore product care in access-based product-service systems. Using the insights identified in this PhD project, designers can create and redesign products in such a way that care activities will be more likely to be performed.

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