Consumer centric design for refurbishment

How designers can enhance consumer acceptance of refurbished products

Wallner, T.S.

DOI
10.4233/uuid:513908e3-10e3-4789-b81b-f2e91658f248

Publication date
2023

Document Version
Final published version

Citation (APA)
Wallner, T. S. (2023). *Consumer centric design for refurbishment: How designers can enhance consumer acceptance of refurbished products*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:513908e3-10e3-4789-b81b-f2e91658f248

Consumer centric design for refurbishment:

How designers can enhance consumer acceptance of refurbished products

TU Delft

This research was funded by This work was funded by Delft University of Technology (grant 912485; 2018).

Front & Back cover design:	Theresa Wallner
Published by:	Delft University of Technology
Lay-out by:	Douwe Oppewal
Printed by:	Gildeprint, www.gildeprint.nl

ISBN/EAN: 978-94-6366-657-2

An electronic version of this dissertation is available at: http://respository.tudelft.nl
The data used for this dissertation can be accessed via DOI 10.17605/OSF.IO/KQBZT

Dissertation
for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus prof.dr.ir. T.H.J.J. van der Hagen
Chair of the Board for Doctorates
to be defended publicly on
Friday 24 February 2023 at 12.30 o'clock

by

Theresa Stephanie WALLNER

Master of Science (Research) in Psychology,
University of Amsterdam, The Netherlands
born in Darmstadt, Germany

This dissertation has been approved by the promotors.

Composition of the doctoral committee:

Rector Magnificus	chairperson
Prof. dr. ir. R. Mugge	Delft University of Technology, promotor
Dr. L.B.M. Magnier	Delft University of Technology, copromotor

Independent members:

Prof. dr. ir. V.H. Gruis	Delft University of Technology
Prof. dr. ir. C.A. Bakker	Delft University of Technology
Prof. dr. J. Vanhamme	EDHEC Business School, France
Prof. dr. F. van Harreveld	University of Amsterdam
Dr. W. Baxter	Imperial College London, England

To my family

Table of contents

English Summary

Global warming will exceed 1.5-2°C during the 21st century unless greenhouse gas emissions are heavily reduced in the next 30 years. The average carbon footprint of a person living in the European Union amounted to 6.7 tons of CO_2 in 2019, of which 70% is related to the way we live, move and consume. The production and use of electronics, is an important factor in the environmental impact of consumption. A key strategy to reduce an electronic product's environmental footprint is to extend its lifetime through refurbishment.

Refurbished products are collected after being used, tested, cleaned, and restored into an acceptable state, and subsequently, they are resold. Yet, lowering the environmental impact of consumption by using refurbished products requires that refurbished products are acquired instead of new ones. However, refurbished products are not as desirable to consumers as new products, which has the consequence that they have lower purchase intentions and are willing to pay less for them.

The aim of this thesis is to understand consumer acceptance of refurbished products and how designers can enhance their desirability. Thus far, marketing strategies, aiming to improve consumer adoption of refurbished products have focused on minimizing the risks associated with refurbished products and underlining their benefits. Refurbished products are, for example, often offered at a lower price than new products and with a warranty. A central issue of these marketing strategies is that they are peripheral to the product, are not applicable to all product categories, and are not appropriate for all consumers. While they can improve the trade-off for refurbished products, they do not help to keep the product at its highest material and economic value.

In this dissertation, we, therefore, explore the main research question: how can designers enhance consumer acceptance of refurbished products by design?

This thesis contributes to the literature by extending the consumer-centric perspective on refurbishment and informing manufacturers and designers about potential design strategies that make the refurbished products more desirable, and that may help to retain the value of refurbished products over multiple life cycles. In contrast to prior research, the focus is on consumer electronics, such as headphones, blenders, radios, and personal care products. To research how to enhance the desirability of refurbished products, we used a mixed-methods approach using methods from different disciplines, such as design, psychology, marketing, and consumer behaviour.

In chapter 1, the research rationale, literature background, research questions and the general outline as described. Chapters 2 and 3 investigate how product appearance contributes to the consumer acceptance of refurbished products. In the second chapter, we explore consumer responses to two design styles that were suggested to be timeless

with in-depth consumer interviews. We investigate the neo-retro design style that evokes nostalgia and benefits from associations with the past and the simplistic design style that is independent of cultural or time-related cues. Our findings provide qualitative support that the neo-retro and the simplistic design styles can improve consumers' evaluations of refurbished products; refurbished products following these design styles are not only considered to be timeless but also more aesthetically attractive. While refurbished neo-retro products benefit from associations with the good quality of the past, refurbished, simplistic products are perceived to be more durable because they are perceived to be so simple that nothing can break. In this chapter, durability is a recurring theme; participants favour products that looked durable and prefer refurbished products made of high-quality materials, such as wood, leather, and metal, because of their durability. Based on these findings, we conclude in chapter 2 that design plays a crucial role in the consumer acceptance of refurbished products. Hence, we propose that designers should emphasize timelessness and durability when designing products for multiple life cycles. We believe that this can ultimately extend the aesthetic lifespan of a product and make it more attractive and, subsequently, more desirable in a refurbished state.

In chapter 3, we examine which factors predict the purchase intentions of refurbished products compared to the factors that predict new products in a quantitative study. This ultimately had the goal of determining the relative importance of design-related factors, such as the product's durability, in the choice for refurbished or new products. Building on the findings of chapter 2, a regression analysis shows that the durability and attractiveness of the product appearance indeed have a positive effect on the purchase intentions of refurbished products. Yet, against our expectations, our results indicate that the product's durability does not play a more prominent role in the choice for refurbished products than for new products. Similarly, the perceived attractiveness of products did not play a more prominent role for refurbished products than for new products. Furthermore, we found that the consumers' environmental concerns and the perceived contamination risk influence the purchase intentions of refurbished products, whereas there are no effects of these factors for new products. Hence, we propose that contamination risk needs to be considered when designing products that have multiple lifecycles and will be refurbished at a later stage. How to address contamination by design is subject to this thesis' last chapters.

In chapter 3, we only included four factors important in determining the purchase intentions of refurbished products due to the focus on product appearance. Hence, in chapter 4, we model the complex interplay of product-related, marketing-related and consumer-related factors in a network analysis. We investigate two product categories (earbuds and speakers) that differ in the degree to which they evoke consumers' contamination concerns. Our findings indicate that the most significant factors related to the intention to purchase refurbished products are the product category, the perceived risk,

and the perception that refurbished products are contaminated by their prior user. These two product categories also differ in which factors are most strongly related to purchase intentions. For refurbished speakers, the belief that refurbished products are financially attractive and the perceived risk are the largest predictors of purchase intentions. For refurbished earbuds, participants' feeling that the product is contaminated by their prior user (territorial contamination) and that earbuds are perceived to be unhygienic because they had been previously used (hygienic contamination) are most strongly linked to the purchase intentions. Depending on the product category, the perceived contamination even seems more important than the price reduction of the refurbished product. We, therefore, conclude that strategies aiming to enhance consumer acceptance of refurbished products should, first and foremost, focus on reducing risks and contamination concerns.

From our research in chapter 4, it was not yet clear how contamination concerns can be addressed in order to increase consumer acceptance of refurbished products. Chapter 5, therefore, explores the effects of possible design and marketing strategies on the choice of refurbished headphones with a conjoint analysis. More specifically, we test the importance of three contamination-reducing strategies, including 1. communication about the clean object state, 2. eliminating signs of use (aesthetic and functional signs of wear and tear) and 3. renewing parts that touch the skin (e.g., ear-cushions). Additionally, we analyse whether different consumer groups are driven by various attributes of refurbished headphones. Our results demonstrate that most consumers value refurbished products that show no signs of wear and tear and that have parts touching the skin renewed during the refurbishment process. Our research shows that these attributes are even more important than the reduced price or warranty, even though these are frequently used for marketing refurbished products. Furthermore, chapter 5 shows that depending on the consumer group, other contamination-reducing strategies are of great influence. While some consumer groups highly value that aesthetic signs of prior use are eliminated through an as-new appearance, others prefer refurbished products with an as-new performance. In contrast to this, for a small consumer group that we called the reuse-enthusiasts, we propose an alternative strategy; contamination could be embraced by designing products that are timeless, durable and become more beautiful with age. Based on our research in chapter 5, we hence recommend four design strategies aimed at decreasing contamination concerns with refurbished products: 1. designing for an as-new appearance, 2. designing for an as-new functionality, 3. designing for cleanability and 4. embracing contamination. Despite these interesting insights, it remained unclear what the underlying reasons for consumers' contamination concerns are and how contamination concerns relate to the product (e.g., wear and tear), the context (marketing), and the consumer itself (e.g., consumer characteristics).

In chapter 6, we explore, with in-depth interviews, why consumers have contamination concerns with personal care products, a product category that triggers even

more contamination concerns. Next to exploring how the product design can prevent contamination concerns, we investigate how marketing strategies can compensate for refurbished personal care products that are perceived to be contaminated. In this qualitative study, we uncover that refurbished personal care products with signs of wear and tear are perceived to be a riskier choice and are expected to malfunction, have a shorter product lifetime and to be contaminated by their prior user. Based on the location and number of scratches, consumers make inferences about how the preceding user treated the device. While light wear and tear indicates everyday use, heavy signs of wear and tear are interpreted as a sign of bad treatment by the previous user. To keep refurbished personal care products at their highest value, we, therefore, suggest five design strategies to minimize contamination concerns by designing a product that smells and looks hygienic after multiple lifecycles: 1. using colours that evoke associations with hygiene, 2. making signs of wear and tear less visible, 3. using smooth (cleanable) materials, 4. minimizing the number of split lines in the product, and 5 giving refurbished products a clean product smell. For refurbished personal care products with signs of wear and tear that cannot be eliminated, we propose mitigating consumers' contamination concerns with marketing strategies.

Finally, in chapter 7, the main findings and conclusions are summarized and discussed. Subsequently, implications for theory about consumer acceptance of refurbished and practical implications for designers and marketers are discussed. Furthermore, in the last chapter, the limitations of our studies, potential avenues for future research and refurbishment, in general, are reflected upon.

To conclude, refurbishment can reduce the environmental impact of our consumption by substituting the purchase of new products. However, to become a viable alternative to new products, refurbished products must retain their value over time. While marketing strategies can make refurbished products more attractive, they do not help to keep refurbished products at their highest value. This thesis concludes that designers need to take the refurbished product stage into account when designing the original product. Only considering refurbishment in the initial design can ensure that the product can obtain an as-new look and functionality when it is later refurbished. If refurbished products do not have an as-new look and functionality, consumers perceive them to be a riskier choice and to be contaminated by their prior use. Consequently, refurbished products lose their ecological and economic value. For products that are already on the market, we suggest following several steps during the refurbishment process to keep refurbished products at their highest value. If the product itself cannot be kept at its highest environmental and economic value through refurbishment, we suggest resorting to marketing strategies to enhance the consumer acceptance of refurbished products, such as lowering their price.

Dutch Summary

De opwarming van de aarde zal in de 21e eeuw meer dan 1,5-2°C bedragen, tenzij de uitstoot van broeikasgassen in de komende 30 jaar sterk wordt verminderd. De gemiddelde CO_2-voetafdruk van een persoon in de Europese Unie bedroeg in 2019 6,7 ton CO_2, waarvan 70% gerelateerd is aan de manier waarop we leven, bewegen en consumeren. De productie en het gebruik van elektronica draagt sterk bij aan de milieu-impact van consumptie. Een belangrijke strategie om de ecologische voetafdruk van elektronica te verkleinen is het verlengen van de levensduur door refurbishment.

Refurbished producten zijn producten die na gebruik worden ingezameld, getest, schoongemaakt en in een acceptabele staat gebracht, waarna ze worden verkocht. Om de milieu-impact van consumptie te verminderen door het gebruik van refurbished producten, moeten deze worden aangeschaft in plaats van nieuwe. Refurbished producten zijn voor consumenten echter minder aantrekkelijk dan nieuwe producten, met als gevolg dat ze een lagere aankoopintentie hebben en bereid zijn er minder voor te betalen.

Het doel van dit proefschrift is inzicht te krijgen in de acceptatie van refurbished producten door consumenten en hoe ontwerpers de aantrekkelijkheid van refurbished producten kunnen vergroten. Tot dusver zijn marketingstrategieën om de consumentenacceptatie van refurbished producten te verbeteren erop gericht de risico's van refurbished producten te verminderen en de voordelen ervan te onderstrepen. Refurbished producten worden bijvoorbeeld vaak aangeboden tegen een lagere prijs dan nieuwe producten en met een garantie. Een centraal probleem van deze marketingstrategieën dat ze niet helpen om de economische en ecologische waarde te behouden, niet voor alle productcategorieën gelden en niet voor alle consumenten van toepassing zijn. Hoewel deze marketingstrategieën de tradeoff voor refurbished producten kunnen verbeteren, helpen ze niet om het product op zijn hoogste materiële en economische waarde te houden.

In dit proefschrift onderzoeken we daarom de belangrijkste onderzoeksvraag: hoe kunnen ontwerpers de acceptatie van refurbished producten door de consument verbeteren door middel van het design?

Dit proefschrift draagt bij aan de literatuur door het consumentgerichte perspectief op refurbishment uit te breiden en fabrikanten en ontwerpers te informeren over mogelijke ontwerpstrategieën die refurbished producten aantrekkelijker maken en die kunnen helpen om de waarde van refurbished producten gedurende meerdere levenscycli te behouden. In tegenstelling tot eerder onderzoek ligt de nadruk op consumentenelektronica, zoals koptelefoons, blenders, radio's en producten voor

persoonlijke verzorging. Om te onderzoeken hoe de acceptatie van refurbished producten kan worden vergroot, hebben we een mixed-methods aanpak gebruikt met methoden uit verschillende disciplines, zoals design, psychologie, marketing en consumentengedrag.

In hoofdstuk 1 zijn de onderzoek rationale, literatuurachtergrond, onderzoeksvragen en de algemene opzet beschreven. In hoofdstukken 2 en 3 wordt onderzocht hoe het productontwerp bijdraagt aan de consumentenacceptatie van refurbished producten. In het tweede hoofdstuk onderzoeken we door middel van diepte-interviews met consumenten de reacties van consumenten op twee ontwerpstijlen die als tijdloos worden beschouwd: de neo-retro ontwerpstijl die nostalgie oproept en voordeel haalt uit associaties met het verleden, en de simplistische ontwerpstijl die onafhankelijk is van culturele of tijdsgebonden signalen. Onze kwalitatieve bevindingen wijzen erop dat de neo-retro en de simplistische designstijlen de beoordeling van refurbished producten door de consument kunnen verbeteren; refurbished producten in deze designstijlen werden niet alleen tijdloos, maar ook esthetisch aantrekkelijker gevonden. Terwijl refurbished neo-retro producten profiteren van associaties met de goede kwaliteit uit het verleden, worden refurbished simplistische producten als duurzamer ervaren, omdat ze zo eenvoudig werden geacht dat er niets kapot kan gaan. In dit hoofdstuk was degelijkheid een terugkerend thema; deelnemers gaven de voorkeur aan refurbished producten die er degelijk uitzien en aan refurbished producten van hoogwaardige materialen zoals hout, leer en metaal vanwege hun degelijkheid. Op basis van deze bevindingen concluderen we in hoofdstuk 2 dat design een belangrijke rol speelt bij de acceptatie van refurbished producten. Daarom stellen we voor dat ontwerpers de tijdloosheid en degelijkheid benadrukken bij het ontwerpen van producten voor meerdere levenscycli. Wij geloven dat dit uiteindelijk de esthetische levensduur van een product kan verlengen en het aantrekkelijker, en dus gewilder, kan maken in een refurbished staat.

In hoofdstuk 3 onderzoeken we welke andere factoren de aankoopintentie van refurbished producten voorspellen en hoe dit verschilt van de factoren die de aankoopintentie van nieuwe producten voorspellen. Dit had uiteindelijk tot doel het relatieve belang te bepalen van ontwerp gerelateerde factoren, zoals de degelijkheid van het product, bij de keuze voor refurbished of nieuwe producten. Voortbouwend op de bevindingen van hoofdstuk 2 blijkt uit een regressieanalyse dat de degelijkheid en aantrekkelijkheid van het uiterlijk van het product inderdaad een positief effect hebben op de aankoopintentie van refurbished producten. Maar tegen onze verwachtingen in blijkt de degelijkheid van het product geen grotere rol te spelen bij de keuze voor refurbished producten dan voor nieuwe producten. Ook de waargenomen aantrekkelijkheid van producten speelde bij refurbished producten geen grotere rol dan bij nieuwe producten. Daarnaast vonden we dat de bezorgdheid van de consument over

het milieu en het waargenomen contaminatierisico de aankoopintentie van refurbished producten beïnvloeden, terwijl deze factoren geen effect hebben op de aankoop van nieuwe producten. Wij stellen dan ook voor dat bij het ontwerpen van producten die meerdere levenscycli hebben en in een later stadium zullen worden gerefurbished, rekening moet worden gehouden met deze contaminatie. Hoe dergelijke contaminatie door middel van het ontwerp moet worden aangepakt, is daarom onderwerp van de laatste hoofdstukken van dit proefschrift.

Vanwege de focus op het productontwerp zijn in hoofdstuk 3 niet alle factoren meegenomen, die van belang zijn bij het bepalen van de aankoopintenties van refurbished producten. Daarom modelleren we in hoofdstuk 4 het complexe samenspel van product-gerelateerde, marketing-gerelateerde en consument-gerelateerde factoren in een netwerkanalyse. We onderzoeken twee productcategorieën (oordopjes en luidsprekers) die verschillen in de mate waarin ze de contaminatieproblematiek bij consumenten oproepen. Uit onze bevindingen blijkt dat de volgende factoren het sterkst verband houden met de koopintentie van refurbished producten: de productcategorie, het ervaren risico en de perceptie dat refurbished producten gecontamineerd zijn door hun vorige gebruiker. De twee productcategorieën verschillen in de factoren die het sterkst samenhangen met de aankoopintentie. Voor refurbished luidsprekers zijn de overtuiging dat refurbished producten financieel aantrekkelijk zijn en het waargenomen risico de grootste voorspellers van de aankoopintentie. Voor refurbished oordopjes zijn de overtuiging dat het product door de vorige gebruiker is gecontamineerd (territoriale contaminatie) en dat oordopjes als onhygiënisch worden ervaren omdat ze eerder zijn gebruikt, de grootste voorspellers van de aankoopintentie. Afhankelijk van de productcategorie lijkt de ervaren contaminatie zelfs belangrijker dan de prijsverlaging van het refurbished product. De conclusie van dit hoofdstuk was dan ook dat strategieën om de acceptatie van refurbished producten door de consument te verbeteren zich in de eerste plaats moeten richten op het verminderen van risico's en waargenomen contaminatie.

Uit ons onderzoek in hoofdstuk 4 werd niet duidelijk hoe contaminatie problemen worden aangepakt. Hoofdstuk 5 onderzoekt daarom met een conjoint analyse de hoe belangrijk ontwerp- en marketingstrategieën, gericht op het verminderen van contaminatie, zijn in de keuze voor refurbished koptelefoons. Meer specifiek testen we het belang van de volgende drie contaminatie-verminderende strategieën: 1. communicatie over de staat van het schone object, 2. het elimineren van tekenen van gebruik (esthetische en functionele tekenen van slijtage) en 3. het vernieuwen van onderdelen die de huid raken (bijv. oorkussens). Daarnaast analyseren we of verschillende consumentengroepen zich laten leiden door verschillende kenmerken van refurbished hoofdtelefoons. Uit onze resultaten blijkt dat de meeste consumenten waarde hechten aan refurbished producten die geen tekenen van slijtage vertonen

en waarbij onderdelen, die de huid raken tijdens het refurbishment proces worden vernieuwd. Uit ons onderzoek blijkt dat deze kenmerken nog belangrijker zijn dan de gereduceerde prijs of de garantie, ook al worden deze laatste vaak gebruikt om refurbished producten op de markt te brengen. Verder bleek uit hoofdstuk 5 dat, afhankelijk van de consumentengroep, andere strategieën om contaminatie tegen te gaan van grote invloed zijn. Terwijl sommige consumentengroepen veel waarde hechten aan het verwijderen van esthetische tekenen van eerder gebruik door een "als nieuw"-uiterlijk, geven andere groepen de voorkeur aan refurbished producten met een "als nieuw"-functioneren. Voor een kleine groep consumenten, die we de hergebruik-enthousiastelingen hebben genoemd, stellen we daarentegen een alternatieve strategie voor; contaminatie zou kunnen worden omarmd door producten te ontwerpen die tijdloos en duurzaam zijn en mooier worden naarmate ze ouder worden. Op basis van ons onderzoek in hoofdstuk 5 adviseren we daarom vier ontwerpstrategieën die erop gericht zijn de bezorgdheid over contaminatie bij refurbished producten te verminderen: 1. ontwerpen voor een als-nieuw uiterlijk, 2. ontwerpen voor een nieuwe functionaliteit, 3. ontwerpen voor reinigbaarheid en 4. contaminatie omarmen. Ondanks deze interessante inzichten was het nog onvoldoende duidelijk waarom consumenten bezorgd zijn over contaminatie en hoe dit verband houdt met het product (bijv. slijtage), de context (marketing) en de consument zelf (bijv. consumenten karakteristieken).

In hoofdstuk 6 onderzoeken we met diepte-interviews waarom consumenten zorgen over contaminatie hebben bij persoonlijke verzorgingsproducten, een productcategorie die veelal extra zorgen over contaminatie oproept. In het hoofdstuk, onderzoeken we verder hoe het productontwerp zorgen over contaminatie kan voorkomen. Daarnaast onderzoeken we ook hoe marketingstrategieën refurbished verzorgingsproducten die als gecontamineerd worden ervaren alsnog aantrekkelijker kunnen maken. De resultaten van deze kwalitatieve studie laten zien dat refurbished verzorgingsproducten met tekenen van slijtage worden gezien als een riskantere keuze en dat verwacht wordt dat ze slechter werken, een kortere levensduur hebben en gecontamineerd zijn door de vorige gebruiker. Op basis van de plaats en het aantal krassen maakt de consument uit hoe de vorige gebruiker het apparaat heeft behandeld. Terwijl lichte slijtage duidt op normaal gebruik, worden zware tekenen van slijtage geïnterpreteerd als een teken van slechte behandeling door de vorige gebruiker. Om refurbished producten voor persoonlijke verzorging zo waardevol mogelijk te houden, stellen wij daarom de volgende vijf ontwerpstrategieën voor om de bezorgdheid over contaminatie te minimaliseren door een product te ontwerpen dat na meerdere levenscycli hygiënisch oogt en ruikt: 1. kleuren gebruiken die associaties oproepen met hygiëne, 2. tekenen van slijtage minder zichtbaar maken, 3. gladde (reinigbare) materialen gebruiken, 4. het aantal breuklijnen in het product minimaliseren, en 5. refurbished producten een schone geur geven. Voor refurbished verzorgingsproducten met tekenen van slijtage die niet

kunnen worden geëlimineerd, stellen we voor de bezorgdheid van de consument over contaminatie te verminderen met marketingstrategieën. Tenslotte worden in hoofdstuk 7 de belangrijkste bevindingen en conclusies samengevat en besproken. Vervolgens worden implicaties voor de theorie over de consumentenacceptatie van refurbished producten en praktische implicaties voor ontwerpers en marketeers bediscussieerd. Tot slot wordt in het laatste hoofdstuk ingegaan op de beperkingen van ons onderzoek, mogelijke wegen voor toekomstig onderzoek en refurbishment in het algemeen.

Concluderend kan refurbishment de milieu-impact van onze consumptie verminderen door de aanschaf van nieuwe producten te reduceren. Om echter een levensvatbaar alternatief voor nieuwe producten te worden, moeten refurbished producten hun waarde in de loop van de tijd behouden. Hoewel marketingstrategieën refurbished producten aantrekkelijker kunnen maken, helpen ze niet om ze hun hoogste waarde te laten behouden.

In dit proefschrijft wordt geconcludeerd dat ontwerpers bij het ontwerpen van het oorspronkelijke product rekening moeten houden met het stadium van het opgeknapte product. Alleen rekening houden met refurbishment in het initiële ontwerp kan ervoor zorgen dat het product een as-nieuw uiterlijk en functionaliteit krijgt wanneer het later wordt refurbished. Als opgeknapte producten er niet als nieuw uitzien en niet goed functioneren, beschouwen consumenten ze als een riskantere keuze en als gecontamineerd door hun eerdere gebruik. Als gevolg verliezen opgeknapte producten hun ecologische en economische waarde. Voor producten die al op de markt zijn, stellen wij voor tijdens het opknapproces verschillende stappen te volgen om opgeknapte producten hun hoogste waarde te laten behouden. Als dit niet kan, stellen wij voor om marketingstrategieën te gebruiken, zoals het verlagen van de prijs, die de consumenten acceptatie van opgeknapte producten te vergroten.

CHAPTER 1

Introduction

In 2001, I inherited my first pair of headphones. The new Walkman-headphones combination gave me unprecedented freedom of movement, and the sound was magnificent– but the best of all? The headphones smelled like my father's aftershave!

Twenty years later, I bought my third pair of headphones. The technological advancements in the past 20 years have made headphones cordless, the headphones respond to speech commands, and they can cancel out background noise. And the sound – it is even more magnificent! When purchasing headphones, I had different options. Either I could buy new headphones costing me 270 euros during a Black Friday deal, headphones in a second-hand state for about half the price but with no guarantee that they would actually work, or headphones in a refurbished state for 240 euros. My choice was clear: I would go for the refurbished ones! At a slightly lower price, I would receive a pair of guaranteed well-functioning headphones with a year of warranty. On top of the financial benefits, purchasing refurbished headphones would also have a lower environmental impact than buying new headphones. Win-win-win? So, I thought until I put them on for the first time. They smelled like a man's perfume! And this time, I didn't appreciate the smell as much.

This anecdote illustrates the choices and some of the risks and benefits consumers experience when buying refurbished products. Refurbished products are products that are collected after being used, tested, restored into an acceptable state, cleaned and subsequently, resold (see Figure 1, Pigosso et al., 2010). Through collecting, refurbishing and reselling products, new business models are created, opening up new streams of revenue and creating new jobs (McMahon et al., 2021). Perhaps the most important reason to buy refurbished products is that one can reduce their environmental footprint by minimizing the generation of greenhouse gases, electronic waste and use of critical raw materials (Ellen MacArthur Foundation, 2016). However, refurbished products are not always desirable to consumers, which has the consequence that consumers have lower purchase intentions and are willing to pay less for them. This thesis investigates the role of product design and marketing in enhancing the consumer acceptance of refurbished products.

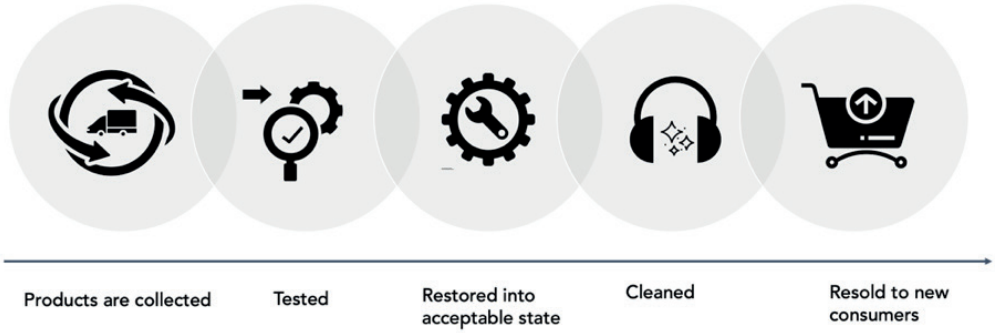


Figure 1. Refurbished products are collected after their first use, tested, restored into an acceptable state, cleaned and then resold to new consumers.

1.1 Research Rationale: Reducing the environmental impact of consumption through refurbishment

Refurbishment can help to reduce the environmental footprint of our consumption and can help to minimize electronic waste. Especially the extraction of raw materials and the industrial process needed to manufacture new electronic products contribute to the emission of greenhouse gases. The production phase of electronic products requires enormous amounts of energy and raw materials. For instance, 600kg of raw materials need to be extracted to manufacture a laptop weighing 2kg, and during the production, 227–270 kg of CO_2 are emitted (ADEME, 2021; Deng et al., 2011). Partly due to our consumption, the average carbon footprint of a person living in the European Union (EU) equals 6.7 tons of CO_2 annually (Eurostat, 2021). Greenhouse gas emissions are likely the main driver of global warming and, subsequently, the retreat of glaciers and sea level rise. Global warming already affects regions across the globe and can lead to an increase in extreme weather events, such as heatwaves, heavy precipitation (cloudiness), droughts, storms, and biodiversity loss (IPCC, 2021). Global warming will exceed 1.5-2°C during the 21st century unless deep reductions in the emissions of CO_2 and other greenhouse gas emissions occur (IPCC, 2022). Therefore, the EU has set the target to reduce their carbon emissions by 55% by 2030 and has the ambition to reach net zero by 2050. Until then, every additional ton of greenhouse gas emissions released into the environment contributes to global warming (IPCC, 2021).

Greenhouse gases are, however, not the only unintended negative impact of our consumption. In the EU, annually, almost 8.5 million tons of electronic waste are produced, most of which end up in landfills, where it can harm the environment by releasing toxic substances into the atmosphere and groundwater (Eurostat, 2019). At the same time, resources that are used to build electronic devices are finite resources (European Commission, 2020). A smartphone, for example, contains 42 different minerals on average (see example in Figure 2), all of which are not only finite but also mined at the expense of the environment and great human costs (Broad, 1980; Le Billon, 2007).

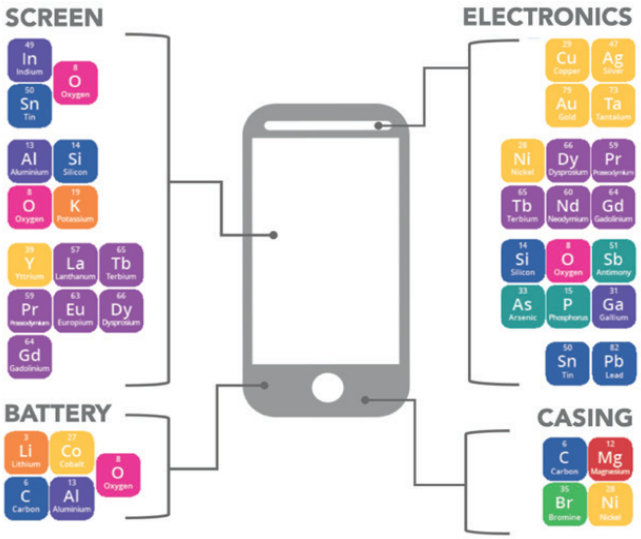


Figure 2. The average smartphone contains about 42 raw materials, of which most of them are critical

Critical materials are not only scarce resources, which will become inevitably more expensive to mine the more the concentration of minerals diminishes, but they are also associated with an increase in conflict, crime, and eruption of violence in areas where they are mined (e.g., Le Billon, 2007; Broad, 1980). The United Nations, therefore, call for more "responsible production and consumption patterns" by decoupling our environmental impact from the welfare of all (UNEP, 2015). Sustainable consumption is defined as "a holistic approach to minimizing the negative environmental impacts from consumption and production systems while promoting quality of life for all" (UNEP, 2015).

1.2 From linear to circular consumption

Decoupling our consumption from negative environmental impacts was described to be probably the largest challenge in post-modern history and requires us to change the way we produce electricity, eat and move (Bocken et al., 2022). One way of reducing the environmental impact caused by the consumption of electronic products is to shift our current linear consumption patterns to circular ones (European Commission, 2020). Currently, our economy is mainly linear; in a linear economy, critical raw materials are mined, used to manufacture products, and products are often discarded after one use cycle, after which they lose their value. Hence, after being used, products lose their material as well as economic value (Ellen MacArthur Foundation, 2016), ultimately depleting resources and hindering long-term economic and social prosperity. However, to keep products at their highest economic value and save products from becoming waste, we need to transition to an economic system in which products retain their value. The circular economy is such a regenerative system in which resource inputs and waste, emissions, and energy leakage are minimized. This can be achieved by keeping products in the loops of the circular economy as long as possible (Geißdörfer et al., 2017). The concept of the circular economy is frequently depicted in the form of a butterfly diagram (see Figure 3).

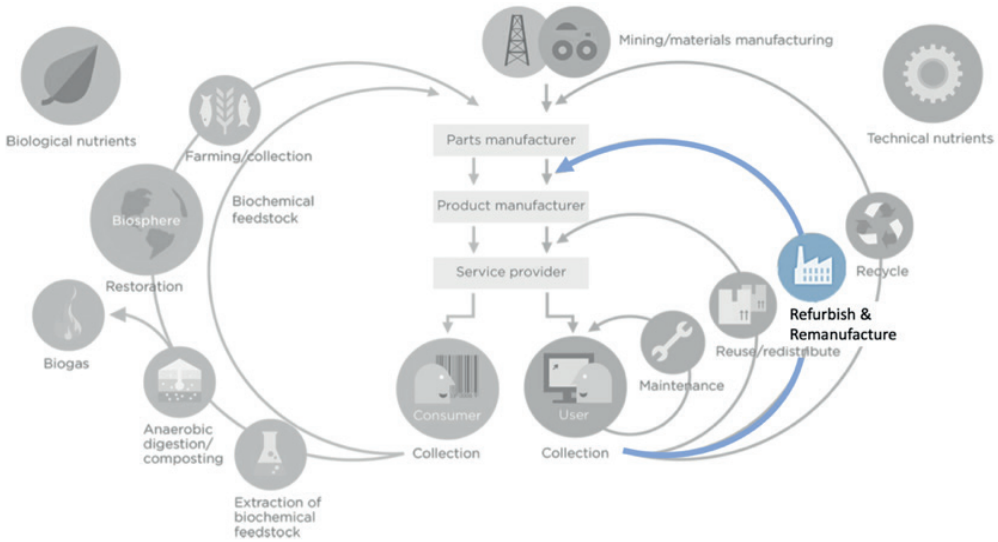


Figure 3. An overview of key circular strategies with an emphasis on refurbishment (Ellen MacArthur Foundation, 2013)

Strategies aiming to reduce the environmental footprint of the production and use of electronic products currently take place in the loops depicted on the right side of the diagram. The most preferred strategies in a circular economy try to maintain the highest utility and value of products by keeping products or components intact (Achterberg et al., 2016). This can be achieved through extending use periods either with the first owner via maintenance and repair or a successful subsequent life via reuse, refurbishment or remanufacturing (Ellen MacArthur Foundation, 2016). According to the value hill (Achterberg et al., 2016), products and components have the lowest negative environmental impact when they are kept longer and are maintained, repaired, or reused (e.g., sold on the second-hand market) without being renewed. However, many products in an economy have to circulate among multiple users and substitute manufacturing new products. This can be achieved through refurbishment and remanufacturing. While refurbishment is defined as the product being tested and brought into an *acceptable state*, remanufacturing includes an industrial process in which a product is always disassembled and brought into an *as-new state* (Hatcher et al., 2011). For example, a remanufactured smartphone would always receive a new battery during the remanufacturing process, while a refurbished phone would potentially keep the original battery if it functions at 95% of its original capacity. Circular lifetime extension strategies save production costs, such as energy, water, and virgin resources that would be needed to manufacture new or recycled products. In contrast to the inner loops, recycling has received a lot of attention in the circular economy, even though it can only be part of the solution when it comes to electronic products (Potting et al., 2018). In fact, from an environmental perspective, it is one of the less preferable circular strategies because it involves products being taken back from the consumer, disassembled, and the materials shredded and reprocessed before a new product can be made and sold. This often requires more energy and resources than producing new materials or exchanging small parts during the maintenance of products (Potting et al., 2018). Furthermore, in recycling, certain materials are still lost as it is not economically viable to take out materials that are present in products in small amounts. To support a transition to the circular economy, manufacturers, designers, waste managers, and policymakers should hence shift their focus from recycling to reuse strategies to retain the value of products for as long as possible (Zacho et al., 2018). Especially designers have a powerful role in the transition to the circular economy because "better design can make products more durable or easier to repair, upgrade or remanufacture" (EPRS, 2017, p. 7) as described by the European commission. Next to making the product easy to refurbish from a technical perspective, designers play a key role in designing products that remain desirable to consumers in their second and perhaps subsequent lives.

1.3 Refurbishment can be a viable business model to extend the lifetime of products

Through refurbishment, products can be kept in the loop, and therefore, have a lower environmental impact compared to manufacturing new products or recycling products (Pigosso et al., 2010). For example, refurbishing smartphones can reduce their carbon footprint by 87% as opposed to manufacturing new ones (Zumegen, 2020). Additionally, refurbishment can lead to new streams of revenue and the creation new jobs (McMahon et al., 2021).

To make refurbishment a successful business model, two conditions need to be met: First, products must be refurbishable from a technical perspective (Hatcher et al., 2011; Ijomah et al., 2007; Östlin et al., 2009). Second, refurbished products must be a financially attractive business opportunity (Atasu et al., 2008, 2010; Hatcher et al., 2011). The first aspect is related to the product architecture. Refurbishment entails that components that do not sufficiently perform or malfunction are changed during the refurbishment process. However, many products are technologically complex and were designed to be durable (e.g., resistant to shocks and water). As a consequence, many products are difficult to disassemble, which makes repairing or substituting parts difficult and time-consuming (De Fazio et al., 2021). Consequently, products become more expensive to refurbish for manufacturers and refurbishment parties and, therefore, less economically viable (Boothroyd & Alting, 1992; De Fazio et al., 2021; Kwak et al., 2009).

Another important aspect that determines whether refurbishment can be a financially viable business model is that consumers are willing to pay enough for them (Blomsma & Tennant, 2020). Refurbishment is not a new concept. Houses, antiques, cars, and bicycles have been refurbished for decades and are the norm rather than the exception. That consumer electronics are refurbished is, however, a recent development. Smartphones or computers are nowadays sometimes refurbished and sold via the manufacturer's website (e.g., Apple) and web shops, such as Backmarket, Refurbed or Rebuy. However, in comparison to houses and, to some extent, cars, refurbished consumer electronic products are generally seen as less desirable compared to new products because they are perceived to have lower value, durability, performance, and quality (Mugge et al., 2017b). In the transition to a circular economy, more electronic products will have to be kept in the loop through refurbishment and ultimately substitute new products. If refurbished products are to substitute new products using and acquiring refurbished products needs to result in a similar satisfaction and use level as new products. Hence, to increase the number of refurbished products on the market and decrease the number of new products, it is crucial to develop refurbished products that are and remain desirable to consumers (Blomsma & Tennant, 2020; Jiménez-Parra et al., 2014).

1.4 Decision-making for or against refurbished products

To give an overview of factors that influence the desirability of refurbished products, we will break down the decision-making process of consumers regarding refurbished products into different steps. Based on qualitative interviews, Van Weelden et al. (2016) developed an integrated overview of the different phases that consumers go through in the decision-making process for or against refurbished products. This model was originally based on the Engel Kollat Blackwell (EKB)-Model of consumer behaviour (Engel et al., 1968) and describes consumer decision-making as a problem-solving process. In the next section, I will describe the four stages of Van Weelden's model of consumer decision-making regarding refurbished products with the example of me buying headphones (see Figure 4).

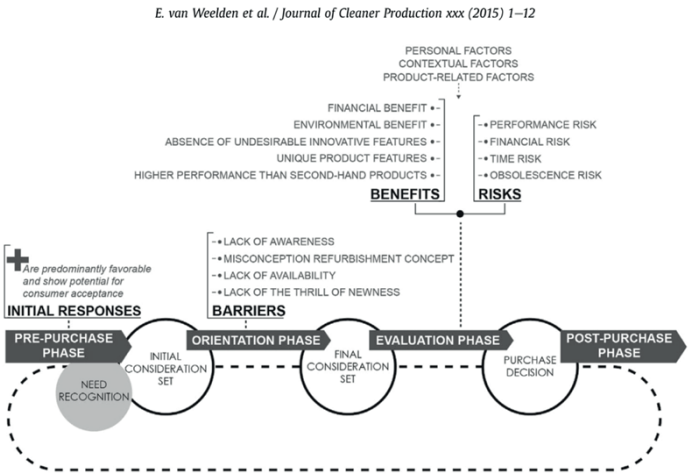


Figure 4. Model of consumer-decision making process showing the main factors that influence consumer acceptance of refurbished products (van Weelden et al., 2016).

In the decision-making process, consumers start in a pre-purchase phase, in which they recognize a need or a problem (Van Weelden et al., 2016), such as me wanting to buy headphones that are wireless, as described in the anecdote at the beginning of this dissertation. In this phase, consumers usually already have an initial consideration set of ideas, attitudes and impressions of what headphones exist (Singhal et al., 2019) and what they might want based on their knowledge and memories (memory retention, Engel et al., 1968). I, for example, had been exposed to marketing about wireless headphones and stories that friends told me about the exceptional noise-cancelling quality of their

headphones. Through this, I formed an initial idea of what kind of features I wanted my future headphones to have. Doing research on refurbishment, I was also aware of the different product states that I could choose from, such as new products, refurbished products and second-hand products, and I had my initial preference (refurbished, of course). With this initial consideration set in mind, consumers go into the second phase, an orientation phase in which they look for different options and alternatives (information phase; Van Weelden et al., 2016). In this phase, barriers can prevent consumers from buying refurbished products, such as people simply not being aware that refurbished products exist, they are not sure what refurbishment means or mistake it to be the same as second-hand (Van Weelden et al., 2016). Other barriers are that refurbished products are not available everywhere all the time and are not as exciting to buy as new products (Van Weelden et al., 2016). In my example, when buying headphones, I looked at options on the new, second-hand and refurbishment market and discovered multiple alternatives, such as Black Friday deals that had a similar price to refurbished ones. By gathering all this information, one builds a final consideration set, a set of alternatives one is aware of and that are eligible for detailed consideration. This set of options (final consideration set) then becomes part of the evaluation phase. In this third phase, consumers evaluate the advantages and disadvantages of each option. In my example, refurbished products were harder to access and more expensive than second-hand products, but they did have a longer warranty. The evaluation phase is usually the most crucial one when it comes to refurbishment because consumers make a trade-off between the advantages and disadvantages of refurbished products, which eventually leads to the decision to either purchase a refurbished or a competing new or second-hand product (see Figure 5).

Figure 5. A trade-off between the benefits and risks of refurbished products leads to the purchase decision

1.5 Benefits of refurbished products

In addition to the perceived environmental benefits of refurbished products, they are an economical choice for consumers because their market value is 10-50% lower than the market value of new products (financial benefit; Abbey et al., 2015; Hamzaoui Essoussi & Linton, 2010; Michaud & Llerena, 2010; Sharifi & Shokouhyar, 2021; Wang & Hazen, 2016). This gives consumers a choice to either save money or buy a refurbished premium product instead of a new product of lower quality for the same price. Next to that, Van Weelden et al. (2016) identified that refurbishment can also be more desirable because refurbished products may lack unwanted innovative features, such as voice control in wireless headphones, that are undesirable to some consumers. Another perceived benefit can be that refurbished products have unique features that are not available in new products anymore, such as an increased memory capacity of refurbished products that was decreased in newer models of the same smartphones (Van Weelden et al., 2016). Compared to second-hand products, refurbished products are perceived to have higher performance and are required to have a warranty. In the evaluation phase, consumers weigh these perceived benefits against the risks associated with refurbished products (see Figure 5).

1.6 Refurbished products are perceived to be a risky consumer choice

Consumers perceive refurbished products to be a riskier choice than new products (Hamzaoui Essoussi & Linton, 2010; Van Weelden et al., 2016) and, therefore, may be afraid of making a bad financial investment (financial risk; Guide & Li, 2010; Hamzaoui Essoussi &, Linton, 2010; Michaud & Llerena, 2011; Wang et al., 2013, Van Weelden et al., 2016). Furthermore, consumers are afraid of buying refurbished products that may not function satisfactorily (functionality risk; Van Weelden et al., 2016; Wang & Hazen, 2016; Sharma et al., 2016), and therefore need to be sent back, costing them time (time risk; Van Weelden et al., 2016). This is because consumers associate refurbished products with second-hand products (Van Weelden et al., 2016), with being less valuable (Wang & Hazen, 2016) and having lower quality and performance than new products. Consumers often do not understand what refurbishment means, and not enough information is provided about the condition of the product. For example, it is often unclear to consumers what is meant by an “as new state” (Hazen et al., 2012, p. 782).

`Compared to second-hand products, refurbished products are harder to find and are more expensive (Van Weelden et al., 2016; Atasu et al., 2008). Compared to

new products, refurbished products can lack new desired features (obsolescence risk; Mugge et al., 2017a; Wahjudi et al., 2020), do not evoke the same thrill of newness when purchasing them (Van Weelden et al., 2016) and can have a less attractive product appearance (Mugge, de Jong, et al., 2018) Additionally, consumers are afraid that refurbished products might be contaminated with traces of a former user (contamination risk; Baxter et al., 2015). As a consequence, consumers have lower purchase intentions for refurbished products and are willing to pay less money for them than for new products (Esmaeilian et al., 2021; Guide & Li, 2010; Hamzaoui Essoussi & Linton, 2010; Harms & Linton, 2016; Michaud & Llerena, 2010; Mugge, Jockin, et al., 2017a; Pang et al., 2015; Wang et al., 2013). Correspondingly, many scientific studies on consumer acceptance of refurbishment have focused on the marketing of refurbished products to increase the willingness to pay and therefore make refurbishment an economically viable option for manufacturers (Boyer et al., 2021; Hamzaoui Essoussi & Linton, 2010; Hao et al., 2019; Harms & Linton, 2016; Michaud & Llerena, 2010).

1.7 Improving the consumer acceptance of refurbished products via marketing

Marketing strategies aiming to improve the consumer adoption of refurbished products have focused on minimizing the risks associated with refurbished products and underlining their benefits (Mahmoodi & Heydari, 2021; Van Weelden et al., 2016). Refurbished products are differentiated from new products by the fact that they are sold at a lower price and from second-hand products by underlining that they were checked by an expert and are provided with warranties (Mahmoodi and Heydari, 2021; Mugge et al., 2017a).

Eco-labels are often used on refurbishment websites and have been shown to increase consumers' willingness to pay for refurbished products; however, this strategy only has an effect on consumers who are motivated to decrease their environmental impact (Boyer et al., 2021; Harms & Linton, 2016; Ihemezie et al., 2018; Jin et al., 2020; Michaud & Llerena, 2010; Sharifi & Shokouhyar, 2021).

Furthermore, the context in which refurbished products are sold, is influential in consumers' choice of refurbished products. A good reputation of the seller and a widely available distribution of the refurbished product on the market has shown to decrease the perceived risks associated with refurbished smartphones and lead to a higher valuation of the product (Agostini et al., 2021; Chen et al., 2020; Sharifi & Shokouhyar, 2021). A central issue of these marketing strategies is that they are peripheral to the product and are not applicable to every consumer. While they improve the trade-off for

the refurbished products, they do not help to keep the product at its highest material and economic value. In the next section, we, therefore, elaborate on how the product's characteristics and the consumer characteristics that influence the choice regarding refurbished products.

1.8 The role of consumer characteristics in buying refurbished products

Prior literature has also explored the role of consumers. Consumers have different needs, desires and characteristics, which drive their consumption decisions (Hunka et al., 2020). Mugge et al. (2017), therefore, pointed out that it is necessary to explore which consumers are likely to buy refurbished products and how they can be given appropriate incentives. They identified that three out of six different consumer groups in their study were likely to buy refurbished smartphones. A consumer group called the Casual Supporters were most likely to buy refurbished products. This consumer group was very concerned about the environment and saw smartphones as mainly utilitarian tools. They scored low on innovativeness, indicating that they do not need the newest products on the market and that a functional smartphone would be enough. Next to this group, a group called the Sustainability Enthusiasts were also likely to purchase refurbished smartphones. This group was characterized by high levels of environmental concern and was motivated to buy a smartphone that fits with their identity and value of being an environmentally conscious person. To some extent, a consumer group called the Susceptible Follower was also deemed likely to purchase refurbished smartphones. This consumer group was characterized by the need to express their identity through products they own (high scores on value-expressive function), and their desire for social status (high scores on social adjustive function) and they may use refurbished smartphones to express their environmental consciousness. All three groups could be incentivized to buy refurbished products by underlining that these products are an environmentally friendly choice. Furthermore, the casual supporters were less concerned with the image and technical details of smartphones and could therefore be incentivized to buy refurbished smartphones that are "good value for money".

Consumers of other groups were less likely to buy refurbished smartphones because they lacked the latest innovative features. In this respect, consumers who were highly involved with smartphones and knew a lot about their features (*expert consumer groups*) did not favour refurbished products. These consumers saw refurbished smartphones as not fitting their personality and had the feeling that peers did not deem refurbished products to be a favourable choice. Other research pointed out that consumers who

are less tolerant of ambiguous situations are willing to pay less for remanufactured smartphones and are less likely to buy them (ambiguity intolerance; Hazen et al., 2012). Gaur et al. (2019) described how socio-cultural factors are associated with the choice of refurbished products. In their qualitative research, US consumers were more likely to buy refurbished (called reconstructed in this paper) products than Indian consumers. This was described to be related to socio-cultural differences in buying behaviour, their attitude towards waste disposal, a perceived obligation to adhere to government conservation norms and environmental value orientation.

While this research was informative on which consumer groups exist when it comes to buying refurbished smartphones, knowledge needs to be expanded concerning the importance of different consumer-related factors. Furthermore, past research did not explore the role of the product itself in consumer acceptance of refurbished products.

1.9 Designing products that remain desirable in a refurbished state

A disadvantage of refurbished products is their appearance; a *product's appearance* is defined as how a product appears like from the exterior (Creusen & Schoormans, 2005), as compared to *product design* which also entails product parts that cannot be seen. Refurbished products are often considered to have a less attractive appearance than new products for two reasons. First, refurbished products can lack a desired new look and do not follow the latest trends (Mugge et al., 2018). Second, signs of wear and tear can make the product less desirable. Signs of wear and tear remind the user of the product's previous use and thereby trigger negative associations that the product may not function as well as a new product (Van Weelden et al., 2016, Baxter et al., 2015).

To keep a product at its highest value, it is, therefore, necessary to explore how the product can maintain its desirability after being refurbished. By changing the product appearance of a product, designers have the unique opportunity to influence consumers' inferences about products that are later refurbished (Mugge et al., 2018). This may also require a change in the product appearance of products that are designed to be refurbished in the future. Research has shown that the appearance of the product gives the user information about the utility and quality of a product (Crilly et al., 2004). For example, consumers perceive objects that are or look heavy to be of higher quality than light products because they associate the product's weight with strength and robustness. Consumers associate this robustness with a higher likelihood that the product will last for a long time (Mugge et al., 2018; Van Rompay & Ludden, 2015). It is, however, unclear which role the product appearance plays in the choice of refurbished

products and how the product appearance of refurbished products can foster positive associations with these products. Designers currently lack knowledge of how products need to be designed to remain appealing to consumers during the multiple lifecycles that are created through refurbishment.

1.10 Differences between product categories

While numerous studies focus on predicting the purchase intentions of refurbished smartphones (Esmaeilian et al., 2021; Hazelwood & Pecht, 2021; Holmström & Böhlin, 2017; Jockin, 2015; Kumar & Mohan, 2021; Mugge et al., 2017a; Mugge et al., 2018; Nasiri, 2021; Sharifi & Shokouhyar, 2021; Singhal et al., 2019) research on other product categories is sparse (Chen et al., 2020; Mugge et al., 2017). In the transition to a circular economy, more electronic products need to be refurbished and successfully marketed. Yet, every product category might raise specific issues that influence the product's desirability in a refurbished state. Generally, prior literature has shown that consumers are more willing to purchase refurbished technological products than personal care products (Mahmoodi & Heydari, 2021). Abbey et al. (2015) distinguished between three different types of reused products that differ in the level to which they evoke consumers' contamination concerns and, therefore, determine their desirability in a reused state: around-you products (e.g., speakers), on-you products (e.g., headphones) and in-you products (e.g., earbuds). While reused around-you products evoke low levels of repulsion in consumers, they found that reused on-you products and reused in-you products evoke high levels of repulsion and are therefore deemed unfit for reuse strategies (Abbey et al., 2015). In contrast to their findings, other studies indicated that while some consumers might feel repulsed by refurbished in-you products, other consumers are open to purchasing refurbished products that are intimately used (Mugge et al., 2017). For example, in qualitative interviews among 18 participants, Mugge et al. (2017) found that more than half were open to the idea of acquiring a refurbished electric toothbrush. This shows that with adequate incentives (e.g., low price), some consumers might still be willing to adopt product categories with high levels of contamination. The latter also makes it evident that more research on other categories is needed in order to understand how these products can be made more attractive for refurbishment.

1.11 Research gap and contributions

The aim of this thesis is to understand consumer acceptance of refurbished products and how designers can enhance their desirability. Refurbishment is a powerful strategy to extend a product's lifetime in the circular economy and lower the environmental impact of our consumption compared to new products. Yet, this requires that refurbished products substitute new products, which can only be achieved if they are designed to last multiple lifecycles and are a competitive alternative for new products to important groups of consumers (Blomsma & Tennant, 2020). However, many products are not yet desirable to consumers because they are perceived as a riskier choice than new products. Thus far, only marketing is used to enhance the desirability of refurbished products. Marketing strategies aiming to improve the consumer adoption of refurbished products have focused on minimizing the risks associated with refurbished products and underlining their benefits (Mahmoodi and Heydari, 2021; Van Weelden et al., 2016). A central issue of these marketing strategies is that they are peripheral to the product, not sufficient for all product categories and are not appropriate for every consumer. While marketing strategies can improve the trade-off for refurbished products, they do not help to keep the product at its highest material and economic value. Knowledge of how products need to be designed to retain their value after being refurbished is lacking. Hence, in this dissertation, we explore how designers can enhance consumer acceptance of refurbished products by design.

This thesis contributes to the literature by extending the consumer-centric perspective on refurbishment and informing manufacturers and designers about potential design strategies that make refurbished products more desirable, and that may help to retain the value of refurbished products over multiple life cycles. In contrast to prior research (Holmström & Böhlin, 2017; Mugge, Jockin, et al., 2017b; Nasiri, 2021; Van Weelden et al., 2016), we focus on consumer electronics other than smartphones by extending findings from the literature on refurbished smartphones to other consumer electronics. Furthermore, we develop new design strategies on how to design refurbished products that are sensitive to contamination concerns, such as personal grooming products, headphones, and blenders.

To research how to enhance the desirability of refurbished products, we used a mixed-methods approach using methods from different disciplines, such as design, psychology, marketing and consumer behaviour.

1.12 Research questions

This dissertation revolves around the question: ***How can designers enhance consumer acceptance of refurbished products?***

To answer our main research question (RQ), we addressed the following sub-questions:

1. *How does the product appearance contribute to consumer acceptance of refurbished products?*
2. *What are the underlying relationships of the factors influencing consumer acceptance of refurbished products?*
3. *How can we decrease contamination concerns of refurbished products via product design and marketing?*

1.13 Outline

The remainder of this dissertation is divided into six sections that describe five studies and a general discussion.

In the first part of the thesis (chapters 2 and 3), we explore the role of product appearance and how it contributes to consumer acceptance of refurbished products (RQ1).

Chapter 2 investigates how to improve the appearance of refurbished products and thereby enhance consumer acceptance of such refurbished products. One potential disadvantage of refurbished products is their aesthetic appearance; refurbished products are often considered to have a less attractive appearance than new products. In this chapter, we explore whether embodying refurbished products in a timeless design can serve as a potential strategy to positively influence consumer acceptance of refurbished coffeemakers, headphones and radios. Specifically, in 21 in-depth interviews, we examine two design styles that were proposed as timeless: the neo-retro design style that evokes nostalgia and benefits from associations with the past and the simplistic design style that is independent of cultural or time-related cues. Our findings provide qualitative support that the neo-retro and the simplistic design styles can improve consumers' evaluations of refurbished products. Both design styles are not only considered to be timeless but also more attractive and elicit favourable associations among consumers about the durability of refurbished products.

In chapter 3, we test in an experiment whether refurbished products' aesthetic durability predicts the purchase intentions of refurbished headphones and blenders. Unfortunately, our experimental manipulation did not work. In an exploratory

regression analysis, we, however, found that a product's durability and attractiveness positively predict the purchase intentions for both new and refurbished products. Contrary to our expectations, the products' durability and attractiveness do not play a larger role in refurbished products than new products. Other factors, such as the consumers' environmental concern and the perceived contamination risk, influence the purchase intentions of refurbished products, whereas no effects are found for new products. In chapter 3, we conclude that designing products to be aesthetically durable and attractive, counteracting consumers' contamination concerns with refurbished products and presenting them as a sustainable choice could be worthwhile strategies for increasing the desirability of refurbished products. Nevertheless, in chapter 3, we only included four factors that are important when it comes to determining the choice regarding refurbished products. In reality, consumer decision-making regarding refurbished products is more complex and includes factors related to the product, the marketing and the consumer.

Chapter 4, therefore, examines the underlying relationships of the factors influencing consumer acceptance of refurbished products (RQ2). In a network analysis, we model which factors predict the purchase intentions of refurbished earbuds and speakers and how these factors relate to one another. We investigate earbuds and speakers because they differ in the extent to which they generate contamination concerns. A network analysis of refurbished speakers and earbuds showed that the most important factors related to the decision to purchase refurbished products are the perceived risk and the perception that refurbished products are contaminated by their prior user. The two product categories also differ in which factors are most strongly related to the purchase intentions. For refurbished speakers, the belief that refurbished products are financially attractive and the perceived risk that the product is a bad investment are the largest predictors of the purchase intentions. However, this is not the case for refurbished earbuds. For refurbished earbuds, participants' concerns about territorial contamination and that earbuds are perceived to be unhygienic because they had been previously used are most strongly linked to the purchase intentions. We, therefore, conclude that strategies aiming to enhance consumer acceptance of refurbished products should, first and foremost, focus on reducing risks and contamination concerns.

Chapter 5 and chapter 6 revolve around the question of how contamination concerns of refurbished products can be decreased via marketing and product design (RQ3). In chapter 5, we explore which contamination-reducing strategies are most important in influencing the consumer choice for refurbished headphones and how this differs among consumer groups. We test three contamination-reducing strategies: 1. communication about the clean object state, 2. eliminating signs of use (aesthetic and functional wear and tear) and 3. renewing parts that touch the skin (e.g., ear-cushions) with a choice-based conjoint analysis. We found that depending on the consumer group,

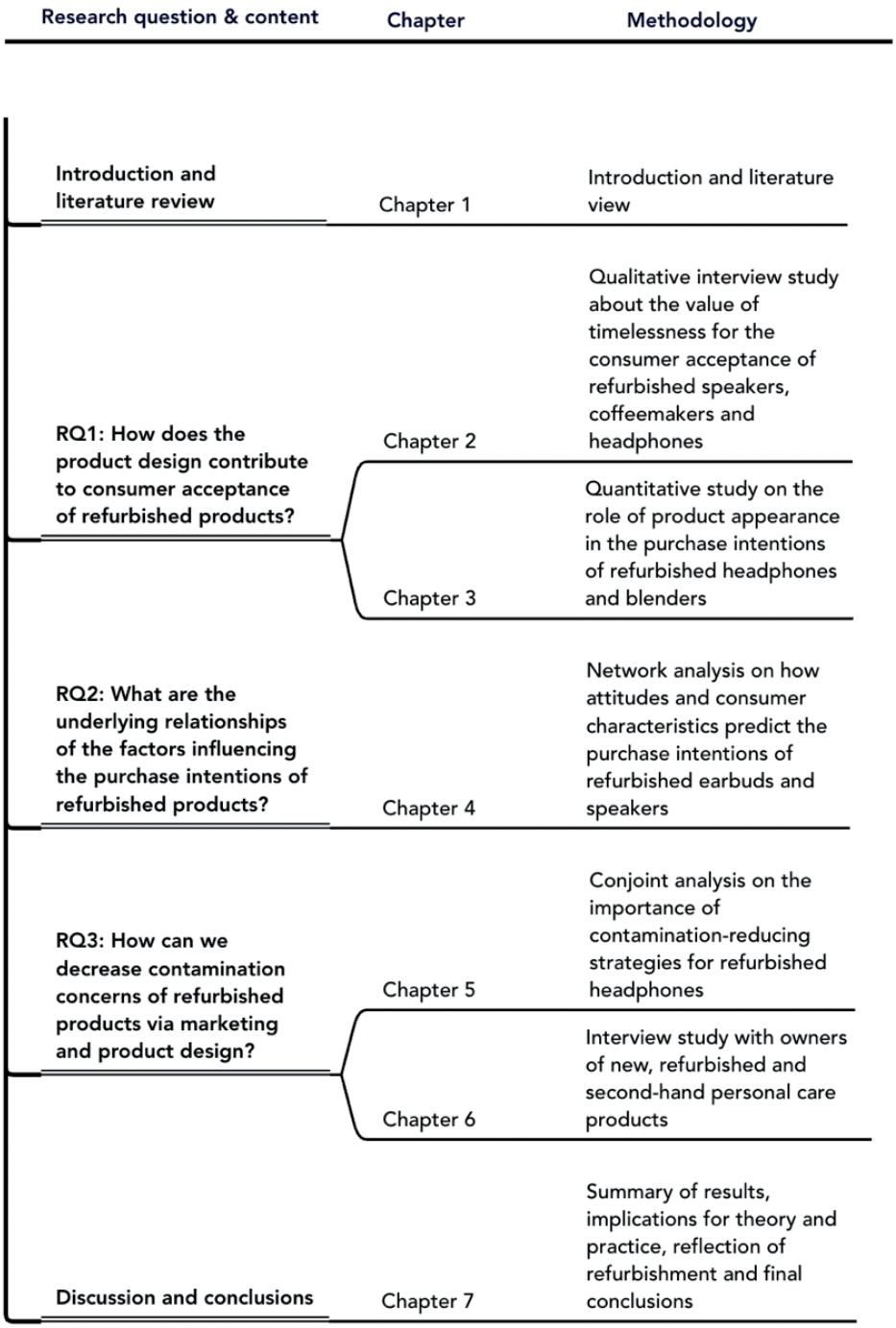
other contamination-reducing strategies are of great influence. While some consumer groups highly value that signs of prior use are eliminated through an as-new appearance, others prefer refurbished products with an as-new functionality. In contrast to this, for a small consumer group that we call the reuse-enthusiasts, we propose a strategy in which contamination is not reduced but embraced.

From this study, it is, however, unclear why consumers have contamination concerns and how product designs can help to prevent such concerns.

In chapter 6, we explore via in-depth interviews why consumers have contamination concerns with personal care products and how product design and marketing strategies can decrease these concerns and make refurbished products a more desirable consumer choice. Next to exploring how the product design can prevent contamination concerns, we also investigate how marketing strategies can compensate for refurbished personal care products that are perceived to be contaminated. Participants feel that refurbished personal care products with signs of wear and tear are a riskier choice and expect the device to malfunction, have a shorter product lifetime and to be contaminated due to the previous use. Based on the location and number of scratches, participants make inferences about how the prior user had treated the device. While light wear and tear indicate normal use, heavy signs of wear and tear are interpreted as a sign of bad treatment by the previous user. In Chapter 6, we suggest five design strategies to minimize contamination concerns by designing a product that smells and looks hygienic after multiple lifecycles to keep refurbished personal care products at their highest value. For refurbished personal care products with signs of wear and tear that cannot be eliminated, we propose mitigating consumers' contamination concerns with marketing strategies.

Chapter 7 concludes the thesis with a discussion of the main findings as well as their implications for industry and academia. Refurbishment in general is reflected upon.

1.14 General outline



CHAPTER 2

An interview study exploring timeless design styles

Based on: Wallner, Magnier, L., & Mugge, R. (2020). An Exploration of the Value of Timeless Design Styles for the Consumer Acceptance of Refurbished Products. *Sustainability*, *12*(3), 1213. https://doi.org/10.3390/su12031213

2.1 Introduction

Chapter 2 explores the role of the product appearance and how it contributes to consumer acceptance of refurbished products (RQ1). One disadvantage of refurbished products is their aesthetic appearance; refurbished products are often considered to have a less attractive appearance than new products for two reasons: First, refurbished products can lack a desired new look and do not follow the latest trends (Wahjudi et al., 2020). Second, wear and tear signs can make the product less desirable because these signs remind the user of the product's previous use, thereby triggering negative associations that the product may not function as well as a new product (Van Weelden et al., 2016).

While most research on the consumer acceptance of refurbished products has focused on functional characteristics (Hatcher et al., 2011; Ijomah et al., 2007; Östlin et al., 2009a), research on aspects related to product appearance is scarce (Mugge, Dahl, et al., 2018; Mugge, de Jong, et al., 2018). This research explores a potential strategy to enhance the appearance of refurbished products by giving these products a timeless design. Timeless designs are generally perceived to be attractive for a longer time and are not as sensitive to trends (Lobos, 2014; Parsons, 2016). This could benefit refurbished products because it prevents their appearance to become out of fashion. We contribute to the current literature by exploring how refurbished products should look like to remain desirable during multiple lifecycles. Specifically, we focus on the value of timeless designs for positively influencing the consumer acceptance of refurbished products. Precisely, we use qualitative research to acquire in-depth knowledge of how individuals derive meaning from the appearance of refurbished products following different timeless design styles, and how the product's meaning influences consumers' attitudes.

2.1.1 Enhancing consumer acceptance of refurbished products via product appearance

In the literature, it has been established that the appearance of the product gives the user information about the utility of a new product (Bloch et al., 2002; Creusen & Schoormans, 2005; Crilly et al., 2004; Mugge, 2011) and consumers use product appearance as a cue for quality (Mugge et al., 2018; Mugge & Schoormans, 2012; Page & Herr, 2002).

One of the few articles on the appearance of refurbished products has revealed that their appearance influences consumer acceptance of refurbished products (Mugge et al., 2018). Specifically, it was found that if signs of wear and tear were present on a smartphone, participants were less likely to buy the refurbished smartphone and wanted to pay less money for it than for a smartphone without scratches. Participants worried that the product was contaminated with physical or digital traces of previous owners on the product. Additionally, participants were afraid that the product would become

obsolete because it might not be possible to update the software of the product. In Mugge et al.'s research (2018), a standard Apple iPhone 5 was investigated, and thus, the effect of appearance was investigated by looking only at the impact of wear and tear. It would, however, be compelling to complement this research by investigating other appearance characteristics, such as the specific design style and to which extent this design style is judged to be timeless.

2.1.2 Timeless designs

Specific design styles, such as timeless designs, are less affected by time and "ever-changing consumer tastes" than other design styles (Lobos, 2014) (p. 2), and therefore remain to be evaluated positively throughout time (Bloch et al., 2002). According to Lobos (2014), timelessness consists of aspects related to the functionality and appearance of the product. While functionality can be made timeless by designing a product that is repairable and upgradable, achieving timelessness in the appearance is related to creating a product that is either unique or by disconnecting it from popular aesthetic cues that will serve as an indicator of time (Flood Heaton & McDonagh, 2017; Lobos, 2014). Lobos' ideas on timelessness were further developed by Flood Heaton and McDonagh (2017) who suggested the following three possible strategies to create a timeless product appearance: exceptionally beautiful designs, nostalgia evoking designs and simplistic designs.

Strategy 1: Exceptionally beautiful designs

Creating beautiful forms was described as the first strategy to achieve timelessness in product appearances. Flood Heaton and McDonagh (2017) describe that exceptionally beautiful designs trigger a "dramatic emotional response" of pleasure (p. 112) in the consumer, which seems to increase the timelessness of the design, perhaps because the product appears to be particularly unique (Lobos, 2014) or because it communicates being of high quality to the consumer as a result of the "What is beautiful is good principle" (Dion et al., 1972, p. 285). However, the experience of beauty of a product is also highly subjective and varies between different consumer groups (Snelders et al., 2014). Consequently, Flood Heaton and McDonagh (2017) see more potential in the other two strategies to create timeless designs.

Strategy 2: Nostalgia evoking designs

Nostalgia evoking designs are considered timeless because of their associations with the past and were suggested to prolong the emotional durability of a product (Haines-Gadd et al., 2018) by integrating values, such as fine craft, innovation and the historical context into the design. Even though nostalgia evoking products may not have been exceptionally popular at the time of their first creation, their cultural and historical

context makes them aesthetically appealing now. One possibility to evoke nostalgia with products is by implementing design characteristics from the past into new designs, such as in the neo-retro design style.

Neo-retro products are technologically up-to-date and show significant design characteristics from the past while still conveying information that these products offer new functionalities (Fort-Rioche & Ackermann, 2013). One example is the Medion Life retro radio (see Figure 6). It has an old wooden frame that antique radios often had in the past, but the display indicates that the radio has new functionalities.

Figure 6. The Medion Life Retro radio (left) shows neo-retro design style features. While it has a wooden frame that is comparable to an antique radio (right), the LCD display shows that the product offers new functionalities.

Although it is suggested that integrating nostalgia evoking elements into the design of a new product makes the product timeless and can be used as a strategy to increase the longevity of the product, it remains unclear whether this strategy can benefit refurbished products as well. In principle, refurbished products show similarities with both old and new products. On the one hand, refurbished products have previously been used by others and are thus old products. On the other hand, refurbished products are thoroughly checked and if needed, repaired to offer similar functionality as a new product. Taking into account this duality, it is interesting to explore if embodying refurbished products in the neo-retro design style can help to transform the prior use and age of the product into a desirable state. By evoking positive historic and contextual associations with old products, refurbished products following a neo-retro design style could improve consumer evaluations of refurbished products.

Strategy 3: Simplistic designs

The third strategy to achieve timelessness in the design of refurbished products consists of creating simplistic products. Simplistic designs generally seek simplicity without losing correspondence "to the essential nature of the product"(Bloch et al., 2002) (p. 112). They are characterized by an internal arrangement that is symmetrical, ordered, and harmonious. Simplistic designs are balanced in proportion, have little contrast in

colour, make use of pure and cold materials (Snelders et al., 2014) and are still highly prototypical. Prototypical products closely resemble a product category's prototype which describes a "cognitive reference points"; consumers use these cognitive reference points to determine whether a product belongs to a certain product category (Rosch, 1975, p. 533).

Prior research has suggested that products that follow the simplistic design style (also referred to as classic designs) may remain strongly preferred over time as they do not follow fast trend cycles (Lobos, 2014; Mugge et al., 2005). Designs with as little ornaments as possible were suggested to be independent of cultural and time-related cues, and consequently timeless (Lobos, 2014). Visually simplistic product appearances can, hence, extend the lifetime of products (Bloch et al., 2002). An example is Dieter Rams' Braun T3 pocket radio that was designed in 1958. Dieter Rams' design principles include that design should be long-lasting, environmentally friendly and as little design as possible (Rams, 2015). Following his principles, the radio is simplistic in its design, is symmetric, and uses little colour but still looks like a prototypical radio (see Figure 7). While Dieter Rams designed this radio already in the late 50s, his designs are still deemed beautiful and have inspired many modern designs, such as the design of the Apple iPod (Dieter Rams: The Legendary Designer Who Influenced Apple., 2018). Making the first version of a product as timeless could benefit the consumer acceptability of the product when it is refurbished in later life cycles.

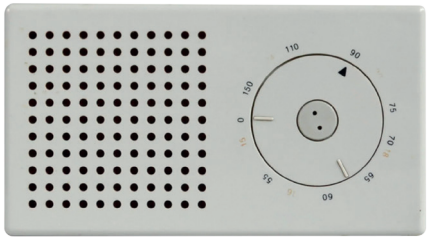


Figure 7. The T3 Braun Pocket Radio designed by Dieter Rams in 1958.

In this study, we focus on nostalgia evoking and simplistic designs because they have not yet been researched in the context of refurbished products and are, therefore, subject to our study.

2.2 Materials and Methods

The principal investigator visited participants (*N* = 21) at home to conduct semi-structured, in-depth interviews. All participants were selected from a university-based research panel (M = 50, 2 years old, ten females). We selected 21 participants of various backgrounds in terms of age (age range 28–76) and socio-economic backgrounds because of the exploratory nature of this study. Specifically, we wanted to capture how different consumers perceive refurbished products and were interested in the full spectrum of responses, rather than focusing on one specific target group. Prior research concluded that different target groups may choose refurbished products for different reasons (Mugge, Jockin, et al., 2017b) and thus it is important to include a diverse group of participants to provide a comprehensive understanding of the influence of specific design styles on responses to refurbished products. In addition, the circular economy will only have significant effects if many consumers are willing to turn to circular alternatives, such as refurbished products.

We decided to interview a total of 21 participants to ensure data saturation. Data saturation is achieved when any new interview only delivers approximately one or two additional codes. To achieve data saturation for heterogeneous groups, research suggests (Guest et al., 2006; Hagaman & Wutich, 2017) to interview 12-16 participants. The interviews took place at participants' homes, which enabled participants to show and discuss their refurbished and second-hand products. During the in-depth interviews, participants were asked to respond to 18 stimuli pictures (see Figure 8, for example stimuli) belonging to three product categories (coffee makers, headphones, and radios) that varied in their design style (neo-retro, simplistic and prototypical). The stimuli were used to evoke associations with refurbished products. We chose coffee makers, headphones, and radios because they are not highly technologically advanced, offer opportunities for refurbishment and are offered in multiple design styles, such as the simplistic and neo-retro design styles. All stimuli can be found in the appendix.

We included prototypical designs to the stimuli to uncover differences in evaluations between refurbished products with a timeless appearance (following either a neo-retro or simplistic design style) and refurbished products with more 'ordinary' appearances (following a prototypical design style) that are not suggested to be timeless.

2.2.1 Pre-test to develop stimulus material (coffeemakers, speakers, and headphones)

All stimuli were selected based on a pre-test to evaluate their design style. In this pre-test, 54 designers and design students (2–34 years of design experience, M = 7.34 years of design experience, 52% female) rated 45 images of the product categories of coffee

makers, headphones and radios on the degree to which the stimulus product showed design characteristics that are neo-retro, simplistic, or prototypical of the product category on a 7-point scale (1 = Completely Disagree; 7 = Completely Agree; for means see Table A1 in Appendices). We used designers and design students to obtain an expert opinion on the design styles. For the neo-retro design style, six stimuli (two for each product category) were selected with high scores on both neo-retro, medium scores on prototypical, and a low score on simplistic. For the simplistic design style, we selected six stimuli with high scores on simplistic and medium to high scores on prototypicality and a low score on neo-retro. Finally, for the prototypical design style, we selected six stimuli with a high score on prototypical, and low scores for neo-retro and simplistic (see Table Appendix A1).

Figure 8. Stimuli used in the study of which 2 each row show the neo-retro design style (left), simplistic design style (middle), prototypical product (right). The stimuli are displayed in a larger size in appendix A3.

2.2.2 Procedure and questionnaire

During the interviews of the main study, the participants were first asked to elaborate on their initial perceptions towards refurbished and other second-hand products, such as antiques (for example: "*Have you ever bought a refurbished product?*", If yes: "*Why did you decide to buy a refurbished product*?"). Second, they were shown the 18 stimuli pictures. We explained that the products on the pictures were refurbished, after which participants

were asked questions about their perceptions of these products (For example, "*Which of these refurbished products do you like best?"; "What are your associations with the product given that it is refurbished?")*. We specifically asked participants to compare the different stimuli to uncover the effects of different design styles in refurbished products (for example: *"What do you think about the quality of this product compared to the other products?*; "*Which product do you think you could use for the longest time? Explain why")*. The full interview guide can be found in Appendix A2. Participants received a small compensation (10 euros voucher) for their participation. The study was approved by the Ethics Committee of Delft University of Technology.

2.2.3 Data processing and coding

All interviews were audio-recorded and transcribed by the principal investigator. Subsequently, the transcriptions were coded using Atlas.ti and analysed. Codes emerged during two coding rounds, which were inductive. The first five interviews were analysed in a collaborative session of all authors, which resulted in 144 codes. The remaining 16 interviews were analysed by the principal investigator and resulted in a total number of 259 codes in the second coding round. Data saturation was reached after the 18th interview, suggesting that our sample size was sufficient. The first-order codes were discussed in the research team, adapted and summarized into 88 second-order codes that were sorted into 29 themes (see table 1 for an example theme). These first- and second-order codes and themes were discussed and agreed upon by the full research team. For this paper, 19 out of 32 themes were used.

Table 1. Coding structure.

Theme	Second-order Code	First-order Code
Neo-retro products evoke associations with the past.	Neo-retro refurbished products evoke sentimental feelings, which can make them more desirable	Neo-retro refurbished products evoke feelings of nostalgia.
		Nostalgia determines product choice.

[1] Example coding structure

2.3 Results

In the next section, we elaborate on our findings related to the general motivations to buy refurbished products, the evaluations of refurbished products following either the neo-retro or simplistic design styles, and the general design characteristics that were identified to make refurbishment more attractive to consumers.

Motivations to buy refurbished products

In general, participants named two main motivations to buy refurbished products: the lower economic costs and environmental benefits, confirming prior research (Abbey et al., 2015; Van Weelden et al., 2016; Wang et al., 2013). Participants either had bought refurbished products in the past because they were cheaper than new products and refurbishment offered them the possibility to go for a premium product, such as an Apple iPad instead of a cheaper tablet brand. Other participants mentioned that they had purchased refurbished products because reusing products saves natural resources and reduces the amount of waste that is produced. Even though participants proposed these motivations to buy refurbished products, one participant suggested that the design should seduce the consumer more to buy refurbished products.

Participant 3: "*We can, of course, all shout out that nobody should produce new goods anymore because we already have enough products on our planet, but I think we should all be looking to reuse things. But it would be great if the design would seduce us to do so.*"

Role of timelessness in the design of refurbished products

Concerning the effects of different design styles, our findings provide preliminary qualitative support for the value of both the neo-retro design style and the simplistic design style for improving consumers' evaluations of refurbished products in comparison to refurbished products with a prototypical design style. The prototypical designs did not trigger inferences on timelessness; prototypical designs were therefore only discussed as a frame of reference for the results of the other design styles.

Evaluations of refurbished products in a neo-retro design

Participants evaluated refurbished products in a neo-retro design to have a timeless design because the neo-retro design style was perceived as less vulnerable to trends than prototypical designs. Participants argued that if it was beautiful in the past and is still beautiful now, it would be aesthetically appealing in the future as well, which makes the design timeless.

> Participant 4: *"I think I would choose (headphone) number 8 (to be beautiful for the longest time) because it just seems more timeless."*

This is in line with research proposing that timeless designs evoke nostalgic feelings in the consumer by integrating values, such as fine craft, innovation, and historical context into the design (Bloch et al., 2002). Refurbished products in a neo-retro design were described to look like 'old' products and therefore, evoke associations with such products in terms of looks and usability. Several participants mentioned that neo-retro products reminded them of antiques, Art Deco, vintage or other old products. This association was generally

positive because products in the past were "made to last,", and would thus have a reduced chance to break down prematurely. As a consequence of this long-lasting value, a neo-retro design style was considered more desirable for products that are bought in a second or even later life cycle after refurbishment.

> Participant 12: *"I think it is an unconscious choice, but I would choose (coffee machine) 1 or 2 because they have an antique appearance and with that comes some sort of eternal value."*

Participants also expected refurbished products in a neo-retro design style to have 'old' functional features, such as mechanistic buttons or wheels that are not necessarily used in today's products. This made the product fun to use for some participants who considered these 'old' features to be positive. Others just mentioned that they expected such 'old' functional features, but this did not determine their product choice. For example, in the neo-retro radios 13 and 14, participants expected the wheels to make squeaking sounds or to be rickety even though they knew that the product was modern in a refurbished state.

> Participant 6: "*Yes, 13. We had such a radio in the past. My association with it is that the wheel is squeaking. It appears to be old. It could be really modern from the inside, but you cannot see this from the outside.'*

Participants appreciated this because it reminded them of the good old times, or they simply liked the look of products from that time because of their historic associations. Participants also associated these refurbished products with a feeling of nostalgia. Multiple participants said that the neo-retro coffee machines 1 and 2 evoked nostalgic feelings about the American sixties (coffee machine 1) or an Italian espresso bar (coffee machine 2) and triggered warm memories of experiences in Italy or the United States.

> Participant 10: *"I would choose this one (coffee machine 2) because I've always liked this one. It's not a real argument, more a form of nostalgia. It reminds me of my vacation in Italy before they used these espresso machines here in the Netherlands."*

While some participants said that the feelings of nostalgia also determined participants' product choice for the refurbished products in a neo-retro design style, others said that nostalgia was good but that the quality of the object was still more important. An important drawback of current refurbished products is that people perceive them to have lower quality than new products (Sharma et al., 2016; Wang et al., 2013). Interestingly,

when presented with pictures of refurbished products in a neo-retro design style, participants did not express such negative associations. Participants even indicated that refurbished products in a neo-retro design style looked durable, solid, and robust and reminded them of the good quality of the past. Participants proposed that products of the past were made to last while they believed that today's products often break down prematurely, also known as planned obsolescence.

> Participant 8: *"I think that the quality is more or less the same for all products but that (coffee maker) 1 and 2 are better than number 5 because they (1 and 2) are classic models like they were built in the past. In the past, everything was built so that it would last for as long as possible. At the moment, [it is designed] for just three years because otherwise, they don't earn enough money anymore. So, I think that 1 and 2 could be more durable."*

Another disadvantage of the refurbished products that are on the market nowadays is that consumers do not receive information about their prior use or history of the product (Van Weelden et al., 2016). Other kinds of second-hand products, such as antiques, often benefit from the fact that people believe that there is a narrative attached to the product, which provides extra emotional value and makes the product special. Refurbished products are usually not associated with having a narrative. However, our findings provide some first insights that the appearance of the refurbished product can play a role in triggering such a narrative. Specifically, some participants mentioned that refurbished products following a neo-retro style evoke associations with the products, having a narrative more than simplistic or prototypical products.

> Participant 14: *"I think that some refurbished products have a story. Not all, of course. […] It depends on your own interpretation. (Coffee machine) 1, really has a story, and the other ones don't have that at all. I think it is an unconscious choice. A so-called unconscious choice that is probably related to my memories. The weird thing is that I have no memories of it because I had not been born in that time yet."*

Participants suggested that refurbished products in a neo-retro design style looked unique, charming, prominent, extravagant, and more beautiful than other refurbished products, because of their old appearance. One participant also said that the "old" look of a refurbished product in a neo-retro design style gives it an extra value because the appearance is more attractive. Participants appreciate the use of wood in radio 14 and thought that the metal parts of headphone 8 and coffee maker 1 and 2 made the products more robust.

> Participant 2: *"It looks like an old-fashioned radio (radio 13). And that wooden cover, not plastic. I think that is just more beautiful. That is the reason why I would choose that one."*

Evaluations of refurbished products in a simplistic design

Our findings suggested that refurbished products following a simplistic design style were considered to have a timeless design as well. Nevertheless, the underlying reasoning for the value of a simplistic design style for creating a timeless experience and thereby improving consumers' evaluation of refurbished products differed from that of refurbished products in a neo-retro design style. Specifically, participants explained that they perceived the refurbished products in a simplistic design style as timeless because these were not associated with any particular time in history.

> Participant 6: "*Yes, I think that I would use (radio 15) it the longest because it is so independent of... it is just really timeless.*"

Refurbished products in a simplistic design style were not related to any period of time and therefore considered timeless. This is in line with the suggestion that some products are timeless because the design is independent of time-related cues (Lobos, 2014). One reason why consumers often prefer new products over refurbished products is the appearance of refurbished products (Mugge, de Jong, et al., 2018). Refurbished products often do not have an as-new appearance and sometimes do not follow the latest trend and may, therefore, be less desirable. Refurbished products in a simplistic design style were, however, described as inconspicuous, simple-looking, nice and easy to use, and were preferred over prototypical products because of their inconspicuous appearance.

> Participant 11: "*I think I would choose (radio) number 15 because it looks good in different kinds of interiors because it is really inconspicuous. That's good!"*

Refurbished products are generally associated with lower quality than new products (Sharma et al., 2016; Wang et al., 2013). Our findings suggest that specific appearances may diminish this negative quality effect. Specifically, refurbished products in a simplistic design style were perceived to have a higher quality compared to prototypical products. The provided rationale for this difference in quality was that refurbished products in a simplistic design style reminded participants of objects that were designed by high-quality brands, such as Apple or the Dieter Rams' Braun designs. As a consequence, participants favoured this design style in refurbished products over more prototypical designs.

Participant 12: "*I would go for (radio) number 15. It has this Apple look. I think it is really beautiful.*"

From the appearance of refurbished products in a simplistic design style, participants also inferred that the product is so simple that nothing can break, such as buttons or the electronics inside of the product. This was considered to be positive because participants preferred durable products.

Participant 18: "*Maybe I could use (radio) 15 for the longest time because there are not many things that can break. It seems like that. For example, this one has a turning wheel. It seems like it would last for a long time.*"

Desirable design characteristics of refurbished products

In addition to the insights on the specific associations of the neo-retro and simplistic design styles, our results also uncovered general design characteristics that were desired in refurbished products. Product characteristics related to the quality of the product, the durability, and the repairability could serve as strategies in how to further enhance the consumer acceptance of refurbished products. Participants stated that generally only products that are of high quality should be refurbished. They mentioned that the quality of the product was an important criterion when choosing a refurbished product, but if the quality was guaranteed, the looks of the product determined the product choice.

Participant 12: *"Modern products can be reused. But the only products that can be reused are products that are well-built because, yes, they [the products] have to be built for longevity in order to be reusable."*

Complex products or products with fragile parts, such as the sleek headpiece in headphone number 10, were seen as breakable and therefore, unfavourable because they were perceived to be less durable. In contrast, participants preferred robust and solid designs in refurbished products as these were believed to be more durable and less likely to break after purchase.

Participant 19: *"With number 9, 10 and 12, I have something like: If something was broken, what can you still repair? I think that they would break after a period of time. I think I would rather buy something more solid."*

Participants appreciated the use of wood, metal, and leather in refurbished products. Metal and brushed aluminium were deemed desirable because of two reasons: First of all, metal products were perceived to be more repairable than plastic products, and it

was easier to determine whether products are in a good state. Wood was associated with warm feelings and the product having a narrative.

> Participant 21: *"A chair with a leather or wooden seat can tell a story better than a Rotan (Ikea) chair because of the wear that it breaks down more beautifully than the other."*

Secondly, metal products were associated with increased durability, whereas plastic was perceived to be less durable. Most refurbished products in the neo-retro design style benefitted from the positive perceptions of these materials, as neo-retro products often include wood, leather, and metal. Refurbished products that looked like they were repairable were modular or consisted of different, non-integrated parts, were more desirable in a refurbished state because they could be repaired easily by the consumer and/or the refurbishers. Consumers assumed that repairable products are also more likely to be successfully refurbished and therefore, more durable and trustworthy than products that were not repairable.

> Participant 5*: "If something is to be refurbished, the question is what exactly can be refurbished. With many coffee machines, you can't even open them anymore. At least that's what I read some time ago. So there is nothing that you can repair about them anymore."*

1.4 General Discussion and Conclusions

The circular economy is a promising path towards more sustainable production of consumer goods. One challenge within the circular economy is, however, that current circular products, such as refurbished products, are often not considered a desirable and viable alternative to new products by consumers (Mugge et al., 2017b; Mugge et al., 2017a). While prior research on consumer acceptance of refurbished products has explored the functional characteristics (Hatcher et al., 2011; Mugge et al., 2018; Östlin et al., 2009b) of refurbished products or why refurbished products are not a desirable consumer choice to most consumers (Mugge et al., 2017b; Mugge et al., 2017a), research

on how to make refurbished products more attractive via design is sparse (Mugge et al., 2018). This research contributes to the current literature on consumer acceptance of refurbished products (Baxter et al., 2017; Mugge et al., 2018; Mugge et al., 2017; Van Weelden et al., 2016) by exploring the value of the product appearance of refurbished products for enhancing consumer acceptance. Prior research has only focused on either verbal or visual information of refurbished products (Mugge et al., 2018) or on the aesthetics of new products (Blijlevens et al., 2012; Creusen et al., 2007; Flood Heaton & McDonagh, 2017; Mugge, 2011; Mugge & Schoormans, 2012; Page & Herr, 2002; Veryzer & Hutchinson, 1998). Building on prior research, we conducted the first qualitative study that combines knowledge on the product aesthetics of new products and knowledge on the consumer response to refurbished products. Thereby we explored potential pathways to design product appearances that remain appealing across multiple product lifecycles in refurbished products. Specifically, we focus on the value of timeless designs for enhancing consumer acceptance of refurbished products.

To summarize, our findings provide qualitative support that the neo-retro and simplistic design styles are considered to be timeless and elicit associations in consumers that are especially favourable in a refurbished state (see table 2). Nostalgia evoking designs of new products, including the neo-retro design style (Fort-Rioche & Ackermann, 2013), were suggested to be timeless and contribute to product longevity by integrating values, such as fine craft, innovation, and the historical context into the design (Bloch et al., 2002). In our study, refurbished coffee makers, headphones and radios following a neo-retro design style additionally benefited from being associated with the good quality of the past, when products were made to last and to have an eternally beautiful appearance. This is especially desirable for refurbished products because they are, by definition, older than newly manufactured products. New products with simplistic designs were, in turn, suggested to be timeless because they are disconnected from cues indicating a specific period of time (Lobos, 2014). In our study, refurbished products following a simplistic design style were not only associated with being timeless but also benefited from associations of greater durability through simplicity and associations with high-quality brands. Durability was a re-emerging theme in general; participants favoured refurbished products with a solid over sleek product appearance and preferred refurbished products made of high-quality materials, such as wood, leather, and metal because of their durability.

Table 2. Summary of differences between refurbished neo-retro products, refurbished simplistic products, and refurbished prototypical products.

	Refurbished products in a neo-retro design	Refurbished products in a simplistic design	Refurbished products in a prototypical design
Timelessness	Refurbished neo-retro products were described as being timeless.	Refurbished simplistic products were described as being timeless.	Refurbished prototypical products were perceived to be out of fashion in the near future.
Quality	Refurbished neo-retro products were perceived to be more durable because they evoked associations with the good quality of the past.	Refurbished simplistic products were associated with quality because they reminded people of brands known for their quality.	Refurbished prototypical products were not associated with high quality.
Durability	Refurbished neo-retro products were associated with durability from the past.	Refurbished simplistic products were associated with durability because they looked so simple that nothing could break. Sleek parts were not desirable in refurbished products.	Only refurbished prototypical products with solid designs were associated with high durability.
Narrative	Refurbished neo-retro products are more likely to have a narrative, reminded people of the past (e.g., the 50s and 60s), created memories and therefore had emotional value.	Simplistic products were not associated with a narrative but often associated with iconic Braun and Apple products from the past.	Refurbished prototypical products were not associated with a narrative.
Appearance	Refurbished neo-retro products were described to have a unique, prominent extravagant, beautiful appearance.	Refurbished simplistic products were perceived to have an inconspicuous appearance.	The appearance of refurbished prototypical products was not mentioned by participants.

2.4.1 Practical implications for designers

Our findings have several practical implications for companies and designers aiming to implement refurbishment and, thereby, encourage circular consumption. By purposefully applying associations that the neo-retro and simplistic design styles evoke, as well as the general design characteristics, in the design process of the appearance of refurbished products, designers can design products that are more likely to be desirable after refurbishment. This has the potential to create products that are attractive for longer and will last for multiple life cycles. It is an especially interesting strategy for many consumer electronics that are discarded prematurely (Cox et al., 2013). Extending the lifetime of a product via refurbishment has implications for the production as well as the business model of the producer. First, products need to be designed for longevity to make refurbished products attractive. Designers should put an emphasis on the

timelessness, durability, and quality of the product when designing the first version of the product. This can extend the product's life span and would consequently slow loops currently employed in business models (Nußholz, 2018). Second, designing for longevity may increase production costs for the first version of the product. If the product is, however, perceived as timeless and the original equipment manufacturer refurbishes the product, initial production costs could be compensated by the financial advantages that refurbishment offers after reselling the product.

One potential drawback about implementing design styles that can evoke associations of timelessness is the fact that, in the end, all trends are cyclical and evolve over time. Even though some trends are moving faster than others, it is probably inconceivable to design consumer electronics that will remain desirable for numerous decades. It is also questionable whether the designs that are considered neo-retro today will remain to be perceived as neo-retro. Furthermore, even though prototypes of products do not change frequently, these do evolve in time. Prototypes are "cognitive reference points" that consumers use to determine whether a product belongs to a certain product category (Rosch, 1975, p. 533). Shared characteristics, that products of the same category have, determine the prototype. For example, in the past, a telephone's handle was considered a prototypical characteristic of a telephone. Nowadays, telephones are mobile, and most telephones do not have handles anymore. A high degree of prototypicality has shown to have a positive effect on the attractiveness of products and, therefore, should be taken into consideration when designing for timelessness (Blijlevens et al., 2012; Bloch et al., 2002; Hekkert et al., 2003). Even though these time effects need to be taken into account and limit the 'eternal' desirability of timeless products, this does not mean that timelessness may not contribute to circular consumption. Lifespans of many product categories are decreasing. For example, the lifespan of coffee machines decreased from 2000 to 2005 with 9% to only 6.4 years (Bakker et al., 2014). A successful refurbishment strategy and thus, a second or even third life, may turn the overall lifespan of coffee machines to 12 or more years. In many cases, such an increase in lifespan would, from an environmental perspective, be valuable but is not likely to be strongly affected by changes in fashion cycles or prototypes.

Even though our results suggest that neo-retro and simplistic design styles trigger specific associations that can improve consumers' evaluations, we also realize that the final value of these design styles may differ depending on the consumer group and the product category. First of all, consumers differ in their aesthetic preferences (Snelders et al., 2014). For example, highly educated consumers who are above 50 years old prefer designs that refer to a historic context, such as neo-retro designs, whereas consumers that are lower educated and younger (below 36) prefer tough designs, characterized by power and strength. Consequently, the simplistic and the neo-retro design styles may be more influential for highly educated, older consumers than for younger and lower

educated consumer groups. Whether designing a product in a neo-retro or simplistic style is a good design strategy to enhance consumer acceptance of refurbished products also depends on the product category of the refurbished product. Our results suggest that product categories that are not highly technological, such as coffee machines and radios, can benefit from the positive effects of the neo-retro design style. Nevertheless, it is questionable whether product categories that are continuously advancing in terms of technology, such as smartphones, will also benefit as the association with an 'old' product may then backfire in terms of quality perceptions. In this situation, a simplistic design style could be a more desirable strategy.

2.4.2 Limitations and future research

A limitation of our research is that we took a qualitative approach to uncover the associations that different timeless designs would trigger with consumers, resulting in a relatively small sample size. We believe that our sample size was sufficient for the exploratory focus of our research, which was also supported by the fact that data saturation was reached after 18 interviews. Nevertheless, it would be worthwhile to investigate the effects of timeless designs in more quantitative settings using larger samples. Furthermore, in real purchase settings, consumers often compare refurbished products to new products. It would be interesting for future research to investigate the effects of the design characteristics of refurbished products in choice settings using quantitative research to further validate our findings.

Future research should also explore how the perceptions of refurbished products of various consumer groups differ in detail, using a quantitative approach.

Additionally, our study only explored how consumers perceive the neo-retro and simplistic design style in refurbished products. It is, however, unclear whether the same effect will account for new products as well, resulting in a potential longer first life of the product. Future research needs to explore what role refurbishment plays in the associations that consumers have with neo-retro and simplistic products; perhaps in a comparative study between refurbished products and new products.

Future research is needed to translate and further validate our findings into design guidelines for designers. For example, in our qualitative study, we were not able to distinguish between the effects of the design styles and the effects of specific, general design characteristics. In fact, some general design characteristics are more prevalent in one design style than others. For example, participants preferred products made of wood, leather, and metal because they seemed durable and to age more gracefully. Leather, wood, and metal were most prevalent in the neo-retro products in our study.

Another example is that participants preferred refurbished products with a robust appearance compared to products with sleek parts because they are expected to be less breakable. Most neo-retro products had robust appearances. It is, therefore, interesting for future research to investigate in an experimental setting whether the value of the neo-retro design style for enhancing consumer acceptance of refurbished products is due to the materials and form of the products or due to the associations that the design style evokes in consumers.

Additionally, we acknowledge that even though participants in our study were generally positive about the use of neo-retro and simplistic design styles in refurbished products, this may not be true for all products following these styles. More research is needed to explore what makes some simplistic and neo-retro products attractive, whereas others are considered inauthentic or cheap. Finally, future research could explore the value of appearance, and specifically, specific design styles and design characteristics, for enhancing consumer acceptance of different circular strategies. For products that are circulating among multiple users, such as in sharing systems, other design characteristics may be more important, such as design characteristics that emphasize hygiene (Baxter et al., 2017).

1.5 Conclusions

Refurbishment is a promising circular strategy that can make the production of consumer goods more sustainable by saving finite resources and minimizing waste. Refurbished products are, however, not a desirable consumer choice to most consumers yet, partly because the aesthetic appearance of refurbished products is considered less attractive than the appearance of new products. In this research, we explored whether enhancing the product appearance of refurbished products, by means of two types of timeless design styles, can increase the consumer acceptance of refurbished products. We uncovered that refurbished products in the neo-retro design style and in the simplistic design style evoke favourable perceptions in consumers and subsequently tend to enhance the attractiveness of refurbished products. By considering these findings in the design process, we hope to inspire further research to inform designers on making circular products that remain desirable in multiple life cycles and, therefore, stimulate sustainable consumption with circular products.

CHAPTER 3

Buying new or refurbished? The role of a durable product appearance in determining the purchase intentions of new and refurbished products

Based on: Wallner, T. S., Magnier, L., & Mugge, R. (2021, May 28). Choosing new or refurbished? The influence of the product's durability and attractiveness, contamination risk and consumers' environmental concern on purchase intentions of refurbished and new products. Proceedings of *Product Lifetimes and the Environment, Limerick Ireland (Online), 26-28 May 2021*. https://doi.org/10.31880/10344/10172

3.1 Introduction

Chapter 3 explores the role of product appearance and how it contributes to the consumer acceptance of refurbished products (RQ1). In chapter 2, we discovered that timeless designs could make refurbished products more desirable. Specifically, we have seen that refurbished products following the simplistic and neo-retro design style were not only perceived to be timeless but also elicited favourable associations with the product's durability. While refurbished products, following a neo-retro design style, evoked positive associations with old products and the "good quality of the past ", simplistic products benefited from associations with durability through simplicity. Noticeably, both design styles were not only favoured because their timelessness made them more aesthetically attractive, but consumers also emphasised that they were perceived to be more durable. Additionally, prior research indicated that consumers often have lower purchase intentions for refurbished products because they associate them with lower performance and durability (Van Weelden et al., 2016; Baxter et al., 2017). A limitation of prior research, including chapter 2, is that it has focused strongly on qualitative research, and a comparison to the factors influencing new products is lacking. This research hence contributes by investigating whether a durable product appearance contributes to the purchase intentions of refurbished products compared to new products. Hence, we investigate how important the role of the product's perceived durability is compared to other factors predicting the purchase intentions of refurbished products, such as the product's attractiveness, the perceived contamination risk and the consumers' environmental concern. It additionally aims to uncover how these factors differ from the factors relating to the purchase intentions of new products.

3.2 The influence of product appearance

Consumers draw inferences about the utility and quality of a product based on its appearance (Creusen & Schoormans, 2005; Crilly et al., 2004). For example, consumers perceive objects that are heavy or look heavy to be of higher quality than light products because they associate the product's weight with strength and robustness. Consumers associate this robustness with a higher likelihood that the product will function for a long time (Mugge et al., 2018; Van Rompay & Ludden, 2015). Associations that consumers have with products can be described as product semantics (Krippendorff, 1989). Product semantics are 'symbolic qualities of man-made shapes in the cognitive and social context of their use' (Demirbilek & Sener, 2003, p.3). As semantics change with a product's context, a product with certain appearance-related characteristics may be perceived differently in a refurbished state because the context is changed through the use and refurbishment process.

3.2.1 The influence of a durable product appearance

Refurbished products should optimally communicate durability to counteract the risks that consumers associate with them. Looking back at the history of product design, some products in the past communicated durability and longevity via their design and minimised the use of valuable resources (Nadolni, 2019). An example are designs from the beginning phase of the former German Democratic Republic (GDR). After the second world war, when resources were scarce, products with a Bauhaus design were designed to be long-lasting both from a style in style as well as physical perspective, (Schädlich, 1984), thereby using fewer resources. For new products, a durable product appearance may be preferred from an environmental (Achterberg et al., 2016) and be more desirable to consumers (Mugge et al., 2018). The topic of durability was also uncovered in qualitative research on the effects of product appearance on the acceptance of refurbished products. Refurbished products with a solid, massive product appearance appeared to be desirable in a refurbished state (Wallner et al., 2020). However, this research needs quantitative validation to understand its influence on the purchase intentions of refurbished products compared to new products. Therefore, in this research, we want to test whether consumers have higher purchase intentions of refurbished products with a durable appearance compared to refurbished products that seem more breakable. Furthermore, we want to test whether the perceived durability of refurbished products is more important in refurbished products than in new products.

We, therefore, aim to test the following hypotheses:

> *H1a: Participants have higher purchase intentions for refurbished products with a durable product appearance than for refurbished products with a breakable product appearance Furthermore, the perceived durability of the product has a positive effect on purchase intentions of refurbished products (H1b) and new products (H1c). This effect of the perceived durability is larger for refurbished products than for new products (H1d).*

Nonetheless, the perceived durability of the product appearance is not the only factor determining the purchase intentions of refurbished products. Therefore, we want to test how important the perceived durability is compared to other factors related to the purchase intentions of refurbished products.

3.2.2 The influence of an attractive product appearance

One factor responsible for the desirability of new and refurbished products is an attractive product appearance. Consumers associate attractive products with higher quality, trust (Page & Herr, 2002; Veryzer & Hutchinson, 1998) greater ease of use (Hassenzahl, 2004)

than less attractive products. This stereotype is widely known as the 'what's beautiful is good principle' (Dion et al., 1972). Products that are new and should be kept in the loop as long as possible should therefore have an attractive and timeless product appearance (Mugge et al., 2005). Especially in the context of refurbishment, this seems relevant because refurbished products are perceived to be riskier, or in other words, trusted less by consumers. Decreasing this lack of trust in refurbished products with an attractive product appearance could enhance refurbished products' desirability. We, therefore, hypothesise that:

H2: The attractiveness of the product appearance positively relates to purchase intentions of refurbished products (H2a) and new products (H2b). The effect of an attractive product appearance on purchase intentions is larger for refurbished products than for new products (H2c).

3.2.3 The influence of consumers' environmental concern

Consumers who are more environmentally concerns were shown to be more inclined to purchase refurbished smartphones (Mugge et al., 2017). This is why some consumers favour remanufactured products if they have an eco-label (Wang & Hazen, 2016; Abbey et al., 2014). However, the evidence for the influence of the consumers' environmental concern has been conflicting. Some studies suggested that environmental concern does not predict consumers' purchase intentions of refurbished products (Chen et al., 2020). Counterevidence, however, assumes that consumers know that refurbished products are the environmental choice. Therefore, whether consumers' environmental concern influences the purchase intentions of refurbished products should be tested. We do not expect this effect for new products as they generally don't offer environmental benefits. We, therefore, hypothesise that:

H3: Consumers' environmental concern influences more positively the purchase intentions of refurbished products (H3a) than new products (H3b).

3.2.4 The influence of the perceived contamination risk

Even though refurbished products are cleaned during the refurbishment process, some consumers fear that refurbished products are contaminated with traces of a former user (Van Weelden et al., 2016; Baxter et al., 2017), resulting in a feeling of discomfort or even disgust. However, the higher perceived contamination risk seems strongly related to the context and consumers rather than the product. Shaving razors are a good example: While most consumers would feel uncomfortable buying a second-hand razor, being groomed with a (reused) razor at a barber's shop does not seem to cause an aversive reaction. Furthermore, some consumers are more prone to feel disgusted and do so more

intensely than others; this has been shown to predict avoidant behaviour (van Overveld et al., 2010). For new products, we do not expect an effect because the contamination comes through reusing a product, which is not the case with new products. We, therefore, hypothesise that:

H4: Perceived contamination risk influences more negatively the purchase intentions of refurbished products (H4a), than new products (H4b).

3.3 Methods

3.3.1 Stimuli

Although blenders and headphones are not yet commonly sold in a refurbished state, these product categories are easy to refurbish and provide an interesting category when striving for a circular economy. We created twelve 3D models of blenders and headphones that varied in the durability of the product appearance, while keeping other potential influencing factors (e.g., colour, perspective, material, functions) as similar as possible. The 3D models were created in several iterations of sketching and 3D modelling until we obtained headphones and blenders that sufficiently differed in the durability of their appearance. Durability was operationalised in either a slender (breakable) or massive (durable) product appearance. Twelve 3D models were created with SolidWorks and rendered with Keyshot to include in the pre-test.

3.3.2 Pre-test for the development of stimuli

We conducted a pre-test to select stimuli with product appearances that differed in perceived durability and to prevent possible confounding effects. In a within-subjects design, we exposed 76 participants with experience in design (48 females, age: 20-59, (M=26.5), years of design experience: 1-35 years, M=6.14) to all six blenders and six headphones. Participants rated all stimuli on several 7-point scales (see appendix A4). The pre-test results demonstrated that the stimuli significantly varied in product form (e.g., *The appearance of this blender is*...1. slim - 7. massive), durability (e.g., *These headphones appear to be…* 1. easily broken – 7. will last a long time) and attractiveness (e.g., *The appearance of this blender is*...1. ugly- 7. beautiful) (all p's <.05). Furthermore, the stimuli had a similar level of performance quality (e.g., "*These headphones are of high quality*" 1. strongly disagree, - 7. strongly agree) .and ease of use (e.g., "*This blender looks easy to use*. 1. strongly disagree, - 7. strongly agree; Grewal et al., 1998) (all p's>.05), suggesting that there were no confounding effects for the performance quality and ease of use on our findings. The means and standard deviations of the selected stimuli are displayed

in Table 3; means of all stimuli that were tested can be found in appendix A4. Figure 9 presents the final selection of stimuli.

Table 3. Means and standard deviations of the stimuli determined by a pre-test

Model	Product form	Durability	Attractiveness	Performance quality	Ease of use
Slender headphones	3.31 (.79)	4.11 (1.11)	4.53 (.99)	4.23 (1.08)	3.73 (1.79)
Solid headphones	5.36 (.69)	5.39 (.70)	3.48 (1.24)	4.37 (1.18)	3.29 (1.64)
Slender blender	4.12 (1.61)	4.53 (1.67)	4.28 (1.57)	4.53 (1.43)	5.81 (1.87)
Solid blender	5.33 (1.12)	5.60 (.82)	3.78 (1.57)	4.65 (.92)	5.0 (2.21)

Figure 9. Stimuli for solid/durable (left) and slender/breakable (right) headphones and blenders used in this study.

3.3.3 Participants and procedure of the main study

Three hundred and fifty-one participants from the United Kingdom (Age = 18-80, M_{age}=34.92; 241 females) who were recruited via Prolific participated in the main study. In a between-subjects design, participants saw a picture (6x4cm) of either a white blender or black headphones that was presented as either being in a new or refurbished state with a product appearance varying in durability (durable/solid vs breakable/slender). Furthermore, if they were in the refurbishment condition, they read a text defining what

refurbished products are. Participants in the new condition read the same introductory test but not description of refurbishment. Subsequently, participants answered questions concerning assessment of the product.

3.3.4 Measures

In the main study, we assessed participants' purchase intentions with two items on 7-point Likert scales (1 = strongly disagree- 7 = strongly agree; Dodds et al., 1991; $r = .87$, $p < .001$). An example item was: "*If I would buy refurbished headphones/blenders, I would consider buying these headphones/blenders*". Furthermore, we assessed the durability of the product with four items on 7-point Likert scales (1 = strongly disagree-7 = strongly agree; Grewal et al., 1998; a = .92). An example item was "*These headphones/blenders will last a long time*". We assessed the product's attractiveness with three items on 7-point semantic differential scales (e.g., 1 = ugly- 7 = beautiful; a = 95). The environmental concern of participants was assessed with four items on 7-point Likert scales (1 = strongly disagree- 7 = strongly agree; Mugge et al., 2017, a = .91). An example item was "*I make a special effort to buy products that are made from sustainable materials*". To measure the contamination risk of the product, we used four items on 7-point semantic differential scales ("*I expect that this blender will be: 1 = not contaminated – 7 = contaminated*"; =.89). All scales can be found in Appendix A5. The study was approved by the Ethics Committee of Delft University of Technology.

3.4 Results

3.4.1 Manipulation check

A manipulated check revealed that, while there was variability between participants' ratings for product appearance, there were no significant differences in the perceived durability between the slender ($M = 4.52$, $SD = 1.24$) and solid condition ($M = 4.58$, $SD = 1.18$) $t(349) = 0.69$, $p = .94$, see Table 4. This indicates that our experimental manipulation was unsuccessful. Even though our manipulation of perceived durability was unsuccessful, we decided to test hypothesis H1a nonetheless and conduct a few exploratory analyses.

Table 4. Mean values of durability for all conditions in the study.

	Blenders M (SD)				Headphones M (SD)			
	New		Refurbished		New		Refurbished	
	Slender	Solid	Slender	Solid	Slender	Solid	Slender	Solid
								
Perceived durability	4.81 (1.42)	4.29 (1.28)	4.66 (1.21)	4.71 (.94)	4.42 (1.14)	4.68 (1.26)	4.19 (1.14)	4.63 (1.24)

3.4.2 Testing the effect of perceived durability on purchase intentions

To test hypothesis H1a we used an Analysis of Variance (ANOVA). Accordingly, we conducted an ANOVA with the purchase intentions as the dependent variable and the product appearance (slender vs. solid) and the product state (refurbished vs. new) as independent variables. With this, we aimed to test whether participants have higher purchase intentions for products that have a durable appearance compared to those that have a more breakable appearance; and whether this depends on the product state. Concerning H1a, we expected to find a significant interaction between product appearance (slender vs. solid) and product state (refurbished vs. new) on the purchase intentions. However, no significant interaction for product form and state on purchase intentions was found, and thus Hypothesis 1a could not be confirmed $F(1, 347) = 2.90$, $p = .09$. Moreover, there was no main effect of the product appearance (slender vs. solid) on purchase intentions $F(1, 347) = .001$, $p = .97$. A main effect was found for product state $F(1, 347) = 9.59$, $p < .001$ and product type $F(1, 343) = 10.59$, $p = .001$. Participants had higher purchase intentions for new products ($M = 3.96$, $SD = 1.57$) than for refurbished products ($M = 3.42$, $SD = 1.61$; $t(349) = 3.11$, $p < 0.01$). Additionally, there was no significant three-way interaction between product appearance, product type, and product state (p above .05), with purchase intentions as the dependent variable. Controlling the effect of the perceived attractiveness did not change these findings.

Considering that our manipulations were unsuccessful and that there was variability in the durability that participants perceived in the stimuli, we decided to test how important the perceived durability was for influencing the purchase intentions of both refurbished and new products in comparison to other factors (H1b and H1c) by specifically focusing on the individual scores of perceived durability. Therefore, we computed two regression models: One for new products and one for refurbished products, thereby combining the data of the headphones and the blenders. The

purchase intentions of new or refurbished products were used as the dependent variable, and the scores on product's perceived durability, attractiveness, environmental concern and perceived contamination risk were included as the independent variables. Both regression models were significant (new products: see Figure 11; $F(4, 164) = 29.81$, $p < .001$, $R_2 = .42$; refurbished products: see Figure 10; $F(4,176) = 36.01$, $p < .001$, $R_2 = .45$). However, the extent to which the different factors explained the purchase intentions differed between new and refurbished products. To explore the remaining hypotheses, we will elaborate on the individual beta values of variables in the regression analysis. The means of all variables and correlations can be found in table 5 and 6 subsequently.

Table 5. Mean values of all variables

	Blenders M (SD)				Headphones M (SD)			
	New		Refurbished		New		Refurbished	
	Slender	Solid	Slender	Solid	Slender	Solid	Slender	Solid
Purchase intentions	4.23 (1.59)	4.13 (1.41)	3.59 (1.38)	3.93 (1.58)	3.96 (1.43)	3.53 (1.78)	2.97 (1.53)	3.22 (1.82)
Durability	4.81 (1.42)	4.29 (1.28)	4.66 (1.21)	4.71 (.94)	4.42 (1.14)	4.68 (1.26)	4.19 (1.14)	4.63 (1.24)
Attractiveness	3.60 (1.51)	3.56 (1.28)	3.62 (1.45)	3.73 (1.48)	3.65 (1.60)	3.24 (1.60)	3.33 (1.50)	3.52 (1.64)
Environmental concern	4.26 (1.62)	4.73 (1.54)	4.53 (1.36)	4.31 (1.44)	4.60 (1.43)	4.39 (1.43)	4.14 (1.77)	4.19 (1.44)
Perceived contamination	1.79 (.96)	2.14 (1.09)	2.27 (1.18)	2.37 (1.38)	2.31 (1.28)	2.35 (1.16)	2.53 (1.50)	2.88 (1.49)

Table 6. Correlations of all variables

		Purchase intentions	Durability	Attractiveness	Environmental concern	Perceived Contamination
Refurbished	Purchase intentions		.59**	.54**	.15*	-.34**
	Durability	.59**		.49**	.01	-.25**
	Attractiveness	.54**	.49**		.08	-.12
	Environmental concern	.15*	.01	.08		-.04
	Perceived Contamination	-.34**	-.25**	-.12	-.04	
New	Purchase intentions		.60**	.58**	-.01	-.13
	Durability	.60**		.47**	.00	-.28**
	Attractiveness	.58**	.47**		.06	-.27**
	Environmental concern	-.01	.00	.06		.07
	Perceived Contamination	-.13	-.28**	-.27**	.07	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

3.4.3 Regression analysis on factors determining choice for refurbished products

A regression analysis indicated that for refurbished products, the perceived durability (*ß* = .29, *p* < .01) and attractiveness (= .37, *p* < .01) positively predicted the purchase intentions, confirming H1b and H2a.

The consumers' environmental concern (*ß* = .13, *p* < .05) had a positive effect and the perceived contamination risk had a negative effect on purchase intentions *(ß* = .26, *p* < . 01) of refurbished products, confirming H3a and H4a.

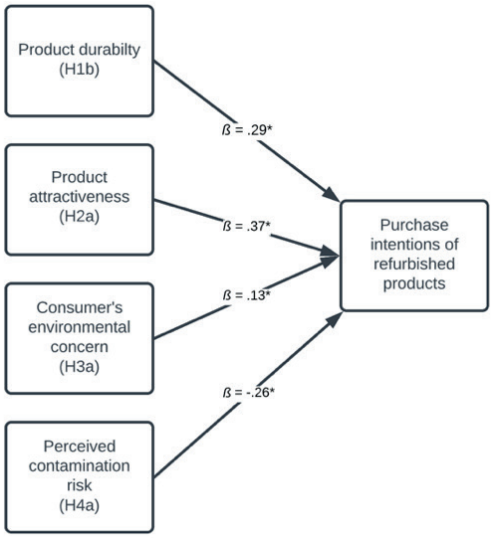


Figure 10. The regression model shows that product-related factors (perceived durability and attractiveness), consumer's environmental concern and perceived contamination risk predict the purchase intentions of refurbished products.

3.4.4 Regression analysis on factors determining choice for new products

A regression analysis indicated that the perceived durability (H1c; *ß* = .32, *p* < .01) and attractiveness (H2b; *ß* = .49, *p* < .01) of new products positively predicted the purchase intentions, providing support for H1c and H2b.

Neither the consumers' environmental concern (*ß* = .04, *p* > .05) nor the perceived contamination risk (*ß* = - .09, *p* >.05) predicted the purchase intentions of new products, supporting H3b and H4b.

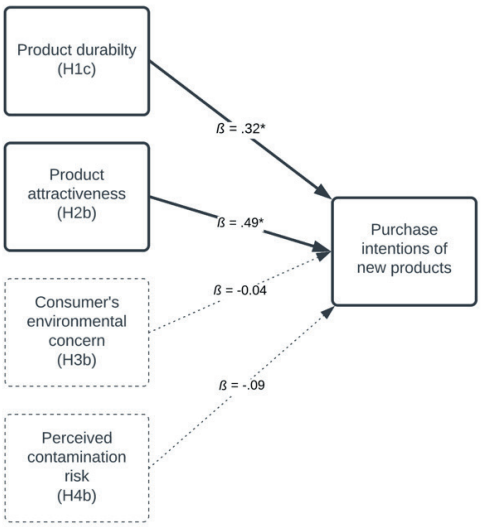


Figure 11. The regression model shows that product-related factors (perceived durability and attractiveness), but not consumer's environmental concern and perceived contamination risk predict the purchase intentions of new products.

3.4.5 Exploratory analyses: Differences in between new and refurbished products

To test whether there were differences in the regression coefficients between new and refurbished products, we analysed whether the regression coefficients of variables were significantly different for predicting the purchase intentions of refurbished compared to new products. The influence of the products' perceived durability on the purchase intentions was not significantly larger for refurbished products than for new products (*ß* =.29 vs. *ß* =.32, $t(345) = -.09$, $p > .20$), and thus no support was found for H1d. The influence of the product's attractiveness on the purchase intentions was also not significantly larger for refurbished products than for new products (*ß* =.37 vs. *ß* =.49, $t(345) = -1.34$, $p > .10$), failing to support H2c. Environmental concern was a larger predictor for the purchase intentions of refurbished products than for new products (*ß* = .13 vs. *ß* = -.04, $t(345) = 2.40$, $p < .05$).

The perceived contamination risk was a larger predictor for the purchase intentions of refurbished products than for new products (*ß* = -.26 vs. *ß* = .09, $t(345) = -4.08$, $p < .01$). Additionally, we ran a regression analysis with interaction factors using with a dummy variable (RNR) for refurbishment which coded refurbished products as 1 and all other products as 0. The product's attractiveness and durability as well the consumers environmental concern and contamination concerns were standardized and added to the regression model. We also included the product category (blenders

or headphones) as a covariate by including a dummy variable with headphones being coded as 1 (PI=a+b0 RNR + b1 durability +b2 attractiveness +.... +b11durability*RNR+b21 attractiveness*RNR + ... + covariate). The regression analysis with purchase intentions as the dependent variable was significant (see Table 7). The regression analysis yielded main effects for durability $ß = .67$ and attractiveness $ß = .63$, confirming the finding of prior analyses. Interestingly there as a main effect for the product type $ß = -.38$ hinting at differences between blenders and headphones (means can be found in Table 5). For perceived contamination there was a main effect $ß = .26$ as well as an interaction effect of contamination and refurbishment $ß = -.51$. As expected, there was an interaction effect for environmental concern with refurbishment $ß = .25$.

Table 7. Regression analysis for refurbishment (dummy variable), durability, attractiveness, the consumers environmental concern and contamination concerns on purchase intentions

Variable	Standardized coefficients b-estimate	Unstandardized coefficients b-estimate	*p*-value
Intercept	4.19		
Durability (z-score)	.67	.46	<.001
Attractiveness (z-score)	.63	.39	<.001
Environmental concern (z-score)	-.07	-.04	.43
Perceived contamination (z-score)	.26	.13	.04
Dummy Variable refurbishment	-.53	-.16	<.001
Attractiveness x refurbishment	-.12	-.05	.41
Environmental concern x refurbishment	.25	.11	.05
Durability x refurbishment	-.04	-.02	.76
Perceived contamination x refurbishment	-.51	-.24	<.001
Dummy product type	-.38	-.12	.00
Model	$F(10,340)= 35,47, p < .001$, $R^2 = .51$		

3.5 Discussion and conclusion

This study aimed to investigate how important the role of the product's perceived durability is compared to other factors predicting the purchase intentions of refurbished products, such as the product's attractiveness, the perceived contamination risk and the consumer's environmental concern. Regression analyses indicated that the durability that individual participants perceived in the product and its attractiveness both play a role in predicting purchase intentions of refurbished products. However, we did not find any difference in the predictive power of perceived durability on the purchase intentions of refurbished products compared to new products. This indicates that perceived durability is unlikely to be a more powerful predictor of the purchase intentions of refurbished

products than of the purchase intentions of new products. The results additionally uncovered how these factors differ from the factors predicting the purchase intentions of new products. While we could not confirm our hypothesis that consumers prefer solid appearances for refurbished products over slender ones, we did find support for our hypotheses that the product's perceived durability and attractiveness positively predict the purchase intentions for both new and refurbished products.

This study supports and extends the literature on durable and attractive product appearances (Mugge et al., 2018; Wallner et al., 2020) by demonstrating the importance of these product-related factors in all stages of a product's circular life. However, our results indicated that the product's perceived durability and attractiveness do not play a larger role in refurbished products than new ones. The main contribution of this study is that consumer's environmental concern and perceived contamination risk influence the purchase intentions of refurbished products, whereas there are no effects for new products. This is in accordance with previous literature suggesting that refurbished products can trigger contamination concerns because of their previous use (Baxter et al., 2017, Van Weelden et al., 2016). Our research is, however, the first to show in a quantitative study that the perceived contamination risk has a quantifiable effect on the purchase intentions of refurbished products, even when controlling for the attractiveness and perceived durability of refurbished products, and that the effect is larger than the effect of the consumer's environmental concern. While previous research has mainly focused on increasing purchase intentions of refurbished products via the route of environmental awareness, for example, by exploring the effect of eco-labels (Abbey et al., 2015; Hamzaoui Essoussi & Linton, 2010; Wang & Hazen, 2016), we argue that future research should also focus on exploring strategies to counteract the contamination risk. For example, future research could explore how the design of products can be optimised for cleaning and changing parts. For example, one could examine whether changing the ear cushions can eliminate the perceived contamination risk of refurbished headphones. Second, research should explore how communication about the refurbishment and cleaning process can be improved. Third, research should explore whether consumer characteristics, such as disgust sensitivity, contribute to perceived contamination; and make certain consumer groups more prone to reject refurbished products.

3.5.1 Limitations and reflections on the experiment

Our research in chapter 2 indicated that refurbished products were favoured by consumers when they were associated with durability (Wallner et al., 2020). In this study, we wanted to test whether changing the appearance of the product into a more solid (vs. slender) appearance would influence the product's perceived durability, and thereby positively affect the purchase intentions of a refurbished product. We, therefore, operationalised perceived durability via the product form by creating 3D models of products that had

either a durable/sold or rather breakable/slender product appearance. While in a pre-test (using a within-subjects design), participants with expertise in design rated the slender and solid product appearances as significantly different in their perceived durability, in the main study (using a between-subject design), the manipulation, unfortunately, did not work out as planned; participants without design expertise did not perceive the solid product appearance to be significantly more durable than the slender product appearance. Furthermore, we did not find that robust products are preferred over breakable (slender) refurbished products. This might have had several reasons; one possible explanation for this finding could be that due to the experimental design (between–subjects design), participants did not have the same frame of reference for the stimuli's perceived durability as the design experts had in the pre-test. A second reason might be that the difference between the slender and solid products was not visible enough for the participants of the main study, while designers could have noticed the difference due to their design expertise. A third reason might be that the quality of the stimuli was not good enough. To create stimuli that were completely alike but only differed in durability, we created artificial 3D models of blenders and headphones. However, these products might not have been realistic enough to trigger a true response in consumers. Future research could check whether using stimuli of higher quality of operationalising durability differently may lead to different findings.

Given the focus on product appearance, we only measured two factors related to the appearance of refurbished products and two additional factors. Other factors, such as the product's warranty and price, were not assessed, presenting a limitation to our study. Another limitation of our study is that we only measured the purchase intentions and did not put participants into a realistic choice setting. Future research could model the consumer choice for refurbished products more closely and perhaps include additional consumer characteristics, product-related factors (e.g., price of the product) and contextual factors (e.g., the seller's reputation).

3.5.2 Conclusion on predictors of consumers' purchase intentions of refurbished products

To conclude, product-related factors, such as the product's perceived durability and attractiveness, are important predictors of consumers' purchase intention across the different phases of a circular life. Contamination risk and the consumer's environmental concern, however, play an essential role in influencing purchasing intentions of refurbished products. These findings suggest that the perceived 'cleanness' of refurbished products and the notion that refurbished products are a sustainable choice could be worthwhile strategies for increasing the desirability of refurbished products.

CHAPTER 4

A network analysis of factors influencing the purchase intentions of refurbished electronics

Based on: Wallner T.S., Haslbeck, J.M.B., Magnier, L., & Mugge, R. (under review). A network analysis of factors influencing the purchase intentions of refurbished electronics.

4.1 Introduction

In chapter 3, we concluded that product-related factors, such as the product's perceived durability and attractiveness, are important predictors of consumers' purchase intention across the different phases of a circular life. Contamination risk and the consumer's environmental concern, however, play an essential role in influencing purchasing intentions of refurbished products. Nevertheless, in the previous chapter, we did not provide a comprehensive analysis of the various factors that are important when it comes to determining the purchase intentions of refurbished products due to the focus on product appearance. In reality, the results were a simplification of the consumer decision-making process that also involves other factors related to the product, the consumer and marketing-related factors (Van Weelden et al., 2016) and might differ per product category (Abbey et al., 2015). Chapter 4 therefore explores the underlying relationships of the factors influencing consumer acceptance of refurbished product (RQ2) with a network analysis.

Prior literature has explored how marketing-related factors can make refurbished electronics more desirable (Alqahtani & Gupta, 2017; Atasu et al., 2008; Esmaeilian et al., 2021; Govindan et al., 2019; Mugge et al., 2017). However, while prior research has identified factors that linearly predict purchase intentions regarding refurbished electronics, it is not known which factors are most influential in the consumer choice and how these factors relate to each other. Furthermore, consumer decision-making for or against refurbished electronics involves a complex interplay of product-related, marketing-related and consumer-related factors that influence each other (Wallner et al., 2021). Yet, few studies have considered the roles of the product and the consumer in combination with marketing-related factors (Hazen et al., 2012; Mugge et al., 2017; Wallner et al., 2022a,b). By exploring the complexity of the factors that are at play, we build on prior research (Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016) and contribute to research on consumer acceptance of refurbished electronics by shedding light on the underlying psychological processes. By doing so, we aim to develop more sophisticated strategies for the successful design and marketing of refurbished electronics to enable these products to retain their value over multiple lifecycles.

4.1.1 Consumer acceptance of refurbished electronics

Consumer decision-making regarding refurbished electronics is frequently described as a trade-off between advantages and disadvantages that are weighed against alternatives, such as new electronics or second-hand electronics (Van Weelden et al., 2016). Compared to second-hand electronics, refurbished electronics are seen as a safer choice because they are provided with money-back guarantees and warranties (Alqahtani & Gupta, 2017; Mahmoodi & Heydari, 2021; Mugge et al., 2017). Compared to new electronics, refurbished electronics have a lower price and are seen as an environmentally friendly option (Abbey et al., 2015; Harms & Linton, 2016; Mahmoodi & Heydari, 2021; Michaud & Llerena, 2010; Mugge et al., 2017; Sharifi & Shokouhyar, 2021; Wahjudi et al., 2020).

These benefits are however often not strong enough to compensate for the perceived disadvantages. Consumers typically perceive refurbished electronics to be a riskier choice than new electronics because of their previous use (Hamzaoui Essoussi & Linton, 2010; Singhal et al., 2019; Van Weelden et al., 2016). Consumers expect refurbished electronics to have lower utility (e.g. decreased battery capacity), to have a shorter product lifetime, to become technically obsolete quicker and to be contaminated by their prior use (Abbey et al., 2015; Baxter et al., 2015; Nasiri, 2021; Van Weelden et al., 2016; Wallner et al., 2022a,b). This can cause a feeling of unease in the consumer for two reasons: first, it can decrease their trust in the refurbished product as a satisfactory financial investment and consequently they may dispose of it earlier than they would dispose of a new one (Guide & Li, 2010; Hamzaoui Essoussi & Linton, 2010; Michaud & Llerena, 2010; Van Weelden et al., 2016; Wang et al., 2013). Second, it may cost them time if the product needs to be sent back (Van Weelden et al., 2016). Prior qualitative research has indicated that the balance between the advantages and disadvantages is influenced by a complex interplay of factors related to the product, marketing and the consumer (Van Weelden et al., 2016; Wallner et al., 2022b).

4.1.2 Product-related factors influencing the advantage-disadvantage trade-off

A central factor in determining how advantageous consumers perceive a refurbished product to be is the product itself, more specifically its *perceived utility* (Abbey et al., 2015; Chen et al., 2020; Wahjudi et al., 2020). Consumers find it hard to evaluate the utility of refurbished electronics because they are the result of an often opaque refurbishment process, in which products are cleaned, disassembled, inspected, tested and brought into an acceptable state (Tereyağoğlu, 2016). Consumers therefore often fall back on determining the utility of the product based on their product appearance (Creusen & Schoormans, 2005; Crilly et al., 2004; Krippendorff, 1989). In general, *aesthetically attractive electronics* are associated with higher quality, trustworthiness (Page & Herr, 2002; Veryzer & Hutchinson, 1998) and greater ease of use than less attractive electronics (Hassenzahl, 2004). Another factor that reflects on the utility of a product is how durable the product is perceived to be (Mugge et al., 2018). A product that is perceived to be *durable* is also perceived to have a lower probability of malfunctioning and suffering from an insufficient product lifetime. It is therefore not surprising that the perceived attractiveness and durability of refurbished electronics have been shown to strongly relate to purchase intentions (Wallner et al., 2021).

Another product-related factor that can potentially make refurbished electronics undesirable is *the presence of signs of wear and tear*, such as scratches. Signs of wear and tear are associated not only with a lower product functionality, a shorter product lifetime

and an increased perceived risk but also with a feeling of unease or even disgust (Mugge et al., 2018). Signs of wear and tear indicate that the product has been used extensively and might be contaminated by the prior user (Wallner et al., 2022b). *Contamination* is based on the law of contagion, according to which a source (e.g. a previous user) transfers its essence (e.g. skin particles or their smell) to a recipient (e.g. headphones). These traces of contamination remain on the recipient even after the contact with the source is broken (Mauss, 2005; Rozin et al., 2015; Rozin & Nemeroff, 1990). The feeling that a product has been contaminated by its prior user can cause consumers to feel uncomfortable and has been shown to be an influential factor decreasing purchase intentions in various product categories, such as recycled water, used shopping carts and second-hand clothing (Huang et al., 2017; O'Reilly et al., 1984; Rozin et al., 2015).

Baxter et al. (2017) distinguished three different types of contamination in circular electronics: hygienic contamination, utility contamination and territorial contamination (HUT model; Baxter et al., 2017). Qualitative research has shown that all three make refurbished electronics less desirable (Wallner et al., 2022b). *Hygienic contamination* describes the risk consumers perceive concerning objects that were used before and which may pose a threat to one's health as a result of pathogens or dirt (Baxter et al., 2017). *Utility contamination* has a functional nature; consumers feel unease because the prior use of the product is believed to have decreased its functionality (Baxter et al., 2017). *Territorial contamination* suggests that the product is perceived to be uncomfortable to use because it interferes with one's personal space (Baxter et al., 2017), such as headphones smelling like a previous user.

Contamination is dependent not only on the condition of the electronic product but also on its context (Baxter et al., 2017; Wallner et al., 2022). For example, whether a product is expected to have a decreased functionality due to its prior use (utility contamination) does not only depend on whether it shows signs of wear and tear but also on its warranty and price (Wallner et al., 2022b).

4.1.3 Marketing-related factors influencing the advantage-disadvantage trade-off

A widely researched marketing factor predicting the purchase intentions for refurbished electronics is their price (Abbey et al., 2015; Atasu et al., 2008; Bittar, 2018; Grewal et al., 1998; Mugge et al., 2017; Subramanian & Subramanyam, 2012; Wahjudi et al., 2020). Refurbished electronics are an economical choice for consumers because their market value is 10-50% lower than the market value of new electronics (e.g. Refurbed, 2022). *A low price* has the potential to decrease the perceived risk that the product is a bad financial investment, while at the same time it serves as a financial incentive to buy refurbished electronics over new electronics. It is not clear, however, whether price decreases the perceived riskiness of refurbished electronics or serves as a financial incentive to consumers.

In addition to the price, *warranties* can incentivize consumers to buy refurbished electronics over new electronics. Wallner et al. (2022b) discussed that a warranty can compensate for the risk that consumers associate with refurbished electronics, even those with visible signs of wear and tear. Moreover, for a consumer to trust the retailer to grant the promised warranty, the retailer needs to be trustworthy. *A good brand reputation* has been shown to decrease the perceived risks associated with refurbished smartphones (Agostini et al., 2021; Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016) and lead to a higher perceived value of the product. The decreased risk and the higher perceived value in turn lead to higher purchase intentions for refurbished electronics (Agostini et al., 2021).

4.1.4 Consumer-related factors influencing the advantage-disadvantage trade-off

To add another level of complexity, consumers have different needs, desires and characteristics, which drive their consumption decisions (Hunka et al., 2020). Consumers who are *environmentally concerned* are not only more likely to buy refurbished electronics in general (Barber et al., 2014; Fransson & Gärling, 1999; Mugge et al., 2017; Schultz, 2001; Wallner et al., 2022a,b; Wallner et al., 2021) but also more likely to choose a refurbished product that shows signs of wear and tear, such as scratches (Wallner, et al., 2022a). Furthermore, prior research has pointed out that consumers who are keen to find good financial deals and receive *good value for money* are incentivized to buy refurbished electronics because of their lower price (Mugge et al., 2017). For these value-conscious people, a lower price might be the most important factor in determining their choice to buy refurbished electronics. Additionally, in a qualitative study, consumers who described themselves as *disgust sensitive* had more concerns about the hygienic and territorial contamination of refurbished personal care products (Wallner et al., 2022b).

4.1.5 Differences between product categories

Consumers are more willing to purchase refurbished technology products than personal care products (Mahmoodi & Heydari, 2021). Abbey et al. (2015) distinguished between three different types of reused electronics that differ in the level to which they evoke consumers' contamination concerns and therefore determine their desirability in a refurbished state: *around-you electronics* (e.g. speakers), *on-you electronics* (e.g. headphones) and *in-you electronics* (e.g. earbuds). While reused around-you electronics evoke low levels of repulsion in consumers, reused on-you electronics and reused in-you electronics evoke high levels of repulsion and are therefore deemed unfit for reuse strategies (Abbey et al., 2015). In contrast, other studies have indicated that some consumers are open to purchasing refurbished electronics that have been intimately used (Mugge et al., 2017; Wallner et al., 2022b). For example, Mugge et al. (2017) found

that more than half of their interviewees were open to the idea of acquiring a refurbished electric toothbrush. This shows that with adequate incentives (e.g. a low price), some consumers may adopt refurbishment for product categories with high levels of contamination. How product categories with high levels of contamination can be made desirable to consumers and how this differs from product categories with low levels of contamination remains unexplored. In our research, we therefore aim to explore which factors influence the purchase intentions for refurbished electronics that differ in terms of how intimately they are used.

To summarize, consumers' decisions to purchase refurbished electronics are a complex process that involves the interaction of factors related to the refurbished *product itself*, the *marketing* and the *consumer*. While researchers have identified factors that might be at play in predicting the purchase intentions for refurbished electronics (Mugge et al., 2017; Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016), knowledge on how these factors interplay and which factors are most important is lacking.

4.1.6 The network approach

In this study, we address the aforementioned complexity by performing a network analysis of consumer characteristics and beliefs about refurbished electronics. In a network, different influencing factors – such as beliefs and consumer characteristics – are represented by nodes. Links between nodes, also called edges, represent their statistical relationship to one another (Newman, 2018). More specifically, an edge indicates a statistical relation between two nodes after controlling for every other node in the network as the network is based on partial correlations. These edges are weighted (between -1 and 1) and undirected (i.e. the direction is not indicated). Moreover, by including intentions to purchase as a node in an attitude network one can gain insights into which elements meaningfully predict behaviour (Dalege et al., 2016), such as buying refurbished electronics. Node centrality indicates the relative importance of nodes in the network, and illustrates the effect that influencing one node can have on the entire network. Node strength, a form of node centrality, can provide information on the predictive value of nodes in an attitude network (Dalege et al., 2017; Bringmann et al., 2019). To display the structure of the network, we used an algorithm that places clusters of connected nodes close to each other. Red (blue) edges indicate negative (positive) partial correlations and the width of the edges is proportional to the absolute value of the corresponding partial correlation (Newman, 2018).

A network analysis allows us to capture the interactions between the beliefs about refurbished electronics involved in the decision to purchase refurbished electronics and thereby goes beyond predicting a single outcome measure, such as purchase intention. For example, Zwicker et al. (2020) used the network approach to determine factors that influence consumers' purchase intentions for bio-based plastic bottles. Network analysis

has been conducted in various fields including modelling social networks (Losee et al., 2022), climate adaption policies (Ingold & Balsiger, 2015; Verschoor et al., 2020) and, more recently, consumer attitudes (Dalege et al., 2016; Zwicker et al., 2020).

4.2 Materials and methods

4.2.1 Choice of methodology and contribution

We conducted the network analysis for two reasons. First, we aim to provide an overview of factors involved in the purchase intention for refurbished electronics, including beliefs about refurbished electronics, their marketing and consumer characteristics and how they interact. By exploring the complexity of the factors that are at play, we build on prior research (e.g. Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016) and contribute to research enhancing consumer acceptance of refurbished electronics by shedding light on the underlying psychological processes. Studies investigating consumers' purchase intentions for refurbished products have provided interesting insights on factors that linearly predict the intention to purchase refurbished products (Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016). However, it would be interesting to have an overarching view on the relationships between factors to guide more detailed theory building and analysis. Thus, our second aim is to perform a network analysis that can yield a comprehensive understanding of these overarching relationships across different variables related to the refurbished electronics themselves, the marketing of refurbished electronics and the consumer. Networks are based on partial correlations, which allow the models to cancel out the effects that variables have on each other. Insights on how product-related factors, marketing-related factors and consumer-related factors interact can lead to more sophisticated strategies for how electronics need to be designed and marketed to have multiple life cycles. Additionally, by identifying which factors differ in predicting the purchase intentions for refurbished electronics in different categories, we hope to contribute to the understanding of how these strategies should differ between different product categories.

4.2.2 Choice of product categories

Prior research has shown that every product category might raise specific issues that influence the product's desirability in a refurbished state (Mugge et al., 2017). Generally, prior literature has shown that consumers are more willing to purchase refurbished technological products than personal care products (Mahmoodi & Heydari, 2021). Based on the three categories of Abbey et al. (2015; around-you products, on-you products and in-you products), we chose to investigate two electronic products that differ in the degree

to which they evoke contamination concerns but have similar functional values. Speakers (around-you product) are a product category that is unlikely to evoke contamination concerns. In contrast, earbuds (in-you product) are worn in close contact with the ear. We selected these two product categories based on a pre-test (see Table 8 for more information). In the pre-test (n=50), we showed each participant a visual representation of an in-you product (earbuds), an on-you product (headphones) and around-you product (speakers). Subsequently, they rated the products' intimacy of use ("*Please rate how intimately the following products are used*"; 1 = Not intimate at all, 7 = Extremely intimate) and the degree to which the products evoked contamination concerns when bought in a second-hand state ("*Can you please indicate how comfortable you would be to use the products below if these were second-hand*?"; 1 = Not comfortable at all, 7 = Extremely comfortable, reversed). A repeated-measures ANOVA showed that earbuds, headphones and speakers greatly differed in how intimate their use is perceived to be ($F(2,48) = 35.35$, $p < .001$) and the degree to which they are perceived to be contaminated ($F(2,46) = 50.19$, $p < .001$). We chose speakers and earbuds (see Figure 12) because they had the highest mean differences in the intimacy of their use ($M = 2.68$, $SD = 1.84$, $M = 5.86$, $SD = 1.59$, respectively; $t(49) = 26.05$, $p < .001$) and their perceived contamination ($M = 2.10$, $SD = 1.27$, $M = 5.58$, $SD = 1.92$, respectively $t(47) = 8.71$, $p < .001$).

Table 8. Means and SDs for earbuds, headphones and speakers

Variable	Product category	Mean	SD
Intimacy	Earbuds	5.86	1.59
	Headphones	4.90	1.66
	Speakers	2.68	1.84
Contamination	Earbuds	5.58	1.92
	Headphones	4.31	1.77
	Speakers	2.10	1.27

Figure 12. Stimuli used in study

4.2.3 Participants

To determine the number of participants for a network with Likert-scale variables with 18 nodes, we used the following estimation: a network with 18 nodes contains 171 parameters, 18 intercepts and 153 partial correlations (Isvoranu & Epskamp, 2021). Using a minimum of five observations per parameter as a rule of thumb, this leads to a sample size requirement of 855 for each of the two groups, leading to a required minimum sample size of 1710 participants. We use the rather liberal rule of thumb of five observations per parameters due to the exploratory nature of the study, and because we use statistical methodology to control for false positives (see below).

To obtain a sufficiently large number of valid responses, we therefore recruited 1,896 participants via the data collection service Prolific. Seventy-six participants were excluded because they did not pass the attention check and 19 participants were excluded because their survey response time was under 2 minutes (M_{time}=5.2 minutes), resulting in a sample of 1,801 participants. Participants were compensated at a rate of £8.80/hr on average.

Of these 1,801 participants, 895 (49.4%) were male, 899 (49.8%) female and 7 (0.4%) other, with ages ranging from 18 to 84 years old (M_{age}=37.33, SD=13.43). The majority of the participants had either a high school diploma (32.8%) or a bachelor's degree (44.1%). Eighteen per cent had a master's degree, 2.2% had a PhD and 5.3% indicated that they had completed another type of education. Most participants resided in the United Kingdom (72.1%), on the European continent (12.5%), on the American continent (7.4%) or in South Africa (7.4%); a minority resided in Japan, Korea, Israel, New Zealand and Australia (< .5% each).

4.2.4 Procedure and measures

After filling in the informed consent, participants were shown a graph explaining that during the refurbishment process, products are collected from a previous user, tested, repaired, cleaned and resold. The participants were then instructed to imagine themselves considering the purchase of either refurbished earbuds or speakers, depending on the condition they were randomly assigned to, and they were shown a visual representing this category (see Figure 12). Next, they filled in a question about their purchase intentions for either refurbished earbuds or speakers. Subsequently, we assessed their beliefs about refurbished earbuds or speakers in general. Beliefs that predict the purchase intentions for refurbished electronics were categorized into groups related to the retailer (trust in the brand and warranty), the perceived advantages (i.e. financial and environmental benefits), the perceived disadvantages (i.e. perceived risk, hygienic contamination, territorial contamination, utility contamination, expected obsolescence, lack of social status) and the product appearance of refurbished electronics (aesthetic attractiveness, durability, signs of wear and tear). To prevent fatigue in participants, we

used single-item scores to assess the beliefs about refurbished electronics, as has been done in other network studies (e.g. Chambon et al., 2021; Zwicker et al., 2020). Finally, participants answered questions assessing their consumer characteristics (environmental concern, value consciousness and disgust sensitivity) and demographics, such as age, gender, nationality and highest level of education (high school, bachelor's degree, master's degree, PhD or other). All questions are based on validated scales and adapted to the context of refurbishment and were measured on 7-point Likert-scales (1=strongly disagree, 7=strongly agree). An overview of all items can be found in Table 9. The study was approved by the Ethics Committee of Delft University of Technology.

Table 9. Items and scales used in the study

Scale name	Item	Based on
	7-point Likert scale from 1=strongly disagree, 7=strongly agree	
Purchase intentions	If I were to buy speakers/earbuds, I would consider buying refurbished speakers/earbuds.	Dodds et al., 1991
Trust in brand	If I were to buy refurbished speakers/earbuds, I would look for a brand that is trustworthy	Grewal et al., 1998
Warranty	I believe that the warranty period of refurbished speakers/earbuds is sufficiently long.	Mugge et al., 2017
Financial benefits	I believe that refurbished speakers/earbuds are a financially attractive alternative to new earbuds.	Mugge et al., 2017)
Signs of wear and tear	Refurbished speakers/earbuds probably show signs of use (e.g., have scratches on them).	
Environmental benefits	Refurbished speakers/earbuds are an environmentally friendly option.	Mugge et al., 2017
Lack of social status	Buying refurbished speakers/earbuds, I would worry that the product lacks status.	Grewal et al., 2004
Aesthetic attractiveness	The look of refurbished speakers/earbuds is as attractive as the look of new speakers/earbuds.	
Durability	Refurbished speakers/earbuds last as long as new earbuds.	Grewal et al., 1998
Hygienic contamination	Refurbished speakers/earbuds are unhygienic because they have been previously used by somebody else.	Baxter et al., 2015
Utility contamination	Refurbished speakers/earbuds have a lower performance than new speakers/earbuds simply because they have been used by somebody else.	Baxter et al., 2015
Territorial contamination	Using refurbished speakers/earbuds, I would always think about the fact that they had belonged to somebody else.	Baxter et al., 2015
Expected Obsolescence	Buying refurbished speakers/earbuds, I would worry that they would be technologically out of date soon after the purchase.	

Perceived risk	1. I would consider buying refurbished speakers/earbuds as extremely risky in terms of how they would perform. [Performance Risk] 2. I am concerned that I would waste my time having to return dysfunctional refurbished speakers/earbuds. [Time risk] 3. I would worry to lose a significant amount of money, if I ended up with refurbished speakers/earbuds that didn't work. [Financial risk	DelVecchio & Smith, 2005 Stone & Grønhaug, 1993 Van Weelden et al., 2016
Value consciousness	1. When shopping, I compare the prices of different brands to be sure I get the best value for the money. 2. When purchasing a product, I always try to maximize the quality I get for the money I spend. 3. I generally shop around for lower prices on products, but they must still meet certain quality requirements before I buy them	Lichtenstein et al., 1990; α =0.72
Disgust Sensitivity	In the next section, you will be asked to rate the extent to which you feel comfortable or uncomfortable about specific situations below. 1. Using a game controller that your friend, who has a cold, used before. 2. Touching the door handle of a public toilet. 3. Using a rental car of which the steering wheel is stained.	Based on Olatunji et al., 2012, and pre-tested α =0.79
Environmental concern	1. I make a special effort to buy products that are made from sustainable materials. 2. I have changed which products I use because of sustainability-related reasons. 3. I have avoided buying a product because it had potentially harmful effects to people and/or the environment	Kim and Choi, 2005, Mugge et al., 2017 α =0.88
Sex	What is your sex (male, female, other)	
Age	How old are you (number of years)?	
Education	What is your highest level of education? 1. High school 2. University Bachelor Degree 3.University Master Degree 4.PhD 5.Other	

4.2.5 Statistical analysis

We chose Mixed Graphical Models (MGMs; Haslbeck & Waldorp, 2020) as the network model because it allows us to include categorical variables, such as product category. In addition, this class of models allows us to compare the two product categories in one statistical model without the need for additional post-hoc tests (Haslbeck, 2022). Table 10 reports the relevant statistics for each of the nodes in the network (means, standard deviations and significance of mean differences for earbuds and speakers). Finally, we assessed the stability of the network via bootstrapping (Haslbeck & Waldorp, 2020) (see S9 in supplementary materials). The network models are estimated with L1-regularized (lasso) nodewise regression as implemented in the R-package MGM (Haslbeck & Waldorp, 2020). The MGM package was used with default settings. In L1-regularized estimation the negative log-likelihood of the model is minimized together with a penalty that consists

of the sum of the absolute value (i.e. the L1-norm) of all interaction parameters, which is weighted by a regularization parameter l. The regularization term has the effect that all parameters are shrunk towards zero and small parameters are set to exactly zero. It thereby also performs edge-selection, which makes the additional use of hypothesis testing unnecessary (Hastie et al., 2015). By choosing a good regularization parameter l, we achieve an optimal trade-off between model fit and generalizability (i.e. avoiding overfitting). Here, l is chosen by 10-fold cross validation. The nodewise regression scheme yields two estimates for each partial correlation, which we combine with the OR-rule by taking the average of both estimates. The OR-rule is more liberal compared to the AND-rule, which requires that both estimates are nonzero and otherwise sets the overall edge to zero. We chose the OR-rule due to the exploratory nature of the analysis and because we report the stability of all estimates in A11 in the supplementary materials. The code can be found in the online supplementary materials S10.

Table 10. Statistics of the scores for all factors (nodes) of the total sample and the subsamples including the p-value of subsample comparison

Node Nr	Node	Total N = 1801		Speakers N = 901		Earbuds N = 900		Significance of mean difference
		M	SD	M	SD	M	SD	*P* value
2	Purchase intentions	3.83	2.11	4.71	1.82	2.95	2.01	<.001*
3	Trust in brand	6.15	1.09	6.19	1.01	6.10	1.16	.09
4	Warranty	4.08	1.41	4.14	1.42	4.03	1.40	.10
5	Financial benefits	5.09	1.60	5.48	1.35	4.70	1.72	<.001*
6	Signs of use	4.79	1.40	4.81	1.36	4.78	1.44	.59
7	Environmental benefits	6.00	1.16	6.13	1.11	5.86	1.20	<.001*
8	Lack of social status	2.39	1.55	2.33	1.51	2.45	1.59	.10
9	Aesthetic Attractiveness	4.79	1.57	4.86	1.50	4.72	1.63	.05
10	Durability	3.77	1.50	3.89	1.50	3.65	1.49	<.001*
11	Territorial contamination	3.86	2.24	2.89	1.88	4.84	2.14	<.001*
12	Utility contamination	3.23	1.66	3.14	1.65	3.32	1.68	.02
13	Hygienic contamination	3.69	2.15	2.53	1.54	4.84	2.05	<.001*
14	Expected obsolescence	3.55	1.73	3.60	1.73	3.50	1.74	.22
15	Perceived risk	4.16	1.48	4.07	1.52	4.25	1.44	.01
16	Value consciousness	6.18	.83	6.17	.85	6.19	.82	.54
17	Disgust Sensitivity	4.73	1.48	4.71	1.48	4.75	1.48	.55
18	Environmental concern	4.21	1.56	4.17	1.58	4.25	1.55	.24

4.3 Results

4.3.1 Network of total sample

Figure 13 shows the network of nodes related to refurbished electronics based on the total sample. The nodes represent consumer characteristics and the beliefs that participants have about refurbished speakers or earbuds. A complete overview of the edge weights for all networks can be found in the appendices A6-A8. In the following section, we describe the relationships between several selected variables and report their regression weights in parentheses. These variables were selected because of their importance (centrality) in the network, which is visualized by how central they are in the network and their link to the purchase intentions for refurbished electronics (Fruchterman & Reingold, 1991).

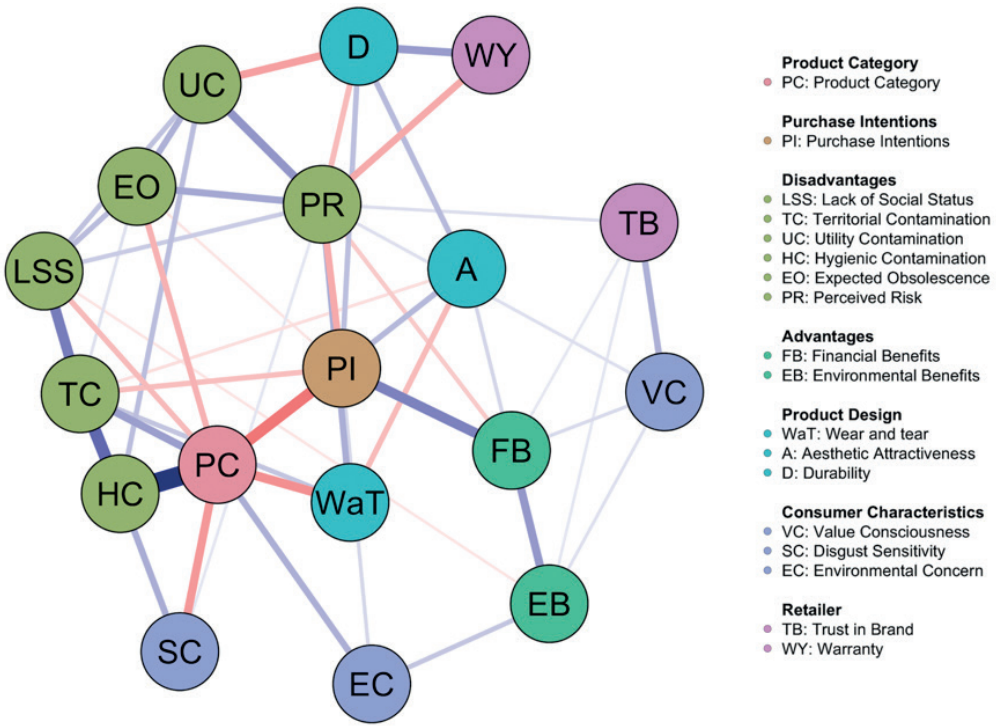


Figure 13. Network of beliefs about refurbished electronics, their purchase intentions and consumer characteristics. Nodes represent the measured factors, and edges represent relations between these factors. Blue edges describe positive relationships and red edges describe negative ones. The strength of the relations is indicated by the colour intensity and edge width.

Node centrality

A graph displaying the importance (centrality/strength) of nodes in our network can be seen in Figure 14. The nodes that ranked highest on centrality are the perceived risk associated with refurbished electronics, the purchase intentions, territorial contamination and the product category (condition). This illustrates the importance of these nodes in the network. The centrality measure indicates that the most effective way to positively change beliefs about refurbished electronics would be to reduce the risks associated with refurbished electronics.

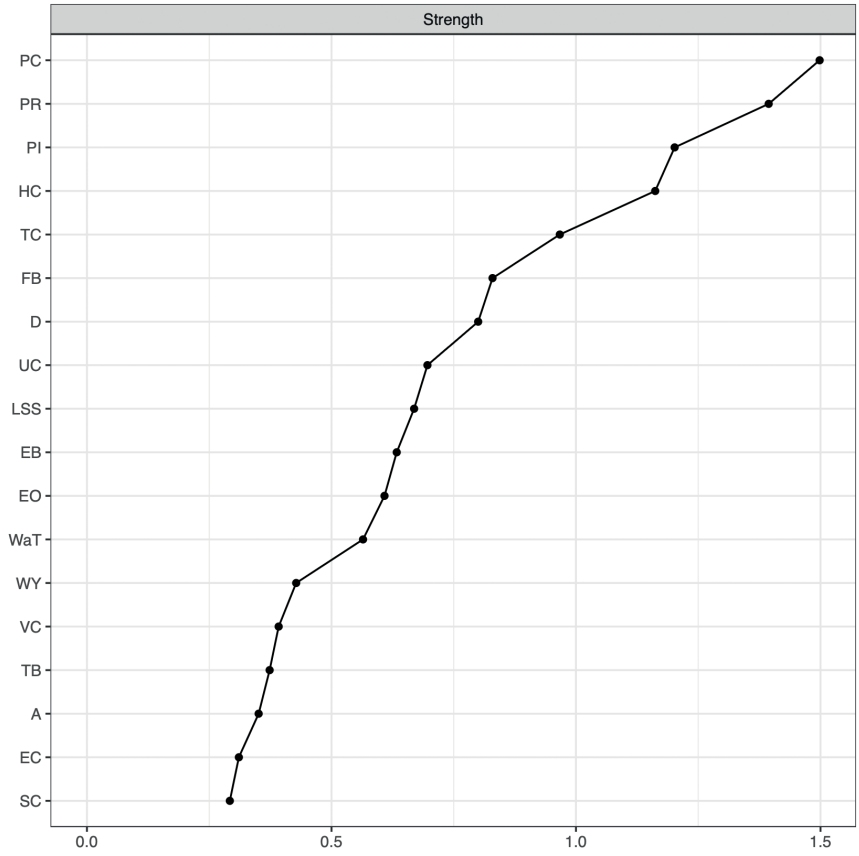


Figure 14. Centrality of the network including both product categories

Nodes related to the purchase intentions for refurbished electronics

To explore which nodes are related to the purchase intentions for refurbished electronics and how these nodes are related to one another, we will elaborate on their edge weights (in parenthesis). The nodes with the strongest relationship with the purchase intentions for refurbished electronics are the financial benefits, perceived risk, territorial contamination and perceived durability of refurbished electronics.

If participants perceive refurbished electronics to be a financially attractive alternative to new electronics (0.28) and to be as durable (0.13) as new electronics, they have higher purchase intentions for refurbished electronics in general. Moreover, a weak edge indicates that environmentally concerned consumers are slightly more likely to purchase refurbished electronics (0.07). Participants are less likely to purchase refurbished electronics if they feel that refurbished electronics are a riskier choice (-0.18), are uncomfortable to use because they are reminded of the prior user (territorial contamination; -0.13) or will become technically obsolete in the near future (-0.05). Furthermore, we see that the product category is highly related to the purchase intentions for refurbished electronics. This indicates that the degree to which people are willing to purchase a refurbished electronic product depends on whether they are asked to consider refurbished speakers or earbuds (-0.32). This is also reflected in the average values of variables showing that the purchase intentions for refurbished speakers are significantly higher ($M = 4.71$, $SD = 1.82$) than those for refurbished earbuds ($M = 2.95$, $SD = 2.01$), $t(1799) = 19.54$, $p < 0.001$.

Before further elaborating on the differences between refurbished speakers and earbuds, we describe the relations of the four strongest predictors of the purchase intentions for refurbished electronics. The relationships between all other variables can be found in S6 in the supplementary materials.

Relationships of the four most important nodes predicting the purchase intentions for refurbished electronics

Financial benefits are most strongly related to the purchase intentions for refurbished electronics. Whether refurbished electronics are perceived to be a financially attractive option compared to new electronics is positively related to their perceived environmental benefits (0.22), the attractiveness of the electronics' appearance (0.08), the expected product's durability (0.04), trust in the brand (0.04) and the consumer's value consciousness (0.07). The riskier refurbished electronics are believed to be, the lower the perceived financial benefit of buying them (-0.10).

Perceived risk involves participants' beliefs that they would lose time or money by buying refurbished electronics or run the risk of purchasing a refurbished product that does not function satisfactorily; the perceived risk is the second-largest predictor of the purchase intentions for refurbished electronics. Nodes that have a positive relationship

with risk perception are the utility contamination (0.22), the expected obsolescence of the refurbished device (0.18) and the expectation that refurbished electronics show wear and tear (0.17). Perceived risk has weak positive relations with the perception that refurbished electronics lack social status, the need to look for a trustworthy brand (0.06), the consumers' value consciousness (0.06) and disgust sensitivity (0.05). Nodes that are negatively correlated with perceived risk are the belief that refurbished electronics have a sufficiently long warranty (-0.18), are durable (-0.14) and are a financially attractive option compared to new electronics (-0.10).

Perceived durability describes the belief that refurbished electronics last as long as new products. In addition to being related to the purchase intentions (0.13), it also has strong positive relationships with the belief that refurbished electronics have a sufficiently long warranty (0.21) and are as aesthetically attractive as new products (0.14). Perceived durability is negatively related to the perception that refurbished electronics have a lower functionality (utility contamination; -0.20) and are a riskier choice (-0.14).

Experienced territorial contamination describes the belief of consumers that they would be reminded that the product was previously used by somebody else. Territorial contamination is negatively related to the purchase intentions for refurbished electronics (-0.13) and shows a weak relationship with the belief that refurbished electronics are less attractive (-0.06). Territorial contamination is highly positively related to the belief that refurbished electronics are unhygienic due to their prior use (0.36), participants' concerns that refurbished electronics lack social status (0.29), show signs of wear and tear (0.11) and are expected to become technically obsolescent soon after purchase (0.06). Furthermore, territorial obsolescence is also highly related to the product category, indicating that there might be differences between refurbished earbuds and speakers (0.20).

4.3.2 Comparing product categories: differences between refurbished earbuds and speakers.

To compare product categories, we estimated a moderated network model, which is visualized in two graphs (Haslbeck et al., 2021). The weighted and undirected networks of both speakers and earbuds can be seen in Figure 15. Figure 15 shows that the strengths of the edges differ, which is visualized through the thickness and intensity of the colours. All edge weights can be found table A7 and A8 in the appendices. To compare these networks, we first elaborate on differences in nodes relating to the purchase intentions for refurbished speakers and earbuds and then on differences in centrality.

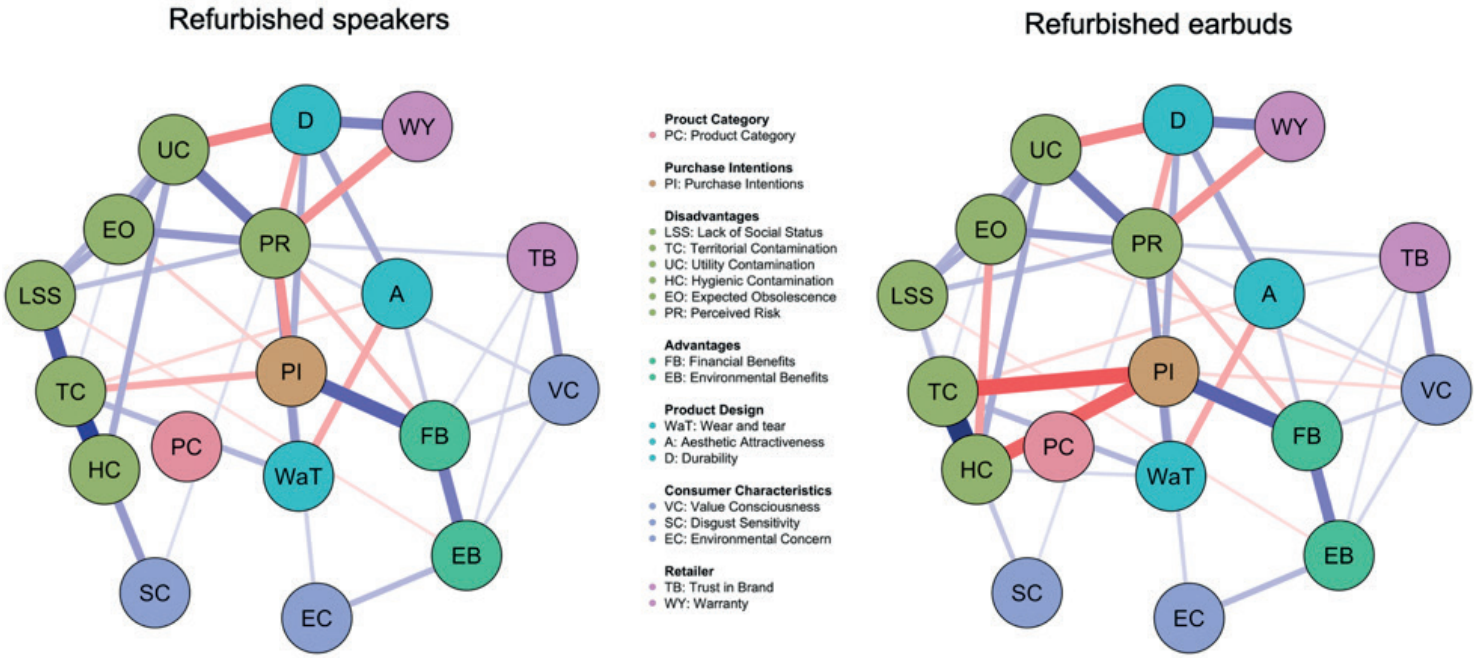


Figure 15. The weighted and undirected networks of beliefs about refurbished speakers (left) and earbuds (right), their purchase intentions and consumer characteristics

Differences in factors related to the purchase intentions

The strongest positive relationship with purchase intentions for refurbished speakers is the belief that refurbished speakers are a financially attractive option compared to new speakers (financial benefits; 0.28). Purchase intentions show negative relations with the belief that refurbished speakers are a riskier choice (perceived risk; -0.18) and territorial contamination (-0.13). In comparison, the purchase intentions for refurbished earbuds are most strongly negatively related to concerns about the fact that the earbuds had belonged to somebody else (territorial contamination; -0.31) and that earbuds are unhygienic because of their prior use (-0.28). Financial attractiveness is the third most important relationship with the purchase intentions for refurbished earbuds (0.28). The purchase intentions for refurbished speakers and earbuds are both equally related to the product's durability (0.13) and the consumer's environmental concern (0.07).

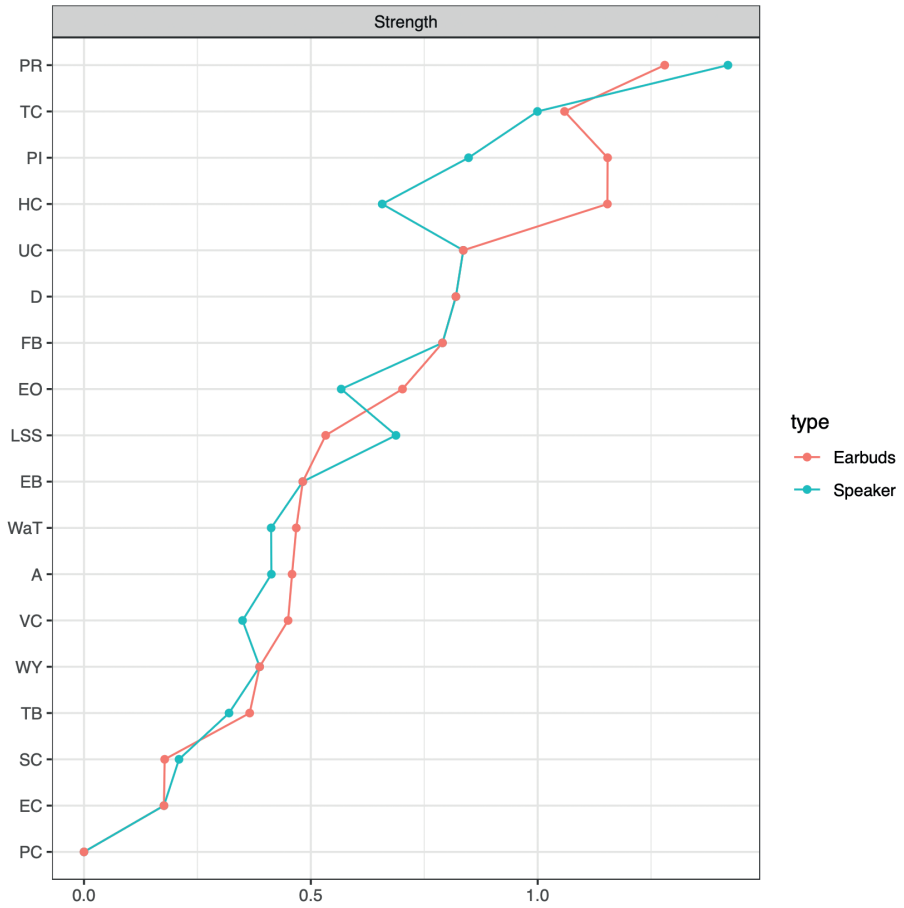


Figure 16. Centrality of refurbished speakers (blue) and refurbished earbuds (red).

Differences in centrality

The differences between refurbished speakers and earbuds are also reflected in the centrality of the network (for centrality plot, see Figure 16). For refurbished earbuds, perceived hygienic contamination is the most central node in the network, whereas the strongest node for refurbished speakers is the perceived risk of refurbished speakers. Interestingly, the feeling that the product is uncomfortable to use because one is reminded of the product's previous use remains one of the most central issues for both refurbished speakers and earbuds.

4.4 Discussion

Prior research has identified factors that linearly predict consumer choices regarding refurbished electronics (Abbey et al., 2015; Agostini et al., 2021; Chen et al., 2020; Mahmoodi & Heydari, 2021; Mugge et al., 2017; Nasiri, 2021; Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016); However, consumer decision-making for or against refurbished electronics involves a complex interplay of product-related, marketing-related and consumer-related factors that influence each other (Wallner et al., 2021). Yet, few studies have taken the role of the product and the consumer into account in combination with marketing-related factors (Hazen et al., 2012; Mugge et al., 2017; Wallner et al., 2022). Additionally, it has remained unclear which factors are most influential in consumer choice and how these factors relate to each other. In this study, we provide a network of beliefs about refurbished electronics, their marketing, consumer characteristics and how they interact. By understanding the complexity and interactions of these factors, we contribute to the literature with insights on the underlying psychological processes that are at play in consumers' purchase intentions regarding refurbished electronics (Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016). Understanding which factors are at play can ultimately facilitate theory building on the consumers' decision to purchase refurbished electronics and to develop sophisticated strategies for how refurbished electronics need to be designed and marketed.

4.4.1 Theoretical implications

To summarize, we found that the factors that were most strongly related to the purchase intentions for refurbished electronics were the product category, perceived risk and the perception that refurbished electronics are contaminated by their prior use (hygienic and territorial contamination). Hence, we argue that the most effective way to change beliefs about refurbished electronics for the positive would be to reduce the risks and contamination concerns associated with them. This is also reflected in the factors that

relate to the purchase intentions for both product categories separately. Participants had higher purchase intentions for refurbished speakers than earbuds. This is in line with literature stating that consumers are less likely to buy reused electronics for intimate use because they feel repulsed by them (Abbey et al., 2015; Mugge et al., 2017, Baxter al., 2017).

With refurbished earbuds, participants' concerns about territorial contamination (thinking about the fact that the product had belonged to somebody else) and that earbuds are unhygienic because they had been previously used were most strongly related to the purchase intentions. In comparison, the belief that refurbished electronics are financially attractive and the perceived risk were most strongly related to the purchase intentions for refurbished speakers. This is in line with research on refurbished smartphones showing that the financial benefits (e.g. Mugge et al., 2017; Sharifi & Shokouhyar, 2021) and perceived risk were important in determining the choice for refurbished smartphones. However, territorial contamination had the third-strongest relationship with the purchase intentions for refurbished speakers. This shows that contamination not only plays a role for in-you products that are intimately used (Abbey et al., 2015), such as earbuds, but is also an important factor for products that are barely touched (around-you products). Our study is hence the first to show different types of contamination concerns, such as that territorial and hygienic contamination, have a quantifiable role in the purchase intentions for refurbished electronics. It furthermore adds to the literature by underlining the negative effect of utility contamination, the perception that the product has lower functionality due to its prior use. We hence argue that contamination concerns need to be added to existing decision-making models about consumer choice for refurbished electronics, such as the model proposed by Van Weelden et al. (2016).

4.4.2 Practical implications

Prior research has often suggested the use of eco-labels as an effective strategy to enhance refurbished electronics' desirability among environmentally concerned consumers (Harms & Linton, 2016; Ihemezie et al., 2018). Confirming prior research (Harms & Linton, 2016; Mugge et al., 2017; Wallner et al., 2021, 2022), we also found that participants who were more environmentally concerned also had higher purchase intentions for refurbished electronics. However, our data suggests that environmental concern had only a weak association with the purchase intentions. Similarly, Khor and Hazen (2017) described that while green awareness might be a driving force behind consumers' initial purchase intentions of refurbished electronics, the actual buying behaviour is related to other factors. To conclude, this highlights that underlining the environmental benefits of refurbished electronics may not be the most effective way to increase consumers' purchase intentions for them.

Based on our results, we suggest that strategies aiming to enhance consumer acceptance of refurbished electronics should, first and foremost, aim at reducing risks and contamination concerns related to refurbished electronics. Risk can be reduced in various ways including a good pricing strategy, warranty, fostering a good brand name and eco-labelling, thereby confirming the findings of prior research (Agostini et al., 2021; Mahmoodi & Heydari, 2021; Mugge et al., 2017; Van Weelden et al., 2016). The perceived financial benefits were strongly related not only to the purchase intentions but also to the perceived risk. If a product is cheaper, the risk of making a bad investment is lower and the financial incentive is higher.

Our data also suggests that in addition to the aforementioned strategies that are mainly aimed at marketing the product correctly, the role of the product is of great importance for enhancing the purchase intentions for refurbished electronics and reducing the risk associated with them. The perceived risk can be reduced by developing refurbished electronics that are durable and updatable from a functional perspective and that do not show signs of wear and tear after multiple lifecycles (Mugge et al., 2018).

Furthermore, for both refurbished speakers and earbuds, the belief that refurbished electronics are a riskier consumer choice can be reduced by tackling contamination concerns. Territorial contamination is hard to reduce in refurbishment because refurbished electronics are second-hand by definition. Confirming prior research, we demonstrate that (territorial) contamination relates to the presence of signs of wear and tear (Baxter et al., 2015; Wallner et al., 2021, Wallner et al., 2022b) and refurbished electronics are more likely to be chosen with an attractive (as new) appearance (Wallner et al., 2022a). Future research could therefore explore what is more effective in reducing contamination: reducing the amount of signs of wear and tear during the refurbishment process or making products that age gracefully and remain attractive over time (Bridgens et al., 2015).

Moreover, utility contamination is related to the risks associated with refurbished electronics (confirming Baxter, 2017; Mugge et al., 2017; Wallner et al., 2022b). Utility contamination concerns could be mitigated by ensuring optimal performance by replacing underperforming parts during the refurbishment process; this should, however, be done with care, as the more parts are changed during refurbishment, the greater the negative environmental impact. Another idea would be to simply manage consumers' expectations by being transparent about the estimated performance (e.g. battery capacity in smartphones) and by providing an estimation of how long the product was used and is estimated to last (van den Berge et al., 2021a,b). Furthermore, consumers' concerns about refurbished electronics were related to the expectation that refurbished electronics would become technically obsolete soon after purchase. Concerns about electronics' obsolescence could be solved by making electronics upgradeable (Mugge et al., 2017). Our data also showed that there are differences

between product categories depending on how intimate their use is. For products that are not intimately used, we suggest underlining the financial benefits of refurbished electronics and their guaranteed functionality, as this can decrease the risk of making a bad financial investment when buying an unsatisfactory product. For product categories that are intimately used, such as earbuds, we strongly recommend the additional step of counteracting consumers' hygienic contamination concerns. For those, we not only recommend eliminating signs of wear and tear to lower hygienic contamination (Wallner et al., 2020b), but also changing parts that touch the skin (Wallner et al., 2022a). To achieve this, refurbished earbuds need to have parts that can be renewed during the refurbishment process. This underlines the importance of not only marketing refurbished electronics differently, but also designing these in a manner that prevents contamination concerns.

4.4.3 Limitations and future research directions

In this study, we explored factors involved in the purchase intentions for consumer electronics, but we only considered two product categories. While this unveiled interesting insights on consumer electronics, future research should also include more categories. It should be validated whether the underlying processes are the same or whether they differ depending on the use and product category of the product. Furthermore, we only included 18 variables in our network. While this served the purpose of exploring the factors that are frequently mentioned in the decision-making process regarding refurbished electronics, not all possible factors could be included. One issue with refurbished electronics is that they require more effort for the consumer to buy because they are not always available or easy to find online. Future research could therefore add other factors depending on the product category and further validate our findings. Moreover, we only measured beliefs about refurbished electronics and how they relate to the purchase intentions for refurbished electronics. While this was sufficient for the exploratory nature of our research, it is unclear whether the factors we identified would lead to actual buying behaviour. Intentions do not necessarily lead to actual behaviour (Behaviour-Intention-Gap; Sheeran & Webb, 2016). It is therefore important to validate our findings by testing real purchase settings with real life data sets. Finally, we would like to stress that we only considered statistical relationships. To establish causality between variables, one requires an experimental setup or additional assumptions required for causal inference (Peters et al., 2017).

4.4.4 Conclusions

Refurbishment is a key strategy to reduce an electronic product's environmental footprint by extending its lifetime. However, consumers have lower purchase intentions for refurbished electronics, which thus far has made them an unattractive business

opportunity for manufacturers. This study contributes by providing an overview of the factors that relate to consumers' purchase intentions for refurbished electronics. With this exploratory work, we hope to contribute to theory building on the consumer acceptance of refurbished electronics. Manufacturers could use these insights to design electronic products that retain their value over multiple life cycles and establish a promising market strategy for them that is both commercially relevant and creates a substantial environmental benefit.

The data and supplementary materials are published on OSF:
DOI 10.17605/OSF.IO/WB8XU
https://osf.io/wb8xu/?view_only=c15bcd778186449ebc82325e0e53d3ab

CHAPTER 5

A choice-based conjoint analysis on contamination-reducing strategies to improve consumers' choice for refurbished products

Based on: Wallner, Magnier, L., & Mugge, R. (2022). Do consumers mind contamination by previous users? A choice-based conjoint analysis to explore strategies that improve consumers' choice for refurbished products. *Resources, Conservation and Recycling*, *177*, 105998. https://doi.org/10.1016/j.resconrec.2021.105998

5.1 Introduction

Chapters 3 and 4 emphasized the importance of the role of consumers' contamination concerns in determining the purchase intentions of refurbished products. Chapter 4 showed that the most important factors related to the decision to purchase refurbished products were the perceived risk and the perception that refurbished products are contaminated by their prior user. We therefore concluded that strategies aiming to enhance consumer acceptance of refurbished products should first and foremost, focus on reducing risks and contamination concerns. Despite the important role that contamination plays for refurbished products, research on the effects of possible strategies to counter such contamination is lacking. Chapter 5 evolves around the research question how consumers' contamination concerns with refurbished products can be decreased via marketing and product design (RQ3). Chapter 5 contributes to the literature on refurbishment by investigating the effects of several contamination-reducing strategies, warranty and price on consumers' choice for refurbished products. Specifically, with a choice-based conjoint analysis we model consumer choices and test whether contamination concerns can be alleviated by changes in the product design, the refurbishment process and the communication strategy when marketing them.

5.1.1 Consumers' contamination concerns

Perceived contamination of refurbished products describes feelings of unease or even disgust consumers experience because of the prior use of a product. Contamination operates according to the law of contagiousness (see Figure 17), which describes that a source (e.g., the first user) transfers its essence (e.g., skin particles) to a recipient (e.g., headphones). These traces of contamination remain on the recipient even after the contact with the source is broken (Mauss, 1972; Rozin et al., 1986).

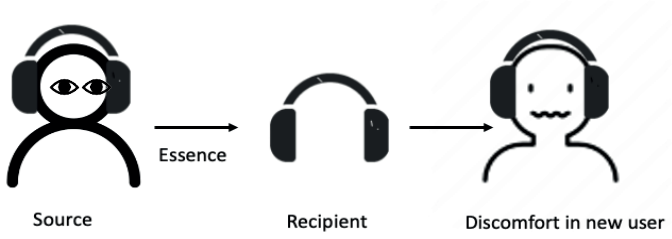


Figure 17. The contamination of an object (recipient) by a source can lead to discomfort in a new user.

According to Baxter et al. (2017), there are different types of contamination; which can be hygienic, utilitarian or of territorial nature (HUT model). Hygienic contamination is characterised as the negative associations that consumers have when they think that an

object may be contaminated with pathogens or dirt, and therefore, may pose a threat to one's health. Utilitarian contamination describes the feeling of contamination that occurs when consumers believe that the functionality of an object is decreased. This functionality can be of technical, but also of social or economic nature (Aurisicchio et al., 2011). One example would be a product that is heavily scratched. As a result of these scratches, consumers may believe it has a decreased functional value because it is not water-resistant anymore. Furthermore, these scratches may lower the social value if one is embarrassed to be seen with a worn-off artefact. Finally, scratches may reduce the economic value because the product cannot be easily resold. Territorial contamination entails that an object has belonged to someone else, which interferes with one's personal space because of the previous user's signs of use. One example would be an object that smells like a previous user's perfume or is marked with the previous user's name.

Furthermore, Baxter et al. (2017) described that the contamination of a (circular) product depends on multiple factors and is indicated by the product state (e.g., how clean the product appears), the product characteristics (e.g., signs of wear and tear), the object setting (is a product turned on or off) and the context (e.g., in which store the product is sold; which objects accompany the refurbished product) and the knowledge of previous use (e.g., who and how many people used the object before you). While the object settings are less likely to be relevant for refurbished products as these are often returned to factory settings, the importance of the context and the knowledge of previous use for triggering feelings of contamination should not be underestimated. For example, most consumers would feel uncomfortable to buy a second-hand or refurbished shaver because it is believed to be dirty as a result of the first owner's usage. However, this contamination problem, does not occur at a hairdressers', when a shaver is used that has also been extensively used on multiple others. This example also illustrates that contamination is not always purely rational.

5.1.2 Improving consumer choice for refurbished products by reducing contamination

The three types of contamination described in the previous section can be present in refurbished products. Despite the cleaning procedure during the refurbishment process, consumers may fear hygienic traces, such as pathogens or oil-residues on the refurbished products. Utilitarian contamination can be present as a result of a lower functionality in refurbished products. This type of contamination commonly occurs because refurbished products are by definition brought into "an acceptable state", which often comes with a lower functionality, such as the presence of scratches and/or a lower battery capacity in electronic products. Territorial contamination is less common, but consumers may nevertheless fear that the refurbished product could be contaminated with smells or

data traces indicating a former user's territory. While utilitarian contamination can have a physical manifestation, territorial contamination is a good example of mostly perceived contamination and hence is harder to reduce.

It is unclear which types of contamination are most relevant to consumers when they encounter refurbished products and with which contamination-reducing strategy they can be alleviated. In this research, we examine the influence of three strategies that are likely to reduce contamination, and that may therefore increase the adoption of refurbished products: 1) communication about clean object state, 2) eliminating signs of use, and 3) renewing parts that touch the skin.

Communication about clean object state

Consumers may not be aware that refurbishment includes a thorough cleaning procedure. A possible strategy to reduce the perceived contamination is to provide more information about the cleaning procedure during the refurbishment process via a 'clean' label. Labels have shown to be effective in different contexts. For example, eco-labels have been shown to increase consumers' purchase intentions of circular products (Boyer et al., 2021; Harms & Linton, 2016). Furthermore, reviews containing words such as cleanliness or clean have been shown to enhance the favourability for short-term rentals in times of the COVID-19 pandemic (Shen et al., 2020). Hence, we expect that communicating clearly that the product was cleaned can decrease contamination concerns for refurbished products. However, there could be reasons why this strategy may not have the desired contamination-reducing effect. First, it tries to counteract a perhaps irrational feeling of contamination with a rational approach. Second, to trust that the product is clean, the consumers' needs to trust that the (re-)manufacturer cleaned the product well, and this is likely dependent on the manufacturer's reputation (Sharifi & Shokouhyar, 2021). Finally, for second-hand clothing items, it was found that highlighting the fact that the product was cleaned and sterilised may also trigger undesired feelings that the clothing was previously used and is contaminated (Ackerman & Hu, 2017).

Eliminating signs of use

Signs of wear and tear on a product indicate that it has been used. If a product is received second-hand or refurbished, this means that it could be contaminated with traces of the previous user. Indicators of use include visual signs of use or a decreased functionality (Baxter et al., 2017). Appearance-related wear and tear has shown to have a negative effect on consumers' evaluation of refurbished products (Mugge et al., 2018). Furthermore, the lower functionality that many refurbished products have, as a result of their prior usage, could trigger a utilitarian contamination concern. Similarly, Nasiri and Shokouhyar (2021) found in an analysis of post-purchase online reviews that signs of use related to the function (battery health) and appearance (scratches on the surface) of refurbished

smartphones are the most worrying to consumers. We believe that offering refurbished products without signs of use will decrease contamination concerns because of the 'out of sight is out of mind' principle. By eliminating signs of use through giving a product an as-new functionality or an as-new appearance, one could reduce contamination concerns.

Replacing parts that touch the skin

Products that touch the skin are especially prone to hygienic contamination because the object is more intimately used and therefore has a higher chance of carrying and transferring harmful substances (Abbey et al., 2015; O'Reilly et al., 1984). While rationally, problems with hygienic contamination should be solved, the irrational feeling that the product is contaminated may still persist due to the knowledge that somebody else owned the product before. Indeed, several studies indicate that an object can still feel contaminated, even after it has gone through a purification procedure (Hejmadi et al., 2004; Rozin et al., 2015). The last strategy to reduce contamination is therefore to replace parts that are in contact with the skin, such as the ear-cushions on headphones. This strategy aims to decrease hygienic contamination. Specifically. the overall feeling of contamination could be decreased by renewing the most contamination-sensitive part (Hazée et al., 2019).

5.1.3 The influence of consumer groups

The importance of attributes of refurbished products may differ between consumers because consumers are not a homogenous bloc" (Hunka et al., 2021, p. 548) they have different needs and desires, which drive their consumption decisions. For example, some consumers may be more easily disgusted, which could make them more sensitive to hygienic contamination of refurbished products (disgust sensitivity; Olatunji et al., 2007). These consumers may be incentivised more by information about the cleaning process of the product or the replacement of parts that touch the skin.

Furthermore, prior research has shown that consumers who are less tolerant to ambiguous situations (ambiguity intolerance; Hazen et al., 2012) are willing to pay less for refurbished smartphones. Hence, these consumers might value warranties of refurbished products. Additionally, we could expect that consumers who are not tolerant of ambiguous situations would prefer a product with little functional and aesthetic wear and tear and would value the replacement of parts that touch the skin because they dislike the uncertainty that comes with the prior use of a refurbished product. Furthermore, if consumers are keen on good deals and receive good value for money, they may be more incentivised by the lower price of refurbished products (value consciousness; Lichtenstein et al., 1990). Some consumers may be driven by the environmental benefits of refurbished products because this fits well with their

identity as environmentally concerned people and would, therefore, be willing to compromise on many aspects to avoid buying a new product (Mugge et al., 2017a). For consumers who value money or are very conscious of the environment, we would expect that contamination-related attributes are less important as long as the financial or environmental costs are attractive. Hence, we will explore whether attributes of refurbished products incentivise different consumer groups and how these consumer groups can be portrayed with the aforementioned consumer characteristics.

To summarise, this research contributes to the literature on the consumer acceptance of refurbished products by investigating how refurbished consumer electronics can be optimised by implementing three contamination-reducing strategies. We aim to test their effects on consumer choices for refurbished products and examine how important these strategies are compared to other more commonly applied strategies, such as years of warranty and different price reductions. Furthermore, we will explore whether there are differences between consumer groups, how these consumer groups can be characterised and which attributes of refurbished products incentivise them most.

5.2 Method

To operationalise strategies reducing contamination, we focused on wireless headphones because, similar to clothing (Meng & Leary, 2021; Tunn et al., 2021), headphones are likely to trigger contamination concerns due to their direct contact with the skin (Abbey et al., 2015; Mugge et al., 2017; Hazée et al., 2019). Furthermore, wireless headphones have a battery and other electronic components, for which an extension of the product lifetime (through refurbishment) may lower its environmental impact. Wireless headphones are also interesting for studying refurbishment because they can be leased (e.g., the brand Gerrard Street leases modular wireless headphones). As such, contamination concerns can arise because products circulate between different users, however leasing offers an opportunity for companies to recollect and refurbish their products, providing them with opportunities to tackle possible contamination issues in the refurbishment process.

We conducted an online choice-based conjoint analysis with the Qualtrics conjoint software to closely model consumer choices and investigated the importance of the contamination-reducing strategies for consumer choice in comparison to other marketing strategies for refurbished products, such as price reduction and years of warranty (Mugge et al., 2017a; Van Weelden et al., 2017). A choice-based conjoint analysis is a method in which consumers' decisions are realistically portrayed as a choice between trade-offs among multi-attribute products (Huber, 2005) and has been used in the past to explore consumer choices for sustainable products (Hao et al., 2019; Rokka &

Uusitalo, 2008). We chose to conduct a choice based-conjoint analysis over other forms of conjoint analysis for three reasons. First, a choice-based conjoint is suggested to best model actual shopping behaviour because it mimics an actual buying situation by giving participants two products with fixed choice-sets (Hair et al., 1998). Second, compared to other conjoint approaches, choice-based conjoint works best for six or fewer attributes. In addition, choice-based tasks are easy to understand for participants and less time consuming than more traditional forms of conjoint analysis such as ranking profiles (Hair et al., 2006). The study was approved by the Human Research Ethics Committee of Delft University of Technology.

5.2.1 Design of the choice task and pre-test

The design of our choice task was based on six design strategies: four (design) strategies to reduce contamination and two strategies (extended warranties and lower price) commonly applied to enhance the consumer choice for refurbished products, which were included in the choice task as attributes.

To select these attributes, we first pre-tested the following characteristics of refurbished headphones: information about the cleaning procedure during the refurbishment process, aesthetic state (aesthetic wear and tear), functional state (battery capacity), renewal of a contamination-sensitive part, year of production, warranty and price.

By providing a certificate that the refurbished product is clean during the refurbishment process, we expected that hygienic contamination and territorial contamination (no smell of a prior user) could be decreased. This decrease in contamination could in turn positively influence participants' choice for the product. The aesthetic appearance and performance of the headphones inform the consumer about their previous use. For wireless headphones, battery capacity is an important functional attribute that may wear out during usage. Similarly, the aesthetic appearance can decrease by showing scratches and discolouring of the material. We, therefore, included attributes in which the functional and aesthetic state of the headphones varied from used to as-new. Replacing components that are sensitive to hygienic contamination with new components during the refurbishment process may reduce contamination. For headphones, the ear-cushions may provide an important contamination risk. Therefore, the ear-cushions were either preserved or changed during the refurbishment process. By providing users with information about the year of production, they can make inferences about the length of the previous life of the product, which may also influence their choice. Additionally, we included price reduction and years of warranty to analyse how important critical contamination-related attributes are compared to other attributes that usually incentivise consumers to purchase refurbished products.

In order to select realistic levels for these attributes, we looked at different websites selling refurbished headphones and chose either two or three attribute levels accordingly. We used attribute levels that were on the lower end of the available spectrum of options, one that was average and one that was in the higher end (e.g., price differences between refurbished and new headphones of 20%, 30% and 40%, respectively).

In the pre-test, to narrow down the number of attributes, we measured the importance of all attributes and subsequently assessed the desirability of the attribute levels. For the choice-based conjoint analysis to yield valid results, the attribute levels across all attributes need to be comparable (Orme, 2010). The selection of an extreme value for one level of a variable could wrongly increase its utility levels. Therefore, to select the final list of attributes and attribute levels for our conjoint analysis, we conducted a pre-test. We exposed 51 participants (32 males; Age: 18–71 years; M = 30.6) to different attributes of refurbished headphones. Participants first assessed the importance of the attributes on a 7-point scale (1 = not important at all - 7 = very important). Subsequently, participants were asked to assess the acceptability of attribute levels.

To choose attributes with a sufficient level of importance, we conducted pairwise comparisons, which showed that production year was significantly less important than all other attributes (*p*'s < .05, see appendices A9-A11 for pairwise comparisons and means). We, therefore, included six attributes in the conjoint analysis, excluding the year of production of the headphones (see Figure 18).

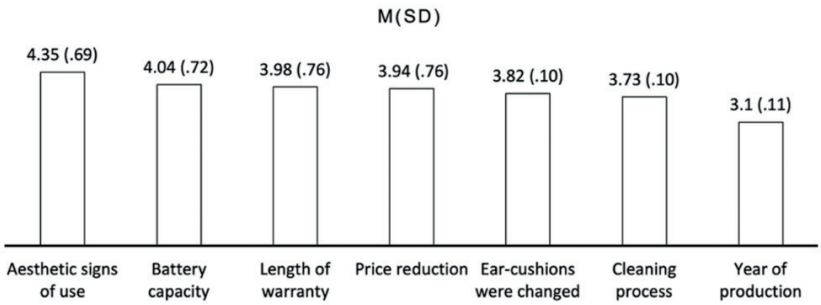


Figure 18. Average importance of attributes.

Finally, we assessed the acceptability of each attribute level with a 4-point scale (1 = Preferred; 2 = Acceptable, 3 = Undesirable; 4 = Unacceptable, see Table 11) for all attributes (Tunn et al., 2021). Results supported that all attribute levels were considered appropriate, ranging in means between preferred and undesirable (1 < M < 3; see Table 11) and were therefore included in the conjoint analysis.

Table 11. The final list of attribute levels and acceptability ratings

Attribute	Attribute level	Acceptability M (SD)
State of the product (aesthetic wear and tear)	The appearance is in an as-new state (product does not show any signs of use and looks new).	1.08 (.27)
	The appearance shows light wear and tear (scratches on the surface that are only visible from close proximity).	2.08 (.39)
	The appearance shows visible wear and tear (larger scratches on the plastic surfaces).	2.92 (.59)
Battery capacity (functional wear and tear)	The battery has 100% battery capacity (~25 hours playtime).	1.02 (.14)
	The battery has at least 80% battery capacity (~ 20 hours playtime).	1.80 (.49)
Length of warranty	One year	2.12 (.59)
	Two years	1.39 (.49)
Price reduction	The refurbished headphones have a 40% price reduction compared to new headphones.	1.59 (.50)
	The refurbished headphones have a 30% price reduction compared to new headphones.	2.12 (.71)
	The refurbished headphones have a 20% price reduction compared to new headphones.	2.84 (.86)
Ear-cushions	The ear-cushions were cleaned during the refurbishment process.	2.33 (.82)
	The ear-cushions were changed during the refurbishment process and are new.	1.06 (.24)
Cleaning process	There is extensive information on how the cleaning process was executed on the company website of the refurbished headphones.	1.29 (.50)
	There is extensive information on how the cleaning process was executed on the company website of the refurbished headphones, and the specific headphones are certified with a sparkling clean label.	1.20 (.45)

5.2.2 Main study

Participants

For the choice-based conjoint analysis, we recruited a convenience sample of 785 participants with the Dutch Nationality (Age = 18-91, M_{age} = 44,32; 348 females, 432 males and five others). First, we recruited 385 Dutch nationals via a university-based testing panel and additionally sampled 400 participants via Prolific to obtain a more diverse sample. The university panel consists of people living in Delft and surrounding area, who have signed up to participate in scientific studies. Participants from this panel were invited to participate in this study via email. The Prolific platform consists of registered individuals who can choose between various experiments. If they fit the criteria of the

study, participants can take the study on a first-come, first-served basis. An inclusion criterion for all our participants was the Dutch nationality to minimise cultural factors, and participants could choose to do the questionnaire in Dutch or English. The highest level of education was varied: 31% of the participants were high school educated, 32,6% had a bachelor's degree, 34,1% had a master's degree, and 2,3% had a PhD). We excluded 10 participants from our sample because they did not pass the attention check. The study was approved by the Ethics Committee of Delft University of Technology.

Procedure and materials

After filling in the informed consent, participants were asked to read a scenario in which they were instructed to imagine themselves looking for refurbished wireless headphones. Subsequently, participants saw a graph explaining that during the refurbishment process, products are collected, tested, repaired and cleaned. Then participants were informed that they would be presented with two different versions of wireless headphones and should choose one of the two options based on their preference (see Figure 19). The conjoint software automatically computes two random options in which the attribute levels vary per choice. After four choice sets, participants filled in a survey assessing different consumer characteristics and demographics, such as age (year of birth), gender (female, male, other), nationality and the highest level of education (high school, bachelor's degree, master's degree, postdoctoral degree).

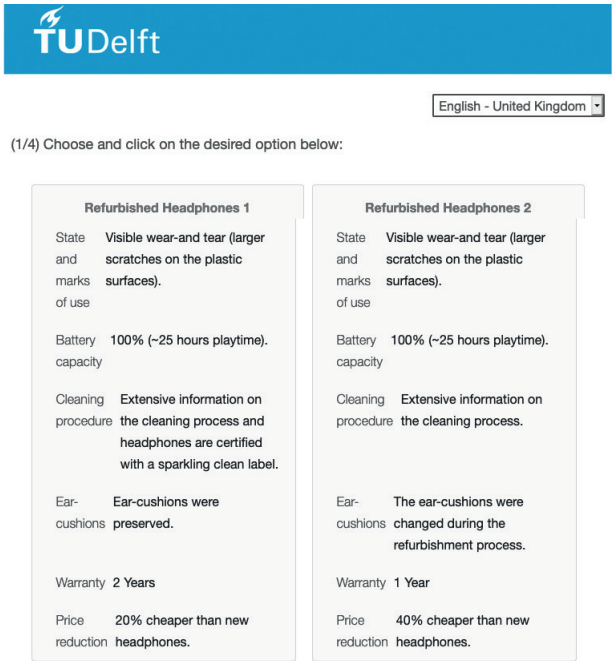


Figure 19. Design of the choice-task.

We assessed consumers' environmental concern with three items on a 7-point Likert scale (Kim and Choi, 2005; Mugge et al., 2017) (1=strongly disagree, 7=strongly agree; α = .87). An example item was "*I make a special effort to buy products that are made from sustainable materials*". We assessed the extent to which consumers want value for money with a value consciousness scale that consists of three items on a 7-point Likert scale (Lichtenstein et al., 1990; 1=strongly disagree, 7=strongly agree; α = .70). While the three items version of this scale had shown high levels of reliability in another study (α = 0.82 in Mugge et a., 2017a), the three items version only showed low reliability (α = .63). We, therefore, deleted one item because it improved the reliability of the scale (α = .70) when the item was deleted). An example item was: "*When shopping, I compare the prices of different brands to be sure I get the best value for the money*". We assessed how frequently and intensively participants experienced disgust using the pathogen disgust domain of the Three Domains of Disgust Scale (Olatunji et al., 2012). We measured the disgust sensitivity with seven items on a 7-point Likert-scale (0= Not disgusting at all, 6= Extremely disgusting; α=0.77). An example item was: "*Please rate how disgusting you find the concepts described in the items, where 0 means that you do not find the concept disgusting at all and 6 means that you find the concept extremely disgusting: Seeing some mould on old leftovers in your refrigerator*". We assessed how tolerant participants were to ambiguous situations with four items of the ambiguity intolerance 7-point Likert scale (Hazen et al., 2012; McLain, 2009; 1=strongly disagree, 7=strongly agree; α = .76). An example item was: "*I am tolerant of ambiguous situations*". All scales are displayed in appendix A12.

5.3 Results

5.3.1 Description of statistical analysis

The results were analysed in two steps. First, based on the choice data from the conjoint analysis, we estimated the overall importance of the attributes, the relative utility of the attribute levels and the individual utilities of all attribute levels with hierarchical Bayes estimation (for a description of the method, see Allenby and Ginter, 1995). This method provides individual utility (part-worth) estimates for the respondents on the basis of only a few product choices by each participant (Allenby and Ginter, 1995). By analysing the importance of attributes and relative utility, one can see which attributes are most important and which attribute levels weigh the heaviest in the choice participants make. Second, we used the individual utility values to conduct a cluster analysis in order to reveal differences between different consumer groups. The optimal number of clusters is determined with the gap statistics method (Berget, 2018). This technique uses the output of a clustering algorithm (K-means in our case) and compares the change in within-

cluster dispersion with the within-cluster dispersion expected under an appropriate reference null distribution (Tibshirani et al., 2001). The optimal number of clusters is therefore indicated with the lowest gap statistics value. Subsequently, we clustered the participants with the k-means clustering method (Hair et al., 2006) using a fixed number of four clusters to determine the optimal cluster partitioning.

5.3.2 Relative importance of attributes

In our study, we tested three contamination-reducing strategies, including 1. communication about the clean object state, 2. eliminating aesthetic and functional signs of use and 3. renewing parts that touch the skin (e.g., ear-cushions). Overall, for the participants in our study, the two most important attributes were related to contamination (see Figure 20) and were an impactful factor in their consumer choice for refurbished headphones. First, participants deemed eliminating signs of aesthetic wear and tear as most important, accounting for 28% of consumer choices. Whether the ear-cushions were replaced during the refurbishment was considered the second most important attribute (24%), closely following the aesthetic wear and tear. The price reduction (19%) was only the third most important factor; the battery capacity (functional wear and tear) (14%), a description of the cleaning procedure or the provision of a sparkling-clean label (7%) and extended warranty (7%) were deemed less important overall.

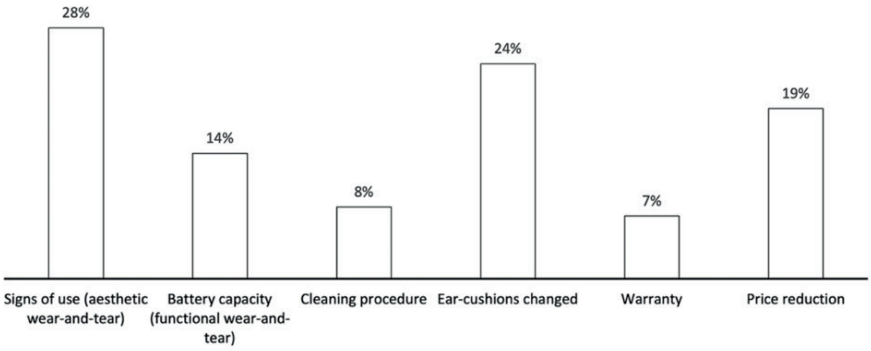


Figure 20. Importance of attributes

5.3.3 Relative utility of attribute levels

The relative utility for each attribute level is shown in Figure 21. Higher positive scores suggest that the attribute level is, on average, of greater influence on the consumer choice.

The results indicated that the level of aesthetic wear and tear was the most impactful attribute on the consumer choice. The aesthetic as-new state was the most

preferred attribute level with a relative utility of 17.30 (contamination-reducing strategy 3, compared to light (-0.62) or visible wear and tear (-16.68). A nearly equally important attribute level was whether the ear-cushions were renewed during the refurbishment process, with a relative utility level of 14.15 (strategy 2). The third most important attribute level was the price reduction of 40% compared to a new product (10.71). A price reduction of 30% at a utility level of 0.11 and a 20% price reduction had a utility level of -10.82. The battery capacity (functional wear and tear; strategy 3) had a relative utility of 7.86 for 100% battery capacity. The two least significant attributes were the cleaning procedure (strategy 1) with a preference for a certified clean product (3.70) and the warranty for which participants preferred a product with two years of warranty (3.33).

The average relative utility of the attributes displays how all participants valued the different product attributes on average. In the following section, we will go beyond the average relative utility by identifying distinct consumer groups that differ in their attribute preferences.

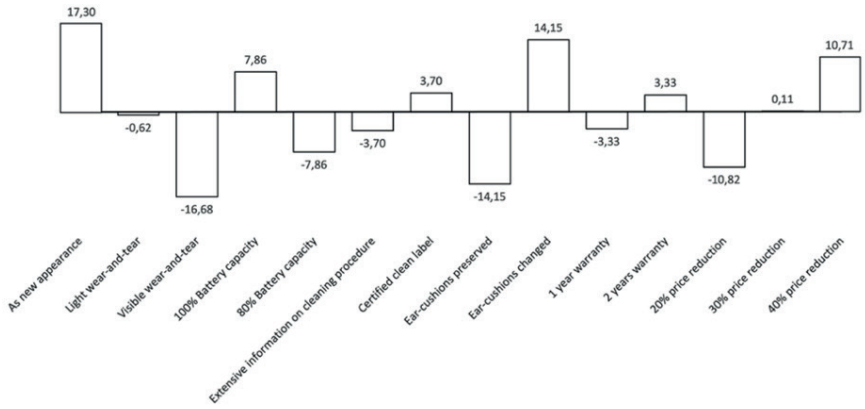


Figure 21. Average utility of the attribute levels

5.3.4 Consumer segments based on attribute level preferences

Not all consumers are incentivised by the same features. To analyse whether there are differences between different consumers, we clustered consumers into consumer groups based on their choice preferences. The optimal number of clusters (consumer groups) was determined following the gap statistics method (Berget, 2018), which revealed four different consumer groups (see Figure 22). This technique uses the output of a clustering algorithm (K-means in our case) and compares the change in within-cluster dispersion with the within-cluster dispersion expected under an appropriate reference null distribution (Tibshirani et al., 2001). The optimal number of clusters is therefore indicated

with the lowest gap statistics value (see Figure 22). Subsequently, we clustered the participants with the k-means clustering method (Hair et al., 2006) using a fixed number of four clusters to determine the optimal cluster partitioning.

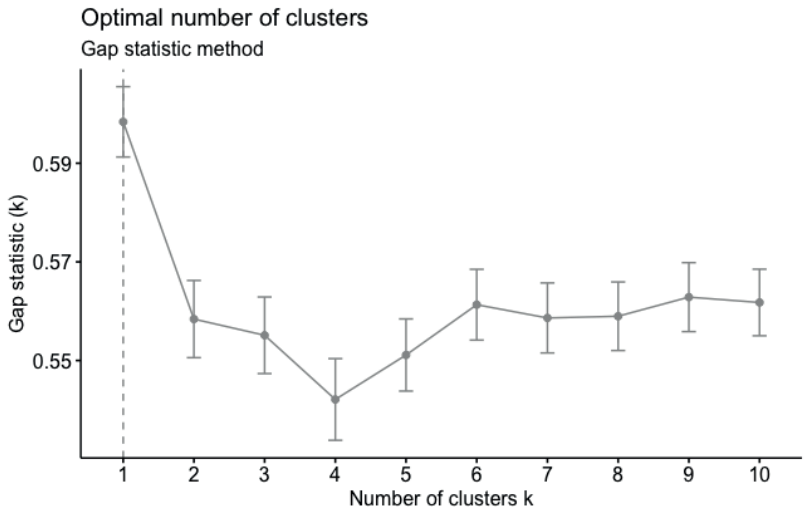


Figure 22. The optimal number of clusters was identified as four clusters according to the gap statistics method.

The participants were grouped into four clusters based on the similarity of their preferences for the attribute levels (see Table 12)

Cluster 1– Budget focused with desires for a new product

The largest consumer group (37% of our sample) is characterised by a strong preference for an as-new product in terms of aesthetics (i.e., no wear and tear and new ear-cushions) as well as battery capacity (functional wear and tear). This consumer group seems very budget minded, as they are strongly valuing a price reduction of 40%. They also highly appreciate it if the product is certified clean and has a warranty comparable to new products. This group is probably not prone to buy refurbished products yet. However, they can be incentivised by a refurbished product that is cheaper than a new product but is practically in an as-new state.

Cluster 2– Function-over-aesthetics

The second-largest group (27% of our sample) is composed of consumers who are focused on price and prefer a refurbished product with an as-new functionality (100% battery). While the aesthetics of the product and the cleaning label are of less importance to this

Table 12. Average utility values of attribute levels per consumer group

Attributes	Attribute levels	Cluster 1 Budget-focused with as-new desires (N=295) Average part-worth utilities (Cluster centres)	Cluster 2 Function-over aesthetics (N=210) Average part-worth utilities (Cluster centres)	Cluster 3 Aesthetics-over-function N=209) Average part-worth utilities (Cluster centres)	Cluster 4 Reuse-enthusiasts (N = 71) Average part-worth utilities (Cluster centres)
State of the product (aesthetic wear and tear)	As-new appearance	28.32	6.35	19.98	-3.31
	Light wear and tear	-1.53	-.46	-.16	1.36
	Visible wear and tear	-26.79	-5.89	-19.82	1.94
Battery capacity (functional wear and tear)	100% battery capacity	12.22	9.67	3.52	-2.28
	80% Battery capacity	-12.22	-9.67	-3.52	2.28
Cleaning procedure	Information on the cleaning procedure	-5.79	-1.57	-4.14	-.24
	Information on the cleaning procedure and certified-clean label	5.79	1.57	4.14	.24
Changed parts	Preserved ear-cushions	-22.19	-9.85	-13.98	6.43
	Changed ear-cushions	22.19	9.85	13.98	-6.43
Warranty	1 year warranty	-5.11	-3.24	-2.45	.98
	2 years warranty	5.11	3.24	2.45	-.98
Price reduction compared to new products	20% cheaper	-17.80	-12.98	-3.59	2.46
	30% cheaper	.05	.63	-.55	1.21
	40% cheaper	17.75	12.36	4.14	-3.68
Consumer characteristics	Environmental Concern	4.42 (1.46)	4.43 (1.46)	4.20 (1.47)	4.78 (1.29)
M(SD)	Value Consciousness	6,07 (0.89)	5.97 (.93)	5.98 (1.03)	5.70 (1.20)
	Disgust Sensitivity	4.97 (1.03)	4.88 (.99)	5.03 (1.08)	5.18 (.96)
	Ambiguity Tolerance	4.04 (.98)	3.99 (1.07)	3.93 (.99)	4.14 (1.06)
Demographics	Age	43.09 (18.32)	45.11 (19.27)	43.84 (18.83)	48.51 (19.78)
M(SD)	Education	10.26 (4.92)	10.36 (5.08)	9.65 (4.96)	9.17 (5.24)
	Gender (f/m/o)	139/154/1	83/126/1	94/114/1	32/38/1

group, they do appreciate it if the ear-cushions are renewed during the refurbishment process. They can be incentivised by an important price reduction and (guaranteed) good functionality.

Cluster 3- Aesthetics-over-function

The third cluster (consisting of 27% of our sample) seems to be less sensitive to the price of the product and is most incentivised by as-new aesthetics. They also highly value if the ear-cushions are renewed during the refurbishment process and are less concerned about the product's functionality. They can be incentivised by a product that is refurbished to look as new.

Cluster 4– Reuse-enthusiasts

The fourth is the smallest cluster (9% of our sample) and is quite distinct from the first three clusters. These reuse-enthusiasts appreciate it if the product's ear-cushions are preserved and are probably less sensitive to contamination. This consumer group does not mind aesthetic and functional wear and tear if the product comes with a small price reduction. This consumer group is most likely already buying second-hand products and could be incentivised by refurbished products with original parts for a lower price than new products.

5.3.5 Individual differences in the characterization of consumer groups

We also analysed and profiled our respondent groups in terms of demographic variables (age, education, gender) and (psychological) consumer characteristics (i.e., disgust sensitivity, environmental concern, value consciousness and ambiguity intolerance), and found that the reuse-enthusiasts scored significantly higher on environmental concern than other groups $F(3, 781) = 2.98$, $p < .05$. Concerning the other variables, no significant differences between the groups were found, as shown in Table 12.

5.4 Discussion and conclusions

This paper contributes to the literature on consumer-centric design for refurbishment by exploring how different attributes of refurbished headphones influence consumer choice. Thus far, refurbishment literature and practice have focused on the rational side of consumer decision-making, mostly exploring factors of an economic nature, such as price reduction and years of warranty as important attributes for marketing refurbished products (Michaud and Llerena, 2010; Harms and Linton, 2016).

We argue that there are also more affective processes at work and believe that contamination is important to understand the behaviour of consumers.

Our findings demonstrate that to make refurbishment an attractive offering to consumers, products need to be designed to retain their value through dealing with (sometimes irrational) contamination issues arising due to the multiple lifecycles/ users of a refurbished product. Specifically, our findings demonstrate that for refurbished headphones, an as-new aesthetic, as-new functionality, and the renewal of parts touching the skin (ear-cushions) have a stronger influence on consumer choice than the reduced price or years of warranty. Our research indicates that consumers have adverse reactions to refurbished products that are in contact with the skin. This was suggested by previous research in the context of reused circular products (Abbey et al., 2015; Baxter et al., 2017; Clube & Tennant, 2020; Tunn et al., 2021); however, to the best of our knowledge, strategies aiming to counter these adverse reactions had never been empirically tested.

Furthermore, our findings indicate that depending on the consumer group, contamination-reducing strategies may be more or less important. While some consumer groups highly value that signs-of-prior-use are eliminated through an as-new appearance, others want the functional wear and tear to be eliminated. Communicating about the cleaning process is appreciated but was less impactful than other contamination-reducing strategies.

5.4.1 Contamination-reducing design strategies

With our findings, we aim to inform manufacturers and designers about strategies to deal with contamination issues arising from the multiple lifecycles of refurbished products and address different consumer groups. For designers interested in designing products that can be successfully refurbished, we recommend the following strategies:

First, we suggest designing for an as-new look. Because many consumers value an as-new appearance, designers should think about the aesthetic durability of a product. Designers could implement materials that either keep an as-new appearance in time or can be easily returned into an as-new state. Interesting options would be to use materials that can be easily sanded off (e.g., stainless steel), self-healing materials (Toohey et al., 2007; Wool, 2008), or to use coatings that can easily be renewed.

Second, we suggest designing for an as-new functionality. Some consumers seem to value functionality more than appearance. Designers could aim to design products in a way that it is easy to change critical parts to ensure an as-new functionality. This includes planning for disassembly and repair early in the design process. Methods, such as the hotspot mapping for product disassembly (De Fazio et al., 2021), can be used to evaluate how repairable and therefore refurbishable the product is. This can be supported by making the product (partly) modular (Meehan et al., 2007). Modular design additionally facilitates that contamination-sensitive parts touching the skin can

be easily renewed during the refurbishment process. Note, however, that manufacturers should be careful not to replace too many parts containing critical materials due to their large environmental impact (Liu et al., 2015).

Third, we suggest designing for an easy-to-clean product. This includes using materials that are durable enough to endure multiple cleaning procedures and avoiding split lines in which dirt can assemble.

Fourth, for the smallest consumer group (reuse-enthusiasts), we propose a strategy in which contamination is not reduced but embraced. Designing products that are timeless (Wallner et al., 2020), durable and become more beautiful with age could incentivise the last consumer group. This strategy is probably the most environmentally friendly because little resources are needed to refurbish the product. Another interesting finding of this consumer group was that these consumers were more environmentally concerned than other consumer groups; this group might therefore be more receptive to other strategies, such as eco-labels.

5.4.2 Limitations and future research

Although our study offers valuable implications for researchers and practitioners, some limitations deserve attention and should be taken into account in further research. Most of the psychometric variables were not significantly related to the participants' choices. This is however, not a single occurrence as psychometric variables often cannot be linked to consumers' buying behaviours (Rokka & Uusitalo, 2008). In our study, we believe that this could have happened for two reasons: first, consumers do not always practice what they preach. While some consumers intend to make more sustainable behavioural choices, their attitudes do not necessarily translate into behaviour, a phenomenon known as the value-action gap (Olson, 2013). This further underlines the importance of behavioural testing and putting consumers in choice situations when researching how to enhance the consumer acceptance of circular products. Furthermore, variables that were found to significantly predict the purchase intentions of refurbished products arise from studies comparing refurbished products to new products (Hazen et al., 2015; Mugge et al., 2017a; Wallner et al., 2021). As the products presented in the choice-based conjoint were all refurbished, these variables may not have predictive power because they are more relevant to predict the choice between new and refurbished products.

In practice, consumers often choose between a refurbished premium product and a cheaper new alternative. Past research has compared new and refurbished products and revealed that the contamination of refurbished products is a critical factor in determining the product choice for or against refurbished products compared to new products (Wallner et al., 2021). In this research, we therefore focused on uncovering how strategies aiming to reduce contamination concerns can enhance the overall preference of refurbished products. Future research could however further compare refurbished

products to new and perhaps even second-hand products to single out factors that differ in consumers´ product choices.

Another limitation of our study is that we explored contamination-related strategies with a choice-based conjoint analysis, which did not allow us to measure the effect of the strategies on contamination perceptions. Future research should consolidate our findings and explore whether the proposed strategies indeed decrease the perceived contamination or just make the product more attractive in general.

In our study, we additionally left out the year of production due to the findings of our pre-test. We initially included the year of production as means to signify the number of lifecycles a product might have had. While the year of production may not be as important in the case of headphones, we believe that the number of life cycles and the year of production can be more relevant for other products for which technological advancement is important, such as smartphones or cars and should be explored in future research.

Moreover, prior research about refurbishment has indicated that the product category can be of influence when it comes to the level of contamination. Abbey et al. (2015) made a distinction between products that are in-you products (e.g., electric toothbrushes, in-ear earplugs), which create the highest level of contamination, products that are close to you ('on-you' products, such as headphones, smartwatches), which create a medium level of contamination and products that are around-you (food containers, laptops) which may trigger the least amount of contamination. In our research in chapter 5, we made the conscious decision to focus on a product that represents the middle ground. As an 'on-you' product, headphones trigger contamination issues but may still be considered desirable when refurbished, while electric toothbrushes (in-you products) are less likely to be bought in a refurbished state due to contamination concerns. Our findings may be specific to on-you products, and we, therefore, encourage future research to also look into other product categories and explore how they can be optimised for contamination, as this may differ per product category depending on the level of contamination.

CHAPTER 6

Contaminated by its prior use: an interview study on strategies to design and market refurbished personal care products

Based on: Wallner, T. S., Snel, S., Magnier, L., & Mugge, R. (2022). Contaminated by Its Prior Use: Strategies to Design and Market Refurbished Personal Care Products. *Circular Economy and Sustainability*. https://doi.org/10.1007/s43615-022-00197-3

6.1 Introduction

Chapter 6 revolves around the research question how consumers contamination concerns with refurbished products can be decreased via marketing and product design (RQ3). Chapter 3 and 4 showed that consumers' contamination concerns are very influential in the decision to purchase refurbished products. Subsequently, in chapter 5, we investigated different strategies aimed at decreasing consumers' contamination concerns with refurbished headphones. The results showed that most consumers prefer refurbished products that show no signs of wear and tear and that have parts touching the skin renewed during the refurbishment process. These attributes are more important than the reduced price or warranty, even though these are frequently used to market refurbished products. From the previous chapters, it however remains unclear why consumers have contamination concerns

And elaborate on the underlying processes that take place when consumers experience contamination concerns. Further, we investigate in-depth how contamination concerns relate to the product (e.g., wear and tear, design, location of wear and tear), the context (marketing), and the consumer itself (e.g., consumer characteristics). In this chapter, we explore personal care products, which are even more intimately used and thereby trigger more contamination concerns. With this research, we build on the suggested contamination-reducing strategies from chapter 5.

6.1.1 The influence of contamination-reducing strategies

Strategies to reduce contamination can be related to the context of the product or the product itself (Baxter et al., 2015) and have been shown to influence the choice of refurbished products (Agostini et al., 2021; Sharifi & Shokouhyar, 2021; Wallner et al., 2022). Consumers' concerns that a refurbished product has a lower functionality due to its prior use (utility contamination) and concerns about its hygiene (hygienic contamination) can be addressed by communicating about the product's state. The refurbishment procedure entails that products are thoroughly cleaned during the refurbishment process and brought into an acceptable state. This is, however, not always clear to consumers (Van Weelden et al., 2016). Prior research, therefore, tested whether communicating that the product is cleaned and giving it a sparkling clean label would influence the choice for refurbished products by reducing its contamination (Wallner et al., 2022). This cleaning label was, however, less important in determining the product choice than other contamination-reducing strategies that decrease contamination via product design. The importance of a certified clean label could have been reduced because it unintendedly triggers users' contamination concerns. In reused clothing, communicating that a product was cleaned and sterilized unintendedly reminded users of the product's previous use (Ackerman & Hu, 2017). Additionally, while a certified-clean label might address consumers' contamination concerns via the product's marketing, it

does not help to keep the product at its highest economic and environmental value. We will therefore explore how the product appearance can be optimized to prevent contamination concerns.

The product's appearance helps consumers assess the quality and functionality of a product (Creusen & Schoormans, 2005; Crilly et al., 2004). Research on the contamination of circular products has shown that the product state (e.g., the degree to which the product is clean or unclean) and the product characteristics (e.g., visibility of wear and tear) can evoke associations of contamination (Baxter et al., 2015). Research on refurbished headphones has shown that most consumers choose refurbished products that show no signs of aesthetic wear and tear (e.g., scratches) and that have parts touching the skin (e.g., ear-cushions in headphones) renewed during the refurbishment process (Wallner et al., 2022). Renewing contamination-sensitive parts and preventing or eliminating signs of wear and tear during the refurbishment process were therefore suggested to be effective strategies to enhance the desirability of refurbished products. Furthermore, while consumers prefer new materials and experience the ageing process of reused products as negative, there are materials that are perceived more positively when showing signs of wear and tear (Bridgens et al., 2015). We hence consider it worthwhile to explore how the material choice influences the perception of refurbished personal care products with wear and tear. While prior research established that signs of wear and tear and traces of a former user are responsible for these contamination concerns, in this research, we want to explore how to prevent future contamination concerns when designing the first version of a product. By exploring which features of the product evoke contamination concerns, we hope to acquire insights on how to decrease the perceived contamination via the product design. Due to the exploratory nature of this research, we use qualitative research to acquire in-depth knowledge of why product-related factors, personal factors, and context-related factors of personal care products can trigger contamination concerns and how product appearance can help decrease them. We chose to conduct in-depth interviews because they help to reveal rich information about the personal experiences of consumers (Patton, 2002).

6.2 Method

6.2.1 Procedure and participants

Two interviewers conducted audio-recorded semi-structured interviews online with 15 female participants (Age: 21 to 67 years, all living in the Netherlands) that had purchased an Intense Pulsed light device (see Figure 23).

Figure 23. The Philips Lumea Prestige – an Intense Pulsed Light device (IPL) to prevent hair growth (Philips, 2021)

We decided to interview a total of 15 participants to ensure data saturation. Data saturation is attained when any new interview delivers approximately one or two additional codes. To attain data saturation for homogenous groups, multiple sources propose that a sample size of 10-16 participants is sufficient (Francis et al., 2010; Guest et al., 2006; Hagaman & Wutich, 2017). In our case, data saturation was achieved after 12 interviews. The interviews were conducted online via Zoom due to the Covid-19 pandemic between February and June 2021. We interviewed a convenience sample of 15 female participants living in the Netherlands who owned new, second-hand or refurbished IPL devices to obtain diversity in responses regarding refurbished products (see Table 13). Four participants who had bought a refurbished IPL device were recruited via a banner on the manufacturer's website. Participants could sign up for this research after they had purchased the device. Five participants with a second-hand IPL device and six participants with a new IPL device were recruited through posts on IPL device Facebook groups or on the online second-hand selling platform Marktplaats. The first interview was conducted by one of the two interviewers, but with both interviewers present to synchronize on how to conduct the interviews. All interviews were conducted in Dutch except for one interview, which was conducted in English.

Table 13. Product states of the IPL device that participants owned

Product state	Participant number
New	6,7,11,12,13,15
Refurbished	1,3,4,5
Second-hand	2,8,9,10,14

Participants were first interviewed on their general choice for the IPL device and why they chose it in a new, second-hand or refurbished state. Furthermore, the product state of the IPL device (e.g., "Can you describe the condition of the product at its arrival?") and the first product use ("Can you describe your first use experience?") were discussed to prompt a discussion on contamination concerns for users that had bought a refurbished or second-hand IPL device (hygienic, utility, and territorial contamination concerns Baxter et al., 2015) without directly suggesting contamination concerns to participants. For users of a new product, we hoped to spark a conversation on how they perceive the characteristics of the device, such as the laser. Furthermore, to explore the product experience participants had with new, refurbished or second-hand IPL devices, we discussed how they experienced the product aesthetics ("Can you describe the appearance of the product?"), their emotional experience ("How did it feel when you first used the Lumea? ") and why they did (not) choose a refurbished one (e.g., "What made you decide to buy a refurbished device over a new one?"). These questions were based on the framework of product experience (Desmet & Hekkert, 2007) which describes different affective responses (aesthetic, emotional, and meaning) that can be experienced in human-product interactions. We explored the human-product interaction to prompt a discussion on motivations to choose a product, how the product state (new, second-hand or refurbished) relates to participants' choices for the product and whether there were differences in the interaction with the product. Second, all participants were shown six scenarios which were used to stimulate the imagination of buying refurbished IPL devices with different attributes and stimulate further thought on refurbished IPL devices with different designs, signs of wear and tear and price. We explained that these products were refurbished, after which participants were asked which one they would buy if they had been offered this choice and to explain why. The interview guide can be found in appendix 16.

We added these scenarios because the consumer's choice for refurbished products often consists of compromises between different attributes, such as the presence of signs of use and the price. We added these scenarios to discuss how participants considered these attributes and which compromises they were willing to make. All scenarios can be found in appendix 17. Interviews lasted between 30 and 40 minutes. An informed consent was obtained from all individual participants included in the study. Participants received a small compensation (10 euros voucher) for their participation. The study was approved by the Human Research Ethics Committee of the Delft University of Technology.

Figure 24. Example scenario with a white IPL device with heavy scratches and a lower price (left) and one with light scratches and a higher price (right)

6.2.2 Stimulus material – an Intense Pulsed Light device (IPL)

The Philips Lumea Prestige is an IPL device to prevent the regrowth of hair (Philips, 2021). To use the IPL device, users must first remove their hair (e.g., by shaving), then the IPL device is pressed on the skin (face, legs, armpit, or bikini line), and an IPL light flash is activated by pressing on a button. The IPL brings hair follicles into a resting phase and prevents their regrowth. We decided to use an IPL device for our study because it is a personal care product that is intimately used and, therefore, more likely to trigger contamination concerns. Furthermore, the price of the device (370-500€) makes it attractive to buy it in a refurbished state because of the considerable amount of money consumers can save. It is designed for a particularly long product lifetime (15+ years) and is available in different product states (new, refurbished, and second-hand). It is, therefore, a product for which refurbishment makes sense as a lifetime extension strategy, and it was possible to find consumers who bought it in a reused state. The six scenarios that participants were exposed to consisted of two options side by side that differed in colour (black or white), material (smooth or rubber), number of scratches (light or heavy) and location of scratches (on housing or on buttons or attachment) and price (290-450€). An example scenario is displayed in Figure 24, and all scenarios are presented in Table 14 and in the appendices. The first scenario was used to prompt a discussion on the tradeoff between price and product state (as new vs with scratches), and the second to evoke a discussion on the material (rubber vs smooth) in combination with the colour of the device. The third scenario was designed to initiate a discussion on the location of signs of wear and tear, whereas the fourth scenario was used to spark a discussion on the tradeoff between price and signs of wear and tear on functional parts. The fifth scenario was used to elicit discussions on the role of the colour of the device, and the sixth to trigger a discussion on the tradeoff between price and the amount of wear and tear (light vs heavy). The images were created in Adobe Photoshop.

Table 14. Participants were exposed to two Lumeas side by side that differed in state, material, colour, and price

Scenario	State	Material	Colour	Price
1	As-new state	Smooth	White	395
	Scratches	Smooth	White	290
2	As-new state	Smooth	White	395
	As-new state	Rubber/matt	Black	395
3	Scratches (on buttons and attachment)	Smooth	White	290
	Scratches (on housing)	Smooth	White	290
4	New (not refurbished)	Smooth	White	450
	Scratches (housing, attachment, and buttons)	Smooth	White	290
5	Scratches (housing, attachment, and buttons)	Smooth	White	290
	Scratches (housing, attachment, and buttons)	Smooth	Black	290
6	Heavy scratches (housing, attachment, and buttons)	Smooth	White	290
	Light scratches (housing and attachment)	Smooth	White	395

6.2.3 Data processing

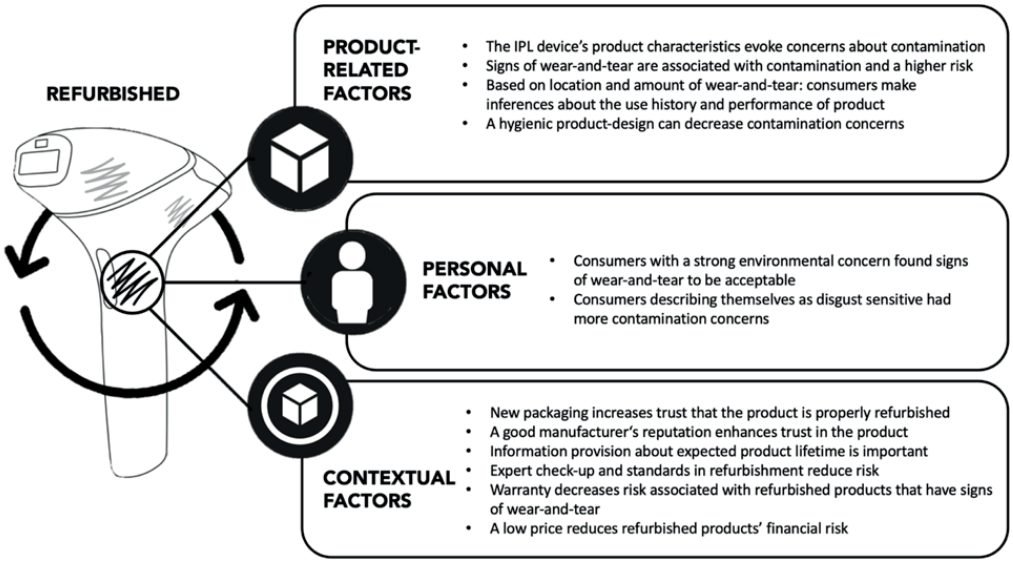
All interviews were audio-recorded, transcribed, and analysed by the principal investigator in Atlas.ti. Codes were developed during two inductive coding rounds. In the first coding round, the first five interviews were analysed in a collaborative session with the two interviewers. The remaining ten interviews were analysed by the principal investigator in a second coding round, and resulted in a total number of 232 codes. The first-order codes were categorized into 21 second-order codes that were sorted into 12 themes related to contamination (see appendices 13-15 for coding tables). Data saturation was reached after 12 interviews, suggesting that our sample size was sufficient.

6.3 Results

Overall, refurbished IPL devices were considered a riskier choice compared to new ones because they were expected to have a reduced product lifetime, have a lower performance, and be contaminated by their prior user. In line with prior research (Van Weelden et al., 2016), participants worried they would make a bad financial investment buying a refurbished IPL device that has an unsatisfactory performance. The main concern was related to utility contamination (Baxter et al., 2015), namely that refurbished IPL devices might have lower effectiveness in removing hair compared to newer models on the market or of buying a product that simply does not last as long as a new one because of its prior use. These concerns were described to be irrational and mainly based on participants' gut feelings and prior experiences with refurbished products.

Participant 6 (in response to the question of whether she would buy a refurbished IPL if she bought it again): *"I think I would still go for a new one. It is more a feeling than that it has a rational reason because I had a refurbished coffee machine in the past and other things. They were not from Philips but another brand, but they broke down very quickly. So, no idea. I would go for a new one again."*

In the next sections, we will explain how these contamination concerns are related to product-related factors (e.g., signs of wear and tear), personal factors (e.g., disgust sensitivity), and context-related factors (e.g., brand reputation). For an overview of the results, see Figure 25. An overview of codes and themes can be found in tables A13 (product-related factors), A14 (personal factors), and A15 (context-related factors) in the appendices.



6.3.1 The influence of product-related factors on contamination concerns

An IPL device is a 'scary' device because of its product features, such as the light flashes. The IPL is considered to be an innovative device, and its technology is not well understood by consumers. Some participants associated IPL treatment with similar technologies, which are painful when being administered, such as laser hair removal used at professional beauty salons. It is, therefore, scary to use the IPL device for the first time and even scarier to use it in a refurbished state because the risk is higher that it may malfunction. It is, therefore, prone to trigger concerns about utility contamination, the belief that a product's functionality is impacted because of its prior use (Baxter et al., 2015).

> Participant 14: *"It is a technical product that I don't fully understand, and I wouldn't know if it properly functions. That was a concern like: is it [the refurbished IPL device) still properly functioning and safe? It didn't prevent me from trying an old one, but the thought was there. (…) It is and stays a laser. It just doesn't give you a good feeling. And we know about a laser that if you don't use it correctly, or if the product is not put together correctly, that could perhaps be dangerous."*

Additionally, the IPL device is intimately used. When using the IPL device, participants have to press it on their skin on areas that they want to be hairless, such as the armpits or bikini line. This makes it more vulnerable to hygienic contamination (Baxter et al., 2015) when it is bought in a refurbished or second-hand state because users are concerned about finding traces of prior users on the device.

> Participant 2 (owner of a second-hand IPL device): *"I know that the Lumea doesn't remove hair immediately, but I was cautiously looking if there would be something here from somebody else. Yeah, but there wasn't. Specifically, I removed the head (attachment), and I was looking if there would be black marks here or if there would be anything in the split lines on the side."*

Refurbished IPL devices were inspected for signs of use or physical traces but not cleaned before the first use because they were expected to be clean.

> Participant 5 (owner of a refurbished IPL device)*: "No, no – I did not clean it before I used it for the first time. I trusted that it is clean."*

Comparably, second-hand IPL devices were inspected for particles of a prior user (e.g., skin particles, hairs and smells) and cleaned thoroughly before the first use.

> Participant 2: *"It was clean when I got it. It's more like: Somebody owned it before, so let's clean it! Even though it was already clean. I looked at it, and I couldn't see any signs of use in a way, yeah. I read in the instruction manual that, after it has been used for a while, it can be that there are some speckles that show up on the light part. Yeah, I did not see any speckles. Although there was one really tiny one, not that it would look like it had been extensively used."*

6.3.2 Signs of wear and tear increase the contamination risk

Signs of wear and tear increased the risk of contamination. Some participants stated that signs of wear and tear were acceptable on refurbished IPL devices as long as they could still be cleaned well.

> Participant 3: *"I would go for the Lumea with wear and tear. I absolutely think scratches, yes, they come with refurbished products, given that it can still be cleaned well, with detergent."*

Moreover, some participants would choose a more expensive IPL device that is new or has no signs of wear and tear because of the negative association with its prior use and, subsequently, the feeling that it is contaminated. The signs of use were not only associated with skin particles of previous owners (hygienic contamination; Baxter et al., 2015) but also indicated by the smell of a product (territorial contamination; Baxter et al., 2015), which make refurbished products a less attractive option.

> Participant 12: *"I would choose a more expensive Lumea (without signs of wear and tear) because I find that the other one has too strong associations with being used, that it was used by somebody else. And also, I am very sensitive to smells, to say. It is just like a book that has been lying around at somebody else's smelly house. It goes into the paper. So, I am afraid of the smell and remainders that are still on it."*

The presence of signs of wear and tear was perceived to decrease the performance, safety and expected product lifetime of the IPL device. For some participants, a warranty was sufficient to guarantee that the refurbished IPL device was safe and fully functional. Other participants, however, felt that the IPL device is safer without signs of wear and tear, acknowledging that this belief might be irrational.

> Participant 14: *"Well, I know that (the refurbished IPL device) went through a check-up, so the scratches should actually not mean anything in terms of safety and functionality of the product. But I think that I would go for this one (IPL device without scratches) because, for me as a person, the scratches would give me an irrational feeling of anxiety. And then I think it is not worth it."*

Concerns about the product's safety and potential dysfunctionality were influenced by the amount and location of wear and tear. Participants believed that the more signs of wear and tear were present, the riskier it was to buy the refurbished IPL device because of two reasons:

First, participants made inferences on how the previous owner handled the IPL device based on the heaviness of the signs of wear and tear. While light signs of wear and tear reflect normal use, heavy signs of wear and tear reflect bad treatment. For example, it is hard to scratch the IPL device according to participants' experiences; heavy signs of

wear and tear give the indication that the product has been dropped multiple times and hence the risk is higher that technical parts are damaged.

> Participant 10: *"Looking at the picture, I see that there are scratches literally everywhere. That thing has fallen from the stairs, fell on the floor, and the dog chewed on it. Let's say I know first that it has been used a lot and, second of all, that it was treated badly."*

Second, heavy signs of wear and tear were associated with a longer use time and hence indicated a reduced product lifetime.

> Participant 10: *"That (heavy scratches on the IPL device) doesn't help very much with the life cycles of the thing. They (IPL devices) only have a limited number of flashes, that are only a number. So, if I look at the IPL device (with heavy signs of wear and tear), then I think that you are through half of your light flashes. That is not handy."*

Furthermore, participants made inferences about how signs of wear and tear were made based on their location. Scratches on the body of the product signalled normal signs of use. Scratches on parts that touch the skin, parts that are hard to damage, or functional parts, such as the buttons or the attachments, indicate bad treatment by the previous user and an increased functionality risk.

> Participant 14: *"I think to me, scratches on the attachment (product part that is pressed on the skin) would make a difference. Even if they are just on the plastic part and not on the window, let's say. I know myself that this is irrational but sorry. I would be afraid that it (the attachment) can break, and the laser comes through places where it shouldn't be."*

Moreover, participants indicated that the device might have lower performance because the outside state of the IPL device reflects its inside.

> Participant 4: *"I think because the buttons have been scratched, I think that there could be something going wrong on the inside as well, and through this that the button is harder to press in."*

6.3.3 A hygienic product appearance can decrease contamination concerns

A hygienic product appearance can help decrease contamination concerns. We define a hygienic product appearance as a product design that is easy to clean and, in turn, that enables us to see how clean the product is. Overall, the IPL device was rated to have a hygienic design, and that made the device more desirable in a refurbished state.

> Participant 7: *"Yes, it's good if it is designed in such a way that it can just work hygienically. Of course, its (the device's) hygiene also depends on the person in question: on how their skin was treated and how it (the device) was treated."*

A neat and hygienic product appearance can decrease the feeling of contamination by being cleanable and by designing the product in a way that the visibility of wear and tear is minimized. This is in line with prior research indicating that participants prefer refurbished products without signs of wear and tear because if contamination is not in sight, it is not in the mind (Wallner et al., 2022).

> Participant 14: *"It's especially important that the Lumea is clean, isn't it? But still, it just gives a nice feeling when it also looks a bit neat. I would go for one where the scratches are less visible because I know about myself that if I am using it (the one with fewer scratches), then I wouldn't pay attention to it, and that would do something with my feeling of safety because the scratches are just a little bit less visible."*

A hygienic appearance was associated with the texture of the IPL device, the colour, and the product form. The white colour of the IPL device evoked an association with hygiene and being easy to clean.

> Participant 13: *"Then give me the white one anyway. And yes, I think because of hygiene considerations anyway. I think this is easier to clean. It is nonsense, of course, because it's the same material (as the black one), so it doesn't make sense."*

On the other hand, some participants preferred a black IPL device because the scratches were less visible on it.

> Participant 13: *"Maybe I would go for the black one because you can see the scratches less."*

Next to the colour, the material was critical when it came to hygiene. Participants favoured a smooth texture because it was easier to clean, and participants could check whether the IPL was clean when they received it.

> Participant 2: *"It's very hygienic (the material) because it's very smooth. … if it was a coarse material, then maybe you know certain skin residue or bacteria, or something might get stuck in it. But in this way, it just, yeah, it seems like something that you might be able to clean."*

Additionally, participants appreciated it if there were few split lines and holes in the object in which dirt could assemble, even though they understood that these are necessary to make a product that can be disassembled.

> Participant 2: *"I would like it if there were less of the splits (split lines), but probably yeah, if you want a product that can be refurbished that it needs to have this so that we can reach the inside and remove and exchange components".*

6.3.4 Consumer characteristics determine consumers' proneness to contamination concerns

Consumer characteristics, such as pro-environmental concerns, can determine how people perceive and judge the presence of signs of wear and tear (Mugge et al., 2017). Participants who had bought refurbished IPLs were environmentally motivated and were also more willing to accept signs of wear and tear, given that the product was checked by the manufacturer and, therefore, fully functional. This adds to previous research pointing out that great environmental concern is associated with a willingness to choose a refurbished product with signs of wear and tear (Wallner et al., 2022).

> Participant 1: "*Yes, yes, I am really very conscious about sustainability, so I would go for the one with scratches. Because I know, I read that the manufacturer is going to check them."*

On the other hand, participants who said about themselves that they were sensitive to feeling disgusted would typically be more concerned about the contamination risk of the IPL device and, therefore, rather buy a new one. This is in line with prior research showing that there are individual differences between consumers in the frequency and degree to which they feel disgusted (disgust sensitivity; van Overveld et al., 2010). Furthermore, this finding extends prior research demonstrating disgust sensitivity as a predictor of avoidant behaviour towards stimuli that are deemed to be disgusting, such as recycled water (Rozin et al., 2015).

> Participant 14: *"It was a little bit of a struggle because I didn't know how to clean the device. I couldn't find it back in the manual because you naturally don't want to break the window (glass part of the attachment). And you're only allowed to clean it with a little bit of water and a moist cloth, if I understood correctly. And well, maybe I am also just sort of a disgust-sensitive person, and then again, I think about: Is it completely clean?"*

Personality characteristics set a baseline of how contamination of personal care products is perceived (Wallner et al., 2022); While one should not attempt to change consumers' characteristics, appropriate marketing can help to ease their perceived contamination concerns.

6.3.5 Marketing strategies can compensate for the contamination risk

While contextual factors cannot prevent contamination risks, they can help to make refurbished products more attractive by compensating for the contamination risk by enhancing the financial and environmental benefits (Atasu et al., 2010; Michaud & Llerena, 2010) and decreasing the perceived financial and performance risk (Van Weelden et al., 2016). First, refurbished IPL devices are an economical option because consumers can save 100-200 euros when buying a refurbished or second-hand one. The higher the price difference between a new IPL device and a refurbished one, the lower the risk that one makes a bad financial investment. If the price was low enough, participants were, therefore, more inclined to choose a refurbished IPL device with signs of wear and tear.

> Participant 13: *"I think the price difference with this one (IPL device with heavy scratches) is worth thinking about buying one with scratches."*

Confirming prior research (Mahmoodi & Heydari, 2021; Mugge et al., 2017), we found that the warranty and an expert check-up during the refurbishment process can make the product less risky and incentivize consumers to choose a refurbished IPL device. The fact that a refurbished product is checked by an expert and therefore adheres to a certain standard makes them a safer choice compared to second-hand ones. A try-and-buy period and an extended warranty reduce the risk because they know whom to contact if the product does not work and that they will receive another functional product in that case.

> Participant 15: *"Indeed, there is a real warranty; you know what you are buying. There is a number you can call when there is something not right. So, those are all things that make me feel: okay, I would consider buying that there (participant points towards refurbished IPL device in the presented dilemmas)."*

A good manufacturer's reputation (Agostini et al., 2021; Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016), is influential because it increases the perceived quality of the product, whether it can be refurbished well and whether the manufacturer can be trusted to grant the promised warranty. Additionally, the reputation of the refurbisher and, in our case, also manufacturer influenced whether people trust that the product is fully functional and safe to use. The reputation was determined by a good brand image and reviews.

> Participant 3*: "I just have quite a lot of faith in Philips in terms of factory or equipment. And, of course, I know people around me who have also used Philips, and they are very satisfied with it. But I think I would give others (other brands) a chance too, but you know, Philips just has a good name."*

The retail experience also has an influence on how desirable and risky refurbished products are. One concern that consumers had been that the product was sold as refurbished but was not processed properly and, therefore, might not have been tested, cleaned and repackaged. New packaging indicates that the product has been processed and properly refurbished (tested, checked, cleaned), and this can decrease contamination concerns.

> Participant 14: *"I trust a brand like Philips that stands behind it and promises me that if they put a whole new package on it and sealed it and checked it and say: we cleaned it, that they will have really cleaned it."*

Finally, the information provision about the refurbished product determines the IPL device's desirability. Knowing how long a refurbished product is designed to last and how long it has already been used would help the consumer to determine whether the product is a good investment.

> Participant 13: *"I would question: how long is it (the refurbished IPL) going to last? You know, if they would say that it can be used for a certain number of flashes and it would last for that long. Okay, they don't know how many flashes you use per time, but it would make a difference."*

6.4 Discussion and conclusions

This research contributes to the literature by explaining why consumers' contamination concerns increase the perceived riskiness of refurbished products and how they can be reduced. To keep refurbished personal care products at their highest value, we propose five design strategies to minimize contamination concerns by designing a product that looks and smells hygienic even after multiple lifecycles. Through this, we hope to address not only rational concerns that consumers have but also emotional ones. For refurbished personal care products with signs of wear and tear that cannot be eliminated, we suggest marketing strategies that can mitigate consumers' contamination concerns and therefore enhance their desirability.

Our findings demonstrated that consumers generally deemed refurbished personal care products with signs of wear and tear to be a riskier choice. Confirming prior research (Baxter et al., 2015; Mugge et al., 2017; Van Weelden et al., 2016), the risk that the device malfunctions was expected to be higher; participants estimated that products would have a shorter product lifetime (utility contamination) and would be contaminated by a prior user (hygienic and territorial contamination). These risks were increased for refurbished IPL devices with heavy signs of wear and tear and signs of wear and tear on functional components, which is in line with prior research stating that aesthetic signs of wear and tear signal contamination by a former user (Baxter et al., 2015). We additionally argue that the aesthetic wear and tear may signal to consumers that the functionality risk is higher and the device is more likely to be contaminated with traces of a prior user. Building on prior research (Baxter et al., 2015), we found that based on the location and amount of wear and tear, users make inferences on how the prior user has treated the device, which in turn indicates a lower functionality of refurbished personal care products.

6.4.1 Design strategies for personal care products

When designing products for multiple lifecycles, it is important to understand that contamination concerns are more feelings than rational thoughts. Even though consumers rationally know that products are tested, repaired, and cleaned during the refurbishment process, feelings of unease due to contamination persist. When designing for refurbishment, designers, therefore, need to address feelings in addition to cognition. We, therefore, recommend designing products in a manner that minimizes the feeling of contamination by reducing signs of wear and tear and evoking associations that make the consumer feel safe. Prior research suggested designers use materials that are either aesthetically durable and keep an as-new appearance over time or by using materials that can be easily returned into an as-new state (Wallner et al., 2022). Wallner et al. (2022)

recommended using materials that can be easily sanded off (e.g., stainless steel), self-healing materials (Toohey et al., 2007; Wool, 2008), or to use coatings that can easily be renewed. Based on our findings, we would like to extend existing design strategies for refurbishment by recommending the following strategies specific to personal care products:

1. Evoking associations with hygiene: The white colour in our study was associated with hygiene. While this was acknowledged to be an irrational association, white products were perceived to be cleaner than black ones. We, therefore, recommend testing which colours are associated with cleanliness and therefore help reduce consumers' contamination concerns.
2. Making signs of wear and tear less visible: Colours that made signs of wear and tear less visible were considered desirable for refurbished personal care products. Especially for devices that will be heavily used during their life cycle, we recommend using colouring, patterns or textures that help to minimize the visibility of wear and tear because if signs of wear and tear are "out of one's sight", indeed they are "out of one's minds".
3. Smooth materials: For hygienic products, we recommend using materials that are smooth over materials that are rougher as consumers have the association that smooth materials are easier to clean while in rougher materials, dirt and bacteria assemble.
4. Few split lines: Similarly, consumers preferred as few split lines in hygienic products as possible so that no dirt could assemble in them.
5. A clean product smell: Personal care products with wear-and tear were associated with a bad smell. To counter this perception, we, therefore, recommend not only addressing contamination concerns aesthetically but through all senses by giving the product an as-new or clean smell.

6.4.2 Marketing strategies to compensate for contamination

While marketing strategies cannot prevent contamination concerns of products with signs of wear and tear, they can make refurbished products a less risky choice despite being contaminated. By offering refurbished products for an economical price and with an extended warranty, retailers can reduce the risk consumers experience (Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016). Furthermore, to foster the trust that the product was processed and fully functional, we recommend communicating that the product was checked by an expert by offering it in new packaging and fostering a good brand image. Additionally, retailers could decrease the risk that the product does not last as long as a new product by being transparent about how long the product has been used and for how long it is conceptualized to last. This could be achieved by providing

a product-lifetime label that gives consumers an estimation of how long they could use the product (van den Berge et al., 2021a). To keep products at their highest economic and functional value, contamination should, however, be considered when designing a personal care product.

6.4.3 Limitations and future research directions

While all our participants owned an IPL device, some of them did not have the actual experience of receiving and using a refurbished IPL device but owned a new or second-hand one. A limitation of our study is that we used pictorial stimuli to evoke associations with contamination for refurbished personal care products. We realize that showing signs of wear and tear in a pictorial representation of a product differs from seeing such signs of wear and tear in real life. For example, signs of wear and tear were portrayed in our stimuli to be quite severe. Realistic signs of wear and tear would often be less extensive, which may also result in fewer negative reactions. We nevertheless decided to manipulate it in this way because more subtle signs of wear and tear would have been difficult to see in the scenarios that we shared with participants online. Furthermore, we recognize that contamination addresses more senses than just the visual. We, therefore, believe that it would be interesting for future research to validate our findings in an in-vivo setting by testing contamination concerns of refurbished products with physical products demonstrating actual signs of wear and tear.

Additionally, we only discussed participants' first use experiences and expectations of buying a refurbished or second-hand IPL device. It would be interesting to test in future research whether contamination concerns are long-lasting due to visible signs of wear and tear or decrease after the participant has used the product a few times. Another limitation of our research is that we focused solely on IPL devices as stimuli. This could have influenced our findings in various ways: First, compared to other refurbished products, the IPL device was manufactured, sold, refurbished and resold by the same party, which is the manufacturer. Future research could test whether this had an effect compared to products that are refurbished and resold by a different reseller; consumers may perceive more risk in the refurbishment process due to the involvement of a third party. Second, the device we tested is a luxurious, and therefore expensive, personal care product. The financial benefit of buying a refurbished IPL device is, therefore, higher than for less expensive products. For other personal care products, such as electric toothbrushes or shavers, refurbishment might be less financially attractive and evoke even more contamination concerns in consumers (Mugge et al., 2017). For these product categories, other strategies should be tested, such as emphasizing that those parts touching the skin have been replaced during the refurbishment process. Fourth, due to the nature of the device, we only interviewed female participants that can afford a luxurious IPL device; gender differences have been shown to influence decision-making

about purchasing technological devices (Venkatesh et al., 2000). Future research should therefore explore more diverse consumer responses to refurbishment for more product categories sensitive to contamination to validate and extend our suggested design strategies. Furthermore, while this sample size was sufficient to explore the experiences of a homogenous sample with females using IPL devices, future research should validate our findings with larger and more diverse samples, including participants of different age ranges, genders, and ethnicities.

6.4.4 Conclusions

This research sought to understand why consumers' contamination concerns increase the perceived riskiness of refurbished products and how they can be reduced. Our data suggests that consumers perceive refurbished personal care products with signs of wear and tear to be a riskier choice and expected that the device would malfunction, have a shorter product lifetime and would be contaminated due to the previous use. To keep refurbished personal care products at their highest value, we, therefore, propose design strategies to prevent contamination concerns by designing a product that smells and looks hygienic after multiple lifecycles. For refurbished personal care products with signs of wear and tear that cannot be eliminated, we propose mitigating consumers' contamination concerns with marketing strategies. Contamination has shown to be a barrier in consumer adoption of various circular products beyond refurbishment, such as clothing in product service systems (Tunn et al., 2021), remanufactured consumer electronics (Abbey et al., 2015), or reusable food packaging (Magnier & Gil-Pérez, 2021; Miao et al., 2021) and is therefore important to address in research. This work contributes to the literature on user-centric design and marketing of refurbished personal care products and the understanding of the potential of strategies to reduce contamination concerns in the Circular Economy more broadly. Finally, manufacturers could use these insights to design products that retain their value over multiple life cycles and establish a promising market strategy for refurbished personal care products, which is both commercially relevant and creates a substantial environmental benefit.

CHAPTER 7

Discussion and conclusions

This dissertation explores how designers can enhance consumer acceptance of refurbished products. In chapter 1, the research rational, literature background, research questions and the general outline as described. *Chapters 2 and 3 explore how the product appearance contributes to the consumer acceptance of refurbished products. In chapter 4, we investigate the underlying relationships of factors influencing the consumer acceptance of refurbished electronics. Chapters 5 and 6 zoom in on the topic of contamination and how it can be reduced. This thesis contributes to the literature by extending the consumer-centric perspective on refurbishment and informing manufacturers and designers about potential design strategies that make refurbished products more desirable and that may help to retain their value over multiple life cycles.*

In contrast to prior research, we focus on consumer electronics other than smartphones. This final chapter summarises and discusses the main findings and conclusions. We adhere to the structure of the research questions proposed in chapter 1 of the thesis. Subsequently, implications for theory about the consumer acceptance of refurbished and practical implications for designers, marketers and R&D managers are discussed. Furthermore, this last chapter reflects on the limitations of our studies, potential avenues for future research and refurbishment in general.

7.1 Main findings

1. RQ: How does the product appearance contribute to the consumer acceptance of refurbished products?

In chapters 2 and 3, we investigated how product appearance contributes to the consumer acceptance of refurbished products. In the second chapter, we explored consumer responses to two design styles that were suggested to be timeless; the neo-retro design style that evokes nostalgia and benefits from associations with the past and the simplistic design style that is independent of cultural or time-related cues. Our findings provided qualitative support that the neo-retro and the simplistic design styles can improve consumers' evaluations of refurbished products. Both design styles were considered timeless, making them more aesthetically attractive. Refurbished products following a simplistic or neo-retro design style additionally benefited from associations of greater durability. Refurbished neo-retro products benefited from being associated with *the good quality of the past when products were made to last;* refurbished simplistic products were perceived to be more durable because they were perceived to be *so simple that nothing can break*. Durability was a recurring theme in general; participants favoured products that looked durable and preferred refurbished products made of high-quality

materials, such as wood, leather, and metal, because of their durability. Based on these findings, we concluded that design plays a crucial role in the consumer acceptance of refurbished products. Hence, we propose that designers should emphasise timelessness, durability, and a product appearance that communicates the product's quality when designing products for multiple life cycles. We believe this can ultimately extend the aesthetic lifespan of a product and make it more attractive and, therefore, more desirable in a refurbished state.

In chapter 3, we tested in a quantitative study whether refurbished products' aesthetic durability predicts the purchase intentions of refurbished headphones and blenders. Unfortunately, our experimental manipulation did not work. In a regression analysis, we, however, found that a product's durability and attractiveness positively predict the purchase intentions for both new and refurbished products. Contrary to our expectations, the products' durability and attractiveness did not play a larger role in refurbished products than new products. We concluded that designers should design products likely to retain their aesthetic durability and attractiveness across the different phases of a circular life. Furthermore, we found that consumers' environmental concern and the perceived contamination risk influence the purchase intentions of refurbished products, whereas there were no effects of these factors for new products. Thus, consumers' contamination and environmental concerns play an essential role in the purchase intentions of refurbished products. We proposed that contamination should be considered when designing products that have multiple lifecycles and will be refurbished at a later stage. Therefore, how to address contamination by design is subject to research question 3 and the last chapters of this thesis. Nevertheless, in chapter 3, we only included four factors that are important when it comes to determining the choice regarding refurbished products due to the focus on product appearance. In reality, consumer decision-making regarding refurbished products is more complex and includes factors related to the product, the marketing and the consumer.

2. RQ: What are the underlying relationships of factors influencing consumer acceptance of refurbished products?

In chapter 4, we therefore expand the number of factors at play when evaluating refurbished products and explore their interrelations We analysed their interrelations by modelling the complex interplay of product-related, marketing-related and consumer-related factors identified to influence the purchase intentions of refurbished products. We investigated two product categories (earbuds and speakers) that differ in the degree to which they evoke consumers' contamination concerns. A network analysis of refurbished speakers and earbuds showed that the most significant factors related to the intention to purchase refurbished products were the product category, the perceived

risk, and the perception that refurbished products were contaminated by their prior users. Furthermore, the two product categories differed in which factors were most strongly related to the purchase intentions. The belief that refurbished products are financially attractive and the perceived risk that the product is a bad investment were the largest predictors of the purchase intentions for refurbished speakers. For refurbished earbuds, participants' feelings that the product is contaminated by their prior user (territorial contamination) and that earbuds are perceived to be unhygienic because they had been previously used were most strongly linked to the purchase intentions. These findings build on chapter 3 by specifying that hygienic, territorial, and utilitarian contamination concerns are indeed a powerful predictor of the purchase intentions of refurbished products. Depending on the product category, it even seems more important than the price reduction of the refurbished product. We, therefore, concluded that strategies aiming to enhance the consumer acceptance of refurbished products should, first and foremost, focus on reducing risks and contamination concerns.

3. RQ: How can we decrease consumers' contamination concerns with refurbished products via marketing and product design?

Chapters 3 and 4 underlined that consumers' contamination concerns play a role in consumers' intentions to purchase refurbished products. Yet, from this research, it was unclear how contamination concerns can be addressed to increase consumer acceptance of refurbished products. Chapter 5, therefore, we explored the effects of contamination reducing strategies together with more common marketing strategies on the choice of refurbished headphones. More specifically, we tested several contamination-reducing strategies, including communication about the clean object state, eliminating signs of use (aesthetic and functional signs of wear-and- tear) and renewing parts that touch the skin (e.g., ear cushions). Additionally, we analysed whether different consumer groups are driven by different attributes of refurbished headphones. Our results showed that most consumers value refurbished products that show no signs of wear and tear and have parts touching the skin renewed during the refurbishment process. Our research revealed that these attributes are even more important than the reduced price or warranty, even though these are frequently used for marketing refurbished products.

Furthermore, chapter 5 showed that depending on the consumer group, the importance of these contamination-reducing strategies in determining choice differ. While some consumer groups highly valued that aesthetic signs of prior use are

eliminated through an as-new appearance, others preferred refurbished products with an as-new performance. In contrast to this, for a small consumer group that we call the reuse-enthusiasts, we proposed a strategy in which contamination is not reduced but embraced. Designing products that are timeless (Wallner et al., 2020), durable and become more beautiful with age could incentivise the last consumer group. Based on our research in chapter 5, we recommended four design strategies to decrease contamination concerns with refurbished products: 1. designing for an as-new appearance, 2. as-new functionality, 3. a cleanable object state or 4. embracing contamination. However, from chapter 5 it remained unclear why consumers have contamination concerns and how they relate to the product (e.g., wear and tear, design), the context (marketing), and the consumer itself (e.g., consumer characteristics). Exploring this is important because it can inform designers how to reduce contamination concerns via design and marketing.

In chapter 6, we explored through in-depth interviews why consumers have contamination concerns with personal care products and how product design and marketing strategies can decrease these concerns and make refurbished products a more desirable consumer choice. Next to exploring how the product design can prevent contamination concerns, we also touched upon the role of marketing strategies in decreasing contamination concerns. To extend our research findings from chapter 5, chapter 6 investigated personal care products, a product category that is even more intimately used. The qualitative study revealed that participants felt that refurbished personal care products with wear and tear are a riskier choice and expected the device to malfunction, have a shorter product lifetime, and be contaminated by the previous use. Participants made inferences about how the prior user had treated the device based on the location and number of scratches. While light wear and tear indicates everyday use, heavy signs of wear and tear were interpreted as a sign of bad treatment by the previous user. To keep refurbished personal care products at their highest value, we, therefore, suggested five design strategies to minimise contamination concerns by designing a product that smells and looks hygienic after multiple lifecycles: 1. using colours that evoke associations with hygiene, 2. making signs of wear and tear less visible, 3. using smooth (cleanable) materials, 4. minimising the number of split lines in the product, and 5. giving refurbished products a clean product smell. For refurbished personal care products with signs of wear and tear that cannot be eliminated, we proposed mitigating consumers' contamination concerns with marketing strategies, such as a reduced price, an extended warranty, new packaging and fostering a trustworthy brand image.

7.2 Implications for theory

In the following section, the contributions to theory are outlined and discussed. Subsequently, limitations and future research directions are discussed.

7.2.1 Contribution to theory

Prior research has highlighted the importance of the role of the consumer in the circular economy (Camacho-Otero et al., 2018; Kirchherr et al., 2018). However, how products need to be designed and marketed in a circular economy from a consumer-centric lens was lacking. Especially in the context of refurbishment, prior literature explored technical aspects of refurbished products (Hatcher et al., 2011; Ijomah et al., 2007) and identified factors that influence consumer acceptance of refurbished smartphones (Abbey et al., 2015; Esmaeilian et al., 2021; Harms & Linton, 2016; Mugge, de Jong, et al., 2018; Mugge, Jockin, et al., 2017a; Van Weelden et al., 2016). However, how design contributes to the consumer acceptance of refurbished products was underexplored. With our research, we contribute to the literature on consumer acceptance of refurbished products (Abbey et al., 2015; Harms & Linton, 2016; Mugge et al., 2017; Mugge et al., 2018; Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016) by exploring the value of the product design of refurbished products for enhancing consumer acceptance of these products. Furthermore, we extend findings on consumer acceptance of refurbished smartphones to other consumer electronics.

In chapter 2, we build on prior research by conducting the first qualitative study that brings together research on the appearance of new products (Blijlevens et al., 2012; Creusen et al., 2007; Flood Heaton & McDonagh, 2017; Mugge, 2011; Mugge & Schoormans, 2012; Page & Herr, 2002; Veryzer & Hutchinson, 1998), timeless designs (Flood Heaton & McDonagh, 2017; Lobos, 2014) and research on consumer response to refurbished products (Esmaeilian et al., 2021; Harms & Linton, 2016; Mugge et al., 2017a; Mugge et al., 2017b; Mugge et al., 2018; Van Weelden et al., 2016). Our study is the first to provide qualitative support that two design styles that are proposed to be timeless (Fort-Rioche & Ackermann, 2013; Lobos, 2014), the neo-retro and the simplistic design styles, can elicit favourable associations with refurbished products.

Chapter 3 supports and extends the literature on durable and attractive product appearances (Mugge et al., 2018; Wallner et al., 2020) by demonstrating the importance of these product appearance-related factors in the purchase intentions of refurbished products. Furthermore, we confirm prior research revealing that the consumer's environmental concern (Mugge et al., 2017a) is an influential factor in the purchase intentions of refurbished products (Abbey et al., 2015; Baxter et al., 2017; Mugge et al., 2017). While prior research indicated that consumers avoid buying refurbished products that are intimately used because they feel repulsed by them (Abbey et al.,

2015), our research is the first to show that contamination has a significantly negative and quantifiable role in the purchase intentions of refurbished products. It reveals that contamination concerns have a larger (negative) impact on purchase intentions compared to other factors, such as the consumers' environmental concerns, that positively influence the purchase intentions of refurbished products.

In chapter 4, we deep-dive into the topic of contamination to explore its role in consumer decision-making regarding refurbished products. In this chapter, we build on Baxter's HUT model contamination (Baxter et al., 2015) and distinguish between three kinds of contamination that were proposed to be relevant for reused products. We explore the role of hygienic, utilitarian and territorial contamination (HUT model; Baxter et al., 2015) in the decision-making regarding refurbished products. By doing this, we contribute to theory by showing that all three kinds of contamination are important predictors of the purchase intentions of refurbished products; And hence need to be added to existing decision-making models about consumer choice for refurbished products, such as the model proposed by Van Weelden et al. (2016). Additionally, by identifying which factors differ in predicting the purchase intentions of refurbished products of different categories, we contribute to understanding how different product categories need to be designed and marketed to make them more desirable.

Furthermore, chapter 4 also represents a methodological contribution by conducting a network analysis; this relatively new quantitative methodology allowed us to analyse factors involved in the consumer decision-making process of refurbished products more holistically. Prior research has oversimplified consumers' choice for refurbished products by only analysing market factors that linearly predict consumers' purchase intentions (Mugge et al., 2017a; Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016) and neglecting the role of the product and the consumer. By exploring the complexity of the factors at play, we contribute to research on consumer acceptance of refurbished electronics by shedding light on the underlying psychological processes. Additionally, we focus on two product categories that differ in the degree to which they evoke consumers' contamination concerns.

In chapter 5, we contribute to the literature by showing the importance of contamination-reducing strategies for the choice of refurbished headphones. While prior research identified that consumers' contamination concerns may play a role in the choice of refurbished products (Abbey et al., 2015; Mugge et al., 2017; Mugge et al., 2018; Sharifi & Shokouhyar, 2021; Van Weelden et al., 2016), it was not clear whether reducing them will positively influence the consumer choice for refurbished products. Previous research identified factors, such as the product's price and warranty (Mugge et al., 2017a; Sharifi & Shokouhyar, 2021) as the most important determinants in the consumer choice regarding refurbished products; in contrast we show that contamination-related attributes are more influential in the consumer choice for refurbished products.

Furthermore, we contribute to the literature by proposing several design strategies for refurbished products that reduce contamination concerns and enhance consumer acceptance of refurbished products. Additionally, we demonstrate that different consumer groups are driven by different attributes of refurbished products. The only other study that identified different consumer groups and how they can be incentivised did not consider consumers' contamination concerns and focused on refurbished smartphones (Mugge et al., 2017a). We, therefore, contribute to the literature by making a segmentation of consumer groups more or less interested in refurbished products and how the consumer groups relate to contamination-reducing strategies. Furthermore, this study contributes from a methodological perspective. While most consumer research so far had been qualitative or based on regression analysis, the study shows the importance of contamination-reducing attributes for refurbished products based on a choice setting. Choice-based conjoint analysis aims to mimic an actual buying situation by giving participants two products with fixed choice sets (Hair et al., 2006).

In chapter 6, we further develop these contamination-reducing design strategies and investigate them in the context of personal care products. We further built on prior chapters by elaborating on the underlying processes that take place when consumers experience contamination concerns. Further, we investigate in-depth how contamination concerns they relate to the product (e.g., wear and tear, design), the context (marketing), and the consumer itself (e.g., consumer characteristics). Additionally, chapter 6 explores personal care products, a category that is intimately used, and thereby triggers more contamination concerns (Mugge et al., 2017). Based on our findings, we contribute to the literature by extending our previously developed design strategies to personal care products and showing how the amount and location of wear and tear influences the consumer acceptance of refurbished personal care products. Based on our findings, we suggest five design strategies that could decrease contamination concerns with personal care products.

7.2.2 Limitations and future research directions

In the next section, the limitations and future research directions from a theoretical perspective are discussed. First of all, our research investigated the role of product design and, to some extent, marketing and consumer-related factors in the purchase intentions of refurbished products. Well-established behavioural change theories, such as the theory of planned behaviour (Ajzen, 1991), assume that intentions to perform a specific behaviour, such as the behaviour of purchasing refurbished products, actually leads to the execution of this behaviour. We, therefore, mainly explored the self-reported purchase intentions of refurbished products in this thesis. In chapter 2 and, to some extent, in chapter 6, we assessed the purchase intentions qualitatively and by exposing participants to dilemmas in interviews; in chapters 3 and 4, we assessed the purchase intentions with

scientifically validated scales. While these studies identified factors that play a role in the purchase intentions of refurbished products, it is uncertain if these factors would lead to actual buying behaviour. Often enough, intentions have been shown not to lead to actual behaviour (Intention-Behaviour gap; Sheeran & Webb, 2016). We tried to solve this issue in chapter 5 by using a conjoint method that simulates choice behaviour by letting participants choose between different options for refurbished products. In chapter 6, we recruited participants who had actually bought a refurbished, second-hand or new product and asked them about the decision in hindsight. However, future research should validate our findings by looking at factors that predict actual buying behaviour in real-life settings. An interesting idea would be to use real-life data sets collected through online platforms that sell refurbished products or through experiments conducted in living labs.

Additionally, some behavioural change models, such as the theory of planned behaviour, have shown that sociocultural factors can play a role in the consumer choice for refurbished products. For example, Gaur et al. (2019) suggested that cultural differences between Indian and American consumers play a role in the purchase intentions of refurbished products. Our samples, however, consisted of mainly Western European participants and did not investigate differences in cultural or social norms regarding refurbished products. Future research should therefore validate and extend our findings with multicultural samples.

Furthermore, in our studies, we explored the role of product appearance in the desirability of refurbished products with pictorial stimuli, such as images and 3D models. While there were good reasons to conduct most of our research online, such as that most refurbished products are bought in online shops, seeing a product in a web shop is different from actually having the product in your hands, feeling and smelling it. Especially in the context of contamination, in-vivo interactions with a refurbished product in a shop might be different from thinking about its prior use but not seeing the real device before it is bought.

Furthermore, all our research, except for study 1, was conducted during the Covid-19 pandemic. This could have had the effect that participants had a heightened awareness and concerns about contamination, due to which contamination may have played a larger role than before (or after) the Covid-19 pandemic. Future research could explore the differences between online and offline shops and how contextual changes can influence consumer acceptance of refurbished products. Furthermore, in chapter 6, we found that most participants did not have contamination concerns anymore after they received and used their refurbished IPL device for some time. This was described to be the case because the product looked clean, and participants trusted the manufacturer to have cleaned the device properly. A direction for future research would be to explore contamination in longitudinal studies by investigating how participants perceive

contamination of refurbished devices after receiving the device and to test whether perceptions of contamination vanish over time.

Similarly, future research should explore the post-purchase phase. For products to keep their highest material and economic value, products need to feel valuable to consumers over an extensive period. Refurbished products are, however, associated with lower quality and value, and it would be interesting to look at the effects of how consumers treat and keep their refurbished devices. Van den Berge et al. (2021b) discussed that individuals' perceptions of product value slowly decrease until they assess that the product has made its money's worth. The product is subsequently more easily replaced by a new product that offers relatively more value. Hence, as refurbished products are acquired at a lower cost, they might not be kept as long as new products.

For access-based renting business models, it has been shown that products are treated worse when they are rented than those that are owned (Tunn & Ackermann, 2020). Similarly, prior research has shown that if consumers perceive their products to be less valuable (compared to another more attractive alternative), they make less effort to maintain them, consequently reducing the product's overall lifetime (Bellezza et al., 2017). Hence, future research could explore how consumers treat refurbished products after the purchase and how this impacts the overall lifetime of refurbished products. Moreover, whether refurbished products retain their value to consumers may also relate to the product category and the product quality. Some products, such as high-end luxury products (e.g., Birkin bags) or antiques, become more valuable with age and are associated with durability, uniqueness and timelessness despite their prior use and considerable age (Wallner et al., 2019). Consumers have been shown to keep high-end goods for longer and dispose of them in a more environmentally friendly manner than midrange products (Sun et al., 2021). Hence, future research should explore how the consumer acceptance, use and disposal of refurbished products differs between more product categories and product types.

Furthermore, for products made out of recycled materials (e.g., backpacks made out of used airbags), the narrative of a product can make them more desirable to consumers (Kamleitner et al., 2019). While this form of positive contamination might be difficult to implement for consumer electronics that are associated with contamination concerns, some product categories might benefit from receiving a narrative about their past life. For example, Folkertsma (2017) developed the concept of a baby stroller that is updated aesthetically during every refurbishment cycle; during refurbishment a pattern on the stroller fabric is printed that shows the routes the previous users had walked (see Figure 26), creating a unique stroller and showing the product's history over time. It is, however, unclear whether emphasizing the narrative of a product' prior life would enhance the purchase intentions of such a refurbished stroller. Furthermore, one could also argue

that adapting the stroller after use could stimulate product attachment, which in return is associated with a longer use time and higher emotional durability of products (Chapman, 2009; Mugge et al., 2008). While increasing the emotional product longevity can be beneficial from an environmental standpoint, it might not be the best strategy to foster the use of refurbished products for two reasons. First, refurbished products must go back into the loop after use, and a high product attachment could prevent people from devesting their product. Second, underlining a product's narrative may increase territorial contamination concerns and make the product less attractive to a new user. Whether specific narratives and other positive forms of contamination can be used to enhance consumer acceptance of refurbished products remains unexplored and could be tested by future research.

Figure 26. Concept of a baby stroller that receives a narrative about its past life through a map printed on it during the refurbishment process (Folkertsma, 2017)).

Finally, we only explored refurbishment in the Business to Consumer (B2C) context. However, many electronics, especially IT devices, do not circulate among 'civilian' consumers but are used by corporate organisations, which are also required to reduce their environmental impact. Hence, exploring how refurbished products are perceived in the Business to Business (B2B) context or in access-based product service systems would be interesting. Baxter et al. (2017) described that contamination concerns do not only depend on the product and the consumer but also on the context. Through the context change, contamination would perhaps be less problematic. For instance, while very few consumers would buy second-hand or refurbished mattresses, using them in hotels does not evoke problematic contamination concerns. At the same time, renting or leasing business models could also compensate for some of the risks associated with refurbished products. By being guaranteed that the product will be replaced or repaired during the

duration of the lease, refurbished products could become a more desirable consumer choice because some of the risks are decreased by the guaranteed functionality. Future research could test this.

7.3 Contribution to practice

Our research also contributes to practice, in particular to parties that are motivated to design and market refurbished products. Refurbished products that circulate between multiple users need to be designed in a way that they retain their value to consumers over time. Our research has shown that product design is an important factor in the consumer acceptance of refurbished products and, therefore, for their economic as well as circular value retention. Hence, to enhance consumer acceptance of refurbished products, refurbished products need to be designed in such a way that they continue to be attractive from a functional as well as aesthetic perspective for multiple life cycles. With this research, we explored various routes of how electronic devices have to be designed to stay attractive in a refurbished state and therefore recommend the following three design strategies:

1. Design an appearance that remains attractive over time
2. Take the perceived contamination into account

In the next section, every strategy is elaborated on and discussed.

7.3.1 Design an appearance that remains attractive over time

In chapter 1, we concluded that refurbished products are attractive when they have a timeless design. While we recommend that designers should keep the timelessness of their designs in mind, we acknowledge that timelessness might be harder to achieve in practice than in theory. Our definition of timelessness is highly related to the prototypicality of products, and, in the end, all trends and prototypes are cyclical and evolve over time. Even though some trends are moving faster than others, it is probably inconceivable to design consumer electronics that will remain desirable for numerous decades. For example, it is questionable whether the designs that are considered neo-retro today will remain to be perceived as neo-retro in the future. Furthermore, simplistic products are only considered to be timeless if they are prototypical. Even though prototypes of products do not change frequently, these do evolve over time. Shared characteristics that products of the same category have, determine the prototype. For example, in the past, a telephone's handle was considered a prototypical characteristic of a telephone. Nowadays, telephones are mobile, and most telephones do not have handles

anymore thereby changing the prototype of a phone. A high degree of prototypicality has been shown to have a positive effect on the attractiveness of products and, therefore, should be taken into consideration when designing refurbished products for timelessness (Blijlevens et al., 2012; Bloch et al., 2002; Hekkert et al., 2003). Even though these time effects need to be taken into account and limit the 'eternal' desirability of timeless products, this does not mean that timelessness may not contribute to circular consumption. Lifespans of many product categories are decreasing. For example, the lifespan of coffee machines decreased by 9 % between 2000 and 2005 to only 6.4 years (Bakker et al., 2014). A successful refurbishment strategy, and thus, a second or even third life, may turn the overall lifespan of coffee machines to 12 or more years. In many cases, such an increase in lifespan would be valuable from an environmental perspective but is not likely to be strongly affected by changes in fashion cycles or prototypes.

7.3.2 Take the perceived contamination into account

Chapters 2 and 3 showed that when designing for refurbishment, it is important to reduce risks associated with refurbished products and mitigate consumers' contamination concerns by design. In aiming to do so, it is important to remember that contamination concerns and perceived risks are more feelings than rational thoughts. Chapter 6 showed that even though consumers rationally know that products are tested, repaired, and cleaned during the refurbishment process, feelings of unease due to contamination may persist. When designing for refurbishment, designers, therefore, need to address feelings in addition to cognition. We hence recommend designing products in a manner that minimises the feeling of contamination and the perception of risk. This can be achieved by reducing signs of wear and tear and evoking associations that make the consumer feel safe. Trust in a product can be fostered via its aesthetic attractiveness and by ensuring satisfactory functionality. Based on our findings in chapter 5, we suggest designers to use materials that are either aesthetically durable and keep an as-new appearance over time or to use materials that can be easily returned to an as-new state. To decrease utility contamination (a lower perceived functionality of the product due to its prior use) and ensure that the product has satisfactory performance, products should be designed for easy disassembly. This requires that designers consider which parts and how parts need to be changed during the refurbishment process. It is yet important to consider that the more parts are changed during the refurbishment process, the higher the environmental impact. Therefore, it is a preferable strategy to ensure optimal durability of the products' aesthetics as well as their functionality. However, designers should look at products from a holistic systems perspective and make careful considerations; ensuring that a product is easy to disassemble can be at the cost of its durability. Products that are designed to endure the impact of water or being dropped are often harder to disassemble because parts are often glued together. From an environmental impact perspective, it is not

more sustainable to have a product that is easy to refurbish but that also easily breaks. Depending on the product, it is, therefore, advisable to make careful consideration of how a product needs to be designed.

Especially for products that are more intimately used, it is important to also prevent contamination concerns in the first version of the design. In chapter six, we found that colour, material choice, the number of split lines and a clean product smell can help to make refurbished personal care products more attractive by reducing consumers' hygienic contamination concerns. Depending on the product category and type of product, it is therefore important to consider future contamination concerns when designing the first version of a product. The colour of a product can help to prevent wear and tear and make wear and tear less visible. For example, in reusable food packaging, one would initially think that white would be a good colour because it is associated with cleanliness. However, after the use of such reusable packaging to contain certain types of food, packaging may recolour, which could evoke contamination concerns. Concerning the material choice and the number of split lines, it is important for designers to remember the implications of the material and the product form. Regarding refurbished products, consumers prefer products that they can clean themselves and that smell, look and feel clean. If the product does not feel clean or shows signs of use, the perceived value and functionality decrease. It is, therefore, important to use materials that do not wear after being treated with cleaning products and that split lines can be cleaned easily.

7.4 Reflections on refurbishment

Finally, in the last section of this dissertation, I will reflect on some general assumptions, statements and questions about refurbishment. In my thesis, I argue that refurbishment is a key strategy to extend the lifetime of a product in the circular economy and is more sustainable than producing new products. While I still believe that to be true, one also has to pose the question of whether refurbishment is always more sustainable than buying new products. Under certain conditions, I believe it can be. However, there are several boundary conditions that can make refurbished products less environmentally beneficial. First, the manner in which a refurbished product was acquired and is refurbished is of great influence. A refurbished product that returns to the manufacturer after a full lifecycle of a few years is refurbished, and resold might have an environmentally beneficial effect because it substitutes a new product. However, if the refurbished product comes through product returns of online shopping and needs to be refurbished after only a short use time and then sent back, the environmental savings of buying a refurbished product are low. Currently, it is often the case that refurbished products did not have a full life cycle

but were returned because the customer ordered the product online, tried the product, did not like it and therefore sent it back; a behaviour that should be prevented by a good service and marketing design.

Furthermore, depending on how the refurbished product was originally designed and used, refurbishment can still have a substantial negative environmental impact. If the product was heavily used or the product was designed in a manner that a lot of components need to be changed during the refurbishment process, the negative environmental impact of refurbishment can be quite high. The general rule is: the more components were changed during the refurbishment process, the higher the environmental impact. I would therefore argue that to ensure that refurbishment is both circular and sustainable, products need to be designed to be durable and easy to bring back into an as-new state.

Another factor that can increase the negative environmental impact of refurbishment is the cleaning process. Especially for products that are used on the skin or even puncture the skin, a rigorous cleaning procedure is necessary to ensure safe use. Such rigorous cleaning procedures can however have a considerable environmental impact. For example, sterilizing refurbished medical products with steam or chemicals has a larger negative environmental impact compared to sterilizing products with ultraviolet radiation (Hong et al., 2018; Madanchi et al., 2017). Which sterilization method is used partly also depends on the product's use, design and material. Hence, to reduce the negative environmental impact the refurbishment process itself, the cleaning procedure needs to be considered when designing products.

Moreover, unaccounted rebound effects can also hinder the sustainability of refurbished products. Makov and Front Vivanco (2018) described that the environmental savings of reused products can be reduced by 29% because of rebound effects. Rebound effects describe the unintended negative consequences of buying a sustainable product. In the case of reused smartphones, two types of rebound effects can occur. First, the product fails to substitute the production of new products because it is technically insufficient to do so. Consequently, more products are produced and kept in the loop in total, which leads to a higher negative environmental impact. The second rebound effect is related to the consumer's buying behaviour. Due to the economic savings consumers make, they have greater spending power resulting in additional consumption that might not have happened otherwise (Makov & Font Vivanco, 2018). Both rebound effects are likely to happen for refurbished products. For example, consumers might not keep refurbished products as long as they would have if they had bought a new product because their 'mental book value' of the product is lower or because the refurbished product becomes technically insufficient faster (Okada, 2001). Another rebound effect could occur because consumers might spend the money, they saved by buying a refurbished product on another gadget. One could argue that a strategy for how

rebound effects could be decreased is to sell refurbished products with a lower price difference compared to new products. This way, consumers would have less economic savings to spend on additional gadgets and keep their refurbished products for longer. This can, however, only work if refurbished products are designed and marketed in a way that they retain their value to consumers. On the other hand, the financial benefits of refurbished products were one of the largest motivators in buying refurbished products. Decreasing the financial benefits might lower the overall desirability of refurbished products and lead to fewer people buying them.

Another consequence of keeping refurbished products at their highest value is that the risk of refurbished products cannibalising the market of new products increases. Market cannibalisation describes the phenomenon when a product (e.g., a refurbished product) steals the market of another (new) product, which has higher profit margins for the manufacturer (Atasu et al., 2010; Guide & Li, 2010). Refurbishment cannibalizing the market of new products might hence be undesirable to manufacturers because their profit margins would become lower. So far, it was said that consumers are willing to pay less for refurbished products (e.g., 15%) compared to new ones and that only a small fraction of consumers would actually buy refurbished products (Guide & Li, 2010). Hence, the risk of refurbished products cannibalising the market of new products was estimated to be low (Guide & Li, 2010). However, the risk of market cannibalisation increases when refurbished products are designed to retain their material as well as economic value and hence become a viable alternative to new products. Arguing from the framework of the circular economy, this does not seem undesirable. One could argue that in a future circular economy, refurbishment should be the norm rather than the exception and market cannibalisation, and hence small profit margins are inevitable. Nonetheless, there might always be a, perhaps smaller, market for new products because of two reasons. First, not all consumers will buy refurbished products. In fact, while some consumers were open to the idea of buying refurbished products in our studies, there are still consumer who would prefer new products. Perhaps due to cultural factors, contamination concerns and other individual differences, there will always be consumers who will avoid buying refurbished products as long as they are presented as being used. Second, not all products are reasonable to refurbish. Especially products that change due to high-paced innovation, refurbished models might not be able to keep up with new products due to fast-paced advancements in technology and, therefore, not be able to sustainably substitute new products.

Figure 28. The ID Buzz is the electric version of the iconic VW T1. While the T1 was a prime example of repairability and durability, electric cars have a lower environmental impact over the course of their whole life cycles (Shafique et al., 2022).

Additionally, innovation can also make some new products more sustainable than old ones. Fridges (bought in 2011) were shown to have an optimal product lifetime of 20 years. After that, buying a new and more energy-efficient fridge would be environmentally beneficial (Bakker et al., 2014). Old combustion engine vehicles (CEV) are another example. While some classic old CEV cars are a prime example of product longevity and repairability (e.g., the VW T2, T3 or T4 models), electric cars are argued to have a 44% lower environmental impact compared to a car with a petrol combustion engine (see Figure 28; Shafique et al., 2022). One could argue that replacing a used CEV car with an electric one may decrease the environmental impact (even though it remains questionable whether driving with an electric car can be called sustainable due to the high environmental impact of the production of electric cars). However, depending on the product, design strategies could change this. Instead of bringing refurbished products back into an acceptable state, they could be updated and enhanced. One example would be upgrading an old T2 with an add-on for Diesel motors that allow one to drive it on green Hydrogen. This would require that products are modular and parts to update the product are available. One example is modular telephones by Shift and Fairphone that can be updated to have a better camera (see Figure 29). Perhaps one of the shifts the circular economy needs is that innovation should focus more on redesigning used products than designing new ones.

Figure 29. The shift phone (left) and Fairphone are designed modular and can be updated to have new features over time.

Refurbishment might not be the most sustainable strategy for all consumer products. From an environmental perspective, keeping products for longer and reusing products as they are could be desirable because the refurbishment process leads to carbon emissions, material use and minimised amounts of waste. For some products, we already have a thriving second-hand market. For example, in the Netherlands, on the second-hand selling platform Marktplaats, more than 260.000 advertisements are placed every day, and it is quite normal to buy devices in thrift shops. Especially for cars, bicycles, tools, furniture, and many more product categories circulate in a second-hand state.

Furthermore, compared to many lifetime extension strategies, refurbishment can add value in three ways. First, it creates a futureproof business opportunity for manufacturers and third-party refurbishers. By taking back their products and refurbishing them, jobs are created, and companies can economically profit (McMahon et al., 2021). Second, consumers find it hard to determine the product state of used products and estimate their remaining product lifetime. For products that are a high financial investment for consumers, refurbishment is a more secure option compared to second-hand products because warranties are offered. Third, for many product categories refurbishment is more favourable option for consumers than second hand products because the refurbishment process disconnects the product from its previous user; thereby it decreases contamination concerns. While consumers' contamination concerns with refurbished products were still one of the most influential factors, they are much lower than contamination concerns about second-hand products. Decreasing the perceived contamination risk makes it even possible for personal care products to circulate in the circular economy and contribute to sustainable development.

Finally, one question arising from our work on contamination concerns is an ethical one. Some refurbished products, which do not display functional or aesthetic signs of wear and tear, will have the same characteristics as new products. Refurbished products are by definition also cleaned, which minimized the risk of contracting pathogens

through using them. The sheer fact that refurbished products are labelled as being used can evoke consumers' contamination concerns and reduce the product's value. Hence, one could argue, that selling refurbished products as new and withholding the fact that they have been used could be a solution to this. Consequently, contamination concerns would be eliminated and products kept at a higher value. While this could be considered ethical because the potential harm done by not telling consumers about the prior use is minimal and the environmental and economic gains are large, I find it dishonest. In my opinion, marketing, as well as product design, should be honest. Therefore, products should be sold with all relevant information about their history and characteristics and designed to show us what they are. One could argue that an alternative solution is to decrease consumers contamination concerns through a context change and over time. While it is normal for one to eat with used cutlery at a restaurant, many consumers would not buy second hand cutlery due to contamination concerns. In a future circular economy, reuse could become the new normal and consequently could become the most logical and obvious choice for consumers. New products in turn might have a negative association with being environmentally harmful or excessive in the future. This, however, does not only require that products are designed to be refurbished and refurbished well, but it also requires a cultural change in how we treat and perceived products.

7.5 Final conclusion

To conclude, refurbishment can reduce the environmental impact of our consumption by substituting new products. However, to become a viable alternative to new products, refurbished products must retain their value over time. This thesis concludes that they need to be initially designed to do so, as consumers prefer refurbished products that are refurbished to have an as-new look and functionality. If they do not, consumers perceive them to be a riskier choice and to be contaminated by their prior use, consequently lowering consumers' purchase intentions of refurbished products. For products that are already on the market and were not designed to be refurbished, we suggest following several steps during the refurbishment process to keep refurbished products at their highest value. Only if the product itself cannot be kept at its highest environmental and economic value through refurbishment, we suggest resorting to marketing strategies to enhance the consumer acceptance of refurbished products.

Epilogue

Areas in which resources are mined are associated with an increase in conflict, crime, and eruption of violence (e.g., Le Billon, 2007; Broad, 1980). A possible, and perhaps plausible, approach to decreasing conflict in those areas would be to reduce, or even to stop, mining raw materials. I believe, or at least hope, that transitioning to a circular economy can achieve a drastic reduction of the amount of raw materials we extract, ultimately leading to a more peaceful, prosperous and fair future for everyone. It can also help us to reduce the carbon footprint of our consumption. Preventing a climate disaster and transitioning to a sustainable and circular economy is arguably the largest challenge our generation faces. A transition at this scale is an all-hands-on-deck task in which we have to show solidarity towards all species on this planet. I hope that this thesis delivered a small contribution to the challenges that lie ahead of us.

7

CHAPTER 8

References

Abbey, J. D., Meloy, M. G., Blackburn, J., & Guide, V. D. R. (2015). Consumer markets for remanufactured and refurbished products. *California Management Review*, *57*(4), 26–42. https://doi.org/10.1525/cmr.2015.57.4.26

Abbey, J. D., Meloy, M. G., Guide, V. D. R., & Atalay, S. (2015). Remanufactured Products in Closed-Loop Supply Chains for Consumer Goods. *Production and Operations Management*, *24*(3), 488–503. https://doi.org/10.1111/poms.12238

Achterberg, E., Hinfelaar, J., & Bocken, N. M. P. (2016). The Value Hill Business Model Tool: Identifying gaps and opportunities in a circular network. *In Preparation*.

Ackerman, D. S., & Hu, J. (2017). Assuring me that it is as 'Good as New' just makes me think about how someone else used it. Examining consumer reaction toward marketer-provided information about secondhand goods. *Journal of Consumer Behaviour*, *16*(3), 233–241. https://doi.org/10.1002/cb.1631

ADEME. (2021). *La face cach 'ee du num 'erique*. Available at https://librairie.ademe.fr/cadic/2351/guide-pratique-face-cachee-numerique.pdf?modal=false

Agostini, L., Bigliardi, B., Filippelli, S., & Galati, F. (2021). Seller reputation , distribution and intention to purchase refurbished products ☆. *Journal of Cleaner Production*, *316*(September 2020), 128296. https://doi.org/10.1016/j.jclepro.2021.128296

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Alqahtani, A. Y., & Gupta, S. M. (2017). Warranty as a marketing strategy for remanufactured products. *Journal of Cleaner Production*, *161*, 1294–1307. https://doi.org/10.1016/J.JCLEPRO.2017.06.193

Atasu, A., Guide, V. D. R., & Van Wassenhove, L. N. (2010). So What If Remanufacturing Cannibalizes My New Product Sales? *California Management Review*, *52*(2), 56–76. https://doi.org/10.1525/cmr.2010.52.2.56

Atasu, A., Sarvary, M., & Van Wassenhove, L. N. (2008). Remanufacturing as a Marketing Strategy. *Management Science*, *54*(10), 1731–1746. https://doi.org/10.1287/mnsc.1080.0893

Aurisicchio, M., Eng, N. L., Nicolás, J. C. O., Childs, P. R. N., & Bracewell, R. H. (2011). *On the Function of Products*. 13.

Bakker, C., Wang, F., Huisman, J., & den Hollander, M. (2014). Products that go round: Exploring product life extension through design. *Journal of Cleaner Production*, *69*, 10–16. https://doi.org/10.1016/j.jclepro.2014.01.028

Barber, N. A., Bishop, M., & Gruen, T. (2014). Who pays more (or less) for pro-environmental consumer goods? Using the auction method to assess actual willingness-to-pay. *Journal of Environmental Psychology*, *40*, 218–227.

Baxter, W. L. (2017). Designing circular possessions: Exploring human-object relationships in the circular economy. *PQDT - UK & Ireland*, *March*, 1–193. http://hdl.handle.net/10044/1/52779

Baxter, W. L., Aurisicchio, M., & Childs, P. R. N. (2015). Materials, use and contaminated interaction. *Materials & Design*, *90*, 1218–1227. https://doi.org/10.1016/j.matdes.2015.04.019

Baxter, W. L., Aurisicchio, M., Mugge, R., & Childs, P. R. (2017). Positive and Negative Contamination in User Interactions. *Proceedings of the 21st International Conference on Engineering Design (ICED17)*, *8*(21.-25.08.2017), 509–518.

Bellezza, S., Ackerman, J. M., & Gino, F. (2017). "Be careless with that!" Availability of product upgrades increases cavalier behavior toward possessions. *Journal of Marketing Research*, *54*(5), 768–784.

Bittar, A. de V. (2018). Selling remanufactured products: Does consumer environmental consciousness matter? *Journal of Cleaner Production*, *181*, 527–536. https://doi.org/10.1016/j.jclepro.2018.01.255

Blijlevens, J., Gemser, G., & Mugge, R. (2012). The importance of being 'well-placed': The influence of context on perceived typicality and esthetic appraisal of product appearance. *Acta Psychologica*, *139*(1), 178–186. https://doi.org/10.1016/j.actpsy.2011.11.004

Bloch, P. H., Brunel, F. F., & Arnold, T. J. (2002). Individual differences in the centrality of visual product aesthetics: Concept and measurement. *Journal of Consumer Research*, *29*(4), 551–565. https://doi.org/10.1086/346250

Blomsma, F., & Tennant, M. (2020). Circular economy: Preserving materials or products? Introducing the Resource States framework. *Resources, Conservation and Recycling*, *156*(February), 104698. https://doi.org/10.1016/j.resconrec.2020.104698

Bocken, N., Niessen, L., & Tukker, A. (2022). Impacts of Consumption and the Role of Business. In *The Palgrave Handbook of Global Sustainability* (pp. 1–17). Springer International Publishing. https://doi.org/10.1007/978-3-030-38948-2_136-1

Boothroyd, G., & Alting, L. (1992). Design for Assembly and Disassembly. *CIRP Annals*, *41*(2), 625–636. https://doi.org/10.1016/S0007-8506(07)63249-1

Boyer, R. H. W., Hunka, A. D., Linder, M., Whalen, K. A., & Habibi, S. (2021). Product Labels for the Circular Economy: Are Customers Willing to Pay for Circular? *Sustainable Production and Consumption*, *27*, 61–71. https://doi.org/10.1016/j.spc.2020.10.010

Bridgens, B., Lilley, D., Smalley, G., & Balasundaram, K. (2015). Ageing gracefully to increase product longevity. *Product Lifetimes And The Environment*, *June*, 1–8.

Broad, W. J. (1980). Resource Wars: The Lure of South Africa: Are the Soviets on a drive to monopolize scarce mineral deposits? Should Reagan latch onto South Africa as a mineral ally? *Science*, *210*(4474), 1099–1100. https://doi.org/10.1126/science.210.4474.1099

Camacho-Otero, J., Boks, C., & Pettersen, I. (2018). Consumption in the Circular Economy: A Literature Review. *Sustainability*, *10*(8), 2758. https://doi.org/10.3390/su10082758

Chambon, M., Dalege, J., Elberse, J. E., & van Harreveld, F. (2021). A Psychological Network Approach to Attitudes and Preventive Behaviors During Pandemics: A COVID-19 Study in the United Kingdom and the Netherlands. *Social Psychological and Personality Science*, 194855062110024. https://doi.org/10.1177/19485506211002420

Chapman, J. (2009). Design for (emotional) durability. *Design Issues*, *25*(4), 29–35.

Chen, Y., Wang, J., & Jia, X. (2020). Refurbished or Remanufactured?—An Experimental Study on Consumer Choice Behavior. *Frontiers in Psychology*, *11*(May), 1–11. https://doi.org/10.3389/fpsyg.2020.00781

Clube, R. K. M., & Tennant, M. (2020). Exploring garment rental as a sustainable business model in the fashion industry: Does contamination impact the consumption experience? *Journal of Consumer Behaviour*, *19*(4), 359–370. https://doi.org/10.1002/cb.1817

Cox, J., Griffith, S., Giorgi, S., & King, G. (2013). Consumer understanding of product lifetimes. *Resources, Conservation and Recycling*, *79*, 21–29. https://doi.org/10.1016/j.resconrec.2013.05.003

Creusen, M. E. H., & Schoormans, J. P. L. (2005). The Different Roles of Product Appearance in Consumer Choice*. *Journal of Product Innovation Management*, *22*(1), 63–81. https://doi.org/10.1111/j.0737-6782.2005.00103.x

Creusen, M. E. H., Schoormans, J. P. L., & Veryzer, R. Wl. (2007). The Relationship Between Design Typicality, Novelty and Aesthetic Judgments. *European Advances in Consumer Research*, *34*, 405–408.

Crilly, N., Moultrie, J., & Clarkson, P. J. (2004). Seeing things: Consumer response to the visual domain in product design. *Design Studies*, *25*(6), 547–577. https://doi.org/10.1016/j.destud.2004.03.001

Dalege, J., Borsboom, D., van Harreveld, F., van den Berg, H., Conner, M., & van der Maas, H. L. J. (2016). Toward a formalized account of attitudes: The Causal Attitude Network (CAN) model. *Psychological Review*, *123*(1), 2–22. https://doi.org/10.1037/a0039802

De Fazio, F., Bakker, C., Flipsen, B., & Balkenende, R. (2021). The Disassembly Map: A new method to enhance design for product repairability. *Journal of Cleaner Production*, *320*, 128552. https://doi.org/10.1016/j.jclepro.2021.128552

Demirbilek, O., & Sener, B. (2003). Product design, semantics and emotional response. *Ergonomics*, *46*(13–14), 1346–1360. https://doi.org/10.1080/0014013031000161087 4

Deng, L., Babbitt, C. W., & Williams, E. D. (2011). Economic-balance hybrid LCA extended with uncertainty analysis: Case study of a laptop computer. *Journal of Cleaner Production*, *19*(11), 1198–1206. https://doi.org/10.1016/j.jclepro.2011.03.004

Desmet, P., & Hekkert, P. (2007). *Framework of Product Experience*. 10.

Dieter Rams: The Legendary Designer who Influenced Apple. (2018). https://edition.cnn.com/style/article/dieter-rams-film-exhibition-style-intl/index.html

Dion, K., Berscheid, E., & Walster, E. (1972). What is beautiful is good. *Journal of Personality and Social Psychology*, *24*(3), 285–290. https://doi.org/10.1037/h0033731

Dodds, W. B., Monroe, K. B., & Grewal, D. (1991). Effects of Price, Brand, and Store Information on Buyers' Product Evaluations. *Journal of Marketing Research*, *28*(3), 307. https://doi.org/10.2307/3172866

Ellen MacArthur Foundation. (2016). *Towards a circular economy: Business rationale for an accelerated transition. Retrieved from*. https://www.ellenmacarthurfoundation. org/publications/towards-a-circular-economy-business-rationale-for-an-accelerat ed-transition

Engel, J. F., Kollat, D. T., Blackwell, R. D., Kollat, D., Blackwell, R., & Engel, J. (1968). A model of consumer motivation and behavior. *Research in Consumer Behavior, Holt, Rinehart and Winston, Inc., New York, NY*, 3–20.

EPRS. (2017). *European Parliament Research Service (EPRS). The Ecodesign Directive: European Implementation Assessment; Ex-Post Evaluation Unit of the Directorate for Impact Assessment and European Added Value: Brussels, Belgium, 2017; ISBN 9789284622252.*

Esmaeilian, B., Onnipalayam Saminathan, P., Cade, W., & Behdad, S. (2021). Marketing strategies for refurbished products: Survey-based insights for probabilistic selling and technology level. *Resources, Conservation and Recycling*, *167*(January), 105401. https://doi.org/10.1016/j.resconrec.2021.105401

European Commission. (2020). Critical raw materials resilience: Charting a path towards greater security and sustainability. *Brussels*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0474

Eurostat. (2019). *Waste Electrical and Electronic Equipment (WEEE) by Waste Management on Eurostats Website. Available online:* Available online: https://ec.europa.eu/eurostat/cache/metadata/en/env_waselee_esms.htm

Eurostat. (2021, February). *Greenhouse gas emission statistics—Carbon footprints*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics_-_carbon_footprints

Flood Heaton, R., & McDonagh, D. (2017). Can Timelessness through Prototypicality Support Sustainability? A Strategy for Product Designers. *The Design Journal*, *20*(sup1), S110–S121. https://doi.org/10.1080/14606925.2017.1352671

Folkertsma, L., Mugge, R., & Haagsman, E. (2017). *Enhancing the user relation with refurbished baby equipment by increasing the emotional added value* [Master Thesis]. Delft University of Technology.

Fort-Rioche, L., & Ackermann, C. L. (2013). Consumer innovativeness, perceived innovation and attitude towards 'neo-retro'-product design. *European Journal of Innovation Management*, *16*(4), 495–516. https://doi.org/10.1108/EJIM-02-2013-0013

Francis, J. J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M. P., & Grimshaw, J. M. (2010). What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychology & Health*, *25*(10), 1229–1245. https://doi.org/10.1080/08870440903194015

Fransson, N., & Gärling, T. (1999). Environmental concern: Conceptual definitions, measurement methods, and research findings. *Journal of Environmental Psychology*, *19*(4), 369–382.

Fruchterman, T. M., & Reingold, E. M. (1991). Graph drawing by force-directed placement. *Software: Practice and Experience*, *21*(11), 1129–1164.

Gaur, J., Mani, V., Banerjee, P., Amini, M., & Gupta, R. (2019). Towards building circular economy: A cross-cultural study of consumers' purchase intentions for reconstructed products. *Management Decision*, *57*(4), 886–903. https://doi.org/10.1108/MD-07-2018-0728

Geißdörfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Govindan, K., Jiménez-Parra, B., Rubio, S., & Vicente-Molina, M.-A. (2019). Marketing issues for remanufactured products. *Journal of Cleaner Production*, *227*, 890–899. https://doi.org/10.1016/j.jclepro.2019.03.305

Grewal, D., Krishnan, R., Baker, J., & Borin, N. (1998). The effect of store name, brand name and price discounts on consumers' evaluations and purchase intentions. *Journal of Retailing*, *74*(3), 331–352.

Guest, G., Bunce, A., & Johnson, L. (2006). *How Many Interviews Are Enough? 18*, 24. https://doi.org/10.1177/1525822X05279903

Guide, V. D. R., & Li, J. (2010). The potential for cannibalization of new products sales by remanufactured products. *Decision Sciences*, *41*(3), 547–572. https://doi.org/10.1111/j.1540-5915.2010.00280.x

Hagaman, A., & Wutich, A. (2017). How Many Interviews Are Enough to Identify Metathemes in Multisited and Cross-cultural Research? Another Perspective on Guest, Bunce, and Johnson's (2006) Landmark Study. *Field Methods*, 19. https://doi.org/10.1177/1525822X16640447

Haines-Gadd, M., Chapman, J., Lloyd, P., Mason, J., & Aliakseyeu, D. (2018). Emotional Durability Design Nine—A Tool for Product Longevity. *Sustainability*, *10*(6), 1948. https://doi.org/10.3390/su10061948

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (1998). Multivariate data analysis. Uppersaddle River. *Multivariate Data Analysis (5th Ed) Upper Saddle River*, *5*(3), 207–219.

Hamzaoui Essoussi, L., & Linton, J. D. (2010). New or recycled products: How much are consumers willing to pay? *Journal of Consumer Marketing*, *27*(5), 458–468. https://doi.org/10.1108/07363761011063358

Hao, Y., Liu, H., Chen, H., Sha, Y., Ji, H., & Fan, J. (2019). What affect consumers' willingness to pay for green packaging? Evidence from China. *Resources, Conservation and Recycling*, *141*(October 2018), 21–29. https://doi.org/10.1016/j.resconrec.2018.10.001

Harms, R., & Linton, J. D. (2016). Willingness to Pay for Eco-Certified Refurbished Products: The Effects of Environmental Attitudes and Knowledge: WTP for Eco-certified Refurbished Products. *Journal of Industrial Ecology*, *20*(4), 893–904. https://doi.org/10.1111/jiec.12301

Haslbeck, J. M. B. (2022). Estimating group differences in network models using moderation analysis. *Behavior Research Methods*, *54*(1), 522–540. https://doi.org/10.3758/s13428-021-01637-y

Haslbeck, J. M. B., Borsboom, D., & Waldorp, L. J. (2021). Moderated Network Models. *Multivariate Behavioral Research*, *56*(2), 256–287. https://doi.org/10.1080/00273171.2019.1677207

Haslbeck, J. M. B., & Waldorp, L. J. (2020). mgm: Estimating Time-Varying Mixed Graphical Models in High-Dimensional Data. *ArXiv:1510.06871 [Stat]*. http://arxiv.org/abs/1510.06871

Hassenzahl, M. (2004). The Interplay of Beauty, Goodness, and Usability in Interactive Products. *Human-Computer Interaction*, *19*(4), 319–349. https://doi.org/10.1207/s15327051hci1904_2

Hastie, T., Tibshirani, R., & Wainwright, M. (2015). Statistical learning with sparsity. *Monographs on Statistics and Applied Probability*, *143*, 143.

Hatcher, G. D., Ijomah, W. L., & Windmill, J. F. C. (2011). Design for remanufacture: A literature review and future research needs. *Journal of Cleaner Production*, *19*(17–18), 2004–2014. https://doi.org/10.1016/j.jclepro.2011.06.019

Hazée, S., Van Vaerenbergh, Y., Delcourt, C., & Warlop, L. (2019). Sharing Goods? Yuck, No! An Investigation of Consumers' Contamination Concerns About Access-Based Services. *Journal of Service Research*, *22*(3), 256–271. https://doi.org/10.1177/1094670519838622

Hazelwood, D. A., & Pecht, M. G. (2021). Life Extension of Electronic Products: A Case Study of Smartphones. *IEEE Access*, *9*, 144726–144739.

Hazen, B. T., Overstreet, R. E., Jones-Farmer, L. A., & Field, H. S. (2012). The role of ambiguity tolerance in consumer perception of remanufactured products. *International Journal of Production Economics*, *135*(2), 781–790. https://doi.org/10.1016/j.ijpe.2011.10.011

Hejmadi, A., Rozin, P., & Siegal, M. (2004). Once in contact, always in contact: Contagious essence and conceptions of purification in American and Hindu Indian children. *Developmental Psychology*, *40*(4), 467.

Hekkert, P., Snelders, D., & Wieringen, P. C. W. (2003). 'Most advanced, yet acceptable': Typicality and novelty as joint predictors of aesthetic preference in industrial design. *British Journal of Psychology*, *94*(1), 111–124. https://doi.org/10.1348/000712603762842147

Holmström, S., & Böhlin, H. (2017). *Towards a circular economy: A qualitative study on how to communicate refurbished smartphones in the Swedish market*.

Hong, J., Zhan, S., Yu, Z., Hong, J., & Qi, C. (2018). Life-cycle environmental and economic assessment of medical waste treatment. *Journal of Cleaner Production*, *174*, 65–73.

Huang, J. Y., Ackerman, J. M., & Newman, G. E. (2017). Catching (Up with) Magical Contagion: A Review of Contagion Effects in Consumer Contexts. *Journal of the Association for Consumer Research*, *2*(4), 430–443. https://doi.org/10.1086/693533

Huber, J. (2005). *Conjoint analysis: How we got here and where we are (An Update)*. *98382*, 360.

Hunka, A. D., Linder, M., & Habibi, S. (2020). *Determinants of consumer demand for circular economy products. A case for reuse and remanufacturing for sustainable development*. *August*, 1–16. https://doi.org/10.1002/bse.2636

Hunka, A. D., Linder, M., & Habibi, S. (2021). Determinants of consumer demand for circular economy products. A case for reuse and remanufacturing for sustainable development. *Business Strategy and the Environment*, *30*(1), 535–550. https://doi.org/10.1002/bse.2636

Ihemezie, E. J., Ukwuaba, I. C., & Nnaji, A. P. (2018). Impact of 'Green' Product Label Standards on Consumer Behaviour: A Systematic Review Analysis. *International Journal of Academic Research in Business and Social Sciences*, *8*(9). https://doi.org/10.6007/ijarbss/v8-i9/4647

Ijomah, W. L., McMahon, C. A., Hammond, G. P., & Newman, S. T. (2007). Development of design for remanufacturing guidelines to support sustainable manufacturing. *Robotics and Computer-Integrated Manufacturing*, *23*(6), 712–719. https://doi.org/10.1016/j.rcim.2007.02.017

Ingold, K., & Balsiger, J. (2015). Sustainability principles put into practice: Case studies of network analysis in Swiss climate change adaptation. *Regional Environmental Change*, *15*(3), 529–538.

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

Isvoranu, A.-M., & Epskamp, S. (2021). Which estimation method to choose in network psychometrics? Deriving guidelines for applied researchers. *Psychological Methods*.

Jiménez-Parra, B., Rubio, S., & Vicente-Molina, M.-A. (2014). Key drivers in the behavior of potential consumers of remanufactured products: A study on laptops in Spain. *Journal of Cleaner Production*, *85*, 488–496. https://doi.org/10.1016/j.jclepro.2014.05.047

Jin, J., Zhao, Q., & Santibanez-Gonzalez, E. D. R. (2020). How chinese consumers' intentions for purchasing eco-labeled products are influenced by psychological factors. *International Journal of Environmental Research and Public Health*, *17*(1). https://doi.org/10.3390/ijerph17010265

Jockin, B. G. W. (2015). *The customer acceptance of refurbished smartphones*.

Kamleitner, B., Thürridl, C., & Martin, B. A. S. (2019). A Cinderella Story: How Past Identity Salience Boosts Demand for Repurposed Products. *Journal of Marketing*, *83*(6), 76–92. https://doi.org/10.1177/0022242919872156

Khor, K. S., & Hazen, B. T. (2017). Remanufactured products purchase intentions and behaviour: Evidence from Malaysia. *International Journal of Production Research*, *55*(8), 2149–2162. https://doi.org/10.1080/00207543.2016.1194534

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence From the European Union (EU). *Ecological Economics*, *150*(April), 264–272. https://doi.org/10.1016/j.ecolecon.2018.04.028

Krippendorff, K. (1989). *Departmental Papers (ASC) Product Semantics: A Triangulation and Four Design Theories A Triangulation and Four Design Theories*.

Kumar, N., & Mohan, D. (2021). Consumer Perception and Purchase Intention Towards Refurbished Smart Phones: A Circular Consumption Perspective. In *Global Challenges and Strategic Disruptors in Asian Businesses and Economies* (pp. 270–284). IGI Global.

Kwak, M. J., Hong, Y. S., & Cho, N. W. (2009). Eco-architecture analysis for end-of-life decision making. *International Journal of Production Research*, *47*(22), 6233–6259. https://doi.org/10.1080/00207540802175329

Le Billon, P. (2007). Geographies of War: Perspectives on 'Resource Wars': Geographies of war: perspectives on 'resource wars'. *Geography Compass*, *1*(2), 163–182. https://doi.org/10.1111/j.1749-8198.2007.00010.x

Lichtenstein, D. R., Netemeyer, R. G., & Burton, S. (1990). Distinguishing Coupon Proneness from Value Consciousness: An Acquisition-Transaction Utility Theory Perspective. *Journal of Marketing*, *54*(3), 54. https://doi.org/10.2307/1251816

Liu, W., Sang, J., Chen, L., Tian, J., Zhang, H., & Olvera Palma, G. (2015). Life cycle assessment of lead-acid batteries used in electric bicycles in China. *Journal of Cleaner Production*, *108*, 1149–1156. https://doi.org/10.1016/j.jclepro.2015.07.026

Lobos, A. (2014). Timelessness in Sustainable Product Design. *9th International Conference on Design and Emotion*, 169–176.

Losee, J. E., Webster, G. D., & McCarty, C. (2022). Social network connections and increased preparation intentions for a disaster. *Journal of Environmental Psychology*, *79*, 101726. https://doi.org/10.1016/j.jenvp.2021.101726

Madanchi, N., Thiede, S., & Herrmann, C. (2017). Functional and environmental evaluation of alternative disinfection methods for cutting fluids. Procedia Cirp, 61, 558–563.

Magnier, L., & Gil-Pérez, I. (2021). *Reviving the milk man: Consumers' evaluations of circular reusable packaging offers*. University of Limerick. https://doi.org/10.31880/10344/10227

Mahmoodi, H., & Heydari, J. (2021). Consumers' preferences in purchasing recycled/refurbished products: An empirical investigation. *International Journal of Services and Operations Management*, *38*(4), 594–609. https://doi.org/10.1504/IJSOM.2021.114249

Makov, T., & Font Vivanco, D. (2018). Does the Circular Economy Grow the Pie? The Case of Rebound Effects From Smartphone Reuse. *Frontiers in Energy Research*, *6*, 39. https://doi.org/10.3389/fenrg.2018.00039

Mauss, M. (2005). *A general theory of magic*. Routledge.

McMahon, K., Ryan-Fogarty, Y., & Fitzpatrick, C. (2021). Estimating job creation potential of compliant WEEE pre-treatment in Ireland. *Resources, Conservation and Recycling*, *166*, 105230. https://doi.org/10.1016/j.resconrec.2020.105230

Meehan, J. S., Duffy, A. H. B., & Whitfield, R. I. (2007). Supporting 'design for re-use' with modular design. *Concurrent Engineering Research and Applications*, *15*(2), 141–155. https://doi.org/10.1177/1063293X07079319

Meng, M. D., & Leary, R. B. (2021). It might be ethical, but I won't buy it: Perceived contamination of, and disgust towards, clothing made from recycled plastic bottles. *Psychology and Marketing*, *38*(2), 298–312. https://doi.org/10.1002/mar.21323

Miao, X., Magnier, L. B. M., & Mugge, R. (2021). Developing reusable packaging for FMCG: Consumers' perceptions of benefits and risks of refillable and returnable packaging systems. *Proceedings of EcoDesign 2021 International Symposium*.

Michaud, C., & Llerena, D. (2010). Green consumer behaviour: An experimental analysis of willingness to pay for remanufactured products. *Business Strategy and the Environment*, n/a-n/a. https://doi.org/10.1002/bse.703

Mugge, R. (2011). *The Effect of a Business-like Personality on the Perceived Performance Quality of Products*. 10.

Mugge, R., Dahl, D. W., & Schoormans, J. P. L. (2018). "What You See, Is What You Get?" Guidelines for Influencing Consumers' Perceptions of Consumer Durables through Product Appearance: WHAT YOU SEE, IS WHAT YOU GET? *Journal of Product Innovation Management*, *35*(3), 309–329. https://doi.org/10.1111/jpim.12403

Mugge, R., de Jong, W., Person, O., & Hultink, E. J. (2018). 'If It Ain't Broke, Don't Explain It': The Influence of Visual and Verbal Information about Prior Use on Consumers' Evaluations of Refurbished Electronics. *Design Journal*, *21*(4), 499–520. https://doi.org/10.1080/14606925.2018.1472856

Mugge, R., Jockin, B., & Bocken, N. (2017a). How to sell refurbished smartphones? An investigation of different customer groups and appropriate incentives. *Journal of Cleaner Production*, *147*, 284–296. https://doi.org/10.1016/j.jclepro.2017.01.111

Mugge, R., Jockin, B., & Bocken, N. (2017b). How to sell refurbished smartphones? An investigation of different customer groups and appropriate incentives. *Journal of Cleaner Production*, *147*, 284–296. https://doi.org/10.1016/j.jclepro.2017.01.111

Mugge, R., Safari, I., & Balkenende, R. (2017). Is there a market for refurbished toothbrushes? An exploratory study on consumers' acceptance of refurbishment for different product categories. *Product Lifetimes and the Environment (Plate)*, 293–297. https://doi.org/10.3233/978-1-61499-820-4-293

Mugge, R., & Schoormans, J. P. L. (2012). Product design and apparent usability. The influence of novelty in product appearance. *Applied Ergonomics*, *43*(6), 1081–1088. https://doi.org/10.1016/j.apergo.2012.03.009

Mugge, R., Schoormans, J. P. L., & Schifferstein, H. N. J. (2005). Design Strategies to Postpone Consumers' Product Replacement: The Value of a Strong Person-Product Relationship. *The Design Journal*, *8*(2), 38–48. https://doi.org/10.2752/146069205789331637

Mugge, R., Schoormans, J. P., & Schifferstein, H. N. (2008). Product attachment: Design strategies to stimulate the emotional bonding to products. In *Product experience* (pp. 425–440). Elsevier.

Nadolni, F. (2019). Alltag formen. *Bauhaus-Moderne in Der DDR*.

Nasiri, M. S. (2021). Actual Consumers ' Response to Purchase Refurbished Smartphones: Exploring Perceived Value from Product Reviews in Online Retailing. *Journal of Retailing and Consumer Services*, *62*(December 2020), 102652. https://doi.org/10.1016/j.jretconser.2021.102652

Newman, M. (2018). *Networks*. Oxford university press.

Nußholz, J. L. K. (2018). A circular business model mapping tool for creating value from prolonged product lifetime and closed material loops. *Journal of Cleaner Production*, *197*, 185–194. https://doi.org/10.1016/j.jclepro.2018.06.112

Okada, E. M. (2001). Trade-ins, mental accounting, and product replacement decisions. *Journal of Consumer Research*, *27*(4), 433–446.

Olatunji, B. O., Cisler, J. M., Deacon, B. J., Connolly, K., & Lohr, J. M. (2007). The Disgust Propensity and Sensitivity Scale-Revised: Psychometric properties and specificity in relation to anxiety disorder symptoms. *Journal of Anxiety Disorders*, *21*(7), 918–930. https://doi.org/10.1016/j.janxdis.2006.12.005

Olson, E. L. (2013). It's not easy being green: The effects of attribute tradeoffs on green product preference and choice. *Journal of the Academy of Marketing Science*, *41*(2), 171–184. https://doi.org/10.1007/s11747-012-0305-6

O'Reilly, L., Rucker, M., Hughes, R., Gorang, M., & Hand, S. (1984). The relationship of psychological and situational variables to usage of a second-order marketing system. *Journal of the Academy of Marketing Science*, *12*(3), 53–76. https://doi.org/10.1007/BF02739319

Orme, B. (2010). Interpreting the results of conjoint analysis. *Getting Started with Conjoint Analyis: Strategies for Product Design and Pricing Research*, *2*, 77–88.

Östlin, J., Sundin, E., & Björkman, M. (2009a). Linköping University Post Print Product Lifecycle Implications for Remanufacturing Strategies Product Life-cycle Implications for Remanufacturing Strategies. *Journal of Cleaner Production*, *11*(17), 999–1009.

Östlin, J., Sundin, E., & Björkman, M. (2009b). Product life-cycle implications for remanufacturing strategies. *Journal of Cleaner Production*, *17*(11), 999–1009. https://doi.org/10.1016/j.jclepro.2009.02.021

Page, C., & Herr, P. M. (2002). An Investigation of the Processes by Which Product Design and Brand Strength Interact to Determine Initial Affect and Quality Judgments. *Journal of Consumer Psychology*, *12*(2), 133–147. https://doi.org/10.1207/S15327663JCP1202_06

Pang, G., Casalin, F., Papagiannidis, S., Muyldermans, L., & Tse, Y. K. (2015). Price determinants for remanufactured electronic products: A case study on eBay UK. *International Journal of Production Research*, *53*(2), 572–589. https://doi.org/10.1080/00207543.2014.958594

Parsons, G. (2016). *The Philosophy of Design*. Polity Press.

Patton, M. Q. (2002). Qualitative research and evaluation methods. Thousand Oaks. *Cal.: Sage Publications*, *4*.

Peters, J., Janzing, D., & Schölkopf, B. (2017). *Elements of causal inference: Foundations and learning algorithms* (Vol. 88). MIT Press. https://www.tandfonline.com/doi/full/10.1080/00949655.2018.1505197

Philips. (2021). *Philips Lumea Prestige*. https://www.philips.nl/c-m-pe/ontharing/lumea-ipl?origin=7_700000001545147_71700000020903790_58700002243489759_43700035125598039&gclid=CjwKCAiAnO2MBhApEiwA8q0HYbgK6QNbop9V-TiyXHm99G6OwySzX4HaGSV7WilseNlOoacKMaHwBoC5y8QAvD_BwE&gclsrc=aw.ds

Pigosso, D. C. A., Zanette, E. T., Filho, A. G., Ometto, A. R., & Rozenfeld, H. (2010). Ecodesign methods focused on remanufacturing. *Journal of Cleaner Production*, *18*(1), 21–31. https://doi.org/10.1016/j.jclepro.2009.09.005

Potting, J., Hanemaaijer, A., Delahaye, R., Hoekstra, R., Ganzevles, J., & Lijzen, J. (2018). *Circular economy: What we want to know and can measure* (p. 92). Planbureau voor de leefomgeving. https://www.pbl.nl/sites/default/files/downloads/pbl-2018-circular-economy-what-we-want-to-know-and-can-measure-3217.pdf

Rams, D. (2015). *Less and More. The Design Ethos of Dieter Rams*. Gestalten Verlag.

Refurbed. (2022). *Refurbed. Refurbished electronics with at least 12 months' warranty. Save up to 40%.* https://www.refurbed.ie/?redirect-from=www.refurbed.co.uk

Rokka, J., & Uusitalo, L. (2008). Preference for green packaging in consumer product choices – Do consumers care? *International Journal of Consumer Studies*, *32*(5), 516–525. https://doi.org/10.1111/j.1470-6431.2008.00710.x

Rosch, E. (1975). Cognitive reference points. *Cognitive Psychology*, *7*(4), 532–547.

Rozin, P., Haddad, B., Nemerof, C., & Slovic, P. (2015). Psychological aspects of the rejection of recycled water: Contamination, purification and disgust. *Judgment and Decision Making*, *10*(1), 50–63.

Rozin, P., & Nemeroff, C. (1990). *The laws of sympathetic magic: A psychological analysis of similarity and contagion.*

Sabbaghi, M., & Behdad, S. (2018). Consumer decisions to repair mobile phones and manufacturer pricing policies: The concept of value leakage. *Resources, Conservation and Recycling*, *133*, 101–111. https://doi.org/10.1016/j.resconrec.2018.01.015

Schädlich, C. (1984). The Bauhaus and the Continuation of its Tradition in the GDR. *Journal of Popular Culture*, *18*(3), 175.

Schultz, P. W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of Environmental Psychology*, *21*(4), 327–339.

Shafique, M., Azam, A., Rafiq, M., & Luo, X. (2022). Life cycle assessment of electric vehicles and internal combustion engine vehicles: A case study of Hong Kong. *Research in Transportation Economics*, *91*, 101112. https://doi.org/10.1016/j.retrec.2021.101112

Sharifi, Z., & Shokouhyar, S. (2021). Promoting consumer's attitude toward refurbished mobile phones: A social media analytics approach. *Resources, Conservation and Recycling*, *167*(June 2020). https://doi.org/10.1016/j.resconrec.2021.105398

Sharma, V., Garg, S. K., & Sharma, P. B. (2016). Identification of major drivers and roadblocks for remanufacturing in India. *Journal of Cleaner Production*, *112*, 1882–1892. https://doi.org/10.1016/j.jclepro.2014.11.082

Sheeran, P., & Webb, T. L. (2016). The intention–behavior gap. *Social and Personality Psychology Compass*, *10*(9), 503–518.

Shen, L., Wilkoff, S., Shen, L., & Wilkoff, S. (2020). *Cleanliness is Next to Income: The Impact of COVID-19 on Short-Term Rentals*.

Singhal, D., Tripathy, S., & Jena, S. K. (2019). Acceptance of remanufactured products in the circular economy: An empirical study in India. *Management Decision*, *57*(4), 953–970. https://doi.org/10.1108/MD-06-2018-0686

Snelders, D., Mugge, R., & Huinink, M. (2014). *Using Social Distinctions in Taste for Analysing Design Styles across Product Categories*. *8*(3), 12.

Subramanian, R., & Subramanyam, R. (2012). Key Factors in the Market for Remanufactured Products. *Manufacturing & Service Operations Management*, *14*(2), 315–326. https://doi.org/10.1287/msom.1110.0368

Sun, J. J., Bellezza, S., & Paharia, N. (2021). Buy Less, Buy Luxury: Understanding and Overcoming Product Durability Neglect for Sustainable Consumption. *Journal of Marketing*, *85*(3), 28–43. https://doi.org/10.1177/0022242921993172

Tereyağoğlu, N. (2016). Market behavior towards remanufactured products. In *Environmentally responsible supply chains* (pp. 19–28). Springer.

Thomas J. L. Van Rompay & Geke D. S. Ludden. (2015). Types of Embodiment in Design: The Embodied Foundations of Meaning and Affect in Product Design. *International Journal of Design*, *9*(1), 1–11. www.ijdesign.org

Toohey, K. S., Sottos, N. R., Lewis, J. A., Moore, J. S., & White, S. R. (2007). Self-healing materials with microvascular networks. *Nature Materials*, *6*(8), 581–585. https://doi.org/10.1038/nmat1934

Tunn, V., Bocken, N., & Schoormans, J. P. L. (2021). Consumer adoption of access-based product- service systems: The influence of duration of use and type of product. *Business Strategy and the Environment*, *January*, 1–23.

Tunn, V. S. C., & Ackermann, L. (2020, May). Comparing consumers' product care in access and ownership models. *Proceedings of the Design Society: DESIGN Conference (Vol. 1, Pp. 2167-2176). Cambridge University Press.*

UNEP. (2015). *A rapid Response Assessment. Waste Crime. Gaps in Meeting the Global Waste Challenge*.

van den Berge, R., Magnier, L., & Mugge, R. (2021a). *A poorly educated guess: Consumers' lifetime estimations, attitudes towards repairability,and a product lifetime label*. University of Limerick. https://doi.org/10.31880/10344/10181

van den Berge, R., Magnier, L., & Mugge, R. (2021b). Too good to go? Consumers' replacement behaviour and potential strategies for stimulating product retention. *Current Opinion in Psychology*, *39*, 66–71. https://doi.org/10.1016/j.copsyc.2020.07.014

van Overveld, M., Jong, P. J. de, & Peters, M. L. (2010). The Disgust Propensity and Sensitivity Scale—Revised: Its predictive value for avoidance behavior. *Personality and Individual Differences*, *49*(7), 706–711. https://doi.org/10.1016/j.paid.2010.06.008

Van Weelden, E., Mugge, R., & Bakker, C. (2016). Paving the way towards circular consumption: Exploring consumer acceptance of refurbished mobile phones in the Dutch market. *Journal of Cleaner Production*, *113*, 743–754. https://doi.org/10.1016/j.jclepro.2015.11.065

Venkatesh, V., Morris, M. G., & Ackerman, P. L. (2000). A Longitudinal Field Investigation of Gender Differences in Individual Technology Adoption Decision-Making Processes. *Organizational Behavior and Human Decision Processes*, *83*(1), 33–60. https://doi.org/10.1006/obhd.2000.2896

Verschoor, M., Albers, C., Poortinga, W., Böhm, G., & Steg, L. (2020). Exploring relationships between climate change beliefs and energy preferences: A network analysis of the European Social Survey. *Journal of Environmental Psychology*, *70*, 101435. https://doi.org/10.1016/j.jenvp.2020.101435

Veryzer, Jr., R. W., & Hutchinson, J. W. (1998). The Influence of Unity and Prototypicality on Aesthetic Responses to New Product Designs. *Journal of Consumer Research*, *24*(4), 374–385. https://doi.org/10.1086/209516

Wahjudi, D., Gan, S., Tanoto, Y. Y., & Winata, J. (2020). *Drivers and barriers of consumer purchase intention of remanufactured mobile phones: A study on Indonesian consumers*. 14.

Wallner, T. S., Magnier, L., & Mugge, R. (2022). Do consumers mind contamination by previous users? A choice-based conjoint analysis to explore strategies that improve consumers' choice for refurbished products. *Resources, Conservation and Recycling*, *177*, 105998. https://doi.org/10.1016/j.resconrec.2021.105998

Wallner, T. S., Magnier, L., & Mugge, R. (2020). An Exploration of the Value of Timeless Design Styles for the Consumer Acceptance of Refurbished Products. *Sustainability*, *12*(3), 1213. https://doi.org/10.3390/su12031213

Wallner, T. S., Magnier, L., & Mugge, R. (2019). Can refurbished products feel like antiques? The role of the neo- retro design style on consumers ' evaluation of refurbished products. In M. Nissen, Nils F.; Jaeger-Erben (Ed.), *3rd PLATE Conference* (Issues 18-20 September, pp. 825–834). TU Berlin. https://depositonce.tu-berlin.de/handle/11303/10291

Wallner, T. S., Magnier, L., & Mugge, R. (2021, May 28). Choosing new or refurbished? The influence of the product'sdurability and attractiveness, contamination risk and consumers'environmental concern on purchase intentions of refurbished and new products. *4th PLATE 2021*. Product Lifetimes and the Environment (PLATE), Limerick, Ireland. https://doi.org/10.31880/10344/10172

Wallner, T. S., Snel, S., Magnier, L., & Mugge, R. (2022a). *Contaminated by its prior use: An Interview study on strategies to design and market refurbished personal care products*.

Wallner, T. S., Snel, S., Magnier, L., & Mugge, R. (2022b). Contaminated by Its Prior Use: Strategies to Design and Market Refurbished Personal Care Products. *Circular Economy and Sustainability*. https://doi.org/10.1007/s43615-022-00197-3

Wang, Y., & Hazen, B. T. (2016). Consumer product knowledge and intention to purchase remanufactured products. *International Journal of Production Economics*, *181*, 460–469. https://doi.org/10.1016/j.ijpe.2015.08.031

Wang, Y., Wiegerinck, V., Krikke, H., & Zhang, H. (2013). Understanding the purchase intention towards remanufactured product in closed-loop supply chains: An empirical study in China. *International Journal of Physical Distribution & Logistics Management*, *43*(10), 866–888. https://doi.org/10.1108/IJPDLM-01-2013-0011

Wool, R. P. (2008). Self-healing materials: A review. *Soft Matter*, *4*(3), 400–418. https://doi.org/10.1039/b711716g

Zacho, K. O., Mosgaard, M., & Riisgaard, H. (2018). Capturing uncaptured values & #x2014; A Danish case study on municipal preparation for reuse and recycling of waste. *Resources, Conservation and Recycling*, *136*(October 2017), 297–305. https://doi.org/10.1016/j.resconrec.2018.04.031

Zumegen, A. (2020). *Environmental Impacts of a local circular economy business model. A carbon and Water footprint analysis for smartphone refurbishment*. Jyväskylä University.

Zwicker, M. V., Nohlen, H. U., Dalege, J., Gruter, G.-J. M., & van Harreveld, F. (2020). Applying an attitude network approach to consumer behaviour towards plastic. *Journal of Environmental Psychology*, *69*, 101433. https://doi.org/10.1016/j.jenvp.2020.101433

CHAPTER 9

Appendices

Appendices chapter 2

Appendix A1. Differences between refurbished neo-retro products and refurbished simplistic products.

Product	MEAN Neo-retro	MEAN Simplistic	MEAN Prototypical
1. Neo-retro coffee maker	6.47	2.67	4.33
2. Neo-retro coffee maker	6.13	2.67	4.20
3. Simplistic coffee maker	2.33	6.40	3.53
4. Simplistic coffee maker	3.13	5.80	2.40
5. Prototypical coffee maker	4.0	3.93	4.60
6. Prototypical coffee maker	2.67	3.35	4.40
7. Neo-retro headphone	6.0	3.14	3.86
8. Neo-retro headphone	5.93	1.64	2.93
9. Simplistic headphone	2.86	5.71	3.14
10. Simplistic headphone	2.07	6.21	3.14
11. Prototypical headphone	3.29	4.79	5.57
12. Prototypical headphone	2.79	3.64	4.14
13. Neo-retro radio	6.15	4.0	5.38
14. Neo-retro radio	5.62	4.00	5.38
15. Simplistic radio	2.64	6.43	3.5
16. Simplistic radio	3.67	5.40	4.20
17. Prototypical radio	3.23	2.62	5.23
18. Prototypical radio	3.86	3.36	4.86

Appendix A2 - Interview guide

Refurbished products: I would like to start the interview with a couple of questions about re-used objects. In particular (opgeknapte) products that are recollected by their first used, subsequently tested and restored into an acceptable state before they are resold (Pigosso et al., 2010)

	Have you ever bought a refurbished product? If yes: Which product, what were your experiences with the product? If no: What kind of product would you buy in a refurbished state?
Association	What is your association with refurbished products?
Showing of Stimuli & Choice	Which of these refurbished products is most appealing to you? Why would you choose that product?
Associations	What are your *associations* with this product? **(This question will be repeated with products of all design styles)**
Design of the product	What do you think about the design of the product? **(Also repeated for all three design styles)**
Emotions (also disgust)	What do you feel about using this product? What would you feel if you think about touching this product?
What do you think about the quality of the product?	What do you think about the quality of this product?
Most important factors	Which factor is most important to you to consider purchasing a refurbished product?

Antiques: First, I would like to start with some questions about antique products.

Participants definition of antiques	What are antiques according to your knowledge?
Common definition: Antique products are made in an earlier period and are collected and considered to have value because they are beautiful, rare, old, or of high quality. (Cambridge dictionary). For example, antique radios or furniture. They don't necessarily have to be 100 years old but can be also less old.	
	Do you have any antiques?
Reasons to have them	Why did you buy them? Or Why did you keep them?
Associations	What do you associate with antiques?
Meaning (symbolic, shared history?)	What do antiques mean to you? • Is it negative or positive to you that the product has been used before? • If comes up in response: Is there something associated with the history of the product that appeals to you?
Buying antiques	Which of these antiques would you buy? Why would you buy this object?
Use of antiques	Some antiques have signs of use, such as scratches or torn material. What is your opinion towards these wear- and tear signs? • Which wear and tear signs are desirable, acceptable to you and when is it too much? • Do you use antiques in everyday life?

Let's look at it at a different angle. Antiques are actually second-hand products. Many antiques are also refurbished before they are resold.

Differences antiques and refurbished products

Difference	What is the difference between antiques and other second-hand products, such as refurbished products?
Age	When is an antique object becoming antique for you?
	When does a second-hand object or a refurbished product become an antique?
Difference	Some antique objects are refurbished (opgeknapt) what is the difference between antiques and other products?
Relationship with antiques	Some people think that in antiques, there are some positive qualities, do you see positive qualities in refurbished products as well?
Functionality/use	What do you *use* antiques for compared to refurbished products?
End of life	What do you do with antique products if you do not use them anymore and what do you do with refurbished product
Wear and tear	Related to answer to wear and tear question of antiques: What do you think about wear and tear signs in reused (opgeknapte) products compared antiques?
History and meaning	Related to answer on meaning and history in antiques: Does one of the refurbished products also have a history or meaning to you as antique objects did?

Appendix A3. Stimuli used in the chapter 2


1


2


3


4


5


6

7

8

9

10

11

12

13

14

15

16

17

18

Appendices chapter 3

Appendix A4.

Model	Product Form α = .77 M (SD)	Durability α = .75 M (SD)	Attractiveness α = .85 M (SD)	Performance Quality α = .91 M (SD)	Ease of use /Comfort Single items M (SD)
 **Model 1**	3.13 (.89) With Model 3 *t*(27)=- 4.37, *p* = .00**	3.85 (1.53) With Model 3 *t*(27)=- 2.82, *p* = .009**	4.73 (1.50) With Model 3 *t*(27)=- 2.71, *p* = .012**	4.15 (1.24) **No significant differences for all products**	4.07 (1.58) **No significant differences for all products**
 **Model 2**	3.31 (.79) With model 4 *t*(26)=- 7.07, *p* = .00**	4.11 (1.11) With Model 4 *t*(26)=- 3.44, *p* = .002**	4.53 (.99) With Model 3 *t*(26)=- 2.37, *p* = .026**	4.23 (1.08)	3.73 (1.79)
 **Model 3**	5.02 (1.32)	5.33 (1.05)	3.51 (1.67)	4.15 (.96)	3.40 (1.88)
 **Model 4**	5.36 (.69)	5.39 (.70)	3.48 (1.24)	4.37 (1.18)	3.29 (1.64)

 **Model 5**	5.22 (.96) With model 12 *t*(28)=- 1.32, *p* = .19	5.30 (.61)	3.51 (1.71)	4.50 (.79)	5.67 (1.29)
 **Model 6**	4.62 (1.17) With Model 11 *t*(28)=- .33, *p* = .74	4.78 (.99)	4.18 (.93)	4.48 (.76)	6.00 (.85)
 **Model 7**	3.71 (1.75) With Model 9 *t*(28)=- 3.16, *p* = .004**	4.37 (1.75) With Model 9 *t*(26)=- 2.88, *p* = .008**	4.81 (1.52) With Model 9 *t*(30)=- .39, *p* = .7	4.59 (1.37)	5.69 (1.74)
 **Model 8**	4.12 (1.61) With Model 10 *t*(28)=- 3.86, *p* = .001**	4.53 (1.67) With Model 10 *t*(26)=- 2.96, *p* = .006**	4.28 (1.57) With Model 10 *t*(26)=- 1.40, *p* = .17	4.53 (1.43)	5.81 (1.87)
 **Model 9**	4.49 (1.01)	5.45 (.89)	4.35 (1.54)	4.67 (.83)	5.47 (2.09)

 **Model 10**	5.33 (1.12)	5.60 (.82)	3.78 (1.57)	4.65 (.92)	5.0 (2.21)
 **Model 11**	4.91 (1.45)	5.45 (.89)	5.10 (.96)	4.70 (1.01)	6.0 (1.37)
 **Model 12**	5.75 (.91)	5.61 (.82)	4.44 (1.35)	4.65 (.88)	5.50 (1.41)

Appendix A5. Measures

Scale	Item	Scale points
Perceived durability	*Please rate the extent to which you agree with the statement based on your expectations concerning the performance of these headphones/this blender.*	1. Strongly disagree – 7. Strongly agree
	These headphones are reliable.	
	These headphones will last a long time.	"
	These headphones function very well.	"
	These headphones are of high quality.	"
Durability product form / Breakability	*Please rate how durable you think these Bluetooth headphones/ this blender appear to be. These headphones/ the blender appear to be..*	
	Fragile – Robust	Semantic differential (1-7)
	Breakable- Durable	
	Easily broken – Will last a long time	
	Frail - Sturdy	
Purchase intentions	Based on the description and the picture of the headphones/blender, you have certain expectations about the product. Please rate the following statement.	
	If I would buy a blender, I would consider buying this blender. (1)	1. Strongly disagree – 7. Strongly agree
	If I were to buy a blender, my probability of buying this blender would be... (1)	Low (1) – High (7)
Attractiveness	*In this question, we would like you to evaluate the appearance of these new/refurbished headphones/ blender. The appearance of these headphones is...*	
	Ugly - Beautiful	Semantic differential (1-7)
	Unattractive - Attractive	"
	Poor looking - Nice looking	"
Consumers' Environmental Concern	The next questions are about your buying behavior and sustainable products. Please rate whether you agree or disagree with the statements below.	1. Strongly disagree – 7. Strongly agree
	I have changed which products I use because of sustainability related reasons.	
	I make a special effort to buy products that are made from sustainable materials.	
	I have avoided buying a product because it had potentially harmful effects to people and/or the environment.	
Consumers' Contamination concerns	*Based on the description and the picture of the blender, you have certain expectations about the condition of the blender. Please rate whether you agree or disagree with the following statements. I expect that this blender will be*	Semantic differential (1-7)
	Not clean - Clean	"
	Not hygienic - Hygienic	"
	Not contaminated - Contaminated	"
	Not dirty – Dirty	"

Appendices chapter 4

Appendix A6. Edge weights of total network sample (earbuds and speakers)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Condition		-.32	.00	.00	.00	-.25	.00	-.13	.14	.00	.20	.00	.60	-.15	.00	.00	-.22	.17
2. Purchase intentions	-.32		.00	.00	.28	.00	.00	.00	.00	.13	-.13	.00	.00	-.05	-.18	.00	.00	.07
3. Trust in brand	.00	.00		.00	.04	.00	.05	.00	.00	.00	.00	.00	.00	.00	.06	.16	.00	.00
4. Warranty	.00	.00	.00		.00	.00	.00	.00	.00	.21	.00	.00	.00	.00	-.18	.00	.00	.00
5. Financial benefits	.00	.28	.04	.00		.00	.22	.00	.08	.00	.00	.00	.00	.00	-.10	.07	.00	.00
6. Signs of wear and tear	-.25	.00	.00	.00	.00		.00	.00	-.14	.00	.11	.00	.00	.00	.17	.00	.00	.00
7. Environmental benefits	.00	.00	.05	.00	.22	.00		-.05	.00	.00	.00	.00	.00	.00	.00	.06	.00	.11
8. Lack of social status	-.13	.00	.00	.00	.00	.00	-.05		.00	.00	.29	.12	.00	.13	.10	.00	.00	.00
9. Aesthetic attractiveness	.14	.00	.00	.00	.08	-.14	.00	.00		.14	-.06	.00	.00	.00	.00	.00	.00	.00
10. Durability	.00	.13	.00	.21	.00	.00	.00	.00	.14		.00	-.20	.00	.00	-.14	.00	.00	.00
11. Territorial contamination	.20	-.13	.00	.00	.00	.11	.00	.29	-.06	.00		.00	.36	.06	.00	.00	.00	.00
12. Utility contamination	.00	.00	.00	.00	.00	.00	.00	.12	.00	-.20	.00		.13	.16	.22	.00	.00	.00
13. Hygienic contamination	.60	.00	.00	.00	.00	.00	.00	.00	.00	.00	.36	.13		.00	.00	.00	.17	.00
14. Expected obsolescence	-.15	-.05	.00	.00	.00	.00	.00	.13	.00	.00	.06	.16	.00		.18	.00	.00	.00
15. Perceived risk	.00	-.18	.06	-.18	-.10	.17	.00	.10	.00	-.14	.00	.22	.00	.18		.06	.05	.00
16. Value consciousness	.00	.00	.16	.00	.07	.00	.06	.00	.00	.00	.00	.00	.00	.00	.06		.00	.00
17. Disgust sensitivity	-.22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.17	.00	.05	.00		.00
18. Environmental concern	.17	.07	.00	.00	.00	.00	.11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	

Appendix A7. Edge weights of refurbished speakers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Purchase intentions		.00	.00	.28	.00	.00	.00	.00	.13	-.13	.00	.00	-.07	-.18	.00	.00	.07
2. Trust in brand	.00		.00	.05	.00	.05	.00	.00	.00	.00	.00	.00	.00	.06	.17	.00	.00
3. Warranty	.00	.00		.00	.00	.00	.00	.00	.21	.00	.00	.00	.00	-.17	.00	.00	.00
4. Financial benefits	.28	.05	.00		.00	.22	.00	.13	.00	.00	.00	.00	.00	-.10	.07	.00	.00
5. Signs of wear and tear	.00	.00	.00	.00	.	.05	.00	-.14	.00	.13	.00	.00	.00	.18	.00	.00	.00
6. Environmental benefits	.00	.05	.00	.22	.05		-.05	.00	.00	.00	.00	.00	.00	.00	.06	.00	.11
7. Lack of social status	.00	.00	.00	.00	.00	-.05		.00	.00	.29	.12	.00	.13	.10	.00	.00	.00
8. Aesthetic attractiveness	.00	.00	.00	.13	-.14	.00	.00		.15	-.06	.00	.00	.00	.00	.00	.00	.00
9. Durability	.13	.00	.21	.00	.00	.00	.00	.15		.00	-.20	.00	.00	-.14	.00	.00	.00
10. Territorial contamination	-.13	.00	.00	.00	.13	.00	.29	-.06	.00		.00	.37	.00	.00	.00	.00	.00
11. Utility contamination	.00	.00	.00	.00	.00	.00	.12	.00	-.20	.00		.13	.16	.22	.00	.00	.00
12. Hygienic contamination	.00	.00	.00	.00	.00	.00	.00	.00	.00	.37	.13		.00	.00	.00	.08	.00
13. Expected obsolescence	-.07	.00	.00	.00	.00	.00	.13	.00	.00	.00	.16	.00		.16	.00	.00	.00
14. Perceived risk	-.18	.06	-.17	-.10	.18	.00	.10	.00	-.14	.00	.22	.00	.16		.06	.05	.00
15. Value consciousness	.00	.17	.00	.07	.00	.06	.00	.00	.00	.00	.00	.00	.00	.06		.00	.00
16. Disgust sensitivity	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.08	.00	.05	.00		.00
17. Environmental concern	.07	.00	.00	.00	.00	.11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	

Appendix A8. Edge weights of refurbished earbuds

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Purchase intentions		.00	.00	.28	.00	.00	.00	.00	.13	-.31	.00	-.28	.05	-.04	-.06	.00	.07
2. Trust in brand	.00		.00	.05	.00	.05	.00	.05	.00	.00	.00	.00	.00	.06	.17	.00	.00
3. Warranty	.00	.00		.00	.00	.00	.00	.00	.21	.00	.00	.00	.00	-.17	.00	.00	.00
4. Financial benefits	.28	.05	.00		.00	.22	.00	.13	.00	.00	.00	.00	.00	-.10	.07	.00	.00
5. Signs of wear and tear	.00	.00	.00	.00		-.01	.05	-.14	.00	.13	.00	.07	.00	.18	.00	.00	.00
6. Environmental benefits	.00	.05	.00	.22	-.01		-.05	.00	.00	.00	.00	.00	.00	.00	.06	.00	.11
7. Lack of social status	.00	.00	.00	.00	.05	-.05		.00	.00	.09	.12	.00	.13	.10	.00	.00	.00
8. Aesthetic attractiveness	.00	.05	.00	.13	-.14	.00	.00		.15	-.06	.00	.00	.00	.00	.00	.00	.00
9. Durability	.13	.00	.21	.00	.00	.00	.00	.15		.00	-.20	.00	.00	-.14	.00	.00	.00
10. Territorial contamination	-.31	.00	.00	.00	.13	.00	.09	-.06	.00		.00	.45	.04	.00	.00	.00	.00
11. Utility contamination	.00	.00	.00	.00	.00	.00	.12	.00	-.20	.00		.13	.16	.22	.00	.00	.00
12. Hygienic contamination	-.28	.00	.00	.00	.07	.00	.00	.00	.00	.45	.13		-.16	.00	.00	.08	.00
13. Expected obsolescence	.05	.00	.00	.00	.00	.00	.13	.00	.00	.04	.16	-.16		.16	-.05	.00	.00
14. Perceived risk	-.04	.06	-.17	-.10	.18	.00	.10	.00	-.14	.00	.22	.00	.16		.06	.05	.00
15. Value consciousness	-.06	.17	.00	.07	.00	.06	.00	.00	.00	.00	.00	.00	-.05	.06		.00	.00
16. Disgust sensitivity	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.08	.00	.05	.00		.00
17. Environmental concern	.07	.00	.00	.00	.00	.11	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	

Appendices chapter 5

Appendix A9. Pre-test results and pre-test scales

Importance of attributes

Refurbished headphones differ in several features. Please indicate how important you find the following features when choosing refurbished headphones.

Items	1. Not at all important – 5 Extremely important	M (SD)
There is information on whether the ear-cushions were changed during refurbishment process.		3.82 (1.01)
There is information on the cleaning process.		3.73 (1.04)
There is information on the product state (signs of use on the product, such as scratches on surfaces).		4.35 (.69)
There is information on the battery capacity.		4.04 (.72)
There is information on the length of the warranty.		3.98 (.76)
There is information in which year the headphones were produced.		3.10 (1.06)
There is information on the price reduction of refurbished headphones compared to new ones.		3.94 (.76)

Appendix A10. Pairwise Comparisons on importance (see above which items corresponds to which characteristic)

Item		t	p
1	2	.098	1.000
	3	-.529*	.047
	4	-.216	1.000
	5	-.157	1.000
	6	.725*	.002
	7	-.118	1.000
2	1	-.098	1.000
	3	-.627*	.002
	4	-.314	1.000
	5	-.255	1.000
	6	.627	.126
	7	-.216	1.000
3	1	.529*	.047
	2	.627*	.002
	4	.314	.464
	5	.373	.283
	6	1.255*	.000
	7	.412	.076
4	1	.216	1.000
	2	.314	1.000
	3	-.314	.464
	5	.059	1.000
	6	.941*	.000
	7	.098	1.000

Based on estimated marginal means
* The mean difference is significant at the .05 level.
b Adjustment for multiple comparisons: Bonferroni.

Appendix A11:

Items	Scale: (1) Preferred (2) Acceptable (3) Undesirable (4) Unacceptable	M (SD)
Signs of use		
The appearance is in an as-new state (product does not show any signs of use and look as-new).		1.08 (.27)
The appearance shows light wear-and tear (scratches on the surface that are only visible from close proximity).		2.08 (.39)
The appearance shows visible wear-and-tear (larger scratches on the plastic surfaces).		2.92 (.59)
The appearance shows very visible wear-and-tear (larger scratches on the plastic surface and discolorations of headpiece).		3.47 (.64)
Battery functionality		
Battery has 100% battery capacity (~25 hours playtime)		1.02 (.14)
Battery has at least 90% battery capacity (~ 22,5 hours playtime).		1.39 (.53)
Battery has at least 80% battery capacity (~ 20 hours playtime).		1.80 (.49)
Battery has at least 70% battery capacity (~ 17,5 hours playtime).		2.27 (.57)
Battery has at least 60% battery capacity (~ 15 hours playtime).		2.55 (.67)
Battery has at least 50% battery capacity (~ 12,5 hours playtime).		3.16 (.67)
Battery has at least 40% battery capacity (~ 10 hours playtime).		3.49 (.64)
Cleaning process		
There is no information on the cleaning process, only a general statement that the refurbishment process of the headphones involves cleaning.		2.96 (.77)
There is extensive information on how the cleaning process was executed on the company website of the refurbished headphones.		1.29 (.50)
There is extensive information on how the cleaning process was executed on the company website of the refurbished headphones and the specific headphones are certified with a sparkling clean label.		1.20 (.45)
Changed parts		
The ear-cushions were cleaned during the refurbishment process.		2.33 (.82)
The ear-cushions were changed during the refurbishment process and are new.		1.06 (.24)
Length of warranty		
6 months		3.16 (.70)
1 year		2.12 (.59)
2 years		1.39 (.49)
3 years		1.04 (1.96)
Year of production		
Produced in 2020		1.10 (.30)
Produced in 2019		1.47 (.50)
Produced in 2018		1.86 (.66)
Produced in 2017		2.49 (.61)
Produced in 2016		2.96 (.69)
Produced in 2015		3.33 (.77)

Price of the product	
The refurbished headphones have a 5% price reduction compared to new headphones.	3.82 (.38)
The refurbished headphones have a 10% price reduction compared to new headphones.	3.53 (.58)
The refurbished headphones have a 15% price reduction compared to new headphones.	3.20 (.63)
The refurbished headphones have a 20% price reduction compared to new headphones.	2.84 (.86)
The refurbished headphones have a 25% price reduction compared to new headphones.	2.43 (.64)
The refurbished headphones have a 30% price reduction compared to new headphones.	2.12 (.71)
The refurbished headphones have a 40% price reduction compared to new headphones.	1.59 (.50)
The refurbished headphones have a 50% price reduction compared to new headphones.	1.10 (.30)

Appendix A12: Scales of the main study

Scale and items	Scale points
Value consciousness, (based on Lichtenstein et al., 1990)	Strongly disagree (1) – strongly agree (7)
When shopping, I compare the prices of different brands to be sure I get the best value for the money.	
When purchasing a product, I always try to maximise the quality I get for the money I spend.	
I generally shop around for lower prices on products, but they must still meet certain quality requirements before I buy them.	
Environmental concern (based on Mugge, Jockin, & Bocken, 2017a)	Strongly disagree (1) – strongly agree (7)
I make a special effort to buy products that are made from sustainable materials.	
I have changed which products I use because of sustainability-related reasons.	
I have avoided buying a product because it had potentially harmful effects to people and/or the environment	
Disgust Sensitivity (Three Domains of Disgust Scale (TDDS) – Pathogen disgust (based on Olatunji et al., 2012)	Not at all disgusting (0 – Extremely disgusting (6)
Seeing some mould on old leftovers in your refrigerator	
Standing close to a person who has body odour.	
Shaking hands with a stranger who has sweaty palms	
Stepping on dog poop	
Accidentally touching a person's bloody cut.	
Seeing a cockroach run across the floor.	
Sitting next to someone who has red sores on their arm.	
Ambiguity intolerance (based on McLain, 2009; Hazen et al., 2012)	Strongly disagree (1) – strongly agree (7)
I am tolerant of ambiguous situations.	
I enjoy tackling problems that are complex enough to be ambiguous.	
I generally prefer novelty to familiarity.	
I prefer a situation in which there is some ambiguity.	

Appendices chapter 6

Appendix A13. The influence of product-related factors on contamination concerns

Product-related factors	
Themes	**Second-order codes**
The IPL device's product characteristics evoke concerns about utility and hygienic contamination	Refurbished IPL devices have a higher performance risk, shorter expected lifetime, and obsolescence risk, which results in a higher financial and time risk
	The IPL device is a scary device because of its laser and fear of it damaging one's skin is increased when it is bought in a reused state
	Refurbished IPL devices have an increased contamination risk
The influence of signs of wear-and-tear on the use history and performance characteristics	Signs of wear-and-tear decreases performance, safety and expected product lifetime of device
	Based on the amount and location of aesthetic signs of wear-and-tear, users make inferences on what happened to the product (use history)
Signs of wear-and-tear are associated with a hygiene risk	Association of the IPL devices' prior use with contamination (e.g., particles of a prior user) is strong and makes the IPL device less desirable
	Signs of wear-and-tear makes hygiene contamination concerns worse because they make the product harder to clean and evoke associations that the product being marked with traces of a prior user (e.g., smell)
A hygienic product design can decrease contamination	A neat and hygienic product appearance decreases the contamination risk
	The white color of the IPL device is associated with hygiene and this can decrease contamination concerns. Colors on which aesthetic signs of wear-and-tear are not visible also reduce contamination.
	Smooth material is favorable for hygiene expectations, rougher material is undesirable because it is less cleanable, and fewer bacteria and dirt stick to it
	Fewer splitlines make the product more hygienic because less dirt can assemble in them

Appendix A14: Consumer characteristics determine the proneness to contamination concerns

Personal factors	
Themes	**Second-order codes**
Consumers with a strong environmental concern found signs of wear-and-tear to be acceptable	Financial and environmental benefits make signs of wear-and-tear of a refurbished product acceptable (when functionality is guaranteed) to consumers who are concerned about the environment and/or are conscious about money
Consumers with a high disgust sensitivity had more contamination concerns	Reused IPLS need to be cleaned before first use because consumer is disgust sensitive

Appendix A15: The influence of marketing/context-related factors on contamination concerns

Contextual factors	
Themes	**Second-order codes**
A low price can reduce financial risk associated with the product and enhance the financial benefit	A low price can incentivize consumers to buy a refurbished Lumea with heavy wear-and-tear when the functionality is guaranteed (but the price difference needs to be large enough
Warranty decreases risk associated with refurbished products that have signs of wear-and-tear	Warranty decreases the risk associated with refurbished products because one knows whom to contact if the product does not work and this determines the product choice
	Warranty can make refurbished products with signs of wear-and-tear desirable because it compensates for the perceived risk that the device is dysfunctional or has a lower expected lifetime.
Expert check-up and standards in refurbishment reduce risk that product is unclean or dysfunctional	The fact that a refurbished product is checked by an expert and therefore adheres to a certain standard makes them a safer choice compared to second-hand products
	Standards in refurbishment make them less risky
Information provision about expected product lifetime and prior use	It is important to know for how long the refurbished product is conceptualized to last and how long it has been used.
Image of manufacturer and refurbisher	The trustworthiness and good reputation of a manufacturer has a positive influence on the choice for refurbished/reused products because it enhances trust in the quality of a product and the refurbishment process.
New packaging	New packaging indicates that the product has been processed and refurbished.

Appendix A16. Interview guide for consumer interviews

Subtopic 1 (warming up / intro): Use of the Lumea

- Opening question: Why did you buy the Lumea?

Follow-ups/probes:

- Can you describe your first use experience with the Lumea?
- How often do you use the Lumea?
- We just talked about the use of the Lumea. Now I would like to ask you some questions about the decision to get a new/2nd life Lumea.'

Subtopic 2: Refurbished or 'normal product' decision-making process

*in case of new Lumea

'2nd life products are products that have been recollected after their first use, have been cleaned and checked.'

- Why did you choose the new Lumea over the 2nd life one?
- Were you aware of the availability of 2nd life Lumea's?
- What are pro's and con's of a new Lumea compared to a 2nd life one?

*in case of 2nd life Lumea

- What made you decide to buy a 2nd life Lumea instead of a new one?
- What were your expectations of the 2nd life Lumea?
- What are the positive and negative aspects of a 2nd life Lumea compared to a new one? Please elaborate on its pro's and cons.
- Would you recommend the 2nd life Lumea to friends? Why and why not?

These were the questions about your purchase decision. I would now like to know more about how you use the Lumea'.

Subtopic 3: Perceived cleanness of the Lumea

Opening question: Could you describe your use routine?

- Do you clean the Lumea? Please explain how and why. If yes: How? How often? If no: Why not?
- Does the Lumea meet your hygiene expectations and needs?
  - o If yes: Why?
  - o If no: Why not?

*in case of a 2nd life Lumea

- Could you describe your impression of the products' condition?
- 'After having talked about hygiene, I would like to discuss the appearance of the Lumea with you'
-

Subtopic 4: Appearance of the Lumea

Opening question: How would you describe the appearance of the Lumea?

*in case of 2nd life Lumea

- What did you like or dislike about the appearance of the Lumea?
- Is there anything that you would change about the appearance of Lumea?

Follow-ups/probes:

- What is your opinion on the shape of the Lumea?
- What does it remind you of? What feeling does it give?
- What do you think of the material the Lumea is made of?
- If you could order the Lumea with different materials, would you order another material?
    - o If yes: Could you give an example of the material of another product?
    - o • If no: Why not?
- If the Lumea was available in different colours, would you order another colour? •
    - o If yes: to what and why?
    - o If no: why not?
- What feeling does the Lumea evoke when you use it?
- How did it feel when you first used the Lumea?
- If you had to describe the Lumea as a person, what kind of personality would it have? What characteristics would you give the Lumea?

Appendix 17. Presentation of Dilemmas

C1.2:

Publications associated with this thesis

Journal papers

Wallner, T.S., Magnier, L., & Mugge, R. (2019). Can refurbished products feel like antiques? The role of the neo- retro design style on consumers' evaluation of refurbished products. In M. Nissen, Nils F.; Jaeger-Erben (Ed.), *3rd PLATE Conference* (Issues 18-20 September, pp. 825–834). TU Berlin. https://depositonce.tu-berlin.de/handle/11303/10291

Wallner, T.S., Magnier, L., & Mugge, R. (2020). An Exploration of the Value of Timeless Design Styles for the Consumer Acceptance of Refurbished Products. *Sustainability*, *12*(3), 1213. https://doi.org/10.3390/su12031213

Wallner, T. S., Magnier, L., & Mugge, R. (2021, May 28). Buying new or refurbished? The influence of the product's durability and attractiveness, contamination risk and consumers' environmental concern on purchase intentions of refurbished and new products. *4th PLATE 2021*. Product Lifetimes and the Environment (PLATE), Limerick, Ireland. https://doi.org/10.31880/10344/10172

Journal papers in progress

Wallner, T.S., Haslbeck, J. M.B., Magnier, L., & Mugge, R. (under review). A network analysis of factors influencing the purchase intentions of refurbished electronics.

Conferences papers

Wallner, T.S., Magnier, L., & Mugge, R. (2022). Do consumers mind contamination by previous users? A choice-based conjoint analysis to explore strategies that improve consumers' choice for refurbished products. *Resources, Conservation and Recycling*, *177*, 105998. https://doi.org/10.1016/j.resconrec.2021.105998

Wallner, T. S., Magnier, L., & Mugge, R. (2022). Improving Consumer Adoption of Refurbished Products by Reducing Contamination. In *Congress of the International Association of Societies of Design Research* (pp. 1944-1955). Springer, Singapore.

Wallner, T.S., Magnier, L., and Mugge, R. (2022) Why consumers have contamination concerns in refurbished personal care products and how to reduce them via design, in Lockton, D., Lenzi, S., Hekkert, P., Oak, A., Sádaba, J., Lloyd, P. (eds.), *DRS2022: Bilbao*, 25 June - 3 July, Bilbao, Spain. https://doi.org/10.21606/drs.2022.615

Wallner, T. S., Snel, S., Magnier, L., & Mugge, R. (2022). Contaminated by Its Prior Use: Strategies to Design and Market Refurbished Personal Care Products. *Circular Economy and Sustainability*. https://doi.org/10.1007/s43615-022-00197-3

Acknowledgements

Every PhD represents a journey - a professional and also a personal one. PhDs are not always smooth sailing and I would like to thank both of my supervisors for their support over the past 4,5 years. Supervising me was surely not easy at times; sometimes waters were rough and the wind wasn't in our favour. At all times I was lucky to have you as my co-captains who could guide my way out of misty waters. This PhD was a first for all of us: Ruth, I was your first PhD student whom you supervised as a promotor. I was Lise's first PhD student in general. As for myself: it was my first PhD - and most probably my last. Our academic record shows that we grew as a team professionally but I'd like to believe that we also grew personally in this collaboration. Thank you for your guidance, help and empathy along the way; from the beginning to the end.

As for my papers, I also had several collaborators and colleagues who helped me along the way. Jonas, thank you for your help, guidance and collaboration on the network paper – you're a true code magician! Senna, thank you for your help with the paper on personal care products. Jeff, thank you for your unstoppable enthusiasm about data and for always helping me to get through our data management plan. Agnes, thank you for all the work you did on the PEL – the quality of our data wouldn't have been the same without you.

To all PhD's from the 4th-floor office: I couldn't have wished for better companions! From lunch walks, seal safaris, to winning costume competitions (ok...2nd place). You made this experience truly unique! It is rare to find such a vibrant PhD community of people who support each other. As Beatrice said (when we were all dressed up as Rubik's cube pieces): '*We are nothing without each other*'.

To my Thrive team Dilnoza, Oscar, Sarwan and our supervisors Maud and Han: I had a lot of fun doing our project on circular healthcare. Working through the first lockdown with you was a true (mental) lifesaver!

I would also like to thank my colleagues at the Ministry of IenW DCLE/DGMI/VINK. Thank you for cheering me on in the last phase of the PhD and keeping my back free when it was needed!

Boy, thank you for encouraging me to do this PhD and for never stopping to believe in me! To Renske, Emilia, Nina, Jelle and Phil, thank you for your advice, friendship and for spending time together on the occasional DIY project. Vivian, we were not only 'friendship at first sight' but you also helped me a lot professionally over the years. You did not only help me to come up with the idea for the conjoint study but also encouraged me to make the next step in my career. Thank you!

Steph, there is nobody who loves working more than you do. Thank you for inspiring me to work harder and finding back my passion in my work. Thank you for your companionship, support and for all the moments that make our life together so much fun!

Never underestimate the power of a sloppy kiss and the wet nose of a Whippet. As strange as some people might find it, I also want to acknowledge the contribution of my hound Bali to this thesis. I picked her up a few days before my first PhD admissions interview (she must have brought me luck) and she's been a loyal companion during the different stages of my PhD. Even as am writing the final pages of my dissertation, she is lying beside me.

Finally, I would like to thank my family- this thesis is dedicated to you. To my sister: we grew up together and you have made me what I am. Thank you for helping me to discover my path and inspiring me to stay ambitious! To my parents: From a small age you have taught us to be creative with what we have and to be conscious of the environment. Thank you for always trusting in me and giving me the time and space to find my own path. Finally, thank you for supporting my academic endeavours – this thesis wouldn't be there without you!

The author

Theresa Stephanie Wallner was born in Darmstadt, Germany on 17 August 1991.

After two years of travelling the world, different jobs and internships in the arts and performance sector, Theresa started a bachelor of Psychology and Neuroscience at Maastricht University (2012-2015). During her Bachelor, she spent a semester at Pontificia Universidad Católica de Chile and took part in the Marble Excellence program.

From 2015-2017 she completed a research master of science at the University of Amsterdam. During her master, she did not only discover her love for clinical and political psychology but also did an Internship at the Reichman University (former IDC Herzliya) in Israel and graduated on the topic of trauma and the integration of refugees at the University of Amsterdam (cum laude). Next to her studies and work, worked as a community volunteer, (co-)coordinator and board member of VluchtelingenWerk Amsterdam and Amsterdam Noord. During and after her studies she worked as a teacher at the Politics, Psychology, Law and Economics College at the Faculty of Law at the University of Amsterdam.

In 2018 she started her PhD in the Marketing and Consumer Research Group at the Department of Design, Organization and Strategy (former Department of Product Innovation Management) at the Faculty of Industrial Design Engineering at the Delft University of Technology. During the pandemic, she participated in the THRIVE PhD academy. She visited several international conferences during her PhD.

Prior to finishing this dissertation, Theresa started working at the Ministry of Infrastructure and Water Management in The Hague in 2022. It is her professional as well as personal mission to accelerate the transition to a sustainable and circular economy. She hopes to translate her, during the PhD acquired, knowledge of the Circular Economy from theory into practice.