LAURE HERWEYERS

Designing long-term reuse

Uncovering motivators and barriers to sustained use of reusable alternatives to single-use products

PhD thesis submitted for the degree of doctor of Product Development at the University of Antwerp to be defended by Laure Herweyers.

Designing long-term reuse

Uncovering motivators and barriers to sustained use of reusable alternatives to single-use products

Doctoral dissertation by Laure Herweyers

Doctoral jury
Prof. dr. Alexis Jacoby – University of Antwerp (Belgium) – Chair
Prof. dr. Els Du Bois – University of Antwerp (Belgium) – Supervisor
Prof. dr. Ingrid Moons – University of Antwerp (Belgium) – Supervisor
Prof. dr. Casper Boks – NTNU Trondheim (Norway) – Committee member
Dr. Ivo Dewit – University of Antwerp (Belgium) – Committee member
Dr. Lise Magnier – TU Delft (the Netherlands) – Jury member
Prof. dr. Linda Nhu Laursen – University of Aalborg (Denmark) – Jury member

ISBN **9789057288357**
Wettelijk depotnummer **D/2024/12.293/05**

Funding
TT(ZAP)BOF DOCPRO4 project number 41470
FWO grant for a short study visit abroad (Norway 2022)
FWO travel grant for participation in a conference abroad (Japan, 2023)

Faculteit Ontwerpwetenschappen
Departement Productontwikkeling

Ontwerpen van langdurig hergebruik: Motivatoren en barrières voor het blijvend gebruik van herbruikbare alternatieven voor wegwerpproducten

Proefschrift voorgelegd tot het behalen van de graad van doctor in de Productontwikkeling aan de Universiteit Antwerpen te verdedigen door
Laure Herweyers

Promotoren:
Prof. dr. Els Du Bois
Prof. dr. Ingrid Moons

Antwerpen, 2024

Table of contents

03

04

05

06

Summary

Single-use products (SUP) offer many advantages, thanks to their convenience, attractiveness, and effectiveness in protecting other products. However, they come at a steep cost to the natural environment and human health. With escalating concerns about pollution and resource depletion, the need to adopt reusable alternatives to single-use products is widely acknowledged. In order to have a positive impact on the environment, reusable products have to be used a minimal number of cycles to reach their break-even point, allowing them to surpass the environmental costs associated with their production - such as resource intensity, energy consumption, and water usage. However, a significant challenge arises when many individuals acquire reusable products but fail to use them effectively. Too often, people use them only briefly before discarding them and going back to disposable options. Therefore, it is not sufficient to offer reusable alternatives; people should also be motivated to really reuse the reusable products repeatedly, as this is essential for successfully reducing their environmental footprint.

This PhD research analyses the motivators and barriers to the sustained, long-term usage of reusable alternatives to single-use products. The objective is to formulate recommendations for designers and provide assistance in designing for long-term reuse. To do this, we seek answers to the following research questions. RQ1: What are the motivators and barriers to long-term usage of reusable alternatives to single-use products? Or, in other words, why do people stop using SUP alternatives before their break-even point? RQ2: How do motivators and barriers to long-term reuse vary between types of products, contexts, and users? RQ3: How can designers be supported by the results of this research in developing products/services/product-service systems that enable long-term reuse?

The research design is composed of five research cycles. The first cycle consists of a qualitative exploration of users and barriers (focus groups n=3, RQ1). This is followed by qualitative research with consumers, investigating the barriers and motivators to long-term use of reusable products, which we approach from a user, product, and context perspective (interviews n=32, RQ1 & RQ2). Simultaneously, we employ a quantitative study to investigate cultural differences and user segmentation according to SUP-avoiding intentions and reuse behaviour (survey n=3000, RQ2). The fourth cycle considers more specific cases in which we experiment with

different methods (surveys, interviews, diary studies, RQ1 & RQ2). The fifth cycle focuses on the design component. We explore tools (design assignment with survey n=87, RQ3) and develop a framework based on our findings and further reasoning (with preliminary expert verification and iterations).

As a response to the first research question, we could divide the motivators and barriers that we found into willingness, ability, and routine, which are all necessary to increase the chance of successful long-term reuse. From our quantitative search, we found the existence of four user segments - SUP addicts, SUP avoiders, the apathetic, and situation-driven SUP users (aspirers) - who differ in their intentions to avoid SUP and their motivations for doing so, and in their usage of several reusable products. From our qualitative research, we distinguished four product categories - intimate care, daily shopping, at home, and on the go - providing tailored insights into specific barriers and contexts in which they are used (e.g., inside vs. outside the home). The user groups and product/context categories respond to the second research question. To answer the third research question, we tested and evaluated several preliminary tools for integrating specific personas and single use vs. reuse journey into the product development process. Finally, a framework was developed to direct designers towards reusable solutions that stand a greater chance of long-term success, and first iterations were made based on expert discussions.

From our research, we can conclude there is no 'one size fits all' regarding the successful long-term use of reusable alternatives to single-use products. Some user types might benefit from a product with sole ownership that they can match with their (green) identity and potentially customise (e.g., SUP avoiders). Others are better supported by a product-service system, that decreases time and effort, and avoids having to remember to always take the product with you(e.g., aspirers and SUP addicts). Also, different contextual barriers and product types ask for different design approaches and interventions. With the intervention framework, we bring together and synthesise the data acquired in this research with insights from literature, and we create a translation from theory to practice. It provides an overview of variables that influence long-term reuse in a comprehensible manner, subdivided into willingness, ability, and routine. It highlights critical points, differentiates between user groups and product categories, suggests concrete strategies for interventions, and provides some specific examples.

In future research, the framework should be further elaborated and tested in workshops with design practitioners, students, and academics, as well as professionals from other disciplines who seek solutions for waste and pollution caused by single-use products.

Dutch summary

Wegwerpproducten bieden vele voordelen vanwege hun gebruiksgemak, aantrekkelijkheid, en effectiviteit in het beschermen van andere producten. Ze gaan echter gepaard met een hoge kost voor het milieu en de menselijke gezondheid. De bezorgdheid over vervuiling en de uitputting van grondstoffen neemt gestaag toe, en de noodzaak om wegwerpproducten te vervangen door herbruikbare alternatieven wordt tegenwoordig breed erkend. Om een positieve impact op het milieu te hebben, moeten herbruikbare producten een minimaal aantal gebruikscycli doorlopen om hun break-evenpunt te bereiken. Dit is cruciaal om de hogere milieukosten te compenseren die gepaard gaan met de productie van herbruikbare producten in vergelijking met wegwerpproducten, zoals een hoger materiaal-, energie-, en watergebruik. Het wordt dan ook een ernstig probleem wanneer een grote groep mensen herbruikbare producten aankopen maar niet daadwerkelijk gebruiken. Vaak gebruikt men de producten slechts kortstondig, om ze nadien af te danken en terug te gaan naar wegwerp. Het is dus niet voldoende om herbruikbare alternatieven aan te bieden; mensen moeten ook gemotiveerd worden om de herbruikbare producten herhaaldelijk te hergebruiken, wat essentieel is voor een succesvolle vermindering van hun ecologische voetafdruk.

In dit doctoraat worden de motivatoren en barrières voor wegwerpproducten onderzocht. Het doel is om aanbevelingen voor ontwerpers te formuleren en hen te assisteren in het ontwerpen voor langdurig hergebruik. We zoeken hiervoor antwoorden op de volgende onderzoeksvragen. RQ1: Wat zijn de motivatoren en barrières voor het langdurig gebruik van herbruikbare alternatieven voor wegwerpproducten? Of, met andere woorden, waarom stoppen mensen met het gebruiken van herbruikbare producten voor die hun break-evenpunt bereiken? RQ2: Hoe variëren de motivatoren en barrières voor langdurig hergebruik tussen types van producten, contexten, en gebruikers? RQ3: Hoe kunnen ontwerpers ondersteund worden door de resultaten van dit onderzoek in het ontwikkelen van producten/diensten/product-dienst combinaties die langdurig hergebruik mogelijk maken?

Het onderzoek is opgebouwd uit vijf onderzoekcycli: de eerste cyclus bestaat uit een kwalitatieve exploratie van gebruikers en barrières (focusgroepen n=3, RQ1). Daarop volgt een kwalitatieve studie met consumenten, waarbij we motivatoren

en barrières voor het langdurig gebruik van herbruikbare producten onderzoeken vanuit het perspectief van gebruiker, product, en context (interviews, n=32, RQ1 en RQ2). Ondertussen doen we een kwantitatieve studie om culturele verschillen te onderzoeken en gebruikerssegmenten te identificeren op basis van intenties om wegwerp te vermijden, en gedrag omtrent hergebruik (enquête n=3000, RQ2). Het vierde deel beschouwt specifiekere cases waarin we experimenteren met verschillende methoden (enquêtes, interviews, dagboekstudies, RQ1 en RQ2). Het vijfde deel focust op de ontwerpcomponent. We exploreren tools (ontwerpopdracht met enquête, n=87, RQ3) en ontwikkelen een framework gebaseerd op de bevindingen van dit onderzoek en het daarop doordenken (met voorlopige verificatie door experten en verschillende iteraties).

Als antwoord op de eerste onderzoeksvraag konden we de gevonden motivatoren en barrières indelen in bereidheid, vermogen, en routine, die alle drie nodig zijn om de kans op succesvol langdurig gebruik te verhogen. Uit het kwantitatief onderzoek konden we vier gebruikerssegmenten onderscheiden – SUP addicts, SUP avoiders, apathetic, en situation-driven SUP users (aspirers) – die verschillen in hun intenties en motivaties om wegwerp te vermijden, en hun gebruik van verschillende herbruikbare producten. Uit het kwalitatief onderzoek kwamen vier categorieën – intimate care (intieme hygiëne), daily shopping (dagelijkse boodschappen), at home (thuis), en on the go (onderweg) – die meer gerichte inzichten bieden in specifieke barrières en contexten waarin ze gebruikt worden (bijvoorbeeld binnen- of buitenshuis). De types gebruikers en product/context categorieën geven een antwoord op de tweede onderzoeksvraag. Om de derde onderzoeksvraag te beantwoorden werden verschillende preliminaire tools voor het integreren van persona's en een user journey van wegwerp versus hergebruik in het productontwikkelingsproces getest en geëvalueerd. Uiteindelijk werd een framework ontwikkeld om ontwerpers richting te geven bij het ontwerpen van herbruikbare oplossingen met meer kans op langdurig gebruik. Een aantal eerste iteraties werden gemaakt, gebaseerd op interviews met experten.

Vanuit het onderzoek kunnen we concluderen dat er geen 'one size fits all' bestaat als het gaat om het succesvol langdurig gebruik van herbruikbare alternatieven voor wegwerpproducten. Voor sommige gebruikersgroepen zou een product in eigendom beter werken, aangezien het aansluit bij hun 'groene' identiteit en hun nood om het product te personaliseren (bijvoorbeeld de SUP avoiders). Anderen zouden beter geholpen zijn met een product-dienst combinatie, die de tijdsinvestering en moeite vermindert, en waarbij ook vergeetachtigheid minder een rol speelt (bijvoorbeeld aspirers en SUP addicts). Bovendien vragen verschillende contextuele barrières en producttypes om verschillende ontwerpbenaderingen en interventies. Met het

framework brengen we alles samen en synthetiseren we de data uit dit onderzoek samen met literatuur, en maken we de vertaling van theorie naar praktijk. Het biedt een overzicht van variabelen die langdurig hergebruik beïnvloeden op een begrijpelijke manier, opgedeeld in bereidheid, vermogen, en routine. Het benadrukt kritische punten, maakt onderscheid tussen gebruikersgroepen en productcategorieën, suggereert concrete strategieën voor interventies, en behandelt specifieke voorbeelden.

In toekomstig onderzoek zou het framework verder uitgewerkt en getest moeten worden in workshops met ontwerpers, studenten, en onderzoekers, maar ook met professionals van andere disciplines die zoeken naar oplossingen voor afval en vervuiling veroorzaakt door wegwerpproducten.

Introduction

1 Throw-away society

For most of human history, materials were expensive and considered valuable. The idea to throw something away after only one use would have seemed strange and wasteful. Only in the last decades, disposable products became accepted as normal, mainly driven by the rise of consumerism and the development of plastic materials [1]. Plastics, or synthetic polymers, consist of long chains of atoms organised in repeated units. These units are much longer than most found in nature, and their length and specific arrangements give them their strength, lightweight nature, and flexibility. In simpler terms, these characteristics make plastics so versatile and adaptable, or what we call 'plastic'. The first synthetic polymer, Parkesine, was invented in 1862 by Alexander Parkes, and in 1907, Leo Baekeland invented Bakelite, the first fully synthetic plastic that did not contain any molecules found in nature [2]. Due to their unique properties, low cost, and possibilities for a very wide range of applications, plastics quickly became very prominent in our daily lives [3]. They changed the way we lived in several ways, for example by the design of many new products ranging from furniture and household products to shoes and clothes.

Initially, plastics were only used to produce durable goods. However, the economic system demanded people to buy new stuff, and ironically plastic was 'too durable'. A way to solve this problem was to persuade people to voluntarily throw away stuff and buy new things, and starting from the 1950s, products designed to be single-use entered the market. Since then, the annual production of plastic has witnessed consistent growth, which was made possible by the low price of oil, the possibility of mass production, and the perception of hygiene, which was played out to persuade people of the necessity of disposable products [1]. Next to this, the convenience aspect was emphasised, since no washing of, for example, single-use cups and plates, would be needed. As a result, plastic production reached 391 million metric tons in 2021 alone, and projections indicate a rise to 589 million metric tons by the year 2050 [4,5].

1.1 Negative effects

Environmental impact

Single-use plastics are mass-produced for a very short usage period which leads to large production costs and valuable resource depletion, and they often end up in the environment as waste. The discovery of plastic waste in the oceans during the 1960s increased concerns about the environmental repercussions of plastics, and its reputation was further damaged because of the additives that pose potential threats to human health, such as bisphenol A (BPA) and phthalates [6]. According to research, plastics are the primary source of litter found in oceans and inland waters [7], with an estimated 19 to 23 million tonnes of plastic waste that finds its way into our water systems each year [8]. A part of these plastics sink, while another portion stays buoyant and is transported by surface currents and winds. This way, plastics can eventually enter oceanic gyres [9]. A highly concentrated accumulation of plastics in the North Pacific Subtropical Gyre is commonly referred to as the 'Great Pacific Garbage Patch', first discovered by Charles Moore in 1997, which is still rapidly expanding [10]. Plastic products are not biodegradable, but can eventually degrade into smaller particles, the so-called microplastics (0.1 μm–5 mm) [11]. Macro- and microplastics in the marine environment have detrimental effects on marine life. Many species become entangled or ingest plastic debris, which can potentially cause suffocation [12]. On top of this, plastics act as vectors that attract harmful chemicals, namely persistent organic pollutants [13]. These toxic substances can transfer up the food web and eventually have hazardous effects on human health [14]. Plastic pollution can also significantly alter the ecology of marine systems on a much wider scale. It serves as a stressor and can interact with other environmental stressors like rising ocean temperatures, ocean acidification, and the over-exploitation of marine resources [15]. The accumulation of these stressors can have devastating consequences, such as total ecosystem collapses and reaching critical tipping points [16].

Social and economic impact

From an ecosystem service perspective, plastic pollution significantly impacts human well-being globally, affecting food security, livelihoods, income, and health [17]. It has the potential to reduce fish stocks and the efficiency and productivity of commercial fisheries and aquaculture. This leaves the industry vulnerable, especially in combination with broader factors including climate change and over-fishing [15]. A declining fish population reduces access to valuable sources of micronutrients, and research suggests that in the next few decades over 10% of the world's population could experience deficiencies in micronutrients and fatty acids, particularly in developing countries near the Equator [18].

Next to the detrimental effects of marine pollution on health, income, and food security, plastic waste is in large numbers being transported from primarily Europe, the U.S.A. and Japan (where almost half of all plastics are generated), to non-OECD countries in Asia, South America, and Eastern Europe, where it often ends up in landfills or pollutes the natural environment. Even when plastic exports make their way to recycling plants, it is common for many of these facilities to be notably lacking in cleanliness and environmental standards. Workers in recycling facilities may be exposed to emissions of volatile organic compounds, and toxic residues from additives released during the plastic cleaning process can enter the wastewater and potentially contaminate the environment around the plant. [19]

Figure 1 shows a timeline that starts with the invention of the first plastic material, followed by its evolution through applications like Tupperware containers and single-use cups and bags. The timeline progresses to the discovery of plastic litter, eventually leading to the first single-use plastic ban.

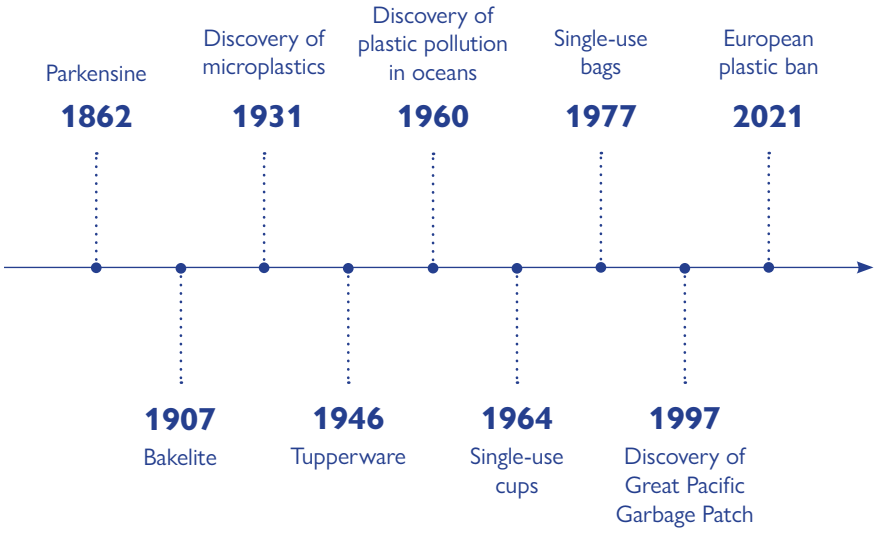


Figure 1. History of single-use plastics

2 Solutions

2.1 Recycling

The recycling norm is widespread and can help keep resources in the economy. However, it is only an end-of-pipe solution with many problems related to the usage phase being neglected [20]. Besides this, in contrast with e.g., aluminium or glass, no plastic material can be endlessly recycled without losing some of its quality, which is called downcycling. Downcycling refers to the process where materials, when reprocessed from waste, experience a reduction in quality compared to their original state. This quality degradation can be categorised into three types: thermodynamic downcycling, functional downcycling, and economic downcycling [21]. Often, recycled plastics are mixed with virgin material to make them keep their quality and be usable, but even then they can only be recycled once or twice [22]. Chemical recycling, in contrast to mechanical recycling, offers the potential for significant enhancements in preserving material quality. However, further research and development are necessary to establish efficient processes and feasibility [23]. At this moment, only 9% of plastic waste is globally being recycled, while the rest ends up in landfills, leaks into the environment, or eventually gets incinerated [24]. Thus, we can conclude that the recycling of single-use products is not an adequate solution to the problem of excessive waste and resource depletion. As plastic is a very suitable material for many reusable purposes, it is much more beneficial to combine recycling at the end of life with the elongated use of plastic reusable products.

2.2 Regulation

Various actions and regulatory measures have been taken to counter plastic pollution, such as the European ban on several types of single-use plastics, e.g., plates, straws, cutlery, and balloon sticks [25]. Additionally, the same measure applies to cups, food, and beverage containers that are made of expanded polystyrene, and all products made of oxo-degradable plastic [26]. As a result, disposable products from other materials (e.g., paper straws and bags, and wooden cutlery) came into scope. However, for example, paper bags consist of more material, and their production costs more energy and water than single-use plastic bags [27]. This means they are not necessarily more environmentally friendly than single-use plastic bags, assuming they are disposed of correctly. The same goes for other disposable products such as paper straws [28]. Plastic straws have been replaced with paper straws in pubs and restaurants with the intention of doing good, but in reality only increasing the negative impact on the environment. Also, consumers are often not aware of the actual impact of certain materials or products, resulting in well-meant but un-

environmentally friendly behaviour, for example by choosing a single-use paper bag over a plastic bag [29]. This way, regulations unintentionally foster misconceptions. Consumers might inaccurately assume they are making the most sustainable choices when another alternative, such as a reusable product, would be preferable [30].

2.3 Alternative materials

Single-use products made of biodegradable or compostable materials have become increasingly prevalent. However, many eco-friendly claims are a form of greenwashing. For instance, in Brazil, a large number of plastic straws have been replaced with so-called biodegradable alternatives, that in fact do not live up to their promises [31]. Moreover, there is some confusion about the difference between materials that come from non-fossil fuel sources, known as 'biobased', and materials that can biodegrade. The problem with biobased materials is that although they are made from natural components, the end product is still as harmful and unbiodegradable as regular plastics. Compostable products are also not the perfect solution, since they rely on proper collection and processing, which, unfortunately, does not occur as frequently as it should. In conclusion, single-use items made of paper, cardboard, or bioplastics are not the solution to waste. Apart from single-use plastics, we decided to focus on disposable products made of other materials as well when tackling the environmental, social, and economic problems related to our throw-away culture.

2.4 Circular economy

Instead of prioritising end-of-pipe solutions such as recycling, continuing our wasteful behaviour with so-called biodegradable products, or creating unintended consequences with not well-thought-out plastic bans, one should take a step back and approach this global environmental problem from a more systemic perspective by following the principles of the circular economy. In a circular economy, products and materials are retained in the system through practices such as maintenance, reuse, refurbishment, remanufacture, and eventually recycling [32]. Recycling is the last step according to Ellen McArthur Foundation's Butterfly model (Figure 2) [33] and ranks third in the five-level waste hierarchy according to the European Waste Framework Directive, with waste avoidance and preparation for reuse placed higher in the hierarchy [23].

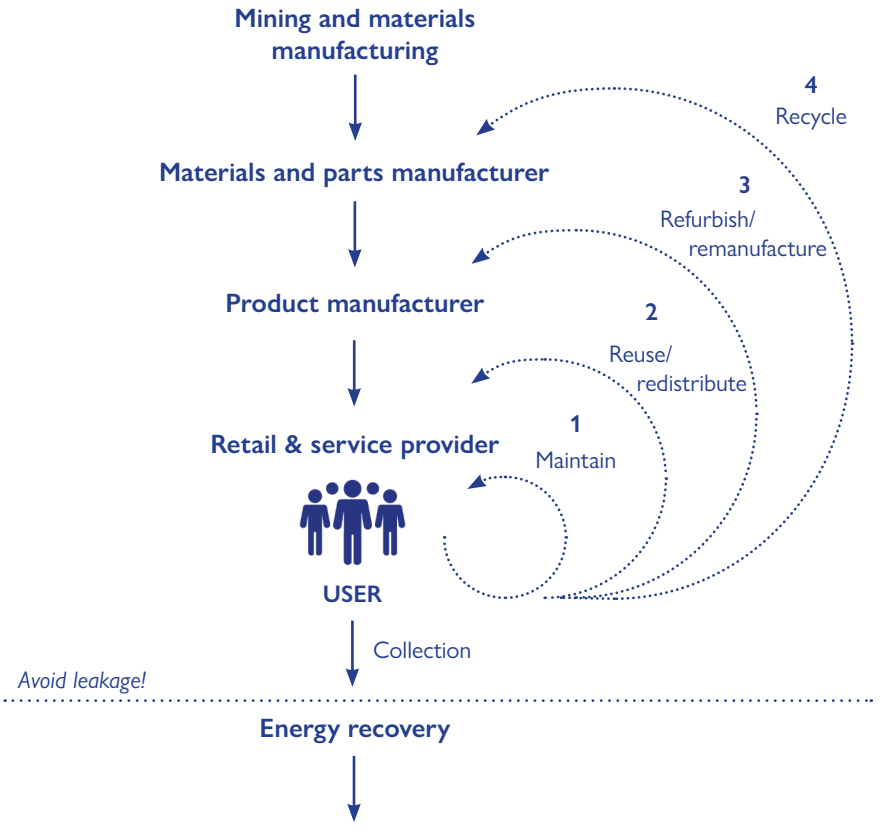


Figure 2. Technical cycle, based on butterfly model Ellen McArthur Foundation [33]

In a linear economy, the material throughput is fast, with fast design, manufacturing, consumption, and disposal. When product lifetimes are very short, many valuable materials and other resources such as water and energy are wasted. The core of the circular economy is optimising the use phase of products, by extending and intensifying it, and reconsidering consumption practices [34]. This can be done by introducing reusable alternatives to single-use products as a way of keeping resources in the loop longer. Reuse has proven to be more effective than recycling, most prominently in waste reduction and resource conservation [35]. It is also increasingly emerging as a solution for addressing plastic pollution. The global market for reusable packaging alone is forecasted a compound annual growth rate (CAGR) of 6,4% over the period 2022-2030, responding to the increasing demand and shift in consumer behaviour [36].

3 Reusable products

And now, we find ourselves back at the starting point of this introduction, once again appreciating the value of materials and considering disposable products as wasteful, much like we did in the past. Reusable products have the potential to reduce the need for single-use products, thereby saving energy and resources, and preventing waste. However, reusables are not automatically environmentally friendly, and there are several pitfalls to take into account when developing alternatives to single-use products.

3.1 pitfalls

Break-even point

Reusable products must be used long enough for them to be more beneficial for the environment than their single-use counterparts. They often consist of more material to withstand multiple uses and their production is typically more energy and water-intensive [37]. The use phase itself has an environmental impact as well, for example, because the product needs to be cleaned after each use [38]. The amount of use cycles a reusable product should at least endure is what we call the break-even point or payback moment [39,40].

Products that make use of fast-paced technology (e.g., smartphones) or products related to high energy use (e.g., refrigerators), have an appropriate or optimal lifetime which often differs from the maximum lifetime. Upgrading to a more energy-efficient alternative can be more environmentally beneficial than continuing to use the old product [40]. Reusable alternatives to disposable products usually have no technology- or energy components, which equals the optimal product life with the maximum product life. However, no product can last forever, so in addition to extending the lifespan of reusable items, it is crucial to integrate reuse with complementary strategies and ensure recyclability at the end of their lifecycle [41].

Reusable products should be designed in a way that they have the potential to reach their break-even point in the first place. In the case of, for example, beeswax wraps, tote bags, and bamboo straws, it has been shown through lifecycle analyses (LCA) that the break-even point cannot be reached because of used energy and resources during production and the intensive manual washing after each use [39,42]. This does not imply that the single-use variant is the solution, but that other materials need to be considered for reuse, for example, those that are dishwasher compatible such as metal or glass. Thus, it is important to research different reusable products before purchase because some have larger impacts than others.

Atypical behaviour

When someone needs a single-use product only once or very rarely (e.g., only using single-use cups when travelling), it might not be beneficial to buy a reusable product as the break-even point is difficult to reach. In that case, if possible, a fully biodegradable, edible, or compostable single-use product might provide a better solution. Another option is a sharing system where the reusable product is used by multiple users.

Sometimes people own reusable products but continue to buy single-use alternatives, for example, owning and using a reusable water bottle but still purchasing and consuming bottled water [43]. When people receive reusables for free, this can change their attitude and increase the chance of using the product, but it also creates the risk of piling up multiple reusable products such as coffee cups or tote bags. Sometimes the additional products are used within different contexts of use, but often they are not used at all. Another cause of owning multiple reusable products with the same purpose is when someone replaces their product with a newer, trendier, or better alternative. An example is the current hype of the Stanley Cup [44], a thermos bottle that many people buy even while already owning a similar product, or the same product in a different colour. In some cases, people abandon their reusable product completely and go back to single-use. [41]

Obsolescence

As we discussed earlier, a true throw-away culture emerged during the last century, where next to the excessive usage of single-use plastics, the concept of planned obsolescence came into scope: products that are meant to last are deliberately designed to prematurely lose their functionality (shortened technical lifespan), so people are forced to buy new products. Obviously, this trend has detrimental effects on the environment and is untenable from a resource perspective. Both planned obsolescence and the introduction of single-use products are the results of an economic system based on fast throughput and ever-increasing sales.

Planned or forced obsolescence is not the only type of premature product disposal, as relative obsolescence also exists. It means that consumers discard products before they stop working. This can be due to dissatisfaction with the product or changing needs. However, people also tend to replace products out of a desire for the newest fashion (psychological obsolescence) or technology (technological obsolescence). In addition, the low cost of replacing products compared to repairing them (economic obsolescence) in combination with a busy lifetime and general shortage of time reduces the effort people want to put into maintenance. [45,46]

Regarding reusable products, people tend to replace functional products with newer, trendier, or more aesthetically pleasing alternatives. Sometimes this comes from the sentiment to remove all plastic products from their lives, even durables. For example, they buy reusable glass jars instead of using plastic boxes they already own or replace their lunchbox with a metal one [47]. This is partly the result of marketing, blogs, and a rising interest in the market of reusable, 'eco-friendly' products.

Rebound effects

Often, when products become more resource-efficient, this is counteracted by increased consumption of said product, which is called the 'rebound effect' [48]. Because of the growth principle, when efficiency increases, usage will often also increase. In the context of reusable products, this could result in people cancelling out the environmental gain of using reusable products with behaving less environmentally friendly in other ways, for example by buying multiple reusable products with the same function as mentioned in the previous paragraph.

Accessibility

Alternatives are not always there and are often less convenient than single-use products [3]. Besides, reusables often cost more than disposables, which can exclude consumers with lower incomes. Additionally, many people do not live near, for example, zero-waste stores or sustainable product shops.

Greenwashing

The market share of reusable products is growing and with it the risk of greenwashing. Some companies distribute branded items like tote bags, coffee cups, or drinking bottles for free to project a green image or boost brand awareness [49]. Moreover, many products are often poorly designed, lacking a genuine focus on long-term reuse, but are created simply to capitalise on the current trend of sustainability.

4 This research

Most research on consumer behaviour has been done from a marketing perspective, focusing on the acquisition of products and ignoring user behaviour and routines such as maintenance, care, repair, and disposal [46]. From a consumer psychology perspective, the majority of research handles willingness or intention to adopt, rather than actual behaviour. Within the field of product longevity, it is recognised that addressing consumer behaviour after acquisition is necessary for successfully elongating the lifespan of products. However, most research on product longevity up until now has been focusing on electric appliances or other consumer durables. The shift from single-use products, deeply ingrained in culture and society, to reusable alternatives requires users to undergo a significant change in behaviour and routines, often more disruptive than with other product types. Also, if users neglect or do not use their reusable products, they often go back to single-use [50]. The combination of reducing the use of single-use products, while elongating the use of reusable alternatives, proves to be an interesting research gap to investigate.

4.1 Research objectives and questions

This research analyses the motivators and barriers to the sustained (long-term) usage of reusable alternatives to single-use products. The objective is to better understand user behaviour, practices, and habit formation, formulate recommendations for designers, and provide assistance in designing for long-term reuse. Consequently, this research contributes to the knowledge related to the 12th Sustainable Development Goal: Responsible Consumption and Production [51] and is in line with the upcoming UN plastics treaty [52]. We seek answers to the following main research questions.

RQ1: What are the motivators and barriers to the long-term usage of reusable alternatives to single-use products? Or, in other words, why do people stop using SUP alternatives before their break-even point?

RQ2: How do motivators and barriers to long-term reuse vary between types of products, contexts, and users?

RQ3: How can designers be supported by the results of this research in developing products/services/product-service systems that enable long-term reuse?

To delimit our research scope, we decided to focus on products that are in users' sole ownership. This allowed us to explore the obstacles that arise when users are

responsible for all aspects of the use phase, including maintenance. We integrate product-service systems as potential solutions in our recommendations, dependent on the user, product, and context. Besides this, we investigate a wide range of reusable products as opposed to focusing on products from one sector, as is usually done (e.g., food packaging). This way, we aim to make a distinction between typical barriers to long-term reuse for different types of products and contexts of use.

4.2 Methodology

We employ a mixed method approach because we believe this leads to better, complementary results, and it is valuable to learn and understand a wide range of qualitative and quantitative research methods during the doctoral trajectory. The PhD is situated in applied research, trying to find explanations for behaviour (discontinuing the usage of reusable products) and creating a framework to make it usable for users, design practitioners, and researchers.

The research design is composed of five research cycles. The first cycle consists of a qualitative exploration of users and barriers (focus groups n=3). This is followed by qualitative research with consumers, investigating the barriers and motivators to long-term use of reusable products, which we approach from a user, product, and context perspective (interviews n=32). Simultaneously, we employ a quantitative study to investigate cultural differences and user segmentation according to SUP-avoiding intentions and reuse behaviour (survey n=3000). The fourth cycle considers more specific cases in which we experiment with different methods (surveys, interviews, diary studies). The fifth cycle focuses on the design component. We explore tools (design assignment with survey n=87) and develop a framework based on our findings and further reasoning (with preliminary expert verification and iterations).

RC1-RC4 applies a research in design context methodology, to answer RQ1 and RQ2. In the confirmative part, these findings are justified, validated and consolidated. RC5 has the ambition to answer RQ3 and is structured using a design-inclusive research approach [53]. Based on the theoretical understandings, a framework is designed to enable designers to see the logical connections between all identified variables.

Reliability and validity

To improve reliability, we employ different (mixed) methods, take large sample sizes, do research over time, and have multiple researchers assist with executing the research and analysing the data. To improve validity, we start from behavioural

models from social psychology to finetune our interview guides and survey, and use existing scales and constructs for our questionnaires. We always compare the results with existing research (construct & content validity). We carefully select respondents for all research activities by using quota or making a participant selection based on observations or a questionnaire to avoid sampling bias.

To improve internal validity, we specifically test people's experiences in the real world. The externalities that can influence the respondents' answers are part of what we want to research. With diary studies, people know they are being studied and might change their behaviour (e.g., due to social desirability bias, or the Hawthorne effect [54]). However, we specifically ask them to write down real-time positive and negative experiences and do not necessarily count how often they use the product. We also do in-depth interviews with each participant after every diary study to ensure we have all information on their honest experiences. For the survey, we offer cross-national validation of the findings, increasing external validity.

Reproducibility

For each of our research activities, we describe how we collected and analysed our data, step by step. The methodology section of each paper in this thesis includes the type of research, the methods, how we selected the participants and their demographic characteristics, the materials and procedure we used, and how the data was analysed and by whom. The raw data is always available on request.

4.3 Outline

The structure of the thesis is presented in Figure 3. The five research cycles are reported as five main parts of the thesis, with a 6th part consisting of a conclusion and personal reflection. An overview of the research methods is shown in Figure 4.

Part one: exploration

Part one serves as an exploration of the initial two research questions, providing a foundation for subsequent in-depth research. In **Chapter 1**, we start with exploratory research by doing three focus groups (n=5) with students. This initial research cycle is dedicated to addressing research questions 1 and 2. In this stage, we explore barriers and motivators influencing the initiation and discontinuation of the use of reusable products. We examine a wide range of elements, including diverse user profiles, various product categories, and contextual factors. The paper *'Barriers to the continued usage of alternatives to single-use plastics by students in student housing'* is published in the proceedings of the 4th Product Lifetimes And The Environment Conference (PLATE 2021).

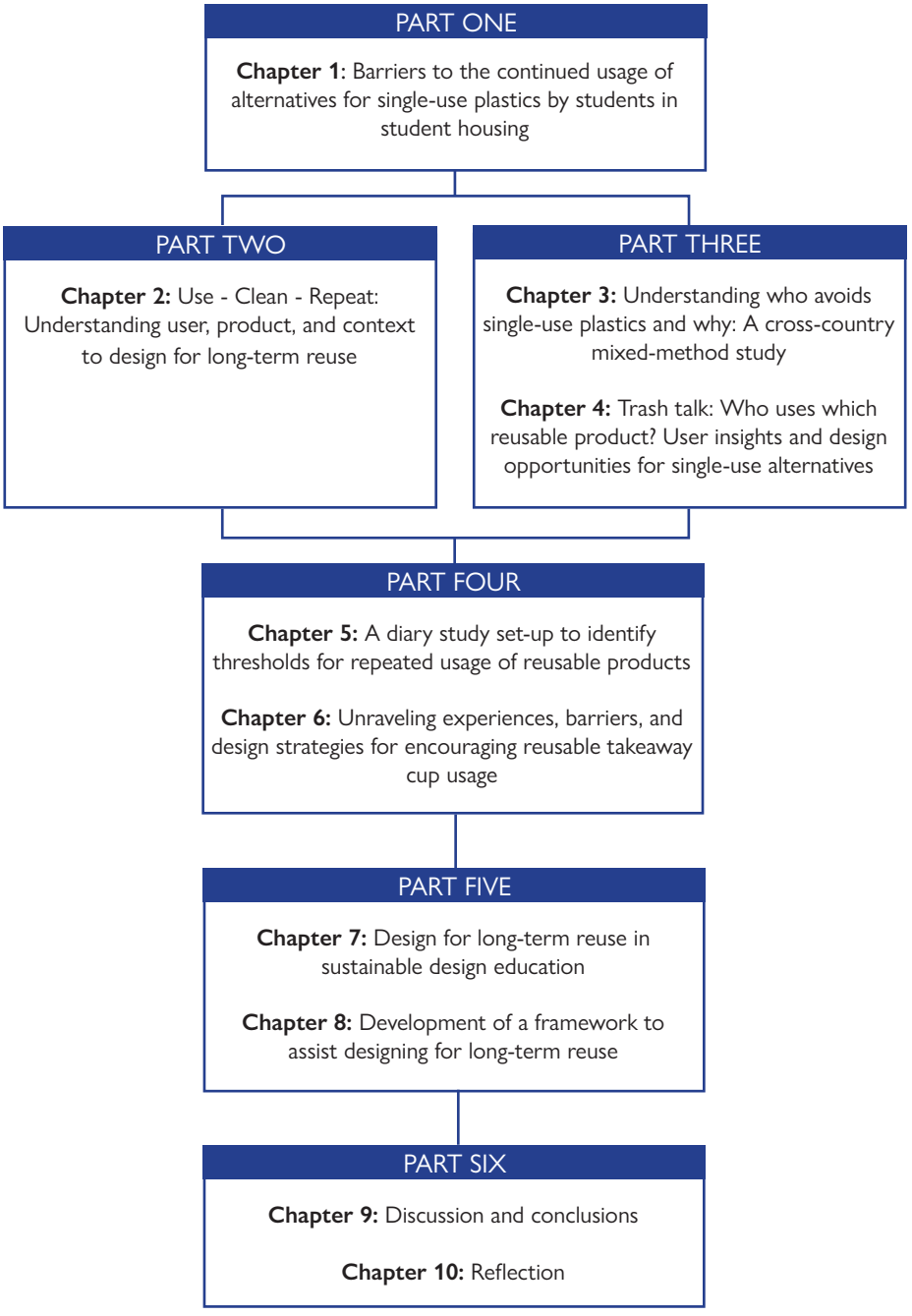


Figure 3. Outline of the thesis

In this first, explorative research activity within this doctoral research project, we are still finetuning the research questions and scope. Consequently, in this study, we focus on alternatives to single-use plastics in general, including compostable, degradable, and packaging-free alternatives. In subsequent research activities, we focus solely on reusable products as alternatives to single-use products in general.

Part two: user, product, and context

This part handles research questions 1 and 2 to a more in-depth extent. We look into barriers and motivators for long-term reuse from a product, user, and context perspective. In **Chapter 2**, we dive deeper into the barriers and motivators for long-term reuse by doing 32 in-depth interviews, addressing the acquisition, usage, and discontinuation of the use of reusable products. The results include a product categorisation based on typical barriers and contexts of use (i.e. at home, daily shopping, on the go, intimate care), a pathway towards long-term reuse including willingness, ability, and routine, and several recommendations for designers. The article '*Use – Clean – Repeat: Understanding user, product, and context to design for long-term reuse'* is published in Resources, Conservation & Recycling (2024).

Part three: user segmentation

In this part, we delve deeper into user insights by examining diverse cultures, looking into various types of single-use plastic-avoiding users, identifying the usage patterns of reusable products, and understanding individual preferences for product properties. **Chapter 3** encompasses a cross-national survey with 3000 respondents. We test a model with structural equation modelling, make a comparison of SUP-avoiding intentions and behaviour between countries (i.e. Belgium, Russia, and the U.S.A), and do a cluster analysis to distinguish four consumer segments (i.e. SUP addicts, SUP avoiders, apathetic, situation-driven SUP users). The results are published in the article *'Understanding who avoids single-use plastics and why: a cross-country mixed-method study'* in Journal of Cleaner Production (2023). **Chapter 4** describes the next part of the study, where we investigate to what extent reusable products are already established in society and what design properties users require. We compare the results between the user clusters from Chapter 3 and the three countries. The paper *'Trash talk: who uses which reusable product? User insights and design opportunities for single-use alternatives'* is published in the proceedings of the Design Society: International Conference on Engineering Design (ICED 2023).

Part four: cases

Part four examines the findings from the initial three sections within the context of specific products from each category. To investigate the long-term use, we employ a variety of methods, such as diary studies, interviews, and questionnaires.

In **Chapter 5**, we report the results of diary studies involving six participants. These studies aim to capture real-time, self-reported behaviour over three weeks using newly introduced reusable products. Each participant is assigned to use both an 'at home' product (food huggers) and an 'on-the-go' product (a reusable coffee mug, bread bag, or food wrap). The paper '*A diary study set-up to identify thresholds for repeated usage of reusable products'* is published in the proceedings of the 5th Product Lifetimes And The Environment Conference (PLATE 2023). **Chapter 6** investigates the reusable coffee cup using a mixed-method approach, employing structured interviews (n=58), a survey (n=300), and diary studies (n=8) with users, and in-depth interviews with baristas (n=8). Next to investigating preferences regarding single-use vs. reuse, we look at coffee-drinking experiences, habits, and routines as well. The paper *'Unravelling experiences, barriers, and design strategies for encouraging reusable takeaway cup usage'* will be published in the proceedings of the Design Society's Design 2024 conference.

Part five: design for long-term reuse

Part five is dedicated to addressing the third research question, seeking strategies to support designers in promoting the sustained use of reusable products by considering variables related to the product, user, and context. **Chapter 7** includes a study done within the course of Sustainable design, in the 2nd Bachelor Product Development at the University of Antwerp. We test various tools with 87 students to assist them in developing reusable solutions that have a greater likelihood of long-term success and ask about their experiences and evaluation of these tools afterwards. The tools are based on the findings from the previous chapters and the exploration with students serves as inspiration for the framework we present in Chapter 8. The paper *'Design for long-term reuse in sustainable design education'* will be published as an e-book proceeding of the EcoDesign 2023 International Symposium. In **Chapter 8**, we propose a framework for designers, with preliminary expert verifications and iterations. This was done by synthesising the results gathered through all research activities in this thesis. The framework helps to approach a reuse design challenge from all its perspectives and enables designers to achieve a more complete picture before making design decisions. We elaborate on how the framework was built and how it is used. The results from this chapter have not been published yet.

Part six: conclusions and reflections

This last, concluding part, consists of two chapters. **Chapter 9** contains the discussion and conclusions in which we formulate answers to the research questions, present the most important contributions and implications of this PhD research, and end with limitations and future research. **Chapter 10** encompasses personal reflections on the process of doing a PhD and growth as a researcher, designer, and person.

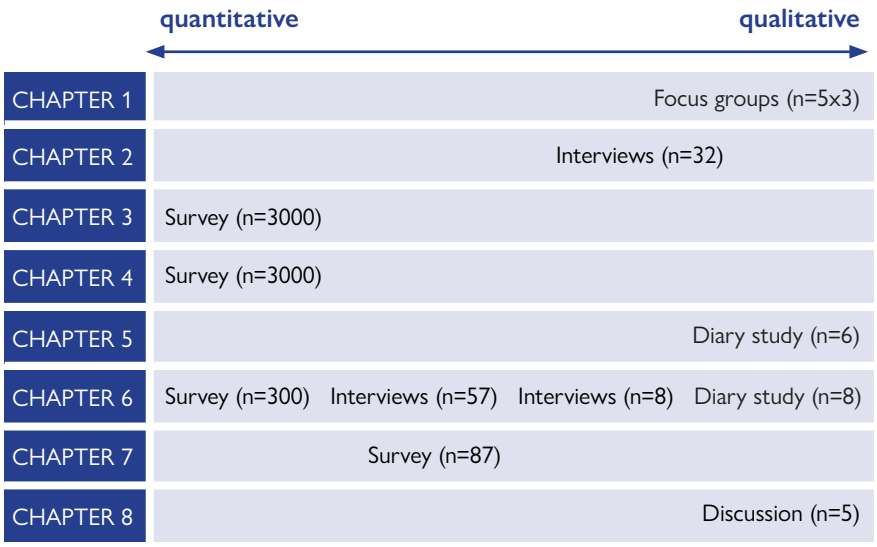


Figure 4. Employed research methods per chapter

4.4 Terminology and semantics

Context

What does 'context' actually mean? In this research, we use a broad definition of context and identify different levels, looking into both the physical and social environment. We focus on product usage and access (location of stores, infrastructure, acceptance), as well as people's personal context (financial situation, family situation, place of living). Context can also be seen as a broader societal influence, which is something we address but do not thoroughly investigate. As we focus on the experience and behaviour from the user perspective, we do not specifically address the business context.

Reuse

There can be confusion about the word 'reuse'. According to the Butterfly Model [33], reuse is equal to repurpose, when someone discards a product and it will be re-used by someone else. In our definition, reuse is more closely related to prolonged usage: we want products designed to be reusable to be used longer than they are now. This does not include reusing SUP. As we specifically focus on reusable alternatives to single-use products, we believe the word reuse is suitable in our context. We want people to make the transition from one-time use, to multiple-time use.

Long-term reuse

Throughout the papers in this thesis, we use the words 'continued usage', 'repeated use', 'long-term use', and 'sustained use', which reflects progressive insights over time, as well as our effort to convey nuanced distinctions in the duration and pattern of use. The term 'continued usage' typically suggests that a product or behaviour has been consistently used without a significant interruption. It implies a continual pattern of use and not necessarily a specific time frame. This is why, after the first paper, we opted to replace the term with 'repeated use', which suggests that a product is used more than once but does not necessarily indicate a specific duration or frequency. We use the term 'long-term use' because it implies the sustained use of a product or behaviour over an extended period and emphasises the temporal aspect more, suggesting that the product has been used for a considerable duration, whereas 'sustained use' implies that the product use has been consistent over an extended period. We think it is interesting to look at the nuances between these definitions when searching for the most suitable terminology. We decided on long-term and sustained usage, since for us, it covers the meaning the most accurately. Although consistency is important, not in the least for the reader, we also believe it is forgivable to use the words interchangeably, since the context often makes this nuance very clear regardless of the terminology used.

4.5 Research philosophy

In this section, I articulate my position as both a design researcher and designer within the broader scholarly landscape. I write this from my personal perspective.

Positioning

I believe that the material world outside humans exists, but that we have constructed ways to describe it. So everything we 'know' about the world, has been explained in a language we understand, such as mathematics. Although we strive for objectivity and universality in our understanding, there will always be limitations to the human perspective. A significant part of my research examines the explanations people give for their own behaviour, which are inherently coloured by human perception. The methodology I use is rooted in phenomenology, which studies conscious experience from a first-person viewpoint. However, whether the constraints on certain behaviours are objective or subjective does not change anything about the respondent's experience, leading to the concept of epistemological relativism, which suggests that people's experiences are by definition relative. My findings are shaped by people's mindsets, context, and momentary feelings, as well as my interpretations of their responses. Therefore, I can only speak of 'tendencies' and draw conclusions through reasoned analysis. It is interesting to see the limitations of striving for

'objectivity' when dealing with the personal experiences of human subjects, but I do not think this is necessarily the kind of knowledge that is most valuable for my purpose.

As a researcher, it is challenging to not influence your subjects while doing research, especially in qualitative studies that focus on intentions, perspectives, and self-reported behaviour. Even while making efforts to minimise this influence by, for example, preparing a detailed interview guide, I had to take this into consideration. In the realm of design, the influence on users can be bigger than, or different from, initial expectations. The world affects how individuals utilise products, and, in turn, designing a product can reshape the world. Design may even have the potential to redefine what we think it means to be human, shaping our behaviour as well. This brings us to the concept of ontological design, which states that 'we design our world, while our world acts back on us and designs us' [55]. This process is circular but evolving, like an endless spiral, never returning to its previous state. [56]

Ontological design

Ontological design is the discipline focused on shaping human experiences. It operates on the foundational belief that when we design objects, spaces, tools, and experiences, we are simultaneously shaping the very essence of the human being. It not only enhances our capabilities but also influences our thought processes and the values we hold. An evident illustration of this is technology, such as smartphones. Rather than merely meeting user needs, it plays a role in shaping those needs and actively curating the user's environment [57]. Regarding encouraging certain behaviours, such as long-term reuse, potential positive spill-over effects towards other sustainable behaviours could be 'designed', although at the moment this is mere speculation and should be further researched [58].

Human beings cannot exist 'outside the world', independently of their surrounding environment. Their behaviour is always interconnected with nature and other forms of life, and never expresses itself in a vacuum. Therefore, considering the context is crucial. Presently, we live in a throw-away society, where single-use alternatives, such as reusable products, are unconventional. Avoiding all single-use products does not align with current societal norms, and is often met with resistance from people reluctant to change [56]. In turn, the context in which people interact with products is influenced by the products themselves, presenting an opportunity for change through design.

By applying Ontological Design principles to the creation of reusable alternatives for single-use products, designers can not only provide users with eco-friendly

choices but also actively shape users' perspectives, behaviours, and attitudes. I believe this approach can contribute to a more profound and lasting shift away from single-use products and towards a culture of reuse and environmental consciousness.

5 State of the art

Below, we present the state of the art research regarding (i) the shift from (daily life) single-use consumer products to reusable products, (ii) product longevity and long-term usage, and (iii) design interventions and strategies for encouraging (long-term) sustainable behaviour.

5.1 Single-use to reuse

Previous research on barriers to the usage of reusable alternatives to single-use products mostly addresses the early adoption phase, not taking long-term reuse into account. Often, the focus is put on one sector, for example, food packaging [59] or household products [20]. Next to products meant for individual use, several research papers focus on refill systems as an alternative to disposable packaging [20,60,61]. Four business-to-consumer models are recognised and vary based on the reusable packaging being refilled by the user themselves or returned to the business, and whether the refill or return takes place on the go or from home: refill at home, refill on the go, return from home, and return on the go. With refill at home, users buy refills at the store and refill their containers at home. Refill on the go encompasses refilling away from home, such as at an in-store dispenser. In both models, the users are responsible for the reusable packaging, including maintenance and cleaning. In the return from home model, the reusable packaging is not owned by the user and is recollected from the user's home after use. Return on the go means that the user delivers the reusable packaging to a store or drop-off point. In these models, a service is responsible for maintaining and cleaning the product, and the user is not the owner. [62]

Methodologically, online surveys are used most often to uncover attitudes and behaviours towards reusable products, investigating attitudes towards different types of packaging and reuse models [61], the influence of emotional factors and social norms [63], and the role of context and culture regarding reuse behaviour [35]. However, the research remains rather fragmented, and more knowledge is needed regarding actual experiences with, for example, reusable packaging systems [60]. Consumer behaviour studies reveal that 85% of individuals express positive attitudes and an intention to purchase reusable packaging, but that the actual engagement with reuse systems is only 16% [64]. This is a manifestation of the 'intention-

behaviour gap' or 'attitude-behaviour gap' [65], which means people's intentions are not translated into actual behaviour.

Several studies use behavioural models to explain and predict pro-environmental/reuse behaviour, most commonly the Theory of Planned Behaviour [66], which has been applied to research single-use plastic bag consumption [67], SUP reduction intention [68], and the purchase of environmentally sustainable products [69]. COM-B and the Behaviour Change Wheel [70] have been used to investigate single-use and reusable cup usage [71] and interventions to curb single-use plastic consumption [72] and improve the correct disposal behaviour of compostable plastics [73]. The Comprehensive Action Determination Model (CADM) [74] has been used to explain waste prevention behaviour [75] and to develop strategies for reusable cup usage [76].

Motivators and barriers

The main barriers towards reusable packaging that have been identified in literature are inconvenience, unavailability, ineffective communication, and higher costs [59]. Also, extra time and effort, contamination risks, and visible wear and tear are mentioned, increasing consumers' concerns about safety and health [60]. Next to individual and product-related barriers, there are several contextual barriers, such as a lack of available infrastructure [77] and cultural barriers [35]. It is also important that people have the opportunity or ability to engage in a reuse system. For example, when the supermarket does not facilitate refill or the bakery or deli counter does not accept a reusable container because of hygiene concerns, the consumer lacks the opportunity to use the reusable product, and even with the best intentions, they are forced to return to single-use [61]. Next, current behaviours and habits linked to disposing of products make it difficult to adopt and keep on using reusable/refillable products [78]. This can result, for example, in forgetting the product when being in a rush. The implementation of new habits, which are needed for continued reuse, is often challenging for the user because of existing habits regarding single-use products. This results in people buying a reusable product with the intention to use it without actually using it, which relates to the previously mentioned intention-behaviour gap [65]. A change of environment can on the other hand disrupt already established sustainable practices towards reuse, and lead people to return to unsustainable use patterns [79]. Literature shows it is important to reduce barriers and promote enablers to encourage consumers' long-term usage [60]. For example, aesthetic aspects that can evoke product attachment are considered important motivators [20] and can counter some of the barriers. Furthermore, there is a need for more research on contextual factors [35] and on social aspects and the broader role of plastics in our society [80].

Interventions

Interventions described in literature that promote reuse and SUP avoidance are financial incentives (charges or discounts), providing the products for free, environmental messaging [81], participatory initiatives such as 'plastic-free July', and regulations and bans [72]. A combination of measures proves to be the most effective [81]. Techniques that have been shown to contribute to successful behaviour change interventions are social norms ('doing the right thing'), simplicity (strong and clear campaigns), and timing [72]. Other interventions include indirect incentives or penalties, highlighting the positive outcomes of not using produce bags, emphasising the availability of reusable bags, and prompting individuals to consider or visualise the negative effects of using single-use bags [82]. An increasing body of research underscores that when one wants to develop behaviour change interventions, it is important to have a thorough knowledge of the variables that influence the required behaviour based on scientific theory [83]. Interventions are increasingly described as theory-based, but there is still much unclarity on how a theory is chosen, and in what way it is used to formulate interventions [84].

5.2 Product longevity

Encouraging people to use their reusable products longer without going back to single-use or prematurely disposing of their product before the break-even point has been reached, is a way of slowing the resource loop [34,85]. As a result, less products need to be produced. It contributes to the goal of decoupling from the exponential use of resources, ensuring resource efficiency is not offset by increased consumption (rebound effect), and shifting towards 'slow consumption' [48]. The field of Design for Longevity includes researching how to successfully elongate product lifetimes [86]. Up until now, the majority of research on design for product longevity is about long-lasting, durable products that are considered useful for a long period of time, such as furniture, electronics, and household appliances [87].

Design for Longevity

Long-term usage is highly dependent on product lifetime, consumer replacement behaviours, and contextual factors. Design for Longevity starts with the question 'Why do people discard products?', which is either due to physical failure or due to emotional failure. Thus, design for longevity can be considered from both a technical and an emotional perspective. From a technical perspective, it focuses on developing durable products that can withstand wear and tear, are resilient, and can adapt or be repaired when damaged. First and foremost this is done by selecting qualitative materials and mechanics, but it also includes design for upgradability and adaptability, which allows further expansion and modification of the product

[87]. Next to this, it includes enabling efficient cleaning and maintenance, and optimisation of the logistic chain (e.g., a beer crate to protect the glass bottles during transport). When products are not able to reach their optimal lifespan, we speak of absolute obsolescence (obsolescence of function or quality).

When products are being replaced because of emotional failure, we speak of relative or perceived obsolescence. Studies have shown that next to dissatisfaction with the product, a desire for fashion and new technology can result in the early replacement of a functional product. Next to this, many consumers are sensitive to low prices at the expense of quality, have low expectations of product life spans, desire periodical change in their possessions, and have harried lifestyles and a general lack of time. Many people fail to do regular maintenance and are not aware of repair options. The acquisition of poorer quality products can lead to more rapid disposal, decreasing people's trust in the product and creating habits of replacing products early [46]. Also, social aspects, consumerism and the throw-away society influence people's replacement behaviour, feeding the desire to own new things. Related to the physical product, aesthetics, weight, and tactility also influence how long a product is kept before disposal.

Interventions

Product attachment

To elongate product lifetime from an emotional perspective, designers can play with the concept of product attachment, which manifests itself when a user has a strong relationship with a product and is more likely to care for it than for other products. This results in better care, reparation when possible and postponing replacement, which creates (indirect) product longevity [88]. The product's meaning for the owner transcends the purchase price or economic worth of the product. The product becomes irreplaceable, and a new, physically identical product loses its symbolic value as the feelings and memories related to the product are not present in the new product [89]. A lack of product attachment can result in products being treated more poorly and discarded earlier. It can even go so far that people will deliberately mistreat their products to break them earlier and have a reason to replace them [90]. Potential strategies for increasing product attachment are matching the product with the owner's identity, and making personalisation possible. Next to this, timeless design, modularity, and the use of specific materials that show less wear and tear can prove to be effective [91]. However, product attachment can also have undesirable effects and can lead to the accumulation and storage of items that are seldom used. Because of the emotional bond, people rather store it than bring it to second-hand shops, impeding the possibility of reuse by someone else. This is called 'product hibernation' [91,92].

Business models

New business models for reusables that work with a product-service system, for example through leasing or renting, can elongate a product's lifetime, but are difficult to implement and are relatively unknown. For example, many companies that want to transition to a circular business model, lack knowledge and financial capacity. Besides this, they depend strongly on other actors in the value chain, which complicates the process [93]. Moreover, not all products are suitable for product-service systems (for example when they are considered personal) [94], and products that are usually sold for sole ownership are likely to be rejected by consumers because they are unfamiliar with the product being offered this way [95]. Additionally, when a service promotes frequent replacement, users may abuse and neglect the product, because there is a fixed longevity through the service [87].

Second-hand market

Product longevity can also be reached when the products get a second life with another owner, for example when the user gifts the product to friends or family, or brings it to second-hand shops. A changing life situation, style, materials, motivations, and emotions all influence the re-domestication of second-hand products in new households [96]. The second-hand reuse of unwanted but functional products is in general considered less wasteful than single-use, but previous owners rely on other people to use their 'waste' [46], and there is no guarantee the product will be reused. Although reuse through the second-hand market is beneficial from a social and environmental perspective, buying new products and offering them second-hand to buy more new products is not sustainable and bypasses slowing the resource loop.

5.3 Design strategies

Below, we present some strategies from design and other disciplines that are used to influence people towards more sustainable behaviours and use patterns: design for sustainable behaviour, design for behaviour change, and nudging. We selected them based on their potential in our case of elongating reusable product usage.

Design for Sustainable Behaviour

Design for Sustainable Behaviour (DfSB) is an interdisciplinary research field that investigates how consumers' sustainable behaviour and activities can be influenced, often with a focus on the interaction with a product. Most DfSB strategies and tools follow one or more of four basic principles [97]: (i) make adopting a desired behaviour easier, (ii) make performing an undesired behaviour more difficult, (iii) create a willingness to perform a desired behaviour, and (iv) minimise the appeal to an undesired behaviour.

Design for Sustainable Behaviour strategies are typically placed on a scale from 'user in control' to 'product in control' [98]. Different versions of the same set of strategies have been developed, always ranging from informing to persuading to determining: information, feedback, enabling, encouraging, guiding, steering, forcing, and automatic [99]. In order to make informed decisions on what strategies may be the most suitable, Daae and Boks [100] developed a set of dimensions that assist the designers in better understanding the target group (what is going on in their mind) and context (what is going on around them) in which the product is used. Most research in this field has been addressing behaviour related to energy, water, food, or product efficiency, and mainly on the interaction with the product itself (often electric appliances). Besides this, the strategies do not necessarily focus on long-term or repeated behaviour. The lack of research on reusables could be explained by the field's focus on interesting and complex interactions during the use phase, while reusable products are often very simple products. However, the dimensions of behaviour change are more adapted to the context of designing for a circular economy, including elongating reusable product usage [101].

Designing for Behaviour Change

In the broader field of Designing for Behaviour Change, more emphasis is put on changing habits, and how products assist people to take action and adopt new behaviours. The field typically applies insights from behavioural economics and psychology and combines them with the principles of product design and development [102]. An example of a tool focused on supporting changing behaviour through design is Fogg's Behavioural Wizard [103], and his behavioural model for persuasive design [104]. It is important to keep in mind that habit formation is not the only way to achieve behaviour change, as learning, knowledge, status quo bias, preference, technology, commitment devices, social influences, and changes to choice environments are alternative mechanisms that can lead to behaviour change as well [105].

Nudging

When governments, marketers, or designers introduce changes in the environment to guide and enable people to change their behaviour, we speak of Nudging. Nudges influence the way in which choices are made, without restricting or forcing the individual. Yet, the presentation or framing of options steers people toward particular directions. Nudging can be done by, for example, simplifying information or offering default choices to facilitate socially desirable decisions. Often, nudges are used to benefit society and the individual's own (long-term) interest [106]. Typical nudges are providing incentives and defaults, understanding mappings, structuring complex choices, giving feedback, and expecting errors. Examples of nudges in the

context of reusables are providing discounts for using reusable cups for takeaway coffee, creating more attractive designs of reusable products, and putting them in a more prominent place in the store. The concept of nudging is not uncontested, as critics argue that nudging is manipulative, violates human dignity, and hinders more crucial structural reforms. On the other hand, certain nudge policies may enhance decision alignment with individual goals, improving decision-making, and thus reinforcing autonomy and agency [107]. In the context of sustainable behaviour, nudges have been mainly used in sustainable consumption domains such as energy use, food, and mobility. There seems to be a consensus that nudges are best used alongside traditional policy instruments (laws and regulations) and economic tools (e.g., fiscal incentives) [108].

5.4 Positioning in research field

Figure 5 below illustrates the gaps (uppercase blue) in each research field that we address within this doctoral research, based on the previous paragraphs.

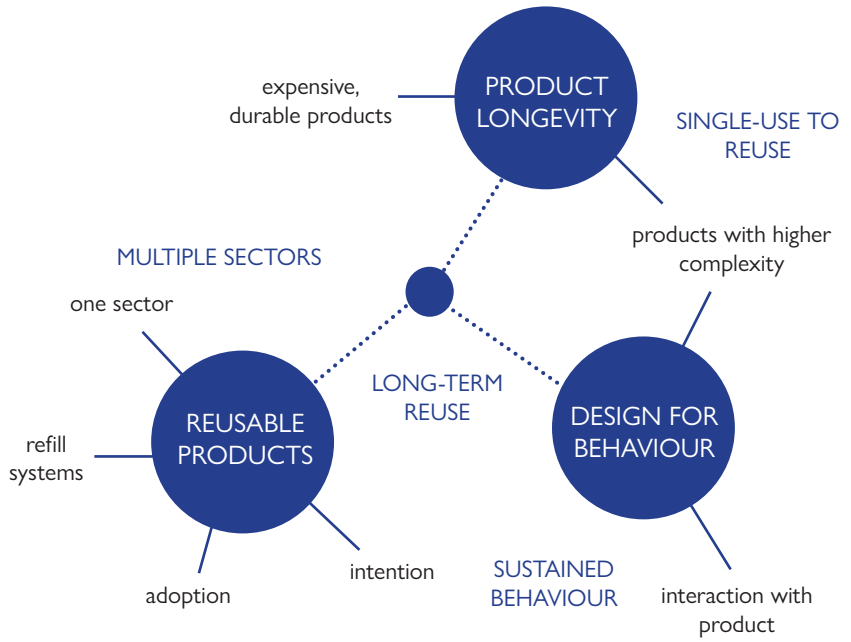


Figure 5. Gaps in main research areas

PART ONE

Part one serves as an exploration of the initial two research questions, providing a foundation for subsequent in-depth research.

In **Chapter 1**, we start with exploratory research by doing three focus groups (n=5) with students. This initial research cycle is dedicated to addressing research questions 1 and 2. In this stage, we explore barriers and motivators influencing the initiation and discontinuation of the use of reusable products. We examine a wide range of elements, including diverse user profiles, various product categories, and contextual factors. The paper '*Barriers to the continued usage of alternatives to single-use plastics by students in student housing*' is published in the proceedings of the 4th Product Lifetimes And The Environment Conference (PLATE 2021).

In this first, explorative research activity within this doctoral research project, we are still finetuning the research questions and scope. Consequently, in this study, we focus on alternatives to single-use plastics in general, including compostable, degradable, and packaging-free alternatives. In subsequent research activities, we focus solely on reusable products as alternatives to single-use products in general.

L. Herweyers, M. Das, S. Bevers, F. Dries, I. Moons, E. Du Bois, Barriers to the continued usage of alternatives for single-use plastics by students in student housing, Product Lifetimes and the Environment (PLATE21) (2021). https://doi.org/10.31880/10344/10178.

CHAPTER ONE

Barriers to the continued usage of alternatives to single-use plastics by students in student housing

Laure Herweyers, Marie Das, Sterre Bevers, Free Dries, Ingrid Moons, Els Du Bois

Abstract: Following the ban on multiple single-use plastics approved by the European Parliament in 2019, effective alternatives will be necessary by 2021. Unfortunately, already existing alternatives are not always used in a sustainable manner. This study is a first attempt to seek answers to the following questions: (i) What thresholds prevent the (continued) usage of alternatives to single-use plastics? (ii) How do different types of ecological users perceive these thresholds, and what are the differences between these groups? (iii) What is the relation between the perceived level of behaviour change and the type of sustainable intervention in the lifecycle of these products? Several existing alternatives are discussed during three focus group sessions (n=5). Part of these products are selected from the Ubuntoo platform, which collects the newest innovative solutions against plastic pollution. This way, both common (e.g., reusable drinking bottles) and less common (e.g., refillable coffee pads) products were investigated. Participants were clustered according to their ecological lifestyle into three explorative focus groups: Eco 1 (least ecological), Eco 2, and Eco 3 (most ecological). The target group consisted of Belgian students who live in student accommodations. The key result of the study indicated that the main thresholds are caused by a change of environment, the cost of the product, personal preference and the practical aspect of the use of the alternative compared to its single-use counterpart, although it is important to note that these results are preliminary. The thresholds should be further examined in the future by testing real-life solutions in the long term, with different target groups.

Keywords: single-use plastics; sustainable behaviour; consumer perception; usage barriers

1 Introduction

Plastics form the main source of litter found in oceans and inland waters [7]. Mass production of plastics started in the 1950s [109], and in 2015, up to 322 million tons of plastic were produced worldwide [110]. In particular, single-use plastics (SUP[1]) are a cause for concern since they are disposed of very quickly [111]. To tackle this problem, the European Union decided to implement a ban and in some cases tax on plastic bag sales [112]. Since the ban was put into practice, the usage has been reduced by two thirds [113]. Paying for plastic bags that were previously free of charge motivates customers to bring reusable bags [114]. In 2019, the European Parliament approved a new law banning multiple other SUP such as single-use cutlery, plates, straws, etc. [25]. However, based on several lifecycle assessment studies [115], it is known that a reusable cotton bag has a much higher environmental impact compared to a single-use low-density polyethene (LDPE) bag. To compensate for this higher environmental impact, the cotton bag needs to be reused 52 times [116]. To succeed in lowering the impact, it is not only necessary to persuade consumers to adopt reusable products but also to make them change their behaviour towards more sustainable patterns of use. Many recent studies on SUP alternatives have focused on the adoption and purchase intention, rather than the actual (long-term) usage of the products. Studies applying the 'Theory of Planned Behaviour' [117] concluded that a positive correlation is found between intention and behaviour [69], suggesting that the intention to use a SUP alternative can be a predictor for actual usage. However, challenges arise when attempting to include habits and long-term, repeated behaviour change in explaining and predicting continued use, since habit strength has a negative influence on peoples' willingness to change their behaviour [118]. The gap between environmental concern and the actual purchase and usage of sustainable products is called the 'Intention-behaviour Gap' [119].

1.2 Aim of the research

A substantial amount of research has been done on the sustainable purchase and adoption of SUP alternatives and other pro-environmental products. However, their continued usage has not yet been widely investigated. Regarding this longer-term usage and related behaviour, the following questions arise:

Q1: What thresholds prevent the (continued) usage of SUP alternatives?

[1] In Chapter 1 and Chapter 3, with 'SUP', we mean 'single-use plastics', while in the other chapters we use SUP to abbreviate the more general 'single-use products'.

Q2: How do different types of ecological users perceive these thresholds, and what are the differences between these groups?

Q3: What is the relation between the perceived level of behaviour change and the type of sustainable intervention in the lifecycle of these products?

Students are an interesting target group to investigate within this research [120,121], as they are often early adopters regarding more ecological lifestyles and are less likely to be fixed by too much routine behaviour [122].

2 Methods

Three explorative focus group sessions have been conducted at the University of Antwerp to carry out formative qualitative research, as it allows open discussion between participants. By applying this method, we could gain insights into the participants' shared experiences and views on their use of alternatives to single-use plastics. Within the target group of students, the participants were limited to those who live in student accommodation during the week. Contrary to students who still live with their parents, they have more freedom to make their own decisions about their (ecological) way of living. The ages of the participants ranged between 18 and 25 years old. Posters put up on the city campus of the University of Antwerp and social media posts were used to recruit participants for a short online questionnaire to determine their ecological mindset and current ecological behaviour. This short survey included a list of alternatives to single-use plastics. The respondents had to indicate which products they were already using. The list consisted of 7 products and there was an option to add extra products. If the respondents answered (less than) 1 item of this list, they were added to the eco 1 group. If they indicated more than 4 products, they were considered eco 3. The respondents who answered 2,3, or 4 products, were added to the eco 2 group. This division in groups is comparable to other research such as the five sustainable attitudes stages [123], where stages 0 (incorporative) and 1 (impulsive) were merged into 'Eco 1', stage 2 (imperial) and 3 (interpersonal) into 'Eco 2', and stage 4 (institutional) was translated into 'Eco 3 (Table 1).

Out of the 21 eligible participants of the questionnaire, three groups of five participants were selected and invited for the focus group sessions. The respondents did not necessarily need to have experience with all the products, since the focus groups were meant to explore their thoughts, empathy, and experience on and with the products. Single-use plastics were used as a reference point to discuss the alternatives. The discussions ran for 90 to 120 minutes and took place at the

University of Antwerp, in November 2019 (pre-COVID-19). From the participants selected for the third focus group (eco 3), two did not show up, resulting in a focus group session with only three participants. The sessions were audiotaped and transcribed afterwards. During the focus group sessions, the discussion was facilitated by a moderator. Next to the moderator, a timekeeper and notator were present. Based on the results of the different sessions, a comparison could be made to answer Q5 regarding the potential difference between different eco-lifestyles.

ECO 1	Students are unfamiliar with or not motivated by the subject of ecological living and sustainable behaviour. They need concrete examples of environmental impact and they focus on impact and implications directly on themselves. Sustainable living is perceived as difficult, time-consuming, and not a priority. They believe individuals have no control over (un) sustainable production methods and that changing consumption patterns cannot have any significant impact on the environment.
ECO 2	Students are more familiar with and motivated by the subject of ecological living and sustainable behaviour. They can process abstract environmental concepts if presented to them. They are occasionally engaged in ecologic living and believe individuals have little control or influence on the environment by changing consumption patterns.
ECO 3	Students are engaged in ecologic living and try to live as sustainable as possible. They believe that the individual is responsible for transitioning from a linear to a circular economy. They do extra efforts and are willing to pay more to prevent pollution.

Table 1. Descriptions of Eco 1, Eco 2, and Eco 3

2.1 Selection of alternatives

To get a broad varying selection of different SUP alternatives, next to a list of common alternatives (e.g., a reusable drinking bottle), the online platform 'Ubuntoo' was used to collect more innovative products that are less well-known (e.g., reusable coffee pads) [124]. The Ubuntoo platform was considered to be suitable as the platform is growing relatively fast and putting lots of effort into combining all products that support ending plastic pollution. Within the 821 solutions presented on the platform, only daily consumer goods were taken into consideration for this study. This focus was chosen because 64% of plastic products' end-users are households [125]. We decided to also include some biodegradable and 'naked' products (products without any packaging) to get an impression of the behavioural thresholds in comparison with reusable products. Since the remaining list of 42

product types was too large to discuss in detail during the focus groups, we decided to select products that are gender-neutral and within the life context of students, i.e. a menstrual cup was not selected. 17 products from the original 42 were discussed during the focus groups (table 2).

SUP ALTERNATIVES	
Reusable drinking bottle	Reusable take-out containers
Reusable food storage containers	Refillable coffee pods
Lunchbox	Refillable shampoo bottle
Reusable shopping bags	Shampoo/soap bare
Biodegradable take-away containers	Compostable coffee pods
Metal straws	Bamboo toothbrush
Reusable cups for events	Toothpaste tablets
Metal tea filter	Concentrated cleaning products
Zero co: eco-friendly cleaning/ body care	

Table 2. List of selected alternatives

3 Results

3.1 Causes of (un)successful adoption of SUP alternatives

The first question asked in the focus groups was: What holds you back from adopting or trying a SUP alternative? The answers to this question did not differ within but between focus groups. Eco 1 mentioned practicality as their main concern, followed by the extra effort needed, and the potential lack of hygiene. Two out of five respondents said that the cost of the product is a factor that holds them back in trying alternatives as well as their personal preference for single-use items. Two people mentioned that they were not sure whether their effort would have a real impact. The influence of the social environment (positive or negative) was mentioned as being a reason (not) to use alternatives. For Eco 2, cost is a recurring reason not to adopt an alternative, as well as extra effort, followed by practicality. Eco 2 answered personal preference (e.g., 'my bottled shampoo is better than any bar shampoo I tried') as well. Two out of five mentioned this as a reason why they would not adopt an alternative. In Eco 3, one person gave health and medical reasons as clarification on why they feel held back in trying new alternatives because their partner deals with severe allergies. One participant stated that the only reason not to try an alternative would be the lack of knowledge thereof. Some mentioned their personal preference for a single-use item as a reason not to use an alternative.

3.2 Reasons for giving up SUP alternatives

The participants were asked whether they ever stopped using an alternative for single-use plastics. Most of the reasons given by the participants could be traced back to the same cause: a change of environment, where their old patterns of use were broken and new habits would emerge. By moving from their parental home into student accommodation, participants suddenly had to do their own household chores. They experienced that effort is needed to maintain an ecological lifestyle. For example, a participant from Eco 1 buys sparkling water in plastic bottles because there is no room for a SodaStream in his room. A participant from Eco 2 does not use a SodaStream anymore because he would need to buy it for himself and it is too expensive. This led to a second observed reason to stop using alternatives: the cost of alternatives. Next, the practical aspect of alternatives was another reason to stop using them. One participant stated that he does not drink sparkling water from glass bottles because they weigh too much. Therefore, he buys plastic bottles. Another participant mentioned that he does not use a lunchbox because it takes up a lot of space in his backpack. In short, they stop using the alternative if they find it annoying or when it does not fit into their daily life or planning.

Another reason to stop using alternatives was personal preference. The participants would start using an alternative, but along the way, notice they do not like the product. As an example, a participant from Eco 3 explained she started using a shampoo bar. After using it a few times, she noticed that the formula would not work with her hair type. After testing alternative shampoo bars, she concluded that shampoo bars would not work for her, and gave up. In Eco 2, someone explained that she started buying bottled water because she did not like the tap water in her student accommodation. She later switched to a Brita-can to eliminate the problem and to avoid the usage of plastic bottles. Also, hygiene was mentioned, as some reusables are hard to clean. There were some slight differences between the three focus groups regarding the second research question. When participants from Eco 1 stopped using an alternative, they would not search for a better solution and only switch to another alternative if it was presented to them. This is in contrast to Eco 2, who put more effort into searching for a better solution for the alternative they stop using. When someone from Eco 3 stopped using an alternative, he or she often tested out different alternatives. They would actively search for the best solution.

3.3 Evaluation of the perceived required behaviour change

During the second part of the focus group, the participants had to collectively classify the selected 17 products in a matrix, with on the x-axis the required level

(difficulty) of behaviour change (low, low-medium, medium, medium-high, high), and on the y-axis the type of sustainable intervention in the product lifecycle (reuse, material optimisation, disposal). Every focus group classified each product in the same category on the y-axis, confirming their basic knowledge of the principle of product lifecycles. Differences were observed on the x-axis between Eco 1, Eco 2 and Eco 3, as can be seen in Figure 1. Participants in Eco 3 classified half of the products in the category 'low' and none in the category 'high'. They perceived the behaviour change as being less difficult. Eco 1 and Eco 2 both classified the products in the matrix more or less the same way. From the differences in classification between Eco 1, 2 and Eco 3, we can conclude that there is a gap in the perception of behaviour change between people with different levels of engagement in ecological living. Whoever is already engaged in ecological living and using most of the products, considers them as requiring less behaviour change since it matches their actual behaviour more.

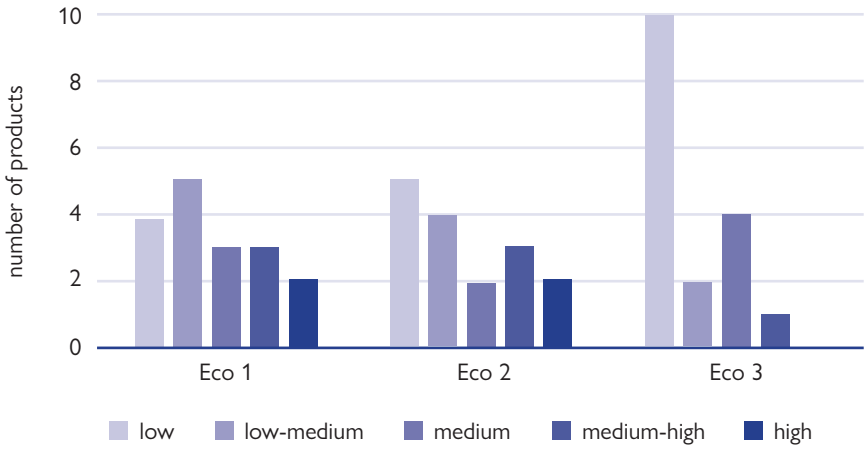


Figure 1. Classification of alternatives to single-use plastics according to their required behaviour change

3.4 Level of behaviour change in relation to type of impact

Products focusing on reuse were spread along the line of the level of behaviour change, from some products requiring almost no behaviour change (low behaviour change) to others being perceived as quite difficult and impactful on current patterns of use (high behaviour change). Products focusing on fewer materials/ resources were often put in de middle spectrum of behaviour change: low-medium to medium-high. Products focusing on disposal were all considered to require no or very little behaviour change.

4 Discussion and conclusion

The purpose of this study was to explore barriers that prevent the successful continued usage of alternatives to single-use plastics. There are two main findings to note from this study related to existing models and theories from behavioural psychology. People mostly stopped using products that require significant behaviour change and are considered less practical, showing us the importance of habit strength, convenience, and situational factors. Another interesting finding is the influence of a change of environment in this specific target group. It can be considered as a situational factor, as well as a habitual influence: the students' habits completely change, which makes it more challenging to keep sustainable practices, but also offers opportunities for creating new habits. These results are consistent with the CADM model for behaviour change from Klöckner and Blöblaum [74] and the Theory of Planned Behaviour [117], which offer the potential for further investigations. In addition, other causes for unsuccessful adoption are the cost of the alternative and the practical aspect of the use of the alternative compared to its single-use item (convenience). Consumers already showing pro-environmental behaviour are more likely to consider the adoption and longer-term usage of new alternatives easier and require less behaviour change, but are also more likely to find areas of improvement regarding their efforts for the environment. When designing reusable alternatives, hygiene and quality should be ensured to create product trust and consumer satisfaction.

Limitations of our exploratory study need to be acknowledged, most notably the relatively small sample (5 students in each focus group). The study was only conducted with students who are residing in student housing facilities, so no generalisations can be made about the whole population. This research should be repeated with a larger sample group and more participants per focus group. However, this exploratory, qualitative research enabled us to find a focus for further research activities. The preliminary findings, such as the influence of habit strength and change of environment, should be further investigated over a longer period of time. This research focuses on intended and reported behaviour, while more research is needed on actual and habitual or unconscious behaviour. Also, the impact of (the perception of) environment and context should be further investigated.

PART TWO

This part handles research questions 1 and 2 to a more in-depth extent. We look into barriers and motivators for long-term reuse from a product, user, and context perspective.

In **Chapter 2**, we dive deeper into the barriers and motivators for long-term reuse by doing 32 in-depth interviews, addressing the acquisition, usage, and discontinuation of the use of reusable products. The results include a product categorisation based on typical barriers and contexts of use (i.e. at home, daily shopping, on the go, intimate care), a pathway towards long-term reuse including willingness, ability, and routine, and several recommendations for designers. The article '*Use – Clean – Repeat: Understanding user, product, and context to design for long-term reuse'* is published in Resources, Conservation & Recycling (2024).

L. Herweyers, E. Du Bois, I. Moons, Use - clean - repeat: Understanding user, product, and context to design for long-term reuse, Resources, Conservation and Recycling. 204 (2024) 107511. DOI 10.1016/j.resconrec.2024.107511

CHAPTER TWO

Use - clean - repeat: Understanding user, product, and context to design for long-term reuse

Laure Herweyers, Els Du Bois, Ingrid Moons

Abstract: With escalating concerns about pollution and resource depletion caused by single-use products, the need to adopt reusable alternatives is widely acknowledged. This paper presents an investigation into the barriers and motivators to the long-term use of reusable products. The qualitative research consists of thirty-two semi-structured interviews with consumers, addressing the acquisition, usage, and discontinuation of the use of reusable products. From the results, we distinguished four product categories - intimate care, daily shopping, at home, and on the go - providing tailored insights into specific barriers. Next to this, we argue that willingness, ability, and routine are needed to increase the chances of successful long-term reuse. Based on these insights, we developed suggestions for designers including several design strategies and intervention points. We recommend incorporating the suggested product categories into future research, delving into persistent usage thresholds through case studies. Besides this, alternative reuse models should be further explored.

Keywords: barriers and motivators to reuse; product longevity; alternatives to single-use products; design for sustainable behaviour; circular design

1 Introduction

Disposable products, of which many are made of plastics, are omnipresent in our society nowadays [3]. Unfortunately, they have a detrimental effect on the natural environment in the form of excessive waste, pollution [11], resource depletion [126], and greenhouse gas emissions [127]. To tackle this problem, various actions

and regulatory measures have been taken, such as the European ban on several types of single-use plastics [25]. Besides the implementation of plastic reduction policies, innovation towards sustainable solutions is crucial [128]. Combined with an increasing consumer avoidance of plastic litter [129–131], both disposable products made of new materials (such as cardboard, bamboo, and hemp) and reusable products are gaining popularity [132]. However, while nine out of ten consumers have the intention of adopting a more sustainable lifestyle [133], they often lack knowledge of what is the most sustainable choice [29], which leads to inadequate behavioural choices [30,134]. Since disposable products made of other materials are not the solution for plastic waste [27], this research will focus on reusable alternatives to single-use products (referred to as SUP) in general and not solely single-use plastics. Examples of reusable products are reusable grocery bags, safety razors, menstrual cups, cloth diapers, reusable coffee cups, reusable water bottles, and reusable packaging.

Although reusable products provide a promising solution for replacing single-use products, each reusable item also comes with its own environmental impact [37]. They often consist of more resource-intensive materials, and water and energy consumption can be higher during the use phase (e.g., cleaning) [38]. In order to be better for the environment than their single-use counterparts, reusable products need to be reused a minimal number of times to compensate for their potentially higher environmental impact during the production and use phase [30]. For example, according to life cycle assessment (LCA) studies, a reusable metal straw has to be reused 50 to 100 times before its total environmental impact is the same as taking a new disposable plastic straw for each use [30,135]. Consequently, each time an alternative is reused, the overall environmental impact decreases [28], until a break-even point has been reached and the alternative becomes more environmentally friendly than the single-use product. In other words, to make reusable products a genuinely sustainable choice compared to single-use products, it is crucial to use them repeatedly over the long term.

1.1 Objective

In this research, we aim to understand the barriers and motivators for people to keep on using reusable products in order to create recommendations for designers to further explore how to go from single use to long-term reuse. Up until now, most research has either been focusing on the intention to adopt reusable products or the avoidance of single-use plastics, while we focus on the repeated usage of reusable alternatives beyond their initial adoption. We do so by investigating a wide range of reusable products as opposed to research focusing on products from one sector (e.g., food packaging). We formulated the following research questions:

Q1: What motivators and barriers influence the long-term use of reusable alternatives to single-use products?

Q2: Can we distinguish coherent categories of users, products, and contexts that relate to similar motivators and barriers?

Q3: Which design interventions can be formulated as an answer to these motivators and barriers, in order to establish the long-term usage of reusable products and avoid premature discontinuation?

1.2 Conceptual model

In our search for conceptual models that explain behaviour to build our research framework and interview guide on, we came across many studies that used the Theory of Planned Behaviour (TPB) [66] or extensions of this theory to study a range of environmental consumer behaviours [35,136,137]. Klöckner and Blöbaum [74] integrated TPB into the Comprehensive Action Determination Model (CADM), which also considers the influence of habits on behaviour [138] and makes a distinction between objective [139] and subjective constraints [140]. Other models focus more specifically on changing behaviour. This includes Fogg's behaviour model (B=MAP) [104], which focuses on designing a change in behaviour by starting from motivation, ability, and prompt, and COM-B [70], which involves three essential conditions for behaviour change: capability, opportunity, and motivation. While B=MAP is more suited for instant solutions for persuasion using in-the-moment triggers, COM-B is more focused on developing a broader behaviour change strategy to fill gaps in people's capability, motivation, or opportunity [141]. In this study, we chose to use CADM for structuring our interview guide, as we consider it the most comprehensive model for our purpose.

2 Materials and methods

We did semi-structured interviews to get in-depth insights into the motivators, attitudes, thresholds, and emotions of each respondent [142]. Each interview lasted approximately 60 min and theoretical saturation was reached after interviewing 32 participants. All the interviews took place with Flemish participants in Belgium (Flanders) in October and November 2020, using online video conferencing.

2.1 Participant selection

The respondents were divided into eight groups (personas) and selected based

on demographic characteristics and household situation. This was done to ensure diversity of the responses and to investigate the potential influence of children and other types of household members on sustainable behaviour [143]. (A) young starter without children, (B) couple with young children, (C) parents with adult children, (D) singles, (E) separated parent, (F) co-houser, (G) family with low income, and (H) retired, with four respondents for each category. To find suitable participants, we used the convenience sampling method. We requested acquaintances to propose friends or relatives, who we selected based on their availability and willingness to participate, and whether they corresponded well with the predetermined criteria. We invited the respondents through email and pseudonymised their names based on their persona type, number in the group (1–4), and gender (e.g., A_1_F = starter, 1st, female). 16 respondents were male, 16 were female. Eight were between the ages of 18 and 25, six between 26 and 35, three between 36 and 45, eight between 46 and 55, three between 56 and 65, and four were older than 65. See Appendix A for more demographic characteristics of the respondents.

2.2 Interview guide

The pretested interview guide was constructed around the general research design that is proposed in Figure 1. It consists of three main parts and can be found in Appendix B. We started with some general user-related questions (current ecological behaviour, single-use and reusable product use,…) after which we went deeper into the user-, product-, and context-related motivators and barriers towards the acquisition and repeated usage of reusable products, overviewing situational constraints, intentional processes, subjective and social norms, habits and asking more in-depth questions about the influence of self-related variables. Finally, we considered suggestions from the respondents for interventions to stimulate the future reuse process, their opinions on potential solutions, and product-related properties that they require from future reusable products.

2.3 Data analysis

The respondents gave consent to record and transcribe their interviews. We used NVivo software to code the transcripts for analysis. Both open and axial coding were applied. We constructed general codes beforehand, according to our model. Open coding allowed us to identify other variables and sub-variables systematically [144]. During the second step (axial coding), we looked for connections between the variables, either confirming or contracting the model. Transcription and coding were done by the three authors, while two other independent researchers assisted in finding connections. Appendix C shows an overview of the code tree.

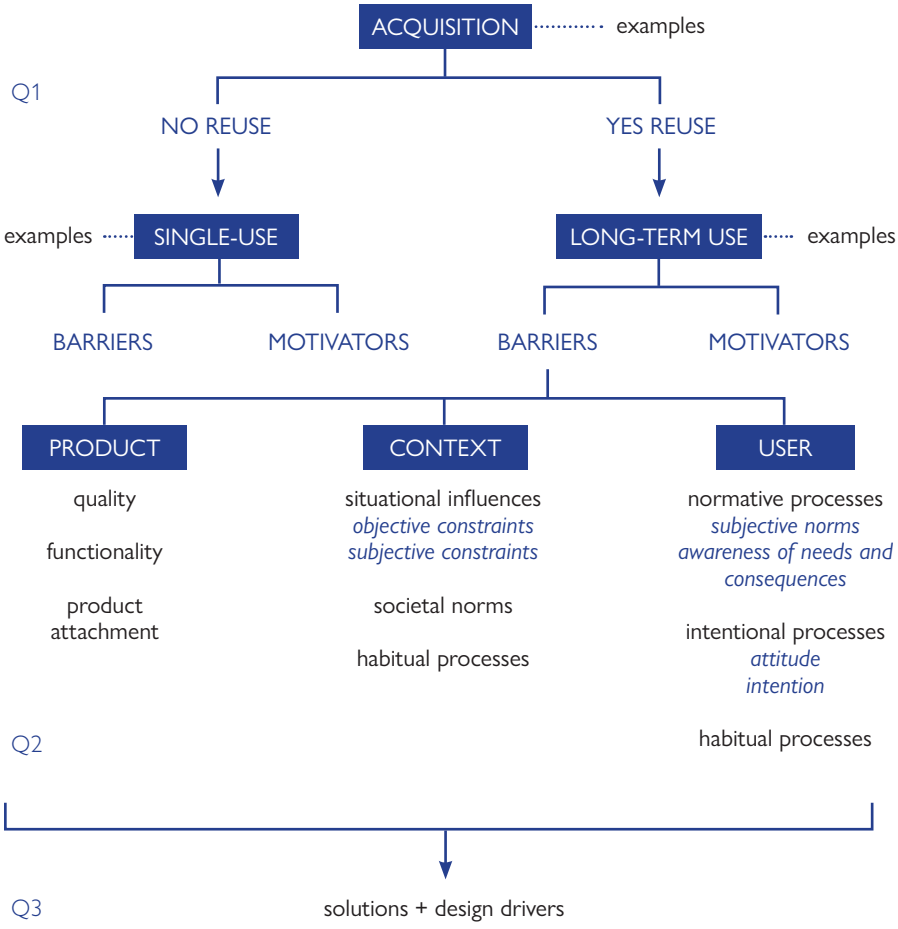


Figure 1. General research design

3 Results

The results are structured into two main parts: initial acquisition and long-term use. In the first part, we address the reasons whether or not to choose a reusable product, and what people find positive and negative about SUP. After that, we go through the barriers for long-term use, divided into product-, context-, and user-related barriers. Finally, the last paragraph handles proposed design interventions by the users.

3.1 Acquisition

Motivators and barriers to choose SUP

The most commonly used SUP are packaging in general, PET bottles, plastic bags, single-packaged biscuits, bathroom products, postal parcels, disposable diapers, medicine packaging, disposable cups and cutlery, and aluminium foil.

Figure 2 shows the motivators and barriers to choosing SUP compared to reusable products that were mentioned by respondents during the interviews. Notably, most aspects are product-related (mainly motivators), or normative (mainly barriers).

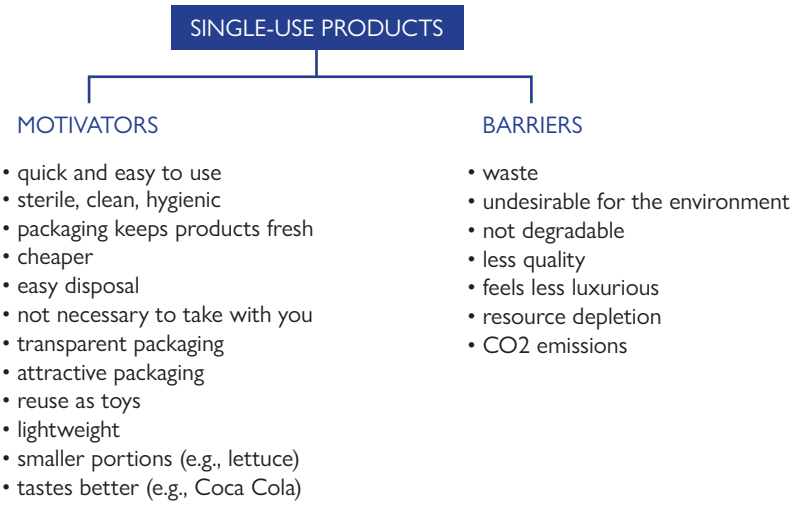


Figure 2. Motivators and barriers towards single-use products

Motivators and barriers to choose reusable products

The most popular reusable products are drinking bottles, lunch boxes, and reusable (produce) bags. The Soda Stream is also relatively popular. Some products, people often get for free, such as drinking bottles and tote bags. In those cases, there was no active choice to acquire the reusable product.

Figure 3 shows the motivators and barriers towards choosing reusable products. The reasons not to choose reusable products are mainly practical and partly based on the perception of the user on, for example, the convenience of a reusable product, which is not necessarily factual.

Figure 3. Motivators and barriers towards reusable products

When asked more precisely for what SUP no suitable alternatives are available yet, food packaging was mentioned most often, with packaging for meat and fish on top, closely followed by biscuits, soda, fruits and vegetables, and chips. In other words, food that loses quality and freshness when not packed airtight. Furthermore, bathroom products, baby products, takeaway packaging, cleaning products, online purchase packaging, and festival-related products came forward as difficult to replace with reusable products. For some of these products, reusable alternatives do in fact exist but are not that widely known. Regarding accessibility, not all reusable products are offered in regular or nearby stores. Some respondents indicated they do not feel responsible for reducing waste and point to industry and government to provide solutions.

Motivators and barriers to reuse and ecological behaviour in general are often influenced by how people grew up and how engaged their parents were in this type of behaviour, which was mentioned by more than half of the respondents. Some respondents' children would influence them as well towards more eco-friendly behaviours. Next to this, partners and close friends were also mentioned as having a positive influence. However, very eco-friendly friends are sometimes considered annoying or 'preachy' which could have the opposite effect. The effect of groups

(e.g., scouting) on (non-) eco-friendly behaviour also came up. One-fourth of the respondents like to identify themselves as ecological people. Another fourth identifies specifically as not ecological, and the rest wants to profile themself neither as ecological nor non-ecological. One respondent indicated she does not see herself as ecological, although other people would, indicating different standards.

'I do not see myself as someone who is behaving very ecologically, because I search a lot for information about it, so I know very well all the stuff that I do not do.' (interviewee A_4_F)

None of the respondents said they are attached to disposable products. However, some indicated they would get attached to the product that the single-use packaging contains (e.g., specific soda brands or cosmetics), or to the experience of drinking from a can in comparison with a glass.

'I'm not attached to the plastic bottle, but to the taste of Coca-Cola. I am afraid it will be different in a reusable bottle. I already do not like the taste of it when it's poured into a glass, I think it is better in a plastic bottle.' (interviewee A_2_F)

Both ecological and financial motives came forward as the most cited reasons to go for a reusable product instead of single-use. Ecological reasons are sustainability, taking care of your environment, and creating less waste. Financial motives relate to reusable products becoming cheaper in the long run, by creating less waste which also leads to lower costs, or by getting a discount for, e.g., a reusable coffee mug. Some older respondents said they use certain reusable products because they were trendy when they were younger, such as Tupperware containers. They also indicated products seemed to last longer. One respondent mentioned aesthetic reasons.

'Something reusable you buy once and then use multiple times. That gives a financial advantage over a single-use product that you have to pay for each time.' (interviewee D_2_F)

3.2 Barriers to long-term use

Figure 4 provides an overview of the barriers to long-term reuse from a product, context, and user perspective.

Product

Bad quality was mentioned most often as a reason to stop using a reusable product. For example, products made of bamboo break quickly. Then, a new product has to

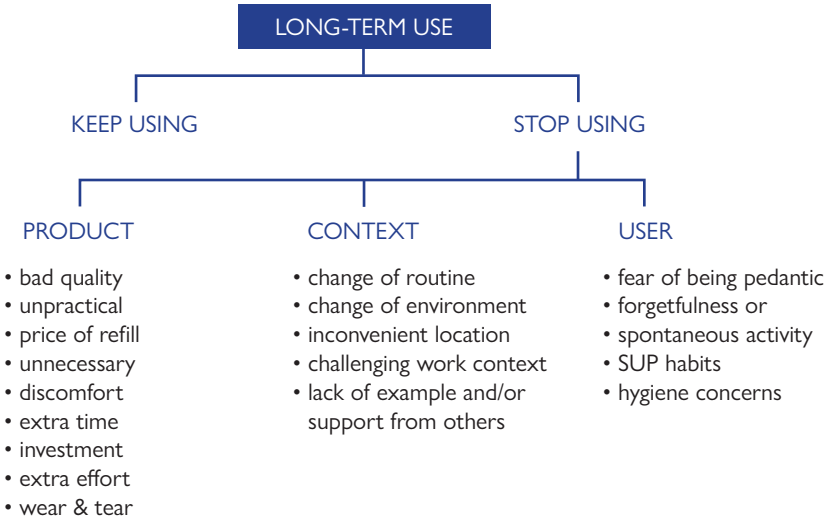


Figure 4. Barriers to long-term reuse

be purchased even if there was no intention of replacing it. Also, the practicality of the product came up, such as unhandy alternatives for cling film and baking sheets. Wear and tear were mentioned as important reasons to discontinue the usage of reusable products as well, for example when the product starts showing scratchesor discoloration. The price also proves to be a factor, even after purchase, for example, when someone suddenly realises how much a refill of soap or cereal costs. Sometimes, a product has proven to be unnecessary after purchase, which led to the respondent not using it anymore. Another reason to stop the usage is discomfort, for example regarding reusable mouth masks.

'I bought some bamboo straws, but it broke super quickly. Then I just bought plastic straws again. I thought it was a shame.' (interviewee B_2_F)

Next, convenience and extra effort came up as barriers related to the product's user journey. Glass bottles are much heavier than plastic bottles, and they need to be returned for cleaning and redistribution. Having to take your reusable mug with you just in case you want to get a coffee is perceived as annoying.

'I am afraid that refilling my own bottle with shampoo or something would cause a big mess in the store. It is just inconvenient.' (interviewee H_3_F)

Several people said they are attached to their reusable product, especially when they have been using it for a longer period of time, and mainly because of its functionality. A frequently mentioned example was the reusable drinking bottle, but also menstrual cups, plastic jars, tote bags, coffee mugs, and lunchboxes came up.

Context

What kept being mentioned was the challenge to consistently use the product in case of a change in routine or context. Timing and location are important factors here. Some respondents stopped using a certain product when they did not need it anymore, for example when their kids left home, or when they changed jobs and suddenly got a meal every day in their workplace.

Almost all respondents agree that it would be easier to continue using reusable products if other people would do it, both in a close social environment and on a societal level. Next to this, most people were positive about seeing other people use these products in public and stated they do not or would not feel awkward when using them, showing a positive attitude towards people who use reusable products. Some even feel that using SUP is frowned upon nowadays. However, a few mentioned being laughed at or seen as 'too serious' or 'green' when using these products, or getting appalling reactions towards e.g., the idea of a menstrual cup.

'Only when they are behaving very un-ecological. For example, when we are together with friends, going to Antwerp, we would all go in our own car. Then I suggest carpooling.' (interviewee D_1_M)

The work context was often mentioned as challenging for reuse behaviour. Examples are drinking fountains with only plastic or paper cups, disposable cutlery, paper towels, many plastic bags, and printed advertisements. On the other hand, colleagues would also positively influence each other.

User

Several respondents indicated they normally use a reusable product, but sometimes use SUP, mostly because they forget to bring their reusable item. Also, spontaneous activities can oppose sustainable intentions, such as getting a coffee on the go or when they go to the store or supermarket unplanned.

'I often go to the store unplanned, without my bags and reusable packaging. I do not have the time to go all the way back home to get them, and frankly, I also do not want to.' (interviewee C_2_F)

Most respondents say they try to encourage sustainable behaviour, mainly in their close social environment (friends, family, colleagues). However, most do not want to interfere with strangers, afraid that they would come across as pedantic.

Also, hygiene concerns came up as reasons to quit using certain reusable products. This seems to be influenced by the COVID-19 pandemic, as several respondents indicated they would buy pre-packaged vegetables again for a while because of safety concerns. However, it is important to note that this can be a temporary effect regarding the moment this study took place.

3.3 Proposed interventions

At the end of the interview, we asked the respondent to give suggestions for interventions to promote long-term reuse. They proposed increasing the availability and accessibility of the products, as well as installing regulations or bans. Next to this, the designs should be improved to be more user-friendly, aesthetically pleasing, durable, easy to transport, store, and clean, while ensuring hygiene and safety. Education and awareness campaigns are necessary to make people more aware of the existence of and need for reusable products.

4 Discussion

Below, we discuss the results according to three conditions that we believe are needed for long-term use: willingness to adopt (mindset, belief, motivators), ability to use (infrastructure, product quality, regulations, accessibility, complexity of user journey), and the creation of a routine or practice (extra effort and time, competition of more convenient SUP, situational obstacles existing habits and practices).

We can state that for successful, long-term usage of reusable products beyond the break-even point, willingness from the user is needed, e.g., from a positive mindset towards sustainability (user), because of financial incentives, because other people are using it (context), because the product is more attractive or works better than a single-use variant (product), or a combination of those. This is heavily related to the potential user's perception of the product. For example, safety and hygiene concerns often hold people back. Narratives from media, the social environment, social and cultural norms, and the visibility of the alternatives influence perception as well. Willingness to use leads to initial adoption which is the first step towards long-term usage. Getting the product for free does not automatically translate into adoption, since there is not necessarily any willingness of the user involved. However, it can potentially stimulate its use as well as the attitude of the user [81].

Next, the user needs to have the ability to use the product, including knowledge, skills, and financial means. They should be able to understand how the product works and afford expensive refills *(user)*. The product should be available nearby, accessible, and accepted by the social environment. Also, the infrastructure that is needed to use the product, such as refill stations, has to be present *(context)*. The product should work the way it is supposed to and fulfil its function, be adapted to the needs of the user, and the user journey must be clear and executable *(product)*. To ensure long-term reuse, most focus is put on how the user journey can be optimised and fitted into existing habits and practices to create a new routine or practice. Barriers are often related to situational constraints such as distraction or stress, being in a hurry, forgetting the product, a change in needs of the user, and (mental and physical) effort *(user)*. The space and time in which the behaviour takes place are key factors that influence long-term use, and a change of environment or context provides a window of opportunity to trigger behaviour change for designers [3] *(context)*. Besides this, the product needs to be durable and physically able to perform until beyond its break-even point, countering planned obsolescence *(product)*. Table 1 shows a simplified overview.

	USER	PRODUCT	CONTEXT
WILLINGNESS	Sustainability mindset	Attractiveness or functionality compared to SUP	Financial incentives, trends, media, social norms
ABILITY	Skills, knowledge, financial situation	Functionality, complexity of user journey, adapted to needs of the user	Infrastructure, accessibility, availability, social acceptance
ROUTINE	Fit into existing habits, mental and physical effort, change of needs	Durability, perform beyond break-even point	Space and time, change of environment

Table 1. Overview of the main motivators for successful long-term reuse regarding willingness, ability, and routine, and from the perspective of user, product, and context

4.1 Product categories

To make our insights useful for designers, we distinguished four product categories based on notable barriers and contexts of use and the examples the respondents gave for each barrier. For instance, we noticed that forgetfulness was frequently mentioned as a barrier for products that are used for carrying food or other products outside the home, such as reusable coffee cups, jars, and bags. Hygiene concerns, on the other hand, were often mentioned in relation to products that come into contact with food, or intimate products such as the menstrual cup. The categories presented in Table 2 are meant as a guide towards a more detailed investigation into specific cases. Each category has its own general set of critical areas, which can be used as a starting point for further analysis.

4.2 Interventions

Suggestions for (product) designers

We suggest that designers target as many of the barriers we found as possible to have the most chance of long-term reuse by a wide range of potential users. Below, we suggest several strategies and interventions on how to address this, based on the results of this research. For selecting a suitable strategy or intervention for a specific case, we refer to the categories and their main critical points to better pinpoint barriers for a specific long-term reuse case.

- **Improve mindset:** Take an interdisciplinary stance on communicating with and informing potential users. For example, collaborate with graphic designers, behavioural psychologists, and marketers to create narratives for a change of mindset. Tackle the recycling norm and misconceptions about sustainable materials. Develop communication strategies on principles of circular economy and r-strategies towards a broader public and pinpoint the importance of reduce and reuse. Question social norms and (cultural) ideas on safety, shame, and reliability [145]. Provide transparent information on what are good solutions. Within the work context, there are opportunities for companies to stimulate their employees to be more sustainable and create spillover effects.

- **Product-user match:** Improve the matchmaking between user and product in the acquisition phase. Many barriers are related to the product not living up to the needs or expectations of the user. This is related to the complexity of the user journey and the ability of the user to perform the necessary actions or behaviours to use the product properly.

CATEGORY	DESCRIPTION
Intimate care *(e.g., menstrual products, diapers, and reusable toilet paper)*	The most striking barriers are related to low willingness (mindset, safety perception, shame, unknown), which sometimes goes into conflict with sustainable values, and a high usage threshold: a new user journey, barriers related to the human body, and a need for personalization, which cause difficulties for long-term reuse. Context variables also cause thresholds, such as a lack of infrastructure (sanitary facilities, sterilization possibilities), which hinder the ability of the user to perform the behaviour. It is a very interesting product category since the potential impact is very high, especially for menstrual products such as the menstrual cup. *Main critical points: hygiene concerns, subjective norms, physical and mental ability, and infrastructure.*
Daily shopping *(e.g., produce bags, jars, tote bags, and refill bottles)*	Barriers are mostly practical and habitual, for example having to remember to take the product with you and having to break the habit of buying pre-packaged food. A lack of infrastructure opposes the ability of the user: often there is no shop nearby where you can use reusable jars, bags, etc. Willingness can be hindered by doubts about hygiene and safety, definitely for meat or fish packaging, and a convenience mindset. Also, the elaborate cleaning process can be a threshold. *Main critical points: habits, situational thresholds, and hygiene concerns.*
At home *(e.g., food huggers, refillable soap bottles, and reusable tea filters)*	These products are used inside of the home and do not need to be transported to any other location as part of the user journey. Their main barriers are related to the usage: users are sensitive to the extra time and effort the use of the product requires. Functionality and practicality are the most important factors here, and the products eventually need to become part of a routine. *Main critical points: functional, practical, and situational thresholds.*
On the go *(e.g., coffee cups, lunch boxes, food wraps, and reusable takeaway containers)*	In contrast with 'at home' products they are typically used on the road, in different locations, and transported from one place to another. They are also much more visible than 'at home' products, hence the users are more sensitive to opinions from other people. Also, it is not always possible to use them, since it depends on the willingness of the provider (e.g., coffee bar or takeaway restaurant). Other thresholds are mostly routine-related, and sensitive to the unplanned nature of its use. Users often forget the product because they did not know they would need it. Besides this, the weight and volume of the product can be perceived as annoying to carry around. *Main critical points: physical and mental ability, social and situational thresholds, and habits.*

Table 2. Categories 'intimate care', 'daily shopping', 'at home' and 'on the go' and their descriptions

- **Long-term investment:** Experiment with strategies such as design for product attachment by matching the product with the personality of the user, making the product customisable, focusing on product aesthetics [20], creating a personal bond by means of storytelling or narratives, or by simply making the product very durable and functional [146]. This can also improve willingness to repair. Consider wear and tear potentially showing on the product after multiple uses while choosing materials [60].

- **Routine creation:** Help the user fit reuse in their existing routines or create new routines by applying design for behaviour change strategies (such as guiding behaviour, providing feedback, working with cues and rewards), or nudging strategies (to make the behaviour change easier) [147,148].

- **Designing context:** Design the broader system in which the product is used, focusing on creating a suitable context. Service design and PSS design can tackle some of the contextual barriers, such as logistics and cleaning, but also situational constraints such as forgetting a product at home. By providing a sharing system, a product that is needed only once can reach its break-even point by being used by multiple people [149].

Thoughts on user agency, targeting specific users, and spill-over effects

Most respondents indicated during the interviews that they want to be guided or steered more in the direction of sustainable behaviour to decrease the mental and physical effort demanded by implementing the new behaviour in their current routines. However, this strategy could have some downsides: potential spill-over effects to other kinds of sustainable behaviour can decrease because people are less consciously aware of their actions [150], and the factor 'willingness' is less strongly present. Asking for more steering might also decrease the feeling of control or freedom by the user. This could result in psychological reactance, creating resistance against the targeted sustainable behaviour. Another option is to do the opposite of what they request and provide them with tools and enable them to act sustainably.

We can also look at specific types of users, and target them accordingly. For a very engaged consumer, the practical barriers to long-term use can be countered by a very strong will and mindset, but often, taking away situational barriers and making habit formation easier is necessary, even for them. Consumers on the other end of the spectrum can be targeted both with attitude-improving narratives or by making the reusable product more desirable than the disposable alternative. This indicates the diversity in solutions that might be needed for people with different incentives to use a reusable product. [151]

Decreasing the extra time and effort one needs to put into using the product and making the change in behaviour as small as possible, will probably increase the chance of long-term adoption. Taking away obstacles in the user journey by creating different scenarios (1st-time use, 2nd-time use, nth-time use) can decrease the risk of unintended consequences and surprises. Apart from that, the authors argue that a change in mindset is always desirable, opening possibilities for spill-over effects, and encouraging sustainable behaviour in other aspects of people's lives [152].

4.3 Novelty and comparison with previous research

Several of the product-related barriers such as wear and tear, decreasing functionality, bad quality, and product aesthetics have been brought up in previous research as well [59,60]. Also, the importance of designing products according to the needs of the user [153], increasing familiarity [154], and the context in which they are used [77] have come up in previous research. Some of the barriers to long-term use have not shown up in many studies before, such as a change of context or situation, the space and time in which the usage takes place, and the overview of product-, user-, and context-related barriers next to willingness, ability, and routine. Next to this, previous research often focused on one sector, such as food packaging [59] or household products [20]. By investigating a wider range of products we could distinguish logical categories based on typical barriers and context, which can be valuable in more specific research in understanding reuse behaviour and designing new products.

4.4 Limitations

We did qualitative, explorative research which has limitations concerning the generalisation of the results. To reach respondents, we used the convenience sampling method. We chose to work with personas and demographic prerequisites to minimise sampling bias. Within the topic of sustainable behaviour, there is an increased chance of social desirability bias. We countered this by asking more in-depth questions and requiring anecdotal details. These details about people's current behaviour were always self-reported. The interviews took place during the COVID-19 pandemic lockdown. This could have influenced people's responses, especially regarding hygiene and safety perception.

5 Conclusions

To tackle pollution and resource depletion from the massive use of disposable products, there is a need to transition from single-use products, which are disposed

of after every use, towards reusable products, that require repeated use cycles. The objective of this research is to understand the barriers that people encounter by looking both at the initial adoption motivators as well as the situational and habitual factors that influence long-term use.

(Q1) The motivators and barriers that influence the long-term reuse of reusable alternatives to single-use products can be linked to either willingness, ability, or routine. The willingness to use a certain reusable product is related to people's attitudes and drivers. This can be ecological reasons but also financial reasons, convenience, trends, and hygiene concerns. Related to ability, the main barriers are the functionality of the product, how its user journey is set up, and the context in which it is used: the lack of offer in stores, convenience of SUP, price, and accessibility. Finally, barriers to routine are extra time and effort, bad quality of the product, fitting the use into existing habits and routines, price, a change of situation, not needing the product anymore, forgetfulness, and spontaneity.

(Q2 and Q3) Designers can respond to these barriers by using product categories (i.e. intimate care, daily shopping, at home, on the go) for further investigation, creating new narratives and ways of communicating towards users, focusing on services and product-service systems to address context-related barriers, improve user-product matchmaking, and use strategies such as designing for product attachment, nudging, and design for (sustainable) behaviour change to more successfully implement reuse behaviours in people's routines. It is important that at all times, designers are aware of their responsibility in changing people's behaviour and the potential (unintended) consequences. Next to this, it is necessary to increase the accessibility of good and qualitative reusable products, to introduce regulations and bans, and to provide more information and clarity on what good alternatives are in order to persuade people to start and stick with the right reusable product that can have a profound impact on the environment.

Regarding future research, case studies are necessary to further investigate and refine the categories, as well as to gain insights on how designers can do their own analysis of a specific reusable product. Besides this, more research is needed on accurately differentiating potential solutions according to both product category and type of users. Finally, other reuse models and their impact on the barriers and enablers to prolonged reuse should be investigated, such as product-service systems or products in the sharing economy. Also, a social practice perspective should complement this research in order to enable (social) change towards a reusing society.

Acknowledgements: Esther Noëth and Stine Moons

Appendix

Appendix A. Profile of interviewees

PSEUDONYM	GENDER	AGE	RESIDENCE	INCOME	EDUCATION	CHILDREN
A_1_M	M	18-25	Rural	Average	Master	No
A_2_F	F	18-25	Urban	Average	Master	No
A_3_M	M	18-25	Rural	Low	Master	No
A_4_F	F	18-25	Urban	Low	Master	No
B_1_F	F	36-45	Urban	High	Master	Yes
B_2_F	F	26-35	Suburban	Average	Master	Yes
B_3_M	M	26-35	Suburban	High	Master	Yes
B_4_M	M	36-45	Suburban	Average	Graduate	Yes
C_1_M	M	56-65	Rural	High	Sec. school	Yes
C_2_M	M	46-55	Rural	High	Master	Yes
C_3_F	F	46-55	Rural	High	Master	Yes
C_4_F	F	46-55	Urban	High	Master	Yes
D_1_M	M	18-25	Urban	High	Master	No
D_2_F	F	26-35	/	/	Sec. school	No
D_3_M	M	36-45	Suburban	Average	Master	No
D_4_F	F	26-35	Urban	Average	Bachelor	No
E_1_M	M	56-65	Suburban	Average	Master	Yes
E_2_M	M	46-55	Suburban	Average	Sec.school	Yes
E_3_F	F	46-55	Urban	Average	Graduate	Yes
E_4_F	F	46-55	Suburban	Average	Bachelor	Yes
F_1_M	M	18-25	Urban	Average	Master	No
F_2_M	M	18-25	Suburban	Average	Master	No
F_3_F	F	18-25	Rural	Low	Bachelor	No
F_4_F	F	26-35	Urban	Average	Master	No
G_1_M	M	46-55	/	Low	Sec. school	Yes
G_2_F	F	46-55	Rural	Low	Master	Yes
G_3_F	F	56-65	Rural	Low	Sec. school	Yes
G_4_M	M	26-35	Urban	Average	Bachelor	No
H_1_M	M	65+	Urban	Average	Sec. school	No
H_2_F	F	65+	Urban	High	Master	Yes
H_3_F	F	65+	Urban	Average	Sec. school	Yes
H_4_M	M	65+	Rural	Average	Sec. school	Yes

Appendix B. Interview guide

Below we present the full interview guide. Be aware that these are guiding questions, and the interviewer would deviate from them according to the answers given by the respondents.

Consent form and information form
Received, read, and approved by the respondent.

Explanation of Research Purpose
With this research, we aim to explore the factors that influence whether people continue to use alternatives to disposable products in the long term or not. We will discuss ecological behaviour, disposable products, and reusable alternatives to said products. In the end, we want to understand what solutions would work for you. This research ultimately seeks ways to design better alternatives for long-term use.

Demographic Questions
Age:
Gender:
Place of residence: city/suburbs/countryside
Education/degree:
Employment status/occupation:
Children: yes/no
Income: high/average/low

Warming up
- What do you do in your daily life? (work, hobbies, family, …)
- What does your average weekday look like?
- Do you feel that you can reflect on your daily activities? Do you feel you have enough time and space for this?
- What things are you consciously engaged with? Why are those important?

Part 1: Current behaviour
General ecological behaviour
- Do you consider yourself someone who generally behaves ecologically? Explain.
- What specific actions, purchases, activities, etc., do you pay attention to regarding sustainability? (keep asking for more examples until you have a number of them. Address purchase, usage, and disposal)
- Are there certain life domains/usage domains where you can apply this better than others? (examples: daily life, traveling, work, parenting)

- Which ones are these?
- Are there domains in which you do not pay much attention to sustainability?
- Why is that? Is it deliberate or unconscious?

Avoiding disposable products

- What do you find positive and negative about disposable products?
- In what situations do you use disposable products?
- Why?
- In what situations do you try to avoid disposable products?
- Which disposable plastics do you find the most difficult to avoid?
- Why?

Reuse behaviour

- Have you ever used a reusable alternative to a disposable product? Examples include: water bottle, lunchbox, produce bags, tote bag, reusable coffee cup, reusable utensils, reusable razor, etc.?
- Why? What was the reason for use/purchase?
- When did you start using these products?
- Do you still use these products? Which products?
- Why do you not use that product anymore? Go through each product. (Dig deeper: forgotten at home, unfavourable situation, insufficient facilitation by the environment, too much effort required,... Can you clarify this? Why exactly? Is this the case with similar products as well?)

Part 2: Barriers and motivators

Situational influences

- Do you feel that you have control over your sustainable behaviour, and more specifically, reuse behaviour?
- Why (not)? What factors make it difficult for you to use reusable products?
- Would it help if the ecological choice were the logical or obvious choice? For example: all vegetables are automatically organic, packaging-free options are available in regular supermarkets, your energy supplier is automatically sustainable, etc. Would you then behave more ecologically?
- In your opinion, for which disposable products is there still no good alternative?
- What makes an alternative bad or good?

Knowledge, awareness of consequences and responsibility

- What do you know about disposable plastics?
- What connection do you see between disposable products and environmental problems?

- Are you familiar with the concept of plastic pollution? (explain if necessary)
- To what extent does this affect you?
- Where do you get information about this? (media, friends, family, ...)
- Do you feel that the issue of plastic pollution is often discussed in mainstream media and social media?
- Has this information changed your purchasing behaviour and use of disposable products compared to before? In what way?
- Do you believe that, as an individual, you can make a significant difference?
- According to you, what is the role of the consumer in a potential solution to this issue?
- What do you think would be a better solution: improving the sorting and recycling of disposable plastics, or using reusable alternatives for disposable plastics?
- Why?

Intentional processes

- Would you like to do more (or further actions) for the environment and against waste?
- What do you think could help you with that?

Subjective norms (normative processes)

- Is there a lot of pollution in your neighbourhood? Do you see a lot of litter on the streets?
- To what extent does this motivate you to use fewer disposable products and look for alternatives?
- Do people in your physical environment also use these reusable products? Do you see this often in the streets?
- Do you feel that people sometimes find it 'strange' that you use these products? Do you feel observed or uncomfortable?
- Would it help if more people used these products?
- Are your family and friends concerned about avoiding disposables and/or using alternatives to disposables?
- If yes, do you feel encouraged by them? In what way?

Opinion leadership + green self-identity

- Do people in your surroundings see you as someone who is environmentally conscious?
- Do you identify yourself with sustainability and reusable alternatives to disposable products?
- Do you also try to persuade people in your surroundings to engage in more

ecological behaviour?
- If yes, what would you advise them?

Hygiene and trust

Just a brief interlude: the current COVID-19 crisis has affected everyone. Certain trends towards more reuse and less disposables have reversed: more pre-packaged food is being sold, and disposable masks are omnipresent.

- If you can choose between pre-packaged vegetables and loose vegetables right now, what would you choose?
- Why?
- Is this different from before the COVID-19 crisis?
- How do you feel about the increased use of disposable food packaging due to the COVID-19 pandemic?
- Do you use disposable masks or homemade masks (or both)?
- Why?

More questions about hygiene, contamination, risk, and quality perception.

Habitual processes

- Do you have reusable alternatives to disposable products that you find it difficult to use (or continue to use) because you don't have the habit of using them?
- What habits you currently have are getting in the way or preventing you from using more alternatives?

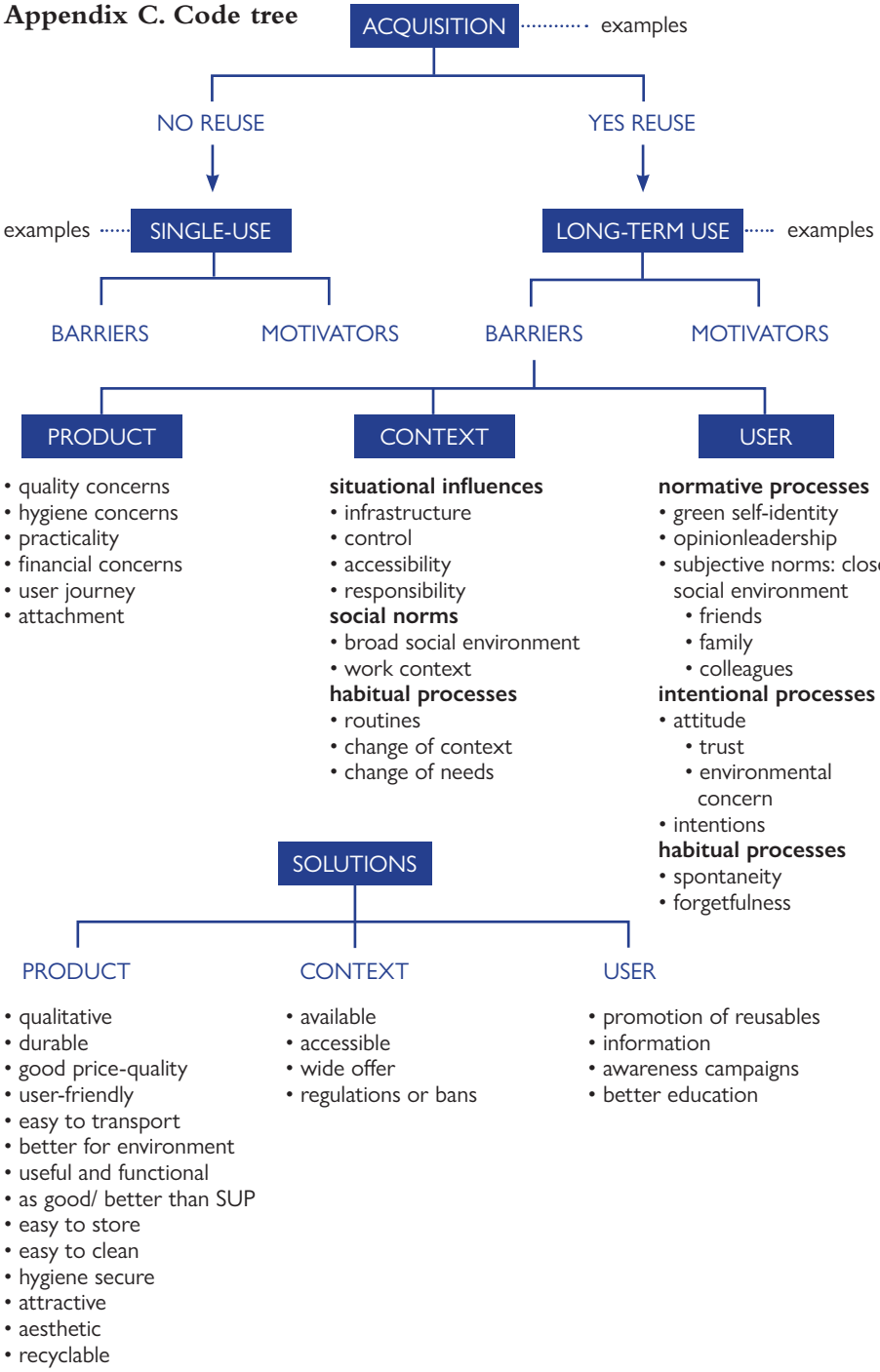
Product attachment

- Are you attached to certain reusable products? Which ones? Explain.
- On the other hand, are you attached to certain disposable products? Which ones? Explain.

Part 3: Suggestions

- What do you think would be most effective in getting the general public on board: government regulations, providing good alternatives, or offering accurate and relevant information?
- What properties should a reusable alternative have according to you?
- Do you have any more suggestions?

Appendix C. Code tree



PART THREE

In this part, we delve deeper into user insights by examining diverse cultures, looking into various types of single-use plastic-avoiding users, identifying the usage patterns of reusable products, and understanding individual preferences for product properties.

Chapter 3 encompasses a cross-national survey with 3000 respondents. We test a model with structural equation modelling, make a comparison of SUP-avoiding intentions and behaviour between countries (i.e. Belgium, Russia, and the U.S.A), and do a cluster analysis to distinguish four consumer segments (i.e. SUP addicts, SUP avoiders, apathetic, situation-driven SUP users). The results are published in the article *'Understanding who avoids single-use plastics and why: a cross-country mixed-method study'* in Journal of Cleaner Production (2023).

Chapter 4 describes the next part of the study, where we investigate to what extent reusable products are already established in society and what design properties users require. We compare the results between the user clusters from Chapter 3 and the three countries. The paper *'Trash talk: who uses which reusable product? User insights and design opportunities for single-use alternatives'* is published in the proceedings of the Design Society: International Conference on Engineering Design (ICED 2023).

L. Herweyers, I. Moons, C. Barbarossa, P. De Pelsmacker, E. Du Bois, Understanding who avoids single-use plastics and why: A cross-country mixed-method study, Journal of Cleaner Production 414 (2023) 137685. https://doi.org/10.1016/j.jclepro.2023.137685.

CHAPTER THREE

Understanding who avoids single-use plastics and why: A cross-country mixed-method study

Laure Herweyers, Ingrid Moons, Camilla Barbarossa, Patrick De Pelsmacker, Els Du Bois

Abstract: The production and consumption of single-use plastics (SUP) has disastrous consequences for the natural environment. Understanding which consumers are more likely to avoid SUP and why is crucial. Building on a comprehensive action determination model of ecological behaviour, this study aims to specify the most relevant drivers and barriers to consumers' intentions to avoid SUP. The results of a qualitative study (N = 32) and a quantitative study (N = 3,000), conducted across multiple countries (United States, Russia, and Belgium), reveal that positive attitudes and subjective norms regarding SUP alternatives enhance consumers' intentions to avoid SUP. Our analysis also shows the existence of four consumer segments—SUP addicts, SUP avoiders, the apathetic, and situation-driven SUP users—who differ in their intentions to avoid SUP and their motivations. While habits in using SUP, situational constraints, and hygienic concerns regarding SUP alternatives do not play a significant role in the whole cross-national sample, they represent crucial barriers for specific segments such as SUP addicts and situation-driven SUP users. The study concludes with several marketing and design recommendations for promoting and developing reusable alternatives to single-use plastics.

Keywords: single-use plastics; sustainable consumption; motivational processes; consumer segments; mixed-method cross-country study

1 Introduction

Plastic production and consumption continue to grow, expected to reach 445 million metric tons by 2025 [5]. Such growth is understandable, in that plastic offers vast advantages; it is lightweight, low-cost, durable, and diverse in its applications

[3]. A specific category, which accounts for approximately 40%–50% of all plastics produced, is single-use plastics (SUP[1]), which are disposable, convenient, attractive, and effective for protecting products [155]. In addition, SUP dramatically damage the environment. These mass-produced products provide only a short usage period, so they create resource depletion, greenhouse gas emissions, and waste. In parallel with growing uses of plastics, more plastic waste is being created globally such that it has doubled in the past two decades (e.g., an average U.S. consumer generates 221 kg of plastic waste annually). This waste might end up in landfills or get incinerated. However, as plastic eventually degrades into microplastics, it ultimately contaminates water, soil, and air, such that it represents a source of harm to animals [11] and humans, each of whom ingest over 50,000 microplastics per year, on average [156]. The extent of the issue is effectively depicted by the Great Pacific Garbage Patch, the largest accumulation of ocean plastic in the world, which is now three times the size of France [10]. Only 9% of plastics produced get successfully recycled [157]. As of 2019, plastics generated 3.4% of total global greenhouse gas emissions, a percentage that is likely to more than double by 2060 [158].

Thus, tackling SUP is a priority. The OECD [159] has proposed three approaches: alter the product life cycle (e.g., ban sales of disposable plastics if easily available alternatives exist), improve waste management (e.g., awareness campaigns, required product information [25]), and undertake remediation activities to "clean" already polluted natural environments (e.g., The Ocean Cleanup). Another meaningful solution might rely on consumers and their daily consumption choices [160,161]. If they actively choose to avoid SUP usage, and make those preferences clear to suppliers, consumers can insist on a production system that creates less plastic pollution. Such consumer decisions represent a type of pro-environmental behaviour, defined as voluntary actions geared toward contributing to environmental preservation and/or conservation [162].

Previous research into consumption decisions surrounding SUP tends to be fragmented and focused on specific products, e.g., bags, straws [163], coffee cups [164], or else specific to a sector such as food-related choices [160]. We note some pertinent insights into the influences of consumers' habits [165] or rational motives [67] as well, most of which purposefully address a single country (e.g., [166]). To add to these considerations, we seek a more comprehensive view. In particular, by integrating multiple theories, we aim to establish how personal norms, situational influences, habits, attitudes, and context-related factors all might relate to sustainable behaviour regarding SUP, as exhibited by consumers across various countries.

[1] In Chapter 1 and Chapter 3, with 'SUP', we mean 'single-use plastics', while in the other chapters we use SUP to abbreviate the more general 'single-use products'.

Moreover, we use a mixed (qualitative and quantitative) method to build on existing studies that tend to use one or the other [167,168].

Accordingly, we turn to the Comprehensive Action Determination Model (CADM) of ecological behaviour [74] to uncover the most relevant determinants of SUP avoidance and thereby establish empirically based typologies of consumers who exhibit different intentions toward SUP avoidance, for different reasons. In our mixed-method study, we conduct a qualitative exploration (in-depth interviews) of Belgian consumers' attitudes (N = 32), from which we derive a conceptual model of the drivers of and barriers to SUP avoidance. Then with a quantitative study, we empirically test this conceptual model, and finally perform a cluster analysis in which we identify consumer segments that differ in their motivations and intentions to avoid SUP. This quantitative study encompasses a large, cross-national sample of consumers residing in the United States (N = 1,000), Russia (N = 1,000), and Belgium (N = 1,000).

By applying the CADM of ecological behaviour [74], we move beyond considerations of specific determinants of SUP avoidance (e.g., SUP habits, Theory of Planned Behaviour [67,165]) and offer a comprehensive motivational framework that allows for the varying relative importance of habits, attitudes, and situational antecedents for determining SUP avoidance intentions. This study also contributes by classifying consumer segments according to their intentions and underlying motivations to avoid SUP, which we can profile based on their demographic characteristics, personal norms and values, and pro-environmental orientations. As we demonstrate, consumers are not homogeneous in their SUP avoidance intentions, and some drivers or barriers are particularly relevant for certain consumer segments but irrelevant for others [169]. In addition, by conducting this study with a large consumer sample across three countries, we effectively establish the validity of our findings and identify cross-national segments of consumers who exhibit similar motivations and intentions to avoid SUP. The segment profiles we present, using managerially relevant characteristics, can inform efforts by various private, governmental, and nongovernmental organisations to design effective, cross-national, pro-environmental campaigns and interventions. In this sense, our study offers relevant implications for practitioners and policymakers. They need to approach distinct consumer segments in different ways, with tailored communication campaigns and interventions that focus on the drivers and barriers that are most relevant for each of them. Finally, our results can inform sustainable innovation strategies and product designs, in that they substantiate the need for better, more accessible, sustainable SUP alternatives that reflect consumers' unique profiles and usability perceptions.

2 Conceptual framework

The CADM is based on other frameworks that have been used widely to understand pro-environmental behaviour [74], including the Theory of Planned Behaviour [66], extended with the concept of habits [138]; the Norm-Activation model [140]; and the Ipsative Theory of Behaviour, which focuses specifically on situational determinants of behaviour [139]. However, the expansive CADM also considers normative processes (personal and social norms), as more general constructs that are distal antecedents of behaviours. Habitual processes, attitudes, and intentions, along with situational factors, mediate the relationships of the norms with behaviours. Accordingly, we build on this framework to find relevant variables that might influence SUP avoidance intentions. In our exploratory qualitative study, as detailed in the next section, we aim to determine whether the antecedents of SUP avoidance intentions proposed by the CADM (i.e. attitudes, personal and social norms, habits, and situational influences) are relevant. We also consider the possibility that other important factors, not included in the CADM, might determine SUP avoidance intentions. On the basis of the evidence we collected in our qualitative study together with that provided by previous research, we establish our research hypotheses.

3 Qualitative study

3.1 Procedure

We conducted semi-structured interviews with Belgian (Flemish) adult respondents in October and November 2020, using online video conferencing. We obtained theoretical saturation after interviewing 32 participants (Appendix A shows the respondents' profiles). To elicit their spontaneous thoughts and experiences, we developed an interview guide based on open-ended questions pertaining to three key points: (1) perceptions of the drivers of SUP avoidance; (2) perceptions of the barriers to SUP avoidance; and (3) personal values, ecological concerns and identity, and current pro-environmental behaviours. We also gathered basic sociodemographic information. The interviews lasted 60 min on average and were recorded and fully transcribed. In a first round, using NVivo software, research assistants generated general codes and then created specific subcodes to describe portions of the text [144]. In a second round, two researchers discussed the codes and themes and linked them to the theoretical framework. If needed, we revisited the transcripts. Linking these findings with prior research, we developed a conceptual model and research hypotheses. Furthermore, the insights generated regarding personal values, ecological concerns and identities, and pro-environmental behaviours served as input for our subsequent cluster analysis, in which we sought to profile consumer segments.

3.2 Drivers and barriers to SUP avoidance intentions

Positive attitudes toward SUP alternatives

Attitude refers to the degree to which a person values a behaviour as favourable or unfavourable [170]. Previous research on pro-environmental behaviour notes that attitudes strongly correlate with intentions to recycle, use cars, purchase eco-friendly goods [171,172], and save energy [173]. People with positive attitudes toward SUP avoidance should be more likely to reduce or avoid SUP [68]. The responses to our qualitative study affirm that people's negative (positive) evaluations of SUP are reflected in higher (lower) SUP avoidance, as the following quote indicates:

'I'm not really interested in alternatives to plastic products as sustainability and avoiding disposable products is not a priority for me. For me, people are more important than the environment.' (Interviewee A_1_M)

Subjective norms toward SUP alternatives

A subjective norm imposes "perceived social pressure to perform or not to perform a behaviour" ([66] p. 188), which might be exerted by family, friends, business partners, colleagues, or the media [174]. In relation to SUP avoidance, previous research already has shown that subjective norms can minimise intentions to use disposable bags, straws, coffee cups, and takeaway containers [175], as well as enhance intentions to use cloth bags while reducing plastic bag usage [176]. Most participants in our qualitative study describe the influences of family, friends, and their work environment on their choice to avoid or use SUP, such as:

'My friend is very passionate about the environment. She made me aware of the impact of single-use products on the environment, and that's the reason why I pay more attention to it now. For example, I try to avoid disposable PET bottles.' (Interviewee A_2_F)

Habits in using SUP

Habits, which are "memory-based propensities to respond automatically to specific cues, which are acquired by the repetition of cue-specific behaviour in stable contexts" ([177], p. 4), have a crucial role in the formation of eco-(un)friendly behavioural intentions, especially when consumers lack willpower, feel stressed, or cannot deliberate on their responses ([138,178]. Notably, habits can be powerful barriers to pro-environmental behavioural changes. Previous research integrating the Theory of Planned Behaviour with measures of habits has shown that habits significantly influence meat consumption [179], travel behaviour [180], electric car adoption [181], and energy consumption [182]. In turn, habitual SUP uses might prevent SUP avoidance intentions. According to Romero et al.'s [165] investigation

of the antecedents of plastic bag avoidance among Brazilian immigrants to Canada, the respondents regarded plastic bag usage as "just a habit" in their homeland. Their move to a different context incentivised their consideration of new habits though, so they showed greater plastic bag avoidance. In describing their habit of using SUP for grocery shopping or in their daily consumption, many of these respondents emphasised how underdeveloped ecological habits led to their greater SUP usage. In our study, a respondent similarly explains:

'I keep forgetting my reusable plastic bags when I go to the supermarket. Because I don't have the habit yet to bring my bags to the store, I frequently buy new ones. I have a whole pile of these bags at home now.' (Interviewee D_3_M)

Situational constraints on SUP alternatives

When people perceive intense contextual or situational constraints on their ability to perform pro-environmental behaviour [74], they regard SUP avoidance as too costly, difficult, and effortful [67]. Previous research identifies the strong positive effect of convenience on SUP usage intentions: Unpackaged products are inconvenient, and plastic packaged goods appear more attractive [183]. The wide availability and low price of SUP also provide strong motives for using disposable plastics. Participants in our qualitative study affirm that they see SUP as widely available, convenient, and cheaper than sustainable alternatives; they also regard SUP as difficult to avoid:

'It's difficult. You can't buy anything anymore without cardboard, foam, or plastic packaging wrapping the product. There is very limited offer of sustainable alternatives; you really have to look for them if you really want them. I would also have to save money to buy such alternatives.' (Interviewee E_2_M)

Hygienic concerns related to SUP alternatives

In addition to the variables implied by the CADM, the in-depth interviews reveal that hygienic concerns related to SUP alternatives inform purchases of SUP. In this context, hygiene generally refers to consumers' concerns about diseases; in particular, the COVID-19 pandemic has increased SUP usage by causing some consumers to shift their priorities from sustainability toward safety [184,185]. Hygiene and related health concerns thus might relate negatively to SUP avoidance [79,186]. That is, self-protection motives lead consumers to prefer SUP, i.e. they consider reusable alternatives less safe or hygienic than SUP [175,184]. When infectious disease cues are salient, consumers are more likely to use and buy SUP products such as plastic bags, straws, takeout cutlery, and plastic food packaging [167]:

'I have to admit that I pay more attention to hygiene in the supermarket now than before the Covid pandemic. I have always been a bit careful, but since Corona I'm even more cautious. The packaging wrapping vegetables makes me feel safer, it's just to be sure that I am safe.' (Interviewee G_3_F)

On the basis of these findings, we offer two hypotheses pertaining to the drivers of and barriers to SUP avoidance intentions (see Figure 1):

H1: (a) Positive attitudes and (b) subjective norms towards SUP alternatives have positive effects on intentions to avoid SUP.
H2: (a) Habits in using SUP, and (b) situational constraints and (c) hygienic concerns related to SUP alternatives have negative effects on intentions to avoid SUP.

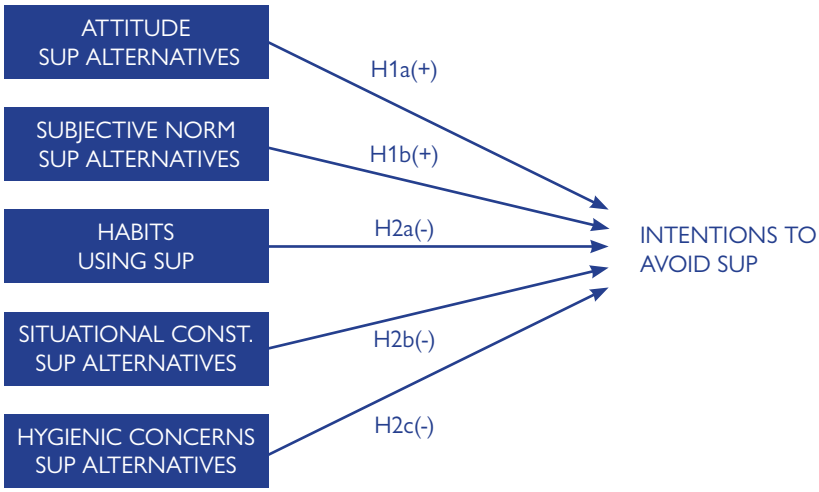


Figure 1. Conceptual model

3.3 profiling variables

With this qualitative study, we also explore how CADM factors, such as personal values, environmental concerns, self-identities, and pro-environmental behaviours, indirectly affect SUP avoidance intentions. As noted, we apply these factors subsequently in our quantitative study in our effort to establish and profile the distinct consumer segments.

Environmental concern

Environmental concern refers to "the degree to which people are aware of environmental problems" ([187] p. 484), and it increases consumers' efforts and intentions to contribute personally to solving them. Environmental concern is positively related to pro-environmental behaviours [188] such as buying green apparel [189] or cosmetics, using electric cars [181] and avoiding or recycling plastic packaging [190]. The respondents in our qualitative study also note connections of environmental concerns with SUP avoidance, such that interviewees who expressed more concern about the environment indicated more awareness of the environmental impact of their consumption choices:

'The problem of single-use plastics touches me, and I'm very concerned about the impact of plastics on the environment. It is highly important to me. I try to think about it in the store when I choose loose apples instead of packaged ones.' (Interviewee F_1_M)

Green self-identity

A green self-identity, or the extent to which people perceive themselves as green consumers [191], is positively linked to pro-environmental behaviour. In particular, it influences intentions to purchase organic products or brands [171], electric cars [192], and eco-friendly paper products [193]. For example, a respondent in our qualitative study notes:

'I like to identify myself as a 'green' person because I like to discuss with other people about the environment and I want to talk about it. I've always had this thing that I wanted to identify myself with something, to really link my personality to it.' (Interviewee A_4_F)

Values

Values are abstract, stable beliefs that transcend specific situations, form important ingredients of a person's self-concept [194], are hierarchically ordered in terms of importance, and can be applied to resolve conflicts or make decisions [195]. Schwartz's Value Survey defines ten value types, based on the motivational goals they reflect, and also organises value types into four higher-order value domains [195]: self-transcendence, self-enhancement, openness-to-change, and conservation. Self-transcendence is characterised by universalism and benevolence; people who embrace this value exhibit concern for the well-being and interests of others. Self-enhancement instead prioritises power and achievement, as well as hedonism, encouraging the pursuit of one's own interests and success, through dominance over others. Openness to change implies self-direction and stimulation, independent thought and action, and readiness for change. It can also include hedonism. In

contrast, conservation is characterised by security, conformity, and tradition motives, seeking order, self-restriction, preservation of the past, and resistance to change. Both prior research and our qualitative study findings concur that personal values, and particularly self-transcendence, relate to pro-environmental behaviour (e.g., [194,196]):

'We don't have to do this [avoid SUP] for ourselves but for future generations. We have to think of the future. We could do so much more.' (Interviewee D_1_M)

Current pro-environmental behaviours

Finally, we define current pro-environmental behaviours as the number of actual pro-environmental behaviours a person exhibits. They can have positive spillover effects, such that that engaging pro-environmentally in one domain favours engagement in other eco-friendly domains [197]. Previous research identifies positive spillover effects of saving electricity, eating less meat, and signing climate protection petitions [198]. From our study:

I prepare myself well when I leave the house. I make food to take with me in a lunch box, always take my reusable drinking bottle. I think it will make it easier to also use other more sustainable products or use these products in different situations. (Interviewee G_3_F)

By reviewing the drivers of and barriers to SUP avoidance intentions, as well as these profiling factors, we develop the prediction that different clusters of consumers vary in their SUP avoidance intentions, reflecting their unique underlying motivations (drivers and barriers), environmental concerns, norms, values, and current pro-environmental behaviours, as well as their sociodemographic characteristics. We cannot predict the number or profiles of these consumer segments in advance, so rather than formulate specific hypotheses, we propose the following research questions:

Q1: How do consumer segments differ in their attitudes and subjective norms toward SUP alternatives, situational constraints and hygienic concerns related to SUP alternatives, habits in using SUP, and intentions to avoid SUP?

Q2: What are the characteristics of different segments in terms of their environmental concerns, green self-identity, personal values, current pro-environmental behaviours, and socio-demographics?

4 Quantitative study

Our quantitative study comprises two parts. First, with covariance-based structural equation modelling, we test the hypotheses, such that we consider attitudes and subjective norms toward SUP alternatives as drivers of intentions to avoid SUP (H1), and SUP habits, situational constraints, and hygienic concerns related to SUP alternatives as barriers to these intentions (H2). Second, with a cluster analysis, we identify relevant groups of consumers who differ in their intentions to avoid SUP and the antecedents of these intentions, then profile these clusters according to their personal characteristics and sociodemographic data.

Our quantitative study includes a cross-national sample of consumers from the United States, Russia, and Belgium, to address concerns regarding the mono-cultural focus in previous research pertaining to the psychological mechanisms that produce pro-environmental behaviour [166]. Whereas the United States, Russia, and Belgium are all developed countries, they differ markedly in pro-environmental behaviours. On the Environmental Performance Index, Belgium scores 58.20, showing its powerful water, air, and waste management efforts; the United States and Russia show lower scores of 51.10 and 37.50, respectively [199]. Regarding plastic waste, the United States produces over 34 million tons annually, whereas Russia and Belgium produce 8 million tons and 663,000 tons, respectively [200].

However, notably, we are not interested in comparing the three countries per se. Our goal, instead, is to identify and assess the existence of cross-national samples of consumers who exhibit similar intentions to avoid SUP and the antecedents of these intentions regardless of their country of residence. The adoption of a cross-national segmentation approach is highly recommended in pro-environmental behaviour research because it follows the strict guidelines provided by previous literature that investigates individual attitudes and behavioural intentions cross-nationally (e.g., [201,202]). This research suggests collecting the data across diverse countries to enhance the variance of the model constructs because of cultural differences [201].

However, it warns of the importance of investigating and assess consumer values, attitudes, and behavioural intentions at the individual level, rather than at aggregate country-based level [202,203], because the underlying assumption that the same perspective is indigenous in all the people from a country "is simply not true" [201]. This approach is also relevant for practice, as many multinational companies and policymakers today increasingly use a cross-national approach.

4.1 Data collection, sample, and measures

The cross-national sample includes 3,000 respondents residing in the United States (N = 1,000), Russia (N = 1,000), and Belgium (Flanders) (N = 1,000). Kantar, a professional market research agency, collected the data online during a three-week period in April 2021. To ensure the samples from the different countries are as similar as possible [204], we applied the same quotas for gender and age in all countries (male = 50%; 18–34 years old = 29%, 35–54 years old = 34%, 55+ years old = 37%; The size of the age quota was calculated based on the average size of the age quota across the three countries). The questionnaire, developed in English, was pretested among our professional colleagues, then translated into the respondents' native language for Russia (Russian) and Belgium (Dutch/Flemish). The Dutch translation was proofread by two professional translators; the Russian version was checked by two native speakers.

First, the respondents were informed that the study aimed to investigate how people interact with and think about reusable and non-reusable plastic products. The rest of the questionnaire consisted of three sections. The first section collected sociodemographic variables (gender, age, education, income, and country of residence). In the second section, respondents completed measurement scales for the model constructs: intentions to avoid SUP, attitudes toward SUP alternatives, subjective norms, situational constraints, hygienic concerns, and habits when using SUP. Finally, the third section contained the scales for the profiling variables, namely, engagement in pro-environmental behaviours, green self-identity, environmental concern, and personal values.

We mainly used existing measurement scales, adapted as needed to the SUP context on the basis of insights gathered from our qualitative study. In detail, we measured intentions to avoid SUP (e.g., "I have the intention to avoid single-use plastics in the near future"), attitudes toward SUP alternatives (e.g., "I am positive towards alternatives to single-use plastics"), and subjective norms (e.g., "My family and friends avoid single-use plastics") by adapting Klöckner and Blöbaum's [74] scales. To measure situational constraints (e.g., "Reusable alternatives to single-use plastics are expensive") and hygienic concerns (e.g., "Single-use plastics are more hygienic than reusable alternatives"), we developed scales, based on the CADM and insights from the qualitative study. For habits (e.g., "Using single-use plastics is one of my habits"), we adapted Verplanken and Orbell's [138] scale. All items feature 5-point Likert scales, anchored by "1 = completely disagree" and "5 = completely agree" (see Appendix B).

With regard to the profiling variables, we measured engagement in pro-environmental behaviour by showing the respondents a list of 10 such behaviours (e.g., recycling, avoiding using cars; [193], then asking them to indicate which ones they engage in primarily due to pro-environmental motives. The resulting scale ranges between 0 and 10. For green self-identity (e.g., "I think of myself as a 'green' consumer"), we used Sparks and Shepherd's [205] self-identity scale; for environmental concern (e.g., "People are severely abusing the environment"), we adopted the short version [206] of the New Environmental Paradigm scale [187,207]. The preceding items were all measured on five-point Likert scales anchored by 1 = "completely disagree" and 5 = "completely agree." Next, we used the ten-item short version of Schwartz's Value Survey to measure respondents' personal values, on a ten-point Likert scale: "As a guiding principle in my life, this value is: −1 = opposed to my values, 8 = of supreme importance" [208]. An exploratory factor analysis of the ten items, based on principal component analysis (PCA) estimation and Promax rotation (KMO test = 0.84; 57% total variance explained), revealed the presence of two components that correspond to self-transcendence and conservation on the one hand, and self-enhancement and openness to change on the other. We calculated these two macro value variables as the means of the items loading on the corresponding factors. The constructs, items, and properties for these variables are detailed in Appendix C.

As sociodemographic variables, we obtained information about respondents' gender (male, female, X), age, level of education (junior high school or lower, high school, bachelor's degree, master's degree, and higher education), perceived income (below country average, average, above average), and country of residence (United States, Russia, Belgium). Finally, we conducted a speed test, as a quality check of the responses.

4.2 Results

Confirmatory factor analysis

We first conducted a confirmatory factor analysis (CFA) to assess the reliability and validity of the model measures using LISREL [209]. The results (Appendix B) indicate good model fit: $\chi 2$ (155) = 1485.11, root mean square error of approximation (RMSEA) = 0.04, square root mean residual (SRMR) = 0.04, confirmatory fit index (CFI) = 0.98, and non-normed fit index (NNFI) = 0.97. The standardised item loadings (λ) significantly load on their intended constructs ($p < .01$) and are greater than 0.50 ($0.58 \leq \lambda \leq 0.90$). The average variance extracted (AVE) for each construct also is greater than 0.50 ($0.53 \leq AVE \leq 0.70$), the composite reliability (CR) is always greater than 0.60 ($0.74 \leq CR \leq 0.86$), and Cronbach's alpha values all exceed 0.70 ($0.72 \leq \alpha \leq 0.84$). In support of discriminant validity,

the shared variance between pairs of factors is always less than the corresponding AVE [210]. We provide the bivariate correlations between the model constructs in Appendix D. Thus, the hypothesised measurement model appears valid and reliable [211]. We also applied Harman's single-factor method to control for the risk of common method bias. The results reveal that a single general factor accounts for only 25.97% of the variance, below the threshold value of 50%, so common method variance is not a concern for this study. Moreover, since we collected the data from different countries, we assessed measurement invariance among the three samples by performing configural and metric invariance tests [212]. Configural invariance, i.e. whether the pattern of fixed and free parameters is the same for the three groups, is met (χ 2(465) = 1939, RMSEA = 0.05, NFI = 0.97, NNFI = 0.97, CFI = 0.98). Metric invariance (M.I.), i.e. whether the factor structure is statistically invariant among the three groups, is not observed (χ 2(493) = 2110, RMSEA = 0.05, NFI = 0.96, NNFI = 0.97, CFI = 0.97; $\Delta \chi$ 2(28) = 171, $p < .01$). We thus performed a partial metric invariance test and unconstrained the items responsible for the metric inequivalence (see Appendix B for further details). Partial metric invariance is met (χ 2(483) = 1961, RMSEA = 0.05, NFI = 0.97, NNFI = 0.97, CFI = 0.98; ΔCFI = 0, $\Delta \chi$ 2(18) = 18, $p = .23$), which is a satisfactory result as most of the factor structure is statistically invariant between the groups [213].

Structural model

Next, we tested the hypothesised relationships with covariance-based structural equation modelling. The results in Table 1 confirm good model fit (χ2 (155) = 1485.11, RMSEA = 0.04, NNFI = 0.97, CFI = 0.98, SRMR = 0.04). Consistent with our predictions, attitudes toward SUP alternatives ($\beta = 0.66$, $p < .01$) and subjective norms related to SUP alternatives ($\beta = 0.31$, $p < .01$) have positive influences on intentions to avoid SUP, in support of H1a and H1b. Respondents' existing SUP habits decrease their intentions to avoid SUP, but this effect does not reach the conventional level of significance ($\beta = -.05$, $p < .10$). Situational constraints related to SUP alternatives have no significant effects on intentions to avoid SUP ($\beta = -.05$, $p > .10$), similarly to hygienic concerns ($\beta = -0.01$, $p > .10$), so we cannot confirm H2a,b,c. Overall, attitudes toward SUP alternatives exert the strongest effect on intentions to avoid SUP; also the effect of subjective norms is substantial. Habits instead exert only a marginally statistically significant, minor effect.

HYPOTHESIZED PATHS	Hp	ß	p-value
Attitude SUP altern → Int avoid SUP	H1a	.66	< .01
Subj norms SUP altern → Int avoid SUP	H1b	.31	< .01
Habits using SUP → Int avoid SUP	H2a	-.05	< .10
Situational const SUP atlern → Int avoid SUP	H2b	-.05	> .10
Hygienic concerns SUP altern → Int avoid SUP	H2c	.01	> .10
Indices of global fit	N = 3,000, χ2 (155) = 1485.11, RMSEA = .04, NFI = .97, NNFI = .97, CFI = .98, SRMR = .04		

Table 1. Strucutal model estimation

Notes: Int avoid SUP = intention to avoid SUP (single-use plastics), Attitude SUP altern = positive attitude towards SUP alternatives, Subj norms SUP altern = subjective norms related to SUP alternatives, Habits using SUP = habits in using SUP, Situational const SUP altern = situational constraints related to SUP alternatives, Hygienic concerns SUP altern = hygienic concerns related to SUP alternatives.

4.3 Consumer segments

With regard to Q1 and Q2, we explore the existence of cross-national segments of consumers who might exhibit similar orientations toward SUP avoidance. In a two-step cluster analysis, we develop an empirically based typology of consumers who differ in their intentions to avoid SUP, according to various factors that contribute to these intentions. To cluster the respondents, we used the model variables: intentions to avoid SUP, attitudes toward SUP, subjective norms, situational constraints, hygienic concerns, and habits. In a first step, we used Ward's hierarchical clustering with squared Euclidean distance to identify a preliminary set of cluster solutions, as a basis for determining an appropriate number of clusters, according to the elbow criterion and dendrogram. This initial analysis suggested a four-cluster solution. Then in a second step, we used a non-hierarchical, k-means clustering procedure to develop a four-cluster solution. The group centroids computed in the hierarchical procedure represent the initial clusters for the k-means clustering [214]. The labels for these clusters reflect the members' intentions to avoid SUP and factors that contribute to these intentions: SUP addicts, SUP avoiders, situation-driven SUP users, and the apathetic.

To check the internal validity of the cluster solution, we performed a multivariate analysis of variance (MANOVA) and compared the four clusters on all cluster variables. It produced a significant result (Wilk's $\Lambda = .11$, $F\ (18, 8460) = 544.37$,

p < .01). In subsequent analyses of variance (ANOVA) and Bonferroni post hoc tests, we confirmed that the four groups differ significantly in their perceptions of the cluster variables (Table 2). Finally, we used relevant individual characteristics (prior engagement in pro-environmental behaviours, green self-identity, ecological concern, and personal values) and sociodemographic variables (age, gender, education, income, and country of residence) to describe the clusters (Table 2, 3).

	SUP addicts[a]	Sit-driven SUP users[b]	The apathetic[c]	SUP avoiders[d]	Test statistic	
N (%)	593 (20%)	871 (29%)	920 (31%)	616 (21%)	F(3,2996)	Sig
CLUSTERING VARIABLES	M	M	M	M		
Intentions to avoid SUP	2.29 b,c,d	3.71 a,c,d	3.04 a,b,d	4.17 a,b,c	1218.73	< .01
Attitude SUP altern	2.75 b,c,d	3.87 a,c,d	3.31 a,b,d	4.40 a,b,c	903.29	< .01
Subj norms SUP altern	1.83 b,c,d	3.29 a,c,d	2.53 a,b,d	3.29 a,c	719.16	< .01
Situational const SUP altern	3.92 b,c,d	3.78 a,c,d	3.10 a,b,d	2.37 a,b,c	703.03	< .01
Hygienic concerns SUP altern	3.43 b,c,d	3.59 a,c,d	2.57 a,b,d	1.83 a,b,c	882.26	< .01
Habits using SUP	3.76 b,c,d	3.40 a,c,d	2.94 a,b,d	2.16 a,b,c	562.60	< .01
DESCRIPTIVE VARIABLES	M	M	M	M		
Pro-environmental behaviors for pro-environmental reasons	.70 b,c,d	2.34 a,c,d	1.52 a,b,d	4.02 a,b,c	342.60	< .01
Green self-identity	2.15 b,c,d	3.48 a,c,d	2.88 a,b,d	3.91a,b,c	899.73	< .01
Environmental concern	3.71 b,c,d	4.42 a,c,d	3.85 a,b,d	4.41 a,b,c	152.23	< .01
Transcendence and conservation values	5.46 b,d	6.08 a,c	5.37 b,d	6.09 a,c	60.01	< .01
Self enhancement and openness-to-change values	3.71 b	4.47 a,c,d	3.63 b	3.82 b	37.49	< .01

Notes: M = Mean, N = Sample size, % = Percentage. Letters "a", "b", "c", and "d" indicate significant differences between the cluster of reference and the other clusters at the .05 significance level (Bonferroni post hoc test).

Table 2. Cluster analysis: Clustering and descriptive variables.

Table 3. Cluster analysis: Socio-demographic variables

	SUP addicts[a]	Sit-driven SUP users[b]	The apathetic[c]	SUP avoiders[d]		Test statistic	
N (%)	593 (20%)	871 (29%)	920 (31%)	616 (21%)		F(3,2996)	
SOCIO-DEMO VARIABLES	M	M	M	M			Sig
Age (years)	49.10 b	44.71 a,c,d	48.72 b	47.85 b		12.27	< .01
N (%)	N (%)	N (%)	N (%)	N (%)	TOT %		
Gender						38.51(6)	< .01
Men	324 (54.6)	430 (49.4)	491 (53.4)	248 (40.3)	49.8		
Women	268 (45.2)	441 (50.6)	427 (46.4)	364 (59.1)	50.0		
X	1 (0.2)	0 (0.0)	2 (0.2)	4 (0.6)	0.2		
Education						48.14(3)	< .01
Lower education	264 (44.5)	283 (32.5)	436 (47.4)	229 (37.2)	40.4		
Higher education	329 (55.5)	588 (67.5)	484 (52.6)	387 (62.8)	59.6		
Income						578.29(3)	< .01
Below average and average	188 (31.7)	670 (76.9)	279 (30.3)	156 (25.3)	43.1		
Above average	405 (68.3)	210 (23.1)	641 (69.7)	460 (74.7)	56.9		
Country						168.51(6)	< .01
United States	207 (34.9)	307 (35.2)	314 (34.1)	172 (27.9)	33.3		
Russia	217 (36.6)	381 (43.7)	269 (29.2)	133 (21.6)	33.3		
Belgium	169 (28.5)	183 (21.0)	337 (36.6)	311 (50.5)	33.3		

Notes: Lower education = Junior high school or lower and High School; Higher education = Bachelor's degree, Master's degree or higher education. M = Mean, N = Sample size, % = Percentage. Letters "a", "b", "c", and "d" indicate significant differences between the cluster of reference and the other clusters at the .05 significance level (Bonferroni post hoc test).

SUP addicts (593 respondents, 20%)

We find the lowest intentions to avoid SUP among the segment of SUP addicts. They also express the lowest attitudes and subjective norms toward SUP alternatives. Their habits in using SUP and situational constraints on SUP alternatives appear significantly higher than in the other clusters, whereas their green self-identity and environmental concerns are lowest among all clusters, as is the frequency with which they consciously behave pro-environmentally. Although they score low on self-transcendence and conservation values, their self-enhancement and openness-to-change values are not significantly different from those held by SUP avoiders or the apathetic. In terms of demographics, their average age is not distinctive, but SUP addicts tend to be men with high incomes who reside mainly in the United States and Russia; Belgian consumers are underrepresented in this cluster.

SUP avoiders (616 respondents, 21%)

The SUP avoiders indicate the highest intentions to avoid SUP, along with the highest attitudes toward and subjective norms related to SUP alternatives. They have strongly abandoned the habit of using SUP, and neither contextual nor hygienic factors motivate them to keep using them. We find the highest green self-identity and environmental concern across all clusters, as well as the highest frequency of consciously behaving pro-environmentally. These consumers score higher on self-transcendence and conservation values than SUP addicts or the apathetic. Their self-enhancement and openness-to-change values are not significantly different though. In terms of demographics, their average age is not notably different from other clusters (again, situation-driven SUP users are younger), but SUP avoiders are mostly women, highly educated, and of high income. They mainly reside in Belgium; U.S. and Russian consumers are underrepresented.

Situation-driven SUP users (871 respondents, 29%)

Situation-driven SUP users indicate the second highest willingness to avoid SUP, attitudes toward SUP, subjective norms, green self-identity, environmental concern, and pro-environmental behaviour. They score high on self-transcendence and conservation values, as well as self-enhancement and openness-to-change values. Compared with SUP avoiders and the apathetic, situation-driven SUP users indicate habitual uses of SUP, hygienic concerns, and situational constraints with respect to SUP alternatives, which impede them from reducing their SUP usage intentions. Situation-driven SUP users are gender balanced and significantly younger than the other clusters, although the difference is rather small. They tend to have lower average incomes as compared to other clusters and mainly reside in the United States and Russia.

The apathetic (920 respondents, 31%)

Members of the apathetic cluster indicate the second lowest intentions, attitudes, subjective norms, pro-environmental behaviours, green self-identity, and environmental concern. Similar to SUP addicts, they score low on self-transcendence and conservation values. Their self-enhancement and openness-to-change values are among the lowest but not significantly different from those held by SUP addicts and SUP avoiders. Habits, situational constraints, and hygiene concerns do not seem to affect this cluster. In terms of demographics, their average age is not notably distinctive. They are mostly men, with slightly lower educational levels than other clusters but rather high incomes. They reside relatively equivalently across the three countries.

5 General discussion

Among consumers in three countries, we find that positive attitudes towards and subjective norms with respect to SUP alternatives are important drivers of intentions to avoid SUP. Overall, the effect of barriers is much weaker than the influence of attitudes and subjective norms. In contrast with our expectations, habits, situational constraints, and hygienic concerns pertaining to SUP alternatives do not significantly influence intentions to avoid SUP. Nevertheless, such barriers play a crucial role in specific consumer segments.

The strong effect of attitudes confirms previous findings pertaining to both pro-environmental behaviour in general (e.g., [172,173]) and SUP usage intentions in particular [68]. Our results also corroborate findings of the importance of social norms in influencing pro-environmental behaviour (e.g., [215]) and SUP usage (e.g., [175]). Habits can be powerful barriers to pro-environmental behaviour changes [165], but surprisingly, in our study, habitual SUP usage has no statistically significant role in affecting SUP avoidance intentions. Perhaps consumers do not consciously recognise that their SUP usage is a habit or, contrary to the context of more highly involving products, such as cars, they do not believe it would be hard for them to change this routine. This proposed explanation is consistent with research that shows that some consumers found it easier to stop using plastic bags for groceries when sustainable alternatives (e.g., reusable bags) became widely available [165]. In our study, situational constraints limiting the use of SUP alternatives (e.g., unavailability of more eco-friendly packaging) and hygienic factors related to SUP alternatives do not significantly affect intentions to avoid SUP. This result is surprising considering that situational constraints and hygienic concerns were salient in our qualitative study. Perhaps these factors were more relevant in the early stages of the COVID-19 pandemic, when we conducted our qualitative study, because consumers lacked clear

understanding of how the virus was transmitted, so they actively sought to protect themselves, such as by overusing SUP. These interviewees may have mentioned their hygienic concerns to explain their increased usage of SUP during the pandemic and drew more attention on the situational constraints [167]. However, as more information about the virus became available, and the pandemic itself was better controlled, consumers gradually perceived it as less threatening. Thus, we speculate that hygienic concerns and situational constraints did not affect SUP avoidance intentions during the quantitative study, which we conducted later. Nevertheless, as we anticipated, these three barriers have significant effects on SUP avoidance intentions in some consumer segments.

We identify four consumer segments, on the basis of their intentions to avoid SUP and the motivations for these intentions. We can assign them to a SUP avoidance continuum. That is, at the highest level, SUP avoiders consistently exhibit strong SUP avoidance intentions, along with powerful attitudes and subjective norms about SUP alternatives, pro-environmental values, green identities, and pro-environmental behaviours. At the lowest level, SUP addicts exhibit diametrically opposed scores. Thus, we can confirm a significant relationship between attitudes, subjective norms, environmental concerns, pro-environmental behaviours, personal values, and green self-identity on the one hand and pro-environmental behavioural intentions on the other (e.g., [194]). Even if habits, situational constraints, and hygienic concerns have no significant influences on SUP avoidance intentions in general, they emerge as relevant for the SUP addict and situation-driven SUP user clusters. That is, perceived barriers related to habits, situational constraints, and hygienic concerns are higher among these groups than for SUP avoiders. Therefore, the perceived barriers should not be ignored because they may have a crucial effect in terms of reducing SUP avoidance among a large proportion of consumers (i.e. the apathetic and situation-driven SUP users together represent almost 60% of the total sample).

Demographic characteristics exhibit relatively minor influences, in line with inconsistent evidence regarding the effects of demographic characteristics on pro-environmental behaviour (e.g., [216]). This finding is meaningful, since it shows that interventions targeted to specific demographic groups will not always be the most effective in achieving desired behaviour change. As a notable difference, and in line with previous research [217], we find that SUP addicts are mostly men, whereas SUP avoiders are mostly women. Regarding countries of residence, all three countries are represented in each of the customer segments, but more than 50% of SUP avoiders are Belgian consumers. In contrast, for clusters of SUP addicts and situation-driven SUP users, U.S. and Russian consumers account for about 70%–80% of the sample. These findings are consistent with Belgium's higher scores

on the EPI compared with the United States and Russia, as well as its substantially lower SUP waste per capita.

5.1 Implications for theory

This study establishes three main theoretical contributions. First, previous literature has mostly focused on specific SUP antecedents (e.g., [165]) or used the Theory of Planned Behaviour more generally to explain SUP-related behaviours (e.g., [67]). We instead leverage the CADM of ecological behaviour [74], refine it with our qualitative study, and derive a comprehensive framework that outlines the relative importance of various crucial drivers of and barriers to the formation of SUP avoidance intentions. As we show, attitudes and subjective norms related to SUP alternatives have strong positive effects on intentions to avoid SUP, whereas SUP habits, situational constraints, and hygienic concerns have generally no significant influence, but are important in two consumer segments (i.e. SUP addicts and situation-driven SUP users).

Second, we identify consumer segments that differ in their intentions and underlying motivations to avoid SUP, then profile them in terms of demographic characteristics, personal norms and values, and current pro-environmental orientations. This theoretical contribution helps establish that not all consumers are equal when it comes to SUP avoidance. Different consumer segments find specific drivers and barriers more important than other segments, such that they exhibit unique motivational processes that inform their SUP avoidance intentions. For example, situational constraints are relatively unimportant to SUP avoiders, but they appear quite relevant to SUP addicts and situation-driven SUP users.

Third, rather than focusing on a single country [166], we apply matching gender and age quotas [204] and conduct a quantitative study across three countries, the United States, Russia, and Belgium, which differ in their environmental performance levels, as well as relevant legislation and regulations. By offering a cross-national validation of the findings related to our research hypotheses, we achieve greater data variance and enhance the external validity of our findings [201].

5.2 Implications for practitioners and policymakers

Our study suggests that communication campaigns designed to encourage avoidance of SUP should address different consumer segments differently, using tailored motivational content. For example, if communications target SUP avoiders and the apathetic, they should stimulate positive attitudes and social norms. Such

efforts might even stimulate SUP avoiders to become ambassadors, reflecting their enhanced, already positive orientations, such that they spread positive information about SUP alternatives or share good practices. These efforts in turn may be particularly effective among the apathetic segment, who are not particularly sensitive to environmental degradation. For example, in a successful effort to build positive attitudes and social norms, the Mei Plastic Vrij [218] (translated: May without Plastics) campaign invited consumers to avoid plastics for one month, using examples and initiatives that consumers could share on social media, such that it evoked positive attitudes and enhanced perceptions of social norms related to SUP avoidance. Similarly, a campaign seeking to alter people's attitudes featured pictures that a photojournalist took of different people in various places, holding the same banner ("IsupportBanPlasticKE"). It evoked emotional components of attitude formation; in addition, the message came from people with whom anyone could identify. In response to this proactive effort, SUP avoiders can take action, while other consumers, such as the apathetic, might start noticing overused plastic in supermarkets.

Communications that predominantly target SUP addicts and situation-driven SUP users should aim to change consumers' perceptions of their own habits, situational constraints, and hygienic concerns. Information about the availability of SUP alternatives (e.g., highlighting easy-to-read, plastic-free labels) and the feasibility of purchasing SUP alternatives are crucial for convincing these segments to avoid SUP (e.g., [161]). Communications that reassure or reward them for their eco-friendly choices also might be effective. An interesting example is the "What's your bag plan?" campaign, which urges shoppers to make more conscious decisions about how to get their groceries home and become a "bagger" (reusable bags), a "boxer" (cardboard boxes), or a "juggler" (neither) [219]. Similarly, Greenpeace encourages consumers to share photos of excessive packaging with the hashtags #RidiculousPackaging or #BreakFreeFromPlastic [220]. These communications campaigns should reflect existing regulations. In addition, the combination of bans on SUP items and efforts to raise awareness among manufacturers, retailers and consumers about SUP avoidance seems essential [197]. More sustainable alternatives (e.g., Konjak Sponge, menstrual cups, shower bars, laundry sheets) should be readily available, easily accessible, and just as convenient as SUP. However, it is important to consider that sustainable alternatives should be used in a sustainable way, and implemented in people's daily routines. To make the SUP alternatives more attractive, manufacturers or retailers might charge consumers who insist on SUP product variants (e.g., deposits for plastic bottles and cans). Together, these factors should stimulate SUP addicts and situation-driven SUP users to include SUP alternatives in their daily lives.

Finally, designers of SUP alternatives might beneficially take the different types of users into account [169]. For example, SUP avoiders are willing to bear more effort to protect the planet and like to signal their green identity to others. Therefore, personalised SUP alternatives that help them signal their green self-identity could be very appealing to SUP avoiders. This strategy may be less effective among SUP addicts and the apathetic though, because they express minimal ecological concerns and pro-environmental orientations. In addition, these consumers perceive high barriers to using SUP alternatives, so when targeting them, an effective option might be to use a return model and offer reusable products that the company commits to clean professionally, such that their usage is both easy and safe. Furthermore, product designs that mimic the versions that consumers are accustomed to, in terms of performance and usability (e.g., reusable straws, cotton bags), may be an effective approach.

5.3 Limitations and guidelines for further research

Our finding that habits, situational constraints, and hygienic concerns only play a role for some consumer segments suggests the need for further investigation. Continued research might explore if some specific habits, situational constraints, and hygienic concerns actually emerge as relevant for different types of SUP, such as plastic bags versus straws or disposable cutlery and kitchenware. For example, hygienic concerns may be more important for packaged food and sanitary products than for disposable cutlery and grocery bags. Conversely, situational constraints may be particularly pertinent for plastic bags, suggesting that unique design requirements apply to various sustainable alternatives. It is also important to consider that reusable alternatives will only be more environmentally friendly when used frequently enough and for a rather long period of time, since lifecycle analyses show that the production of a sturdier carrier bag takes up more energy and water than disposable bags [221]. Thus, future research should consider the long-term usage of reusable products and investigate users' behaviour after purchasing the product. Additional research could also compare our findings with evidence related to other disposable products, such as cardboard packaging or paper bags.

Despite our recommendations for practice, we also acknowledge that legislation and regulation may be more impactful than public awareness campaigns [77]. If a country bans SUP shopping bags or straws and replaces them with reusable alternatives or more eco-friendly materials, the situational constraints and inconveniences for consumers will largely disappear. We call for research into the effectiveness of such measures, as well as the best way to combine them with nudging and other persuasive communication efforts.

The consumer segments we identified cannot be found and reached using basic demographic criteria; they do not really differ much in their demographic characteristics. It would be helpful if research could link the four consumer segments that we have identified to a broader range of consumer characteristics and typical product usage behaviours, which in turn could reveal other sustainable solutions or innovations to steer non-SUP consumption.

Finally, continued research should test our model and corroborate our findings in different settings, countries, and cultures. Culture shapes societally reinforced values and behaviours [166]. Investigating the role of cultural values in the development of pro-environmental behaviour and SUP avoidance might provide valuable insights into how to encourage more pro-environmental behaviour, in ways that reflect different cultures.

Appendix

Appendix A. Qualitative study: Profile of interviewees

PSEUDONYM	GENDER	AGE	RESIDENCE	INCOME	EDUCATION	CHILDREN
A_1_M	M	18-25	Rural	Average	Master	No
A_2_F	F	18-25	Urban	Average	Master	No
A_3_M	M	18-25	Rural	Low	Master	No
A_4_F	F	18-25	Urban	Low	Master	No
B_1_F	F	36-45	Urban	High	Master	Yes
B_2_F	F	26-35	Suburban	Average	Master	Yes
B_3_M	M	26-35	Suburban	High	Master	Yes
B_4_M	M	36-45	Suburban	Average	Graduate	Yes
C_1_M	M	56-65	Rural	High	Sec. school	Yes
C_2_M	M	46-55	Rural	High	Master	Yes
C_3_F	F	46-55	Rural	High	Master	Yes
C_4_F	F	46-55	Urban	High	Master	Yes
D_1_M	M	18-25	Urban	High	Master	No
D_2_F	F	26-35	/	/	Sec. school	No
D_3_M	M	36-45	Suburban	Average	Master	No
D_4_F	F	26-35	Urban	Average	Bachelor	No
E_1_M	M	56-65	Suburban	Average	Master	Yes
E_2_M	M	46-55	Suburban	Average	Sec.school	Yes
E_3_F	F	46-55	Urban	Average	Graduate	Yes
E_4_F	F	46-55	Suburban	Average	Bachelor	Yes
F_1_M	M	18-25	Urban	Average	Master	No
F_2_M	M	18-25	Suburban	Average	Master	No
F_3_F	F	18-25	Rural	Low	Bachelor	No
F_4_F	F	26-35	Urban	Average	Master	No
G_1_M	M	46-55	/	Low	Sec. school	Yes
G_2_F	F	46-55	Rural	Low	Master	Yes
G_3_F	F	56-65	Rural	Low	Sec. school	Yes
G_4_M	M	26-35	Urban	Average	Bachelor	No
H_1_M	M	65+	Urban	Average	Sec. school	No
H_2_F	F	65+	Urban	High	Master	Yes
H_3_F	F	65+	Urban	Average	Sec. school	Yes
H_4_M	M	65+	Rural	Average	Sec. school	Yes

Appendix B. Model constructs' measurement scales, items, and their properties

MODEL CONSTRUCTS	M(SD)	λ	α	CR	AV
INT AVOID SUP	3.32 (.87)		.79	.81	.59
• I have the intention to avoid SUP in the near future		.76			
• I have the intention to recommend reusable alternatives to SUP to my friends		.87			
• I will buy food without packaging as much as possible		.72			
ATT SUP ALTERN	3.59 (.82)		.80	.81	.53
• I'm positive towards alternatives to SUP		.68			
• I don't feel well when I see SUP*		.78			
• I love trying out alternatives to SUP*		.76			
• I think it's important to avoid SUP		.74			
SUB NORMS SUP ALTERN	2.77 (.88)		.76	.80	.58
• My family and friends avoid SUP		.86			
• I feel encouraged by family and friends to search for alternatives for SUP		.90			
• I feel uncomfortable when others observe me putting no effort in avoiding SUP*		.58			
SITUAT CONST SUP ALTERN	3.31 (.90)		.72	.74	.60
• Reusable alternatives are more expensive than SUP		.73			
• Reusable alternatives are more difficult to use than SUP		.90			
HYGIENIC CONCERNS SUP ALTERN	2.89 (.99)		.84	.86	.70
• SUP are safer than reusable products		.91			
• SUP protect you better from contaminants*		.88			
• SUP are more hygienic than reusables		.95			
HABITS USING SUP	3.07 (.91)		.82	.85	.57
• I have the habit of buying plastic bottles		.72			
It belongs to my routine to buy pre-packaged food*		.79			
• I automatically buy a lot of pre-packaged products without thinking		.90			
• Using SUP is something I do without thinking		.88			
• Using SUP is one of my habits		.85			

Appendix C. Cluster descriptors, items, and their properties

CONSTRUCTS USED AS QUALITATIVE DESCRIPTORS	M(SD)	α
Pro-environmental behaviours for pro-environmental reasons	2.11 (2.22)	NA
Recycling waste		
Buying biological or biodegradable soaps		
Being a member of an environmental movement		
Using rainwater		
Having an ecological energy provider		
Avoiding disposable packaging in supermarkets		
Having short showers		
Avoiding use one's car		
Avoiding airplane travels		
Avoiding buying fast fashion clothes		
Green self-identity	3.12 (.89)	.81
I think of myself as a 'green' consumer		
I think of myself as someone who is worried about the environment		
Avoiding single-use plastics contributes positively to my self-image		
Environmental concern	4.05 (.74)	.85
People are severely abusing the environment		
Despite our special abilities, humans are still subject to the laws of nature		
The earth is like a spaceship with very limited room and resources		
The balance of nature is very delicate and easily upset		
If things continue on their present course, we will soon experience a major catastrophe		
Personal values		
Transcendence and conservation	5.74 (1.42)	.81
Universalism		
Benevolence		
Tradition / Conformity		
Security		
Self enhancement and openness-to-change	3.93 (1.84)	.76
Self-direction		
Achievement		
Stimulation		
Power		
Hedonism		

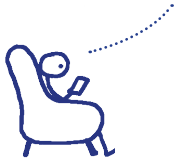
Notes Appendix B and C: INT AVOID SUP = intention to avoid SUP (single-use plastics), ATT SUP ALTERN = positive attitude towards SUP alternatives, SUB NORMS SUP ALTERN = subjective norms related to SUP alternatives, SITUAT CONST SUP ALTERN = situational constraints related to SUP alternatives, HYGIENIC CONCERNS SUP ALTERN = hygienic concerns related to SUP alternatives, HABITS USING SUP = habits in using SUP, M = mean, SD = standard deviation, λ = standardised item loadings, α = Cronbach's alphas, CR = composite reliability, AVE = average variance extracted, * = items unconstrained to obtain partial metric invariance.

Appendix D. Correlations between constructs

	INT AVOID SUP	ATT SUP ALTERN	SUB NORMS SUP ALTERN	SIT CONST SUP ALTERN	HYG CONC SUP ALTERN	HABITS USING SUP
INT AVOID SUP	1					
ATT SUP ALTERN	.68*	1				
SUB NORMS SUP ALTERN	.53*	.44*	1			
SIT CONST SUP ALTERN	-.26*	-.25*	-.14*	1		
HYGIENIC CONCERNS SUP ALTERN	-.19*	-.23*	-.07 (ns)	.46*	1	
HABITS USING SUP	-.30*	-.29*	-.15*	.45*	.35*	1

Notes: INT AVOID SUP = intention to avoid SUP (single-use plastics), ATT SUP ALTERN = positive attitude towards SUP alternatives, SUB NORMS SUP ALTERN = subjective norms related to SUP alternatives, SIT CONST SUP ALTERN = situational constraints related to SUP alternatives, HYGIENIC CONCERNS SUP ALTERN/ HYG CONC SUP ALTERN = hygienic concerns related to SUP alternatives, HABITS USING SUP = habits in using SUP, * = Correlation is significant at p=.05, (ns)= Correlation is not significant. This matrix is diagonal.

Halfway through the thesis.
You can do it!



L. Herweyers, E. Du Bois, I. Moons, Trash talk: Who uses which reusable product? User insights and design opportunities for single-use alternatives, International Conference on Design Engineering (ICED) (2023) 3641–3650. https://doi.org/10.1017/pds.2023.365.

CHAPTER FOUR

Trash talk: who uses which reusable product? User insights and design opportunities for single-use alternatives

Laure Herweyers, Els Du Bois, Ingrid Moons

Abstract: Single-use products often end up in the environment as waste, threatening ecosystems and human life. This indicates a need to transition towards sustainable reuse routines. In this study, we investigate to what extent reusable products are already established in society and what design properties users require. We compare the results between user clusters and countries. To create a meaningful list of reusable products to investigate, we distinguish four categories based on typical barriers by means of focus groups (n=3) and interviews (n=32). Next, we did a survey (n=3000) in three countries (Belgium, Russia, U.S.) to define user clusters and investigate product usage and design requirements. Most established products are hard-material products such as lunch boxes, while intimate care products, such as menstrual cups, are not established yet. Multifunctionality and compactness are the most indicated product requirements. There are significant differences between countries and clusters for both research questions. We conclude that different types of users have different needs: while a sharing system might work for one group, a customisable option would be more suitable for others.

Keywords: long-term reuse behaviour; sustainability; circular economy; cross-country study; user-centred design

1 Introduction

Since the introduction of single-use products (SUP), many objects transitioned from having value to being considered waste after only a very short usage period [61]. Next to resource depletion and greenhouse gas emissions, the immense

amount of waste created each day alongside mismanagement of waste processing has contributed to significant pollution worldwide. Many disposable products are made of plastic, as the material has several advantages such as being lightweight, affordable, and flexible [3]. Plastics were introduced to the broad public in the 1950s and the first single-use shopping bags were introduced in 1965 [222]. Between the 1970s and 1990s, plastic consumption more than tripled [223], and the total amount of plastics produced is forecasted to reach 445 million metric tons in 2025 [5]. When plastics end up in the environment, they can threaten ecosystems and human life [224]. Plastics do not biodegrade, so larger items eventually break down into smaller particles, the so-called microplastics. Since the discovery of the Great Pacific Garbage Patch in 1997, whose area is still rapidly increasing [10], more and more research has been done on the potentially harmful effects of macro- and microplastics [156]. Next to plastics, other materials are also widely used in disposable products. For example, cardboard packaging makes up 33% of global packaging demand, followed by flexible plastics (26%) and rigid plastics (19%) [225]. As societal awareness is rising regarding the environmental impact of waste, 70% of consumers in Europe are concerned about plastic packaging while only 1% worry about cardboard packaging [226]. The potential negative impact of plastics has reached the broad public, while the impact of paper and cardboard, mainly in the production phase, is less well known. Inaccurate ideas about the ecological impact of other materials than plastic such as cardboard and bio-based plastics often result in well-meant, though environmentally unfriendly behaviour, such as replacing single-use plastic items with single-use cardboard items instead of adopting reusable products.

The transition from a throw-away culture towards reuse routines is key to tackling the mountains of waste that are created each day. Since the ban on several SUP by the European Union [25] went into place, several reusable alternatives are popping up, one more successfully implemented than the other. Examples are reusable produce bags, drinking bottles, and straws. If a reusable product is not used at least a minimal number of times, there will be no environmental gain, on the contrary. Reusable products are often more durable, consist of more material, and in general, their production costs more energy and water than single-use items [37]. Besides this, the usage phase (e.g., cleaning process) of these products is often more resource intensive as well [38]. According to a life cycle assessment (LCA) study, a stainless steel straw should be reused at least 150 times instead of using a new single-use plastic straw each time, in order to become better for the environment [135]. In this paper, the minimum amount of times a product should be reused before it is better for the environment than its single-use alternative is referred to as the 'break-even point'. What has to be taken into account, is that LCA studies are not flawless and

often refrain from taking incorrect disposal into account, but they can provide a rough estimation of the break-even point. Each additional reuse cycle decreases the overall environmental impact of the product, so it is vitally important to make sure that reusable products and related services persuade and support people in adopting sustainable reuse behaviour and creating long-lasting routines. Consequently, understanding this is essential for the design of successful reusable products.

1.1 Objective

In order to reach long-term usage of reusable products and move beyond the break-even point, a thorough understanding of the user is important to tackle the barriers to implementing new reuse routines in people's daily lives. A combination of individual and cultural, societal, and social norms and values determine people's mindset and attitude towards reusable products. Next to this, situational factors can facilitate or complicate effective usage. Regarding existing products, some are already well established and accepted in society, while others receive more doubts and backlash. In this study, we investigate whether different user groups, distinguished and described according to individual and context-related variables, differ in their current reuse behaviour and preferences regarding certain reusable products, and we open a discussion on why. We also look at differences between countries to address the monocultural focus omnipresent in previous research [166] and cultural values. The study includes a cross-national sample of consumers from the United States (U.S.), Russia, and Flanders (Belgium), all developed countries but with different pro-environmental behaviours: Belgium scores 58,20 on the Environmental Performance Index, while the U.S. and Russia score respectively 51,10 and 37,50 [199]. The following research questions are formulated:

Q1: To what extent are certain reusable products in different categories already established in society?

- Q1.1: How does this differ between countries?
- Q1.2: How does this differ between user groups?

Q2: What do different user groups and countries expect and require from future reusable products?

1.2 Theoretical framework

To create meaningful user groups to predict and investigate differences in the avoidance of SUP and the (long-term) acceptance of reusable products, we adopt

variables from social-psychological models, such as the Theory of Planned Behaviour (TPB). The model states that three main processes; attitude, subjective norms, and perceived behavioural control, lead to behavioural intent, which is, according to TPB, the most decisive determinant of behaviour [117]. However, the intention-behaviour gap [119] is a well-described phenomenon that illustrates the frequently occurring contradiction between people's intention and actual behaviour, hence our interest in comparing the actual behaviour of different user groups based on, among other things, intention. Besides these variables, other factors also influence behaviour, such as personal values and norms, habitual behaviour, and objective constraints, as proposed in the Comprehensive Action Determination Model (CADM) [74], which we also include in our study. Apart from socio-demographical characteristics, we use the following profiling variables, based on previous research on the adoption of ecological behaviour, to further describe the clusters: environmental concern [207], green self-identity [191], and current pro-environmental behaviour [227].

2 Materials and methods

2.1 Data collection and sample

We did a quantitative survey with a cross-national sample of 3,000 respondents from three countries, i.e. the United States (U.S.) (N=1,000), Russia (N=1,000), and Belgium (Flanders) (N=1,000). The survey method was chosen because it enabled us to collect a large amount of data in a relatively short time and provided the possibility to collect information on a broad range of things, such as demographics, past and current behaviour, and attitudes [228]. On top of this, the data allowed us to perform a cluster analysis, enabling us to construct the consumer groups and make comparisons. Data were collected online by a professional market research agency (Kantar) during a three-week period in April 2021. The same quota for gender and age were used in all countries, based on the mean of the demographic data in each country (gender: male = 50%; age: 18-34 years old = 29%, 35-34 years old = 34%, 55+ = 37%). The questionnaire was originally constructed in English, and translated into Russian and Dutch (Flemish), the native language of our respondents in respectively Russia and Flanders, Belgium. The Russian version was proofread by two separate native speakers and compared with the English version to resolve inconsistencies. The Dutch version was proofread by a professional English - Dutch translator. In total, 5,060 respondents filled in the survey, of which 3,000 responses were valid. Data collection stopped when the age and gender quota were reached. A control question and speed check filtered out unreliable submissions and were not included in the quota.

2.2 Questionnaire

The first part of the survey consisted of questions on demographic characteristics, including age, gender, living area, income, employment situation, education, and family situation. This was followed by seven statements on self-reported habitual behaviour regarding the usage of SUP with a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Next, nine examples of reusable alternatives to single-use plastics were presented, to which the respondents had to answer how often they use those products, ranging from never (1) to always (5). There was also an option 'not applicable' for, e.g., people that don't menstruate and thus don't need a menstrual cup. The following question asked for the reasons to pose ecological behaviour in general, with ten statements. The next block related to people's attitudes. The first question consisted of four statements regarding attitude towards single-use plastics avoidance, with a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5), followed by two statements on attitude and behaviour before and after the COVID-19 pandemic, and a question specifically asking people's attitudes regarding hygiene and safety related to SUP and alternatives. The last question of this block consisted of another five-point Likert scale question with four statements on the intention to use reusable products in the near future. The next block considered situational factors. This included a Likert-scale question with six statements on perceived behavioural control (such as time, price, and ease of use). The next block was more focused on design and asked for preferred characteristics of and requirements for good reusable products. This consisted of eleven items with multiple answers possible, ranging from 'I like it when they can be personalised', to 'I find it annoying to clean/ maintain them'. The next block regarded subjective norm, followed by green self-identity (both multiple-item Likert-scale statements).

2.3 Cluster analysis

We first conducted a factor analysis with reliability test (Cronbach alpha) of the items for all variables, of which the results indicated a good fit. We did a cluster analysis to categorise the respondents, for which we used the variables intentions, attitudes, subjective norms, situational constraints, hygienic constraints and habits. We used Ward's hierarchical clustering with squared Euclidean distance to identify a preliminary set of cluster solutions. This also served as a basis to determine the number of clusters, which resulted in a four-cluster solution. The next step included a non-hierarchical, k-means clustering procedure. Below, we shortly describe the resulting clusters with demographic characteristics and descriptive variables environmental concern, green self-identity, and pro-environmental behaviour for

pro-environmental reasons. The labels reflect each cluster's intention to avoid SUP (SUP) and the factors that contribute to these intentions.

SUP avoiders (616 respondents, 21%) have the highest intention to avoid SUP, as well as attitude and subjective norms towards reusable alternatives. Neither contextual nor hygienic factors influence their reuse behaviour. They show the highest green self-identity and environmental concern and already often consciously behave pro-environmentally. They are mostly women, highly educated with high incomes. They mainly reside in Belgium.

Situation-driven SUP users (871 respondents, 29%) indicate the second highest willingness to avoid SUP, as well as attitude and subjective norms towards reusable alternatives, and green self-identity, environmental concern, and pro-environmental behaviour in general. Compared with SUP avoiders and apathetic, their habitual usage of SUP, hygienic concerns and situational constraints have more influence on their intention to use reusable products. They are gender balanced and significantly younger than the other clusters. They reside mostly in the U.S. and Russia.

The apathetic (920 respondents, 31%) have the second to lowest intentions, attitudes, subjective norms and pro-environmental behaviours towards reusable alternatives, and also their green self-identity and environmental concern are low. Habits, situational constraints, and hygienic concerns do not really affect this cluster. They are mostly men with high incomes who live equally across the three countries.

SUP addicts (593 respondents, 20%) have the lowest intentions, attitudes, and subjective norms to avoid SUP, as well as low green self-identity and environmental concern. Their existing SUP habits and situational constraints on reusable alternatives are significant barriers towards sustainable behaviour. they are mainly men with high incomes from the U.S. and Russia.

2.4 Product selection

We made a list of nine reusable products that can be classified into four categories: (i) on the go, (ii) daily shopping, (iii) at home, and (iv) intimate care. The categories were defined based on consumer focus groups (n=3) and interviews (n=32). The focus groups took place in January 2020 and the interviews in October and November 2020. Each focus group lasted for about 1,5 hours and took place on campus. We did each focus group with a different user group, based on attitude and self-reported pro-environmental behaviour (from very un-ecologically minded towards very eco-minded), and asked for typical products they used and what the

barriers are towards adoption and long-term reuse of these products. We did the interviews online due to COVID-19 regulations with 32 respondents with different demographic backgrounds (gender, age, family situation, income, residence type), and asked more in-depth questions about (possible) barriers for long-term usage of a wide range of reusable products. Each interview lasted for about one hour.

From the results, we could divide products into four categories based on typical contexts and barriers. We found forgetfulness, spontaneity, and weight and volume for 'on the go' products, existing routines and time- constraints for 'daily shopping', practicality and ease for 'at home' products, and hygiene, usability, trust, and shame for 'intimate care' products. Barriers typical for all products are the cleaning process and time investment. Some products fit into two categories. In the category on the go, we selected a reusable coffee cup, drinking bottle, and lunch box or food wrap. The category daily shopping included a reusable jar, lunch box or wrap, and produce bags (reusable bags for fruits and vegetables). The category at home encompasses products solely used at home, for which we selected reusable razors, reusable jars, and the food hugger as an alternative to cling film. For intimate care, we chose a razor, menstrual cup/ pads, and washable diapers. The products were chosen based on how often they were mentioned in the focus groups and interviews, and their wide availability and familiarity.

3 Results

3.1 Products

We compare the means (M) and standard deviations (SD) of the results of the question of how often the respondents use each reusable product in a list of nine products, ranging from never (1) to always (5) (table 1). In the questionnaire, there was a 6th option 'not applicable' that the respondents had to indicate if they did not use the single-use version of the reusable product either. The 'not applicable' option is not included in the analysis and considered a missing value. For the comparison between both the countries and clusters, we did a one-way ANOVA to check significance and a Bonferroni t-test to check which countries and clusters are significantly different.

Country

A one-way ANOVA showed significant differences between all three countries for lunch boxes or wraps and reusable produce bags. The lunchbox is quite popular in Belgium (most used reusable product, M 4.03) and also in Russia (M 3.73) but less in the U.S. (M 3.11). Produce bags are most popular in Russia (M 3.79), also

PRODUCT	jar	coffee cup	lunch-box/wrap	razor	drinking bottle	produce bags	food huggers	menstrual cup/pads	washable diapers
MEAN	3.88	3.67	3.64	3.54	3.52	3.48	2.41	1.59	1.52
SD	1.076	1.423	1.318	1.446	1.282	1.318	1.258	1.169	1.005

Table 1. How often do you use this reusable product (total relevant sample)

in Belgium (M 3.57), and as with the lunch box, less in the U.S. (M 3.08). There is no significant difference between the U.S. and Belgium regarding the mean for drinking bottles (respectively M 3.67 and M 3.70), reusable glass jars (M 3.75 and M 3.84), and reusable razors (M 3.40 and M 3.24), which are all relatively popular. However, there is a significant difference between those two countries and Russia (drinking bottles M 3.19, glass jars M 4.05, Razors M 3.90). Russia and the U.S. show very similar results regarding reusable coffee cups and food wraps but differ significantly from Belgium (respectively M 3.78, M 3.84, and M 3.33 for coffee cups and M 2.47, M 2.58, and M 2.14 for food huggers). Belgium and Russia score similarly for menstrual cups/pads (both M 1.48) and washable diapers (respectively M 1.31 and M 1.36), but differ significantly from the U.S. who scores higher on both products (M 1.82 and M 1.87). However, even the results from the U.S. are still considered low. In general, reusable food wraps, menstrual cups or pads, and washable diapers seem to not be established yet in any of the countries.

Cluster

A one-way ANOVA showed significant differences between the four clusters for reusable drinking bottles, glass jars, produce bags, and coffee cups. We can consistently see that the SUP addicts have the lowest usage of reusable alternatives ($M < 3.50$), apathetic the second-to-lowest, situation-driven SUP users the second-to-highest and SUP avoiders the highest ($M > 4.00$) for these products. This also accounts for the usage of lunch boxes/ wraps, but the results for SUP addicts and apathetic do not differ significantly (respectively M 3.24 and M 3.39). Situation-driven and SUP avoiders score similarly on the usage of food huggers (respectively M 2.77 and M 2.83) but differ significantly with the SUP addicts (M 1.81) and apathetic (M 2.20). Regarding razors, situation-driven and SUP avoiders score similarly (M 3.70 and M 3.80) but differ significantly from SUP addicts and apathetic (M 3.30 and M 3.36) who mutually also score similarly. For menstrual cups and washable diapers, situation-driven and SUP avoiders score similar (M 1.88 and M 1.73 for menstrual cups and 1.84 and 1.61 for washable diapers) but significantly different from SUP addicts (M 1.22 and M 1.16) and apathetic (M 1.44 and M 1.36) who also differ from one another. Only regarding the menstrual cup or pads and the diapers, the

situation-driven users score slightly higher than the SUP avoiders, although usage frequency is low across all four clusters.

3.2 Product requirements

The respondents were requested to indicate statements they agree with regarding reusable products, with no limitation on the number of statements. The statement 'I find it handy when they are multifunctional' is indicated most often by the respondents (55%), followed by 'I prefer them to be compact' (38%) and 'I think quality is more important than price' (38%). 18% think price is more important than quality. 18% prefer to be the sole owner of a product, 16% find it important that a product is attractive, and 14% want a product to be customisable. The least indicated statements are 'I want to show the product to my friends and family' (9%) and 'I feel silly or weird while using them in public' (5%). Regarding the typical barriers, 27% indicate they forget to bring the products with them, and 24% find it annoying to clean the products. The graphs below (Figures 1 and 2) show how much percentage of the respondents of each country and cluster indicated each statement. Regarding the clusters, it is important to note that overall more statements are indicated by the SUP avoiders and situation-driven SUP users, than the apathetic and SUP addicts.

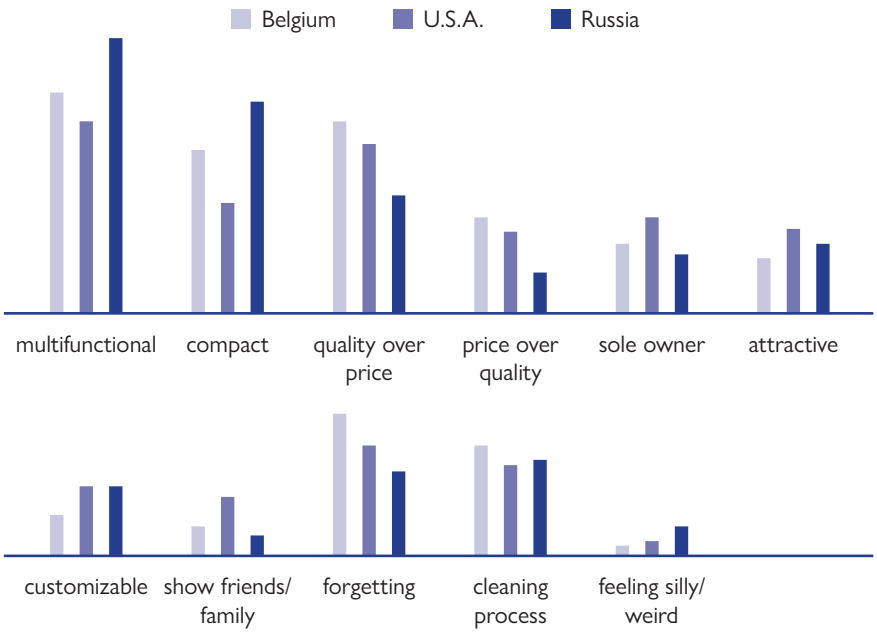


Figure 1. Requirements and barriers indicated per country

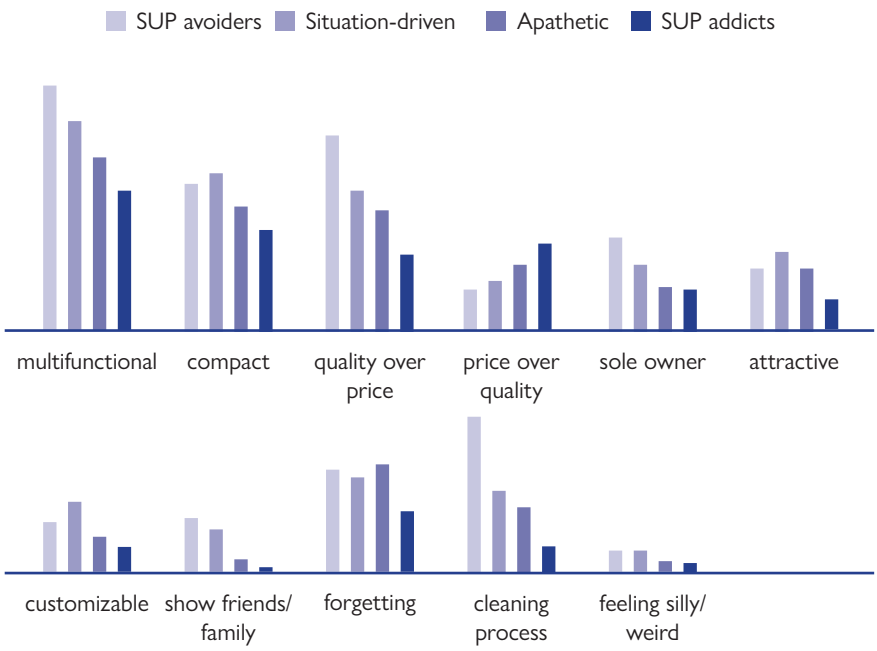


Figure 2. Requirements and barriers indicated per cluster

4 Discussion

This study addresses continued, long-term usage of reusable products, and compares clusters of users based on e.g., attitude and intentions, and countries. Its main purpose is to gain insights into the differences between the user groups and open a discussion on the reasons why, and create drivers and requirements for the future design of reusable products.

4.1 Products

Hard material products such as lunch boxes, coffee cups, drinking bottles, razors, and jars seem to be most commonly used among all respondents. They are usually made out of hard plastic, metal, or glass. A potential explanation can be that they are easy to clean and wear and tear is less visible on these types of materials. Another explanation is the market growth for said products, such as the rise of the reusable coffee cup market, and the increase in tourism and tea- and coffee-drinking habits [229]. Products made out of soft materials such as food huggers, diapers, menstrual

pads and -cups are not that popular, and produce bags are situated in the middle. The materials are generally more vulnerable and less easy to clean. In the case of diapers and menstrual products, trust and safety can be decisive factors, as well as shame, perceived user friendliness and lack of familiarity. Produce bags might be not that frequently used because they are not always necessary and easy to forget. It is interesting to note that less visible products, such as several 'at home' and 'intimate care' products, are less commonly used. This could be due to the absence of subjective norm: other people giving the example and showcasing the products.

Countries

Overall, reusable products are not necessarily more popular in one country compared to another, but there are clear differences in which products are more established already in which country. This is probably culturally defined, and related to what kind of products are considered 'normal' already in what country. For example, lunch boxes are most popular in Belgium, jars in Russia, and coffee cups in the U.S. Another argument is that the reusable product might have never really been replaced with a single-use equivalent to begin with, so the reusable product was always the norm, which could be the case with the safety razor in Russia. According to literature, residents from Eastern European countries have a higher durability expectation and willingness to repair [230]. Intimate care-related products are not popular in any country, which makes us conclude that they are not yet established anywhere.

Clusters

As expected, SUP avoiders use almost all reusable alternatives more frequently than, in descending order, situation-driven SUP users, apathetic, and SUP addicts. We can conclude that having a positive attitude, green self-identity, and subjective norm towards more environmentally friendly and SUP-avoidance intentions is related to more usage of reusable alternatives. However, the intimate care products are not well established in all four categories, and the SUP avoiders score even lower than the situation-driven SUP users. This could be due to unfamiliarity, incompatibility with current behaviours, invisibility, and prejudice towards the products. Also the shame and taboo around menstruation and bodily fluids in general could lead to hesitance regarding trying new products and talking about it with peers.

4.2 Product requirements

In general, practical aspects are considered most important, such as multifunctionality, quality, and whether the product is compact. This can be linked to the predefined barriers, such as weight, volume, and practicality. Barely one-fifth of the respondents

indicated that they find price more important than quality, but this could be an underestimation of the real number since the respondents might be prone to social desirability bias and believe they are expected to value quality over price. Although in general there is a low preference for sole ownership, it can be linked to a higher demand for customisable options and an urge to show the product to the social environment. For some groups, such as the SUP avoiders, and residents from the U.S., this can be an ideal solution, but for most people (only 18% indicated they want to have full ownership over a product) a shared-ownership system might be the better option. Such a system could also assist in reaching the break-even point of the product faster [231].

Countries

Russian respondents indicated practicality, compactness, and multifunctionality more often than the other two countries. They do not feel the need to show the product to others as much as e.g., the U.S. and they are also a bit more hesitant to use them in public. This could be explained by the country's focus on collectivism compared to Western individualism [232], and their unfamiliarity with several reusable products. This is in line with the most commonly used products in Russia: reusable jars, which are quite common everywhere and mostly used at home. Individualism could also explain why residents of the U.S. prefer to be the sole owner of a product, want the product to be attractive and value the option to personalise the product more. They like to show the products they bought as a way of making a statement or showing their identity. They strive towards the value of being different and important [233]. That could also explain the popularity of e.g., coffee cups in the U.S. Belgians, on the other hand, do not value attractiveness and the option to personalise that much. They score slightly higher than the other two countries in their need to show the product to their social environment and they are less awkward about using it in public (although all three countries score low on this one). They also experience more barriers to the use of reusables, such as forgetfulness and annoyance when needing to clean the product. They score high on the need for multifunctionality and practicality, and clearly value quality more than price. When we compare the three countries on the Hofstede dimensions, Belgium and Russia both score high on long-term orientation, in comparison with the U.S. [234,235]. Hence, the focus on quality, practicality and multifunctionality and less on attractiveness and customisation could be explained.

Clusters

In general, SUP avoiders indicate more statements than SUP addicts. This could be explained by the fact that they already adopted more reusable products in their daily lives and routines, and have more clear ideas of what they expect in

reusable products, and what the barriers are. For example, the statement that it is annoying to clean the products is indicated by 45% of SUP avoiders, and only 8% of SUP addicts. This is probably because SUP avoiders have been in contact with these barriers, and most SUP addicts have not. One-fourth of SUP addicts find price more important than quality, against 12% of SUP avoiders. This could be explained by the SUP addicts' preference for cheap, disposable products. They are least interested in paying a higher price for reusable products compared to the other clusters. In comparison, 56% of SUP avoiders think quality is more important than price. They probably know better that quality is key for a good reusable product, and think more long-term. Also, as SUP avoiders are much more focused on achieving other than economic values (i.e. ecological and social values), it seems logical that they value quality over price. Although most statements are mainly indicated by the SUP avoiders, attractiveness and personalisation are chosen more by the situation-driven SUP users. As they are more vulnerable to situational constraints (context factors, legislation, proximity, etc.), attractive and customisable designs could help them overcome these barriers.

4.3 Limitations and generalisation

Although they do not have the exact same size, all clusters are considered to be large enough to be able to generalise the results, as they are based on a large sample of 3000 respondents and fairly equally divided. The participants are mainly residing in cities, so although quota were used, the sample does probably not provide a completely reliable sample of the full population of the countries, but it gives a good impression. Regarding the products, it is possible that not all the respondents were familiar with the products, or understood the description. The continued, long-term behaviour is self-reported and might be inaccurate or wrongly memorised. The sample group for e.g., reusable menstrual products is a lot smaller than the others since the product is not applicable to many respondents (for example people that do not menstruate).

5 Conclusion and recommendations

We can conclude that the frequency of usage of reusable products is positively related to a negative attitude towards SUP, a high environmental concern and green self-identity, and previous ecological behaviour. Hard-material products, often those that are used outside of the home and seen in public, are more popular (e.g., drinking bottles, glass jars, lunch boxes) than soft-material products that are harder to clean, show more wear and tear, are related to shame or taboo, or less visible and used in the private atmosphere. (e.g., food huggers, menstrual products, diapers).

There is no clear distinction in the frequency of use of reusable products between the three countries, but each country has different products that are most popular (e.g., coffee cups in the U.S., jars and produce bags in Russia, lunch boxes and drinking bottles in Belgium). Products related to intimate care such as reusable menstrual products and diapers are not yet widely accepted by any group (clusters nor countries), which could be the result of a lack of information and taboo or shame related to the products. From the product requirements, we composed three recommendations for designers:

- Focus on practicality, durability and quality. Make products multifunctional or take away barriers such as forgetfulness and an extensive cleaning process, and provide compact products that minimise weight and volume, especially when used outside of the home.

- Design different solutions for different types of users. For some users, a sharing system might be a good solution since it decreases several barriers such as forgetfulness and cleaning process (e.g., Belgian consumers, or SUP addicts and apathetic). For others, a personal and customisable, more attractive product could be the best solution (e.g., Americans and SUP avoiders).

- Focus on making products related to intimate care more approachable and well-known, for example by taboo-breaking (marketing) campaigns, creating new narratives around menstruation and childcare, and accessible design.

Future research should look into further explaining the differences between the countries by investigating the culture and the historical background of reuse practices. More insights are needed into the specific requirements for reusable products (e.g., what kind of multifunctionality or customisation do people expect?), and the relationship between material flexibility and acceptance of reusable products. Regarding specific categories of reusable products, such as intimate care, more research is needed on the influence of taboo and shame related to bodily fluids in the context of sustainability. The same experiment could be done with different (types of) products.

Acknowledgements: Camilla Barbarossa and Patrick De Pelsmacker

PART FOUR

Part four examines the findings from the initial three sections within the context of specific products from each category. To investigate the long-term use, we employ a variety of methods, such as diary studies, interviews, and questionnaires.

In **Chapter 5**, we report the results of diary studies involving six participants. These studies aim to capture real-time, self-reported behaviour over three weeks using newly introduced reusable products. Each participant is assigned to use both a 'at home' product (food huggers) and an 'on-the-go' product (a reusable coffee mug, bread bag, or food wrap). The paper '*A diary study set-up to identify thresholds for repeated usage of reusable products'* is published in the proceedings of the 5th Product Lifetimes And The Environment Conference (PLATE 2023).

Chapter 6 investigates the reusable coffee cup using a mixed-method approach, employing structured interviews (n=58), a survey (n=300), and diary studies (n=8) with users, and in-depth interviews with baristas (n=8). Next to investigating preferences regarding single-use vs. reuse, we look at coffee-drinking experiences, habits, and routines as well. The paper *'Unravelling experiences, barriers, and design strategies for encouraging reusable takeaway cup usage'* will be published in the proceedings of the Design Society's Design 2024 conference. The paper received a 'reviewers favourite' award.

L. Herweyers, I. Moons, E. Du Bois, A diary study set-up to identify thresholds for repeated usage of reusable products, Product Lifetimes and the Environment (PLATE23) (2023).

CHAPTER FIVE

A diary set-up to identify threshold for repeated usage of reusable products

Laure Herweyers, Ingrid Moons, Els Du Bois

Abstract: After the European ban on several everyday single-use plastic items, there is a need for sustainable alternatives that can be integrated into people's daily routines. This research focuses on possible thresholds that prevent the repeated usage of reusable alternatives to single-use products. The research questions are: (i) What habits in the daily life of the consumer impede the use of these products? (ii) What are the differences in user thresholds between an on-the-go product and a product that is used at home? (iii) What characteristics should reusable products have so they are used longer? Six participants were invited to start using two reusable products for three weeks: food huggers (used at home, same for all six participants) and an 'on the go' product (two respondents each): a food wrap, a reusable coffee mug, or a reusable bread bag. Physical diary booklets were used to qualitatively collect the users' experiences with the test products. After three weeks, a follow-up interview was held with each participant. The paper concludes with a set of propositions to make repeated usage more likely. A distinction was made between barriers related to the product on the one hand and barriers related to the existing routines of the user on the other hand. The main barriers to using the food huggers are related to practicality, while planning and existing routines influence the regular use of the 'on the go' product the most. In general, according to the users, reusable products should offer the same or more benefits as their single-use counterparts. Future studies should focus on longer usage periods with different types of products such as intimate care related products, and other means (such as digital diaries) could provide more time-specific and rich data.

Keywords: reuse behaviour; long-term behaviour; habits; sustainable design; diary studies

1 Introduction

Plastic pollution is an enormous environmental problem which contributes to water, soil, and air contamination, and has a strong negative impact on wildlife and potentially on human health [156]. As a result of the European ban on several single-use products, the demand for good, reusable alternatives has increased [25]. Since reusable products need to be more durable and qualitative than their single-use counterparts, they usually consist of more material and have higher energy and water usage during the production phase [37]. Therefore, most of the environmental impact is highly dependent on the consumer and their repeated usage of the product. There will only be an environmental gain when the product is used beyond its break-even point, which is the number of reuses needed for the environmental impact to be equal to the impact of each time using a new single-use product [39]. Next to the acquisition of the reusable product, it is important that users change their behaviour accordingly by integrating new habits into their daily routines. Existing habits influence people's behaviour, which often makes the new habit or routine harder to implement [138]. Consequently, understanding the enablers and barriers of repeated reuse is key to designing better reusable products [20]. A substantial amount of research has been done on reusable products such as the comparison with single-use products in terms of ecological footprint [39], the assets and liabilities of these products [61] and the use or purchase of refillable products [20]. However, the underlying causes or motives for the repeated use of reusable products, or the barriers that impede long-term adoption have not yet been widely investigated.

In this study, we focus on potential thresholds that prevent repeated usage of reusable products. We want to create a better understanding of the enablers and barriers that come up during the first weeks of usage of a newly introduced product, and how these products can be implemented into daily routines.

2 Methods

We did a qualitative diary study (n=6) to explore real-time self-reported behaviour over a period of three weeks, investigating enablers and barriers to the repeated use of newly introduced reusable products. The diary study method enabled us to acquire in-depth data and descriptions with rich in-context information on the user's thoughts and feelings towards the products [236]. Besides this, they capture the experience of the participants as realistically as possible and in a real usage scenario.

Each participant used one 'at home' product, namely food huggers (reusable plastic wraps to put on used fruits or vegetables to keep them fresh or to cover cups or plates), and one 'on the go' product: a food wrap (to wrap sandwiches), a reusable coffee mug (foldable silicone coffee cup with a polypropylene lid and holder), or a reusable bread bag. We selected the products because they are relatively new and not yet adopted by the majority of the population. The participants were not familiar with the test products beforehand. We selected them based on their willingness to use reusable products without using them already. To be eligible for the study, they had to have the single-use equivalent of the test products in their daily routines as well, indicating use for the test product, as well as providing a reference point during the study. We divided the participants into three groups of two, based on the above-mentioned requirements (Table 1). Since gender was not part of the requirements, we unintentionally selected only female participants, ages ranging from 25 to 54 years old, with medium income.

Physical diary booklets were used to avoid the thresholds of new digital platforms. Each respondent received two booklets, one for each product, and was requested to track their experiences with the products daily. After one and a half weeks, a short check-up conversation was held with the participants to discuss how it was going and whether they had encountered any problems.

GROUP	REQUIREMENTS
Bread bag + food hugger (1a, 1b)	Often goes to the bakery Currently uses a regular disposable bread bag Uses plastic wrap (occasionally) to cover food
Coffee cup + food hugger (2a, 2b)	Goes regularly (at least 2x/week) to get takeaway coffee Doesn't use a reusable cup yet Uses plastic wrap (occasionally) to cover food
Food wrap + food hugger (3a, 3b)	Gets a sandwich regularly (at least 2x/week) Doesn't use reusable wrap yet Uses plastic wrap (occasionally) to cover food

Table 1. Participant requirements

The booklet contained questions such as 'When did you use the product?', 'What did you find positive and negative about the use?', and 'Why did you choose to use the single-use version instead of the reusable version?'. The participants were also asked to take photos during their use of the product. After three weeks, the diaries

and photos were collected, and a semi-structured follow-up interview was held with each participant to question the overall products' experiences and potential improvements. The interviews lasted around 45 minutes. The data from the booklets and interviews were analysed descriptively, looking for similarities and contrasts in the experiences of the participants.

3 Results

3.1 Food huggers

The food huggers were mainly used to cover and preserve fruits and vegetables. Five out of six participants indicated that they were very convenient for this and that they could be used quickly and easily. Several participants also used the food huggers to cover jars without lids, but they were considered less suitable for this purpose. Identified limitations are related to fit: although three sizes were available, sometimes none of the food huggers would be the right fit. According to five of the six participants, the food huggers were too small which limited their use. This is related to adaptability: the food huggers do not easily stretch to fit over slightly larger objects. Nevertheless, practising improved this skill. The sturdiness of the material also leads to the risk of squashing soft fruit or vegetables. Lastly, one participant indicated that the preformed shape was not so convenient. The participants that put the food huggers in the dishwasher, found that almost every time, dirt or water remained in the folds of the product (Figure 1), and the material would feel sticky. The participants that cleaned the food huggers by hand said they were easy and quick to clean. One participant indicated that she turned the food huggers inside out to clean them, which would work quite well. Difficulties were also encountered in drying the food huggers because they could fold by themselves. Therefore, two of the participants indicated that they had doubts about the hygiene of the product when it would be used for a long time.

Four participants decided they would continue to use the food huggers in combination with reusable jars, since they cannot be used for all applications. Two participants would replace all cling film with the food huggers in the future. Two participants were not convinced after the research period and indicated that they would not continue using the food huggers. One of them even switched back to cling film during the study even though we specifically asked not to. For her, the product was not efficient enough and using it took too much effort. Another stressed the fact that the food hugger fitted quickly in her daily routine: it was easier to get it out of the drawer than the cling film. In addition, the food hugger was ready to use, while the plastic wrap needed extra effort to cut into the right size.

3.2 Bread bag

Positively, the roll-top closing system was immediately clear for both participants and easy to use. The bread inside the bag was perceived to stay fresh longer compared to a normal paper bag. Once closed, a convenient handle for carrying the bag is created. The cleaning of the bread bag was considered easy and time-efficient by both participants. The inner bag could be put out of the outer bag to remove the remaining breadcrumbs. However, participant 1b would have liked a different material, because in her opinion the current material does not allow for thorough cleaning with water. Identified barriers for the bread bag are buying more than one bread at a time, for example for a family of five, or having unfinished bread at home requires an additional bag, which was not provided. Both participants found the bag too small for both homemade bread and bread from the store or bakery, where not every kind of bread would fit in the bread bag, as shown in Figure 2. Social acceptability, especially in the bakery, was also noted as a concern, as well as forgetting to take the bag and implementing it into the existing routine.

After three weeks, participant 1b stated they would not use the bread bag anymore in the future, because there were too many inconveniences and she did not feel comfortable yet bringing it to the bakery. Interestingly, she started using it as a lunchbox alternative instead, indicating an opportunity for multifunctionality. Even though the bag was not perfect, participant 1a was still enthusiastic about the bread bag and committed to using it in the future as an addition to single-use paper bags.

3.3 Coffee cup

Participant 2a often goes to take out a coffee, for which she uses a single-use cup. Participant 2b was planning to buy a reusable cup to win time in the morning and drink her coffee during her drive to work (Figure 3). Positive aspects are the look of the cup and the fact that it is sustainable, which gave them a boost for using it. Also, the cleaning of the product was perceived as relatively easy, although some stains on the lid would sometimes be hard to remove. Identified barriers are that the cup does not keep the coffee warm very long and the heat sleeve is not sufficiently heat resistant, thus making it hard to hold the cup when the coffee is still very warm. It can be a challenge to always anticipate the possibility of having a coffee that day, and thus not forgetting the cup at home. Other thresholds are the practical ease of folding the cup and the inconvenient opening in the lid to drink from. Another remark was that the plastic cup gets stained, strengthening a participant's concern that chemicals from the plastic could leak into the coffee.

3.4 Food wrap

Both participants were pleasantly surprised by the product. They liked the looks of the product and found it overall very practical in use. A big perk of the product is that it can also serve as a placemat (Figure 4). Both participants received positive reactions from colleagues when using the food wrap, stimulating them to use it. The food wrap was perceived as very easy to clean by both participants because of its flat surface and material. On the other hand, both participants were scared that, because it is a relatively unknown product, they would burden the people of the bakery with extra time to figure out its use while buying a sandwich, especially when it was already crowded at the store. Besides this, the food wrap does not completely protect its substance and does not prevent eventual leakage. During her participation in this three-week trial, participant 3a did not use the single-use alternative even once, which in this case are plastic wraps or aluminium foil. Participant 3b needed more time to get used to the food wrap, eventually storing it in the office to prevent forgetting it at home and cleaning it immediately after use. For both participants, the food wrap successfully replaced the single-use variant, and both are willing to use it further in the future.

Figure 1. (upper left) Dirt left in food huggers
Figure 2. (upper right) Bread too big for bread bag
Figure 3. (lower left) Coffee cup in car
Figure 4. (lower right) Food wrap can be used as a placemat

4 Discussion and conclusion

4.1 Limitations

The research method made the success of the study dependent on the motivation of the participants since a large commitment was requested. Besides this, sometimes participants failed to fill in the diary or filled it in afterwards because they forgot or did not have time to do so in the moment. Hence, it was very important to conduct the follow-up interview to fill in missing information. Because of the limited number of participants (n=6), the results cannot be generalised to the broader population.

4.2 Conclusions

To answer the main research question 'What are the thresholds that complicate the use of alternatives of single-use plastics?', a small-scale study was done (n=6) using four reusable products. Based on this research, we can formulate the following propositions:

- Two types of barriers derived from the participants' experience can be distinguished: a) Barriers related to the features of the product itself, i.e. adaptability, size, ease of use, ease of cleaning, multifunctionality, space occupation, quality of the materials, self-explanatory, healthiness, and attractivity, and b) barriers related to the habits and routines of the user, for example, the need to plan in advance, the time consumption, or when they are not comfortable with reactions of people when using the product.

- 'On the go' products often require additional conscious decision-making like planning to successfully use them. As proven by the increased usage of the products during the test period, integration into existing habits or forming a new one is essential to fade away this cognitive task. Putting the product in a visible, convenient place could help to fit them into the existing routine.

- In conclusion, it can be said that for reusable products it is important that they offer the same or higher benefits (cost, comfort, usability) as the single-use variant.

4.3 Future research

The products that were selected for this study are all food-related and assume sole ownership. It would be interesting to compare the results with other types

of reusables, for example, related to intimate care (e.g., menstrual cups or reusable diapers), or different reuse models (e.g., return). The diary study method is an effective and intuitive way to conduct user insights, but it is also important that it is sufficiently prepared. Participants have to be reminded on a regular basis to ensure that enough information can be collected after a long period of time. Future research should consider the usage of digital diaries to follow up the participants closer and in real-time (especially for 'on the go' products), and over a longer period.

Acknowledgements: Fien Huybrechts, Zinke Neyrinck, Sebastian Reyda, Amber Schoetens, and Doris Van Boxem

CHAPTER SIX

Unravelling experiences, barriers, and design strategies for encouraging reusable takeaway cup usage

Laure Herweyers, Els Du Bois, Ingrid Moons

Abstract: The increasing use of disposable takeaway cups negatively affects the environment due to their non-recyclability and waste. This study investigates the adoption and sustained use of reusable takeaway cups in Belgium, including routines and experience. Structured interviews (n=58), a survey (n=300), diary studies (n=8) and interviews with baristas (n=8) are done. The findings provide recommendations including clear communication, incentives, and user-friendly cup design. Future research should test interventions and consider regional and cultural variations in sustainable coffee consumption.

Keywords: single-use; reusable, coffee cups; sustainable behaviour; design for sustainability

1 Introduction

The coffee industry is growing rapidly, and alongside it the use of disposable takeaway cups. The global disposable cups market size was valued at USD 11.88 billion in 2020 and is expected to grow at a compound annual growth rate (CAGR) of 7.2% from 2021 to 2028 [237]. Approximately 500 billion coffee cups are globally produced each year [238]. Many takeaway cups are made from plastics, like Styrofoam and polypropylene (PP) or polyethylene-coated paper, which retain heat well and prevent leakage, but are single-use, not recyclable and resource intensive [239]. The lids, sleeves, spoons, and straws are often difficult to recycle as well. Disposable cups cause a massive amount of waste since they are considered instantly valueless as soon as the beverage is consumed, regardless of their material quality and

durability [240]. The consequences of this throwaway culture are reflected in both land and oceans. When littered, the cups often stay in a landfill for centuries, where they do not biodegrade. When they end up in the oceans, they can harm marine life, either by entanglement or ingestion of microplastics that transfer up the food chain [12,14]. Hundreds of marine species have been reported to be affected [241]. It is expected that a growing resistance against single-use plastics alongside various governmental efforts to prohibit these items will lead to an increasing demand for paper cups [237]. However, the polyethylene (plastic) lining that makes the paper cups watertight as well as contamination of food waste makes them unrecyclable. It is a common misconception that paper cups are recyclable, leading people to put them in the paper recycling bin, contaminating the recycling stream [242]. Next to this, disposable paper cups also cause resource depletion, consume energy and water during production, and create waste, which is de facto unsustainable.

More sustainable and durable options are reusable cups, often made from materials like glass, ceramic, stainless steel, or durable plastics. The cups are mostly purchased for personal use, but cooperative systems exist as well, which offer customers the option to use a reusable cup for a small deposit. They can later return them to the coffee shop or another participating shop and get their deposit back. An example in Belgium is the 'Billie Cup' [243]. As with other reusable alternatives to single-use products, reusable cups should be used a minimal number of times before they have a positive impact on the environment compared to using single-use cups. This is called the break-even point, or payback period [39]. People that have acquired a reusable cup should be prevented from going back to single-use cups and motivated to use the cup beyond its break-even point. From here on, with 'reusable cup', we mean a cup that is meant to be used 'on the go', so not a porcelain mug that is used at home. In this study, we investigate the barriers and motivators to the long-term use of reusable cups from different perspectives.

Previous studies have investigated typical drivers and barriers for reusable cup usage and other sustainable behaviours on both an individual level and an institutional (regulatory) level [244]. Since institutional interventions such as environmental policies often proceed very slowly [245], exploring psychological processes as well as the systems and contexts which influence these are crucial for achieving sustained behavioural changes [246]. On the individual level, typical barriers found in literature are strong habits of using disposable cups, confusion about environmentally friendly options, and pervasiveness of takeaway coffee culture [244,246]. Less widely investigated are barriers and opportunities related to the context in which the behaviour takes place. Previous research on reusable coffee cups applying social practice theory [247] argues that the limited uptake of reusable

cups could be explained by the missing convenience element due to forgetfulness, a lack of comfort, and seeing others using disposable cups, but also because of apparent system-norm barriers related to the coffee vendor's practices [248].

Besides researching the barriers and motivators to reusable cup usage, several interventions to promote their use have been studied on their effectiveness (e.g., monetary incentives, providing freebies, and value- and intention-based incentives) [81,246]. From Poortinga and Whitakers' study, it appears that charging extra for a single-use cup causes the biggest increase in reusable cup usage compared to information posters, selling reusable cups, or giving them for free. However, little research has been done on (i) specific properties of reusable cups, related barriers, and potential design improvements, and (ii) the potential higher-level solutions that intervene on a more systemic level, both addressing other actors and the practices and experiences of the user more in-depth. In this paper, we contribute to the knowledge domain by incorporating the design of reusable cups and cooperative systems, the perspective of the barista, the practices and experiences of the user, and the meanings they attribute to drinking hot beverages from a reusable cup.

1.1 Objective

In this study, we investigate barriers and motivators to the adoption and sustained usage of reusable coffee cups compared to disposable cups, specifically within the context of takeaway drinks in Belgium. We complement these insights by addressing coffee (and other hot beverages) drinking habits and routines, and different contexts of use. This way, we move beyond the usage of the product itself and focus more on the overall experience of the user. Therefore, we look at the use of reusables vs. disposable cups from two perspectives: (i) the practice of getting takeaway, and (ii) the usage of the product itself: a reusable cup or thermos bottle. Next, we include the perspectives of baristas regarding the feasibility of reusable cups, to gain insight into potential barriers on their side. Ultimately, we want to offer useful insights for designers to create reusable cups and contexts that support reuse, not only to appeal to a wider demographic but also to keep the cups in use for an extended period. To research this, we propose the following research questions:

Q1: What are the barriers and motivators for adopting and continuing to use reusable cups from the perspective of the user?

Q2: What barriers do baristas encounter regarding reusable cup usage?

Q3: How do the experience and routines of the user impact the feasibility of long-term reusable cup usage?

Q4: What strategies or interventions could enhance the uptake of reusable cups and promote their long-term usage?

2 Methods and results

We chose a mixed-method approach (Figure 1), including both qualitative and quantitative methods. This approach enabled us to triangulate the results and provide answers to the four research questions. The study involves a diverse pool of participants to capture a wide spectrum of perspectives and experiences. To investigate the first research question, we started by interviewing 58 takeaway customers in coffee bars. In addition, we interviewed coffee bar employees (baristas) to answer Q2. We engaged 300 participants in a survey focused on coffee consumption habits and usage patterns of reusable cups, which allowed us to test our findings further with a larger sample size. We also go more into detail on the usage of reusable cups in general (not only for takeaway), and coffee drinking habits, rituals, and meanings (Q3). The survey also served to find participants for the diary studies (n=8), which were employed to investigate Q3 more deeply. In the subsequent sections of this paper, we elaborate on the specific methodology and the resulting findings for each research task in a dedicated chapter. Finally, in the discussion, we synthesised all the data from the multiple studies and formulated strategies and interventions to enhance the uptake of reusable cups and promote their sustained, long-term usage, answering Q4. Below, we elaborate on the methodology and results of each study. For all studies, we obtained ethical approval and informed consent to ensure participant confidentiality, anonymity, and the right to withdraw from the study without repercussions.

2.1 Observations and structured interviews

Methodology

In autumn 2021, we observed customers at eight coffee bars in different Belgian cities: five in Antwerp, two in Brussels, and one in Ghent. These coffee bars were chosen to represent various types, including those using or not using the Billie Cup system, which is more well-known in Brussels and Ghent than in Antwerp. The selection criteria encompassed factors like the type of coffee offered (e.g., specialty coffee), location (e.g., student or residential areas), atmosphere, and size (chain vs. small businesses). The observations were conducted randomly on both weekends and weekdays to capture a diversity of clients that do takeaways. They

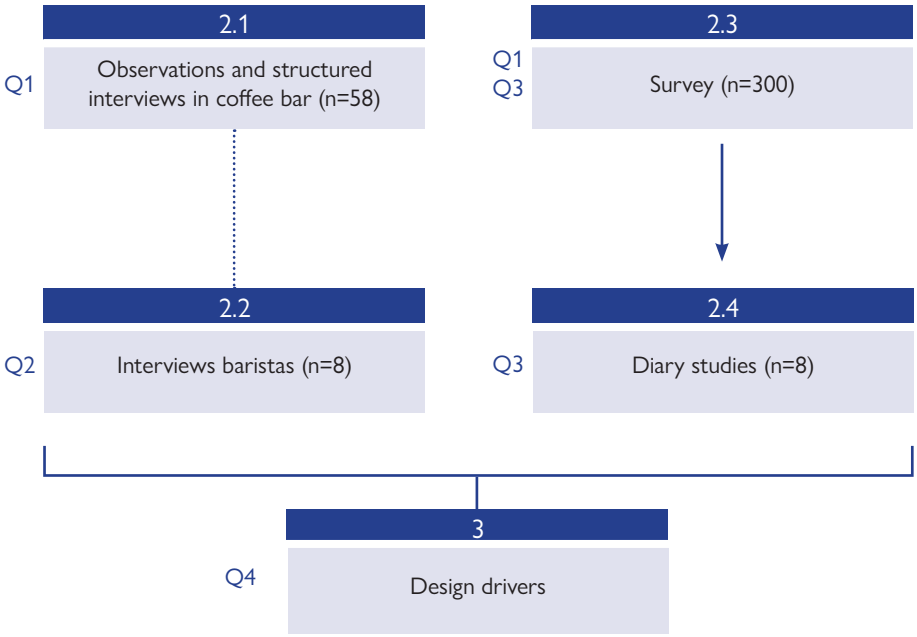


Figure 1. Research design

took approximately two hours in each coffee bar. This allowed us to identify various types of takeaway customers and invite them for on-the-spot interviews. We selected 58 participants across these coffee bars, engaging them in structured interviews. The interviews explored real-time behaviours, interactions, and preferences concerning takeaway cups. The questionnaire was set up in English (to include tourists) and filled in on a tablet. The interviews started with demographic questions covering gender, age, work situation, and whether participants were locals, tourists, or commuters. We questioned their takeaway frequency and use of reusable or disposable cups. This was followed by specific questions tailored to disposable or reusable cup users. Topics included usage patterns, reasons for using either a reusable or disposable cup, physical properties of the cup, and any inconveniences faced. Demographically, 31 respondents are between the ages of 19 and 25, 16 between 26 and 40, 8 between 41 and 65, and 3 under 18. 31 of the respondents are students, 25 are working, and 2 are unemployed. Their takeaway habits vary, with 9 taking out hot beverages less than once a week, 15 once or twice a week, 16 three to four times a week, 9 five to six times a week, and 9 daily. 43 respondents are residents of the city where the interviews were conducted, 10 are commuters, and the rest are tourists. The questionnaires were analysed descriptively.

Results

We questioned 39 people that used a disposable cup at the moment of the interview, and 19 that used a reusable cup. Although the majority of the respondents (52) believes that disposable cups are a problem for the environment, only one-third uses a reusable cup. Interestingly, two-thirds of the disposable cup users stated they had used a reusable cup before. When asked about the reasons behind choosing a disposable cup instead of their reusable one, forgetfulness, inconvenience, and spontaneity came up the most frequently. Other reasons for not using a reusable cup are COVID-19-related hygiene concerns, the size and weight of a reusable cup in their bag or pocket, and the inability to find a suitable cup. Potential leaking and the cleaning process are also indicated as being inconvenient.

The biggest motivations for switching to a reusable cup are a commitment to environmental concerns, followed by convenience, such as retaining the coffee's temperature and enhancing its flavour. A few respondents mentioned financial reasons and because it looks nice or trendy. Half of the people who have a reusable cup (10) indicate that they do not always use it, and more than half (11) have multiple reusable cups. Regarding the material, 7 have a cup made of hard plastic, 6 stainless steel, 2 recycled plastic, 2 ceramics, 1 bamboo, and 1 silicon. Regarding other properties, 9 have a cup with a sealed lid (no leaking), 5 have a cup with an unsealed lid (potential leaking), 3 have an insulated cup, and 5 have heat-protective sleeves. The biggest inconveniences when carrying a reusable cup are forgetting it (7), the volume and weight when carrying it (5), and that it leaks (5), which fits with the reasons given for using a disposable cup. Overall, metal and hard plastics are most preferred by both reusable and disposable cup users. Bamboo or ceramics are not very popular. Three quarters of the respondents stated they would switch to reuse if they would get a discount on their drink, while almost half would use Billie Cup if they could return it somewhere convenient.

2.2 Semi- structured interviews with baristas

Methodology

We conducted in-depth semi-structured interviews with eight baristas from the initial study's coffee bars. The goal was to gain insights into their perspectives on customer preferences, the demand for reusable cups, challenges in promoting sustainability, and strategies to encourage reusable cup adoption. Each interview lasted approximately 40 minutes and was recorded and transcribed. We analysed the results thematically using NVivo software. We began by exploring their perceptions of takeaway and in-house consumption and its evolving trend. Subsequently, we delved into their experiences with reusable cups, customer profiles, common types

of reusable cups, and their efforts to promote their use, including any financial incentives or selling branded reusable cups. We also discussed barriers to providing and promoting reusable cups, as well as their interest in joining the Billie Cup initiative. The interviews allowed for open conversations and in-depth exploration of various topics. We analysed them using open coding in NVivo software.

Results

All interviewees noticed a significant increase in takeaway orders in recent years, particularly since the COVID-19 pandemic. Depending on the type of coffee bar, take-out consists of roughly 20% to a majority of the orders, mostly in student areas. However, only a few customers bring a reusable cup, which forms a minority of takeaway orders in most bars, except for one that exclusively uses the Billie Cup system and has no disposable options. This aligns with our observation results, highlighting the continued prevalence of disposable cups. Nevertheless, the amount of reusable cups is slowly rising, and various types of reusable cups are emerging, including bamboo, metal, plastic, glass, coffee grains, porcelain, and creative options such as a jam jar. Branded cups sold by competing coffee bars are becoming more common, although customer awareness of their acceptability varies. Regular customers are more likely to bring their reusable cups consistently.

All interviewees are positive about the reuse trend, and stimulate it mainly because of environmental concerns and branding opportunities. However, some expressed doubts about the impact on the coffee-drinking experience. For example, one coffee bar actively searched for the 'ideal reusable takeaway coffee cup', with perfect mouthfeel, no taste coming off the material, and dishwasher compatibility, but found nothing that surpassed a porcelain cup. This led them to abstain from participating in the Billie Cup system, as they were unwilling to compromise on experience. Others share this preference for porcelain cups. Half of the interviewees dislike paper cups as they believe it alters the taste of the coffee, especially for filter coffee (without milk). In terms of different cup sizes, while some find it slightly inconvenient if a cup does not fit under the machine, it is not a dealbreaker for most. None of the interviewees considered a universal size to be necessary, given the existing variety of reusable cups. Customers asking for their dirty cups to be cleaned before getting a takeaway coffee is seen as annoying by some baristas, while others do not mind doing so. Many interviewees expressed scepticism about the logistical aspect of the Billie Cup, such as handling excess or insufficient cups and dealing with cash deposits. They were also hesitant to clean cups that were brought in by customers from other coffee bars. The deposit system was confusing for some, and a few were concerned that the plastic material of the cups would affect the taste and overall experience. There were reservations about consumer acceptance,

as the clients would have to drink from a cup that had been previously used by someone else. Although the bars that use or have used Billie Cup state that washing the cups requires more effort than customers using their own reusable cups, they still support the concept. The bar that solely employs Billie Cup (and does not have any disposable cups) occasionally receives annoyed reactions from clients, but most eventually got used to the system. Half of the coffee bars offer a discount for reusable cups, ranging from 10 to 30 cents to stimulate reusable cup usage. Two others used to give a discount but stopped. Communication about these discounts varied among coffee bars, with some failing to inform all customers. Particularly customers who do not use reusable cups would not be informed of the discount, which leads to missed opportunities for encouraging awareness. Five coffee bars sell reusable cups, mostly metal thermoses, of which three offer their own branded versions. One coffee bar used to sell cups but stopped because of the high costs, realising customers could buy them cheaper online. Some bars sell cups of lower quality to accommodate customers with a tighter budget or offer a wider range of reusable cups. During the COVID-19 pandemic, some coffee bars temporarily shifted to disposable takeaway cups for hygienic reasons. There were concerns about potential contamination when passing cups from person to person, although these concerns have lessened in the years following the pandemic. All coffee bars resumed accepting reusable cups at the time of the interviews.

2.3 Survey

Methodology

We administered an online survey to a larger sample of 300 participants to gather a broader perspective on coffee on-the-go consumption routines and attitudes towards reusable cups, and go deeper into the reasons for (not) using a reusable cup. We distributed the survey by sharing it on social media and putting up posters with a QR code in several local coffee bars in Antwerp. For this part of the study, we wanted to focus on local residents of the city of Antwerp (Belgium). Since we wanted most of the respondents to be able to answer the questions in their mother tongue, we decided to set up the survey in Dutch. Data collection took place over the course of three weeks in November and December 2022. Qualtrics was used for questionnaire setup, SPSS for statistical analysis, and NVivo for open-question coding, ensuring privacy by not collecting IP addresses without consent. The start of the questionnaire included demographic information (age, gender, working situation, residence, and family situation) alongside inquiries about coffee and other hot beverage consumption. Among coffee drinkers, questions probed the significance and meaning of coffee in their lives, its relation to rituals and social practices, and motivations for visiting coffee bars. Data on the context of hot beverage

consumption, such as the place, frequency, and takeaway habits, were collected. The survey further explored the use of disposable and reusable cups and introduced the Billie Cup, gauging respondents' familiarity and usage. For those owning reusable cups, questions included frequency of use, purpose of using the cup, its material, type of beverages, duration of ownership, and motivation. Additionally, respondents' satisfaction with reusable cups was assessed by means of a five-point Likert scale ranging from 'not satisfied at all' to 'very satisfied'. Those without reusable cups were queried on their reservations, potential future use, and ideal cup requirements. The survey ended with a request to participate in a diary study. Volunteers could fill in their name, email address and optionally phone number so we could contact them. Demographic analysis revealed that the most prominent age group is 19 to 25 years old, constituting 44% of the respondents, with the second-largest group being aged 41-65 at 31%. The majority of participants identify as women (60%). Regionally, 41% live in cities, 29% in urban fringe areas, and 30% in the countryside. As a result of the way we gathered respondents, it is of no surprise that out of the respondents that filled in the survey, a significant proportion are coffee drinkers (85%), with age correlating positively with coffee consumption (from 78% within the 19-25 group to 100% in the age group 65+). While coffee is prevalent, tea (78%) and hot chocolate (52%) also enjoy popularity.

Results

Half of the coffee drinkers have coffee several times a day, and older age groups reported more frequent consumption than younger respondents. 16% of them gets takeaway multiple times a week. 26 to 40-year-olds get takeaway more often than the other age groups, and only 20% of this age group never do takeaway. Of the 65+ age group,79% never do takeaway. Specialty coffee places are the most popular choice for takeaway (38%), followed by work (24%), chains (18%) and lunch places or tearooms. Other places that were mentioned are Christmas markets, supermarkets, university canteens, school coffee machines, and train stations. The main reasons for takeaway range from breaks during work or school hours to day trips and city visits. One-fifth get their takeaway coffee when on the road between home and work or school, 23% during a walk, and 14% while working from home. Others get it for outdoor breakfast or lunch, or during a long train travel. Notably, a majority of coffee drinkers incorporate coffee into their morning ritual (61%), associating it with relaxation and energy. A substantial number goes to coffee bars for social interactions (37%) and general experiences and service (38%), followed by going purely for coffee (20%) and to work remotely (14%). Open-ended questions revealed that coffee holds various meanings, including awakening, energy, concentration, joy, relaxation, peacefulness, and a moment for introspection. Among those with reusable cups, Billie Cup awareness was low (22%), and among those who heard

of it, usage was limited (15%). Of the respondents with reusable cups, 70% have possessed them for over a year. Notably, 61% of those owning reusable cups still predominantly use disposable cups for takeaway coffee. Only a small percentage use their reusable cups for takeaway (7%). Other uses are taking coffee from home to another place (e.g., work or school) (15%) and walking around in the office space or home (13%). The primary reasons for using reusable cups are environmental considerations (21%), ease of transport (15%), and heat retention (15%). The aesthetics of the cups also play a role (9%), as well as the cup being pleasant to drink from (9%). The most popular materials are metal and durable plastic, confirming the results from the first study. Among those without reusable cups, more than half expressed a desire to use one in the future, primarily for environmental reasons. Perceived barriers include inconvenience and forgetfulness. Respondents' ideal cup requirements encompass leakage prevention, compactness, easy cleaning, durability, heat resistance, aesthetics, user-friendliness, dishwasher compatibility, lightweight, no branding, size adaptability, ergonomics, comfort, and pleasant to drink from.

2.4 Diary studies

Methodology

We used the survey as a selection tool to find eight participants to engage in a two-week diary study in November 2022 to document their reusable cup experiences. We invited them to report on the usage and related challenges and benefits in real-time through WhatsApp, using text, photos, voice memos, and emojis. Each participant received specific, tailored daily reminders. The study involved a pilot test which was excluded from the analysis. Additionally, each participant underwent two interviews, one before the study to explain expectations and obtain consent, and another after the diary study to delve deeper into their experiences and possible changes in their behaviour as a result of the study. The selection of participants was based on specific criteria, including the possession of a reusable coffee cup, a minimum weekly takeaway habit, and willingness to participate. Out of 23 identified profiles, we invited 15 for intake interviews. Eight participants eventually started the diary studies, ages ranging between 21 and 32. Three participants were male, and five female. The group consisted of four students, one intern, and three working people. Data analysis involved thematic coding by three researchers, looking for patterns, emotions, barriers, motivators, and routines within the messages. A comparison was made between the participants to notice specific similarities and differences.

Results

A notable distinction emerged between two types of cups: those designed for takeaway, resembling disposable cups, and thermos bottles, which were praised for

heat retention and leakage prevention. Interestingly, most participants opted for thermos bottles when enjoying tea, while they typically utilised the other type of cup for coffee. Common barriers included cup leakage, cleaning effort, persistent stains, wear and tear over time, forgetfulness, cup size (such as being too large for a coffee machine), taste, and limited opportunities for reuse at coffee bars and machines. Positive feedback was predominantly related to thermos bottles. Participants appreciated their ability to retain heat, their larger size, and the cost-saving benefits associated with their use. The motivations for utilising reusable cups were diverse. Many participants favoured thermos bottles to accommodate larger volumes and to keep their beverages warmer for extended periods, both on the go and at home. At home, the thermos was found to be particularly handy for enjoying a hot drink without needing frequent refills. In some cases, the thermos was so effective at heat retention that the coffee needed to cool down before being consumed. Notably, one participant reported searching for a reusable cup and thermos for a long time, expressing satisfaction with their current choices.

Participants displayed a range of routines and habits related to their reusable cups. For instance, one participant reported a very strict routine with the thermos bottle, cleaning it every evening and always carrying it, whether filled or not. Another participant habitually stored their cup in the side pocket of their backpack after use to prevent forgetting it, while another kept the cup in their car. The importance of consistency in routine was evident, as an intern deviated from their usual takeaway coffee habits during their internship. The cleaning methods also varied, with one participant using soda to clean their coffee cup (with caution due to its inedibility). If participants forgot their cups, their actions varied from using disposable cups instead to abstaining from their drink or enjoying it at the bar. Additionally, some participants noted a shift in their hot beverage consumption patterns, with more consumption during winter compared to summer.

3 Discussion

Through a multifaceted approach encompassing surveys, diary studies, and interviews, this study aims to provide a comprehensive understanding of takeaway coffee consumption experiences, behaviours, and routines, perceptions towards reusable cups, and insights from baristas. The results contribute to a holistic overview of sustainable coffee consumption practices and avenues for promoting the sustained use of reusable cups. Next to this, the methodology we used allowed us to enhance and compare insights gathered with different methods, both quantitative and qualitative. It can be employed in the future to address other sustainability issues in a more systematic way.

In comparison with previous research, this study confirms the influence of existing norms and habits of using disposable cups [246], adding to that the importance of creating new habits with reusable cups by e.g., taking them with you every day or keeping the cup in a designated space. Next to this, financial incentives could help persuade people to use a reusable cup (as shown by [81]), and cups showing wear and tear are one of the barriers to long-term usage [60]. The systemic barriers that came up in the interviews with baristas are consistent with literature [248]. However, we noticed some interesting changes in perception, with many of the baristas being open to using and promoting more sustainable options and some even going for fully reusable with the Billie Cup system.

3.1 Answers to the research questions

Barriers and motivators to reusable cup usage (Q1)

The biggest barriers to making the switch to reusable takeaway cups are the size and weight of the cup, potential leakage, and having to remember to bring the cup or anticipate going to get takeaway. Barriers to continued usage are persistent stains, wear and tear over time, the taste of the material, the size (e.g., not fitting in pocket), and no option for reuse at the coffee bar or machine. The motivators for choosing a reusable cup are mainly environmental concerns, followed by practical advantages such as the taste, feeling, and aesthetics being better than disposable cups, ease of transport and heat retention in case of a thermos, and financial advantages such as discounts.

Perspective of the barista (Q2)

Some baristas find it annoying when customers do not present a well-cleaned cup. Most baristas are sceptical about the experience of drinking from a reusable cup, and how it affects mouthfeel and taste. Some give discounts to stimulate reusable cup usage, but not everyone communicates it well. Barriers to cooperative systems such as the Billie Cup are the confusing deposit system, having to clean cups used by customers of other bars, and the material and feel of the cup.

Experience and routines (Q3)

Regarding the experience, we can look both at the meaning people give to drinking coffee, and the experience of using a reusable cup. Mainly the baristas put emphasis on the superior taste and feeling of drinking out of a porcelain cup in comparison with a disposable or reusable takeaway cup, with which some users agree. What is quite universal, is that the meaning of drinking coffee (and often also other hot drinks) is related to a moment of enjoyment, relaxation, 'me time', and a boost of energy. There are plenty of positive correlations that people make with

drinking coffee. This can be played out in the design of reusable cups, and definitely a cooperative system.

It appears that people with strict routines regarding their reusable cup (always storing it in the same place, cleaning it every time after use, taking it with them every day, even if it is not used) are less prone to forget their cups and use disposables instead. Most baristas typically see a recurring group of customers returning with their reusable cups, often regulars, indicating the advantage of already having a strong routine. It seems that baristas have more ease in implementing little changes into their fixed routines, while users without a routine face the challenge of having to carry the cup with them at all times, just in case they get a takeaway drink.

Design opportunities (Q4)

Based on our findings, we can propose some opportunities for designers to encourage the sustained use of reusable cups. A universal cup size could provide some benefits but is requested neither by baristas nor the users of reusable cups. However, a cooperative system such as Billie Cup has the possibility to adjust the sizes of their cups to the capabilities of the espresso machines, which saves time and increases convenience for the baristas, provided that the deposit system is better structured and able to address concerns about handling excess or insufficient cups, as well as the ease of returning cups. Clear communication about the system and its benefits can encourage customer knowledge and participation.

Many customers who use disposable cups indicate that financial incentives could persuade them to use a reusable cup, but it has to be clearly communicated by the coffee bar to persuade clients to make the switch. Next to this, Coffee bars can offer tiered discounts or loyalty programs that increase with each reuse of a reusable cup. This provides immediate financial incentives for customers and promotes long-term behaviour change. It could also help to develop routines. Collaborative marketing campaigns can also emphasise the cost-saving benefits of using reusable cups.

Related to the design of the cup itself, designers should focus on using materials that do not alter the taste of the drink, are durable enough to perform beyond their break-even point, are lightweight, and avoid showing wear and tear after a couple of uses. We argue that there is room for both thermos bottles and regular reusable takeaway cups, as they are generally used for other purposes and have different requirements. Thermos bottles are expected to keep the drink warm for an extended time and contain more volume. Takeaway cups should be lightweight, and compact, and the content should immediately have the right temperature to drink. We also recommend designing an easy-to-clean, lockable lid to prevent leaks.

3.2 Limitations

The study's findings are subject to limitations, including self-report biases, limited generalisability due to non-random sampling, and the possibility of social desirability bias in self-reported behaviours. Besides this, the study was conducted in 2021 and 2022, which might not capture the full impact of the ongoing COVID-19 pandemic and changing consumer behaviours, as well as any new developments in sustainable practices. The diary studies only took place over the course of two weeks, so the results lack insights into longitudinal behaviour and changing routines over time.

4 Conclusions

This research aims to gain insights into barriers and motivators to the sustained use of reusable coffee cups. To do this, we investigate experiences, behaviours, and routines related to takeaway coffee consumption and perceptions towards reusable cups. In the end, we formulate concrete design recommendations to promote sustained reusable cup usage. The study employs a mixed-method approach, combining qualitative and quantitative techniques. The findings reveal several barriers and motivators to the acquisition and sustained use of reusable cups, related to habitual constraints, practical considerations, and user experiences, both from the user and the barista's perspective. Despite the majority of the respondents acknowledging the environmental issues posed by disposable cups, only one-third currently use a reusable cup. Participating baristas indicate scepticism regarding cleaning and the influence of reusable cups on mouthfeel and taste experience. The design recommendations derived from this research include the need for more streamlined and transparent cooperative systems, incentives such as discounts and loyalty programs, and an improved cup design that prioritises materials, practicality, user experience, and leak prevention. Furthermore, the study highlights the opportunity to enrich the emotional and experiential aspects of coffee and hot drink consumption, including feelings of relaxation, enjoyment, and energy, through thoughtful design interventions.

Future research should investigate potential interventions and design recommendations with case studies in the field. Strategies for coffee bars to effectively communicate discounts and benefits to customers can be further explored, and innovative cup designs and material explorations should be tested with users, as well as the feasibility and effectiveness of cooperative systems in promoting reuse. It would be interesting to further research the differences in the use of reusable cups based on age and demographics, understanding how the preferences and behaviours of different age groups can help tailor strategies and designs. It would also be useful

to explore how cultural and regional factors influence the adoption and use of reusable cups, as different regions and cultures may have varying levels of acceptance and practices related to sustainable coffee consumption.

Acknowledgements: Ella Adriaens, Karolien Bogaert, Estelle Bohner, Maaike Dumon, Orin Gielen, Floor Goddeeris, Anna Peštová, Meerten De Ryck, Renée Sommen, and Anastasia Vandoorne Feys

PART FIVE

Part five is dedicated to addressing the third research question, seeking strategies to support designers in promoting the sustained use of reusable products by considering variables related to the product, user, and context.

Chapter 7 includes a study done within the course of Sustainable design, in the 2nd Bachelor Product Development at the University of Antwerp. We test various tools with 87 students to assist them in developing reusable solutions that have a greater likelihood of long-term success and ask about their experiences and evaluation of these tools afterwards. The tools are based on the findings from the previous chapters and the exploration with students serves as inspiration for the framework we present in Chapter 8. The paper *'Design for long-term reuse in sustainable design education'* will be published as an e-book proceeding of the EcoDesign 2023 International Symposium.

In **Chapter 8**, we propose a framework for designers, with preliminary expert verifications and iterations. This was done by synthesising the results gathered through all research activities in this thesis. The framework helps to approach a reuse design challenge from all its perspectives and enables designers to achieve a more complete picture before making design decisions. We elaborate on how the framework was built and how it is used. The results from this chapter have not been published yet.

L. Herweyers, L. De Schepper, I. Moons, E. Du Bois, (2023) Design for Long-term Reuse in Sustainable Design Education. Going Green - Ecodesign (2023), Nara, Japan.

CHAPTER SEVEN

Design for long-term reuse in sustainable design education

Laure Herweyers, Lien De Schepper, Ingrid Moons, Els Du Bois

Abstract: To mitigate the environmental impact of waste generated by fast-moving consumer goods, several reusable alternatives to single-use products have entered the market, gaining increasing popularity. It is crucial to ensure that these alternatives are reused frequently enough to compensate for their higher environmental footprint during production compared to single-use products. Drawing on prior research, we developed a range of practical tools and exercises to assist design students and professionals in developing reusable solutions that have a greater likelihood of long-term success. The tools were implemented within a six-week sustainable design course, engaging 87 students, with the aim of evaluating the efficacy of the tools in enhancing the eco-design process and quality of outcomes in terms of long-term use. To assess this, we conducted a survey with the participating students after completion of the course. The results revealed that more than one-third of the designs were product-service systems designed to extend the product lifetime and tailored to specific types of users. The students expressed that they learned new ways of reasoning to design for sustainability. Additionally, from the teachers' perspective, the students exhibited a deeper understanding of the particular context and challenges than students in the same course in the previous years. Building upon this initial exploration, our plans include expanding the user journey exercise to a 'lifetime journey', enabling exploration and comparison of various potential timelines. Moreover, we aim to evaluate the tools with design professionals, and with more specific predefined target groups and cases. Future research should also focus more on the nuance between habitual, routine, and one-time usage of a product.

Keywords: sustainable design education; design for behaviour; repeated reuse; single-use products

1 Introduction

Since the 1950s, the production of plastics has been rapidly increasing. Nearly four hundred million tons of plastic are produced globally every year [4] and 79% of all plastic ever produced, ends up in landfills or as litter in natural environments [157]. Due to their protective properties combined with low costs and being lightweight, plastics are often used in packaging and other single-use applications [157]. Evidently, their massive use is undesirable from an environmental perspective, since they eventually lead to resource depletion, and contribute to water, soil and air contamination through pollution, negatively impacting wildlife and potentially human health [11]. To address this problem, a European ban on the sales and usage of several single-use plastic items such as straws, cutlery, plates, cotton swabs and balloon sticks was implemented [25] and more bans will follow shortly. As a result, the demand for good alternatives has increased, and more and more people are adopting reusable products as a means to live more sustainably. However, in order for these alternatives to have a lower environmental impact compared to using a single-use product on every occasion, they must be reused at least a specific number of times. This is because their production entails higher energy and water usage, as well as the use of more durable materials [37]. Furthermore, the use phase itself contributes to the environmental impact, particularly due to the need to wash the product after each use [38]. This underscores the significance of sustained and repeated usage (what we call 'long-term use') beyond this break-even point, emphasising the necessity for a shift in lifestyle [39].

1.1 Eco-design and Design for Behaviour

To facilitate reaching this break-even point, designers can use methods and strategies from design for sustainability (eco-design or circular design) and design for (sustainable) behaviour. Eco-design focuses on the environmental impact of products through their complete life cycle, going from the extraction of materials to production and assembly, packaging, distribution, use, and disposal/ end of life. It aims to close the lifecycle by increasing product longevity, reducing material usage, and facilitating the reuse, redistribution, reassembly, and recycling of products (r-strategies, butterfly model Ellen McArthur Foundation [33]). Since the design of a product directly influences its environmental impact (e.g., through material selection, recyclability, impact during manufacturing, design for disassembly, durability, quality, and avoiding early obsolescence) it is crucial to educate design students on the principles of eco-design [249]. We define Design for Sustainable Behaviour as (i) lessening the environmental and social impact of a product by influencing users' behaviour and interaction with said product, as well as (ii) influencing sustainable

behaviour through design. The first definition focuses on the impact of the use phase of the life cycle and applies behavioural theory to better understand users and create behaviour-changing strategies to develop products, services and systems that encourage environmentally friendly usage [147]. The second definition is brought up by the authors and could also be called 'design for responsible consumption' or 'design for sustainable lifestyles' [250]. We argue that a combination of good eco-design with design for sustainable behaviour creates opportunities for designing single-use alternatives that have more chance of long-term success and help people adopt more sustainable lifestyles.

1.2 Sustainable Design Education

Since designers can play an important role in promoting long-term reuse, (higher) design education has a responsibility in creating the 'environmentally skilled' designers of the future [251] who move beyond the end-of-pipe approach, cleaner production strategies, and merely redesigning products, towards designing products, services, or product-service systems [252] that facilitate the transition to a sustainable society [253]. This includes design for sustainable lifestyles and consumption patterns. Besides this, the educational setting proves to be both a logical and relevant setting to test out the efficacy of new methods and tools [254].

1.3 Objective

In this research, we want to test our theories for designing for long-term, repeated reuse in an educational setting. We developed several tools and exercises derived from existing strategies combined with our own research, which we included in a design course. The aim is to evaluate the students' experience with the tools and the quality of their process and final design solutions, and compare those with the previous years. The research questions are:

Q1: How are the tools evaluated by the students in their applicability and provision of new viewpoints?

Q2: To what degree are the results facilitating long-term reuse, for example by providing a service with the product?

Q3: Does targeting specific users (aside from their demographic characteristics) and identifying critical points lead to innovative and sense-making results?

Though we evaluate the experience of the students, we are not focusing on the

usability of the tools but merely on the quality of the results and distinguished barriers and contexts. Thus, our objective is to find out how to support designers in general in developing solutions for long-term reuse rather than improving design education methods, although this research can provide valuable insights for design educators as well.

2 Design for long-term use

This research is building further upon our previous work that has distinguished different clusters of users regarding the avoidance of single-use products and related reuse behaviour, namely 'single-use product (SUP) avoiders', 'SUP addicts', 'situation-driven users' and 'apathetic' [151], who we suggest targeting with different types of products or product-service systems to optimally stimulate repeated reuse [255]. For example, SUP avoiders often already use a lot of reusables, and like to showcase their green identity. A customisable product for individual use could be suitable for them. For SUP addicts or apathetic, however, convenience would be a very important factor (resulting from low attitude), so a product-service system (PSS) might be more suitable in their case. Next to this, attitude-improving communication campaigns (something that can be done through clever product design as well) provide opportunities to transfer from one user cluster to another. Also, other advantages of reusable products (apart from sustainability) should be considered, i.e. saving money and the products being more aesthetically pleasing because of better design and materials. Next to this, we categorised reusable products into four types based on typical barriers and contexts in which they are used; on the go, at home, intimate care, and daily shopping [255].

On the go products are used typically outside of the home and on the road, for example, to carry takeaway food or drinks. Often this is not repeated but rather one-time behaviour. Typical thresholds are forgetfulness, spontaneity, having to carry it 'just in case', practicality, heaviness, and the cleaning process. Examples are coffee cups, food wraps, lunch boxes, and drinking bottles.

At home products are mainly used inside the house. They typically stay in one place. Thresholds are mainly related to functionality, practicality, and durability. Examples are food huggers, jars, reusable coffee- and tea filters, and silicon baking mats.

Intimate care products are defined as products that come into contact with intimate areas of the human body. Typical barriers are hygiene and safety perception, the cleaning process, shame, and practicality. Examples are reusable menstrual products, family wipes (i.e. toilet paper alternative), reusable cotton swabs, and reusable diapers.

Daily shopping products are typically used on a daily basis, and their usage is very routine-dependent, and as a result time-sensitive and habit-sensitive. Typical barriers are accessibility and proximity, price, and forgetfulness. Examples are produce bags, tote bags, jars, and refillable bottles.

We hypothesise that considering each user cluster and product category in the design process can lead to more specific, suitable solutions with a bigger chance of successful long-term usage.

2.1 Development tools

We developed a series of exercises to apply in a design process to go from a single-use to a reusable product, taking into account the long-term usage of the product and the target user's behaviour and lifestyle. We hereby define 'tools' as guides that enable the students to do the exercises we give them. The following six steps could be integrated into the design process:

1. Introduction to the different product categories and some examples of their typical barriers and contexts [255], which serves as a tool for further analysis. The concept of the break-even point is explained, and attention is put on the fact that any disposable product (also cardboard or bamboo) is undesirable and design is needed to find appropriate and qualitative reusable solutions.

2. Detailing of the specific persona for whom the reusable product is made, based on four consumer clusters [151], and individual and context-related characteristics. The clusters are shortly introduced, and examples of personas are given with an option to create a persona and guidance on what particular characteristics are interesting to focus on.

3. Analysis of the product usage by creating a user journey for the persona. First, this is done for the existing single-use product, after which an exercise follows where a user journey is made for the same product if it would 'suddenly be reusable'. This can be visualised at will. Figure 1 shows a simplified example of a user journey of a reusable bread bag given to the students, indicating possible problems regarding reuse from the users' perspective.

4. Comparison of the two user journeys to better identify barriers, opportunities, and challenges for reuse, which can be translated into concrete design requirements and critical points for both the product and service system that is needed.

5. Guiding questions to help find opportunities for reuse, starting from the individual, the product, and the context in which it is used: Can it make people more environmentally conscious? Can you link the use of the product to existing habits and routines? *(User)* Does the material show wear and tear after repeated use? Is the product more aesthetically pleasing than the single-use alternative? Is the cleaning process easy and quick? Does the product have a clear advantage over the single-use variant? *(Product)* Is the product available and accessible (near the user)? Is the usage accepted by the social environment? *(Context)*.

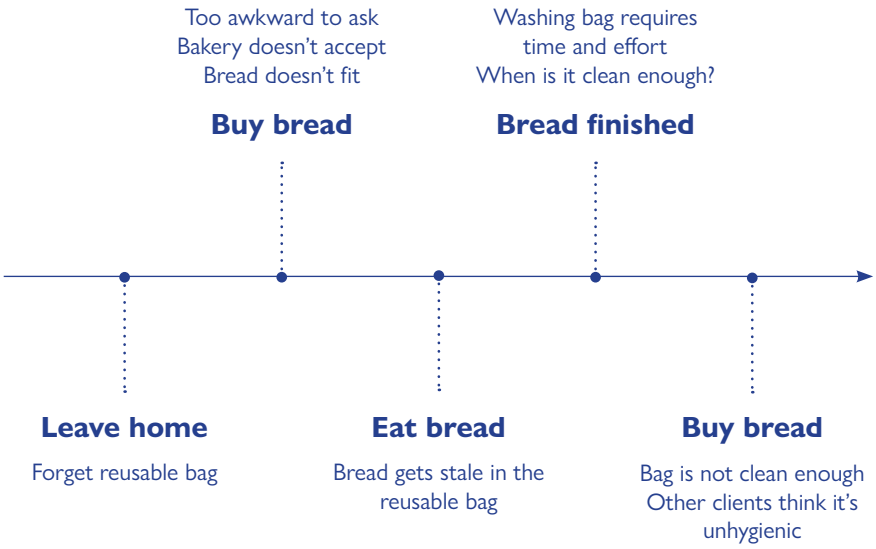


Figure 1. Simplified user journey reusable product

In addition to design activities, designers must also be supported in the optimised evaluation of their design solutions to make proper decisions. Hence, the following tool was created to help with idea selection.

6. Ecological trade-off based on circular design principles, extended with the list of critical points based on the identified barriers and opportunities from the previous exercise. The critical points were included in the trade-off for the selection of the final product.

3 Methods

The tools were tested during a Sustainable Design course (3ECT) in the 2nd bachelor of Product Development at the University of Antwerp. The students were challenged to design a reusable solution for a daily-life single-use product of their choice and think beyond the first usage. In total, 87 students took part in the experiment. They had no prior experiences or previous classes on eco-design and circular design yet, and the design of a product-service system is only found in the curriculum of the 1st masters (4th-year students). Figure 2 shows the full process of the six-week course, which has had this structure for several consecutive years now.

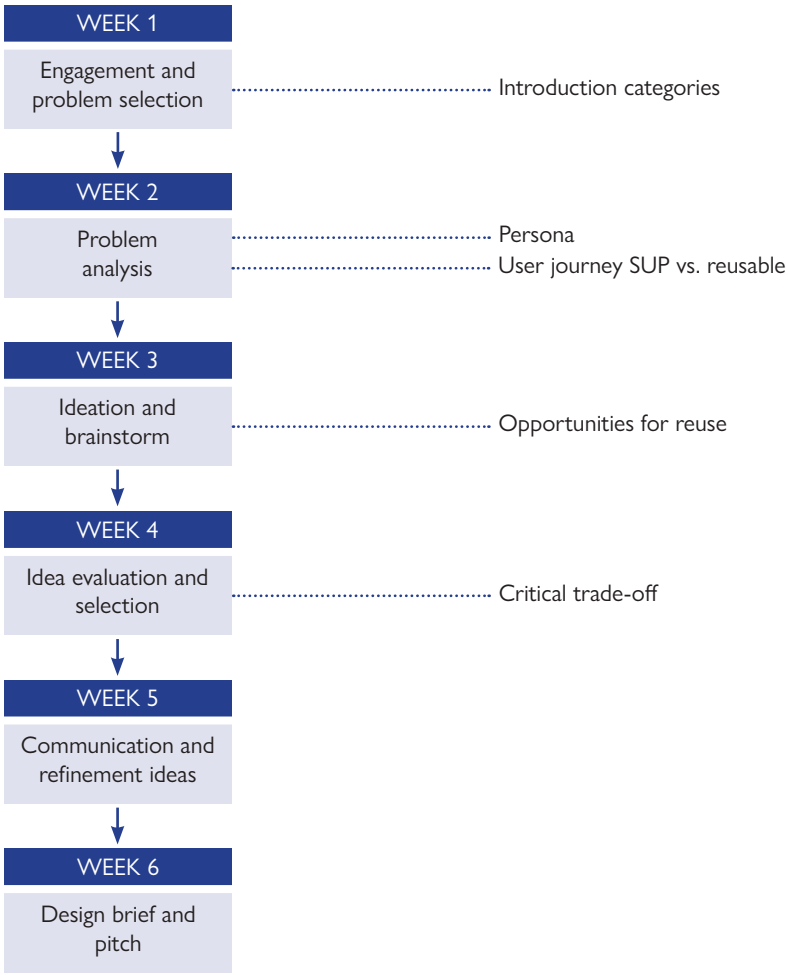


Figure 2. Structure of the sustainable design course with integrated tools

3.1 Context of the course

Every year, the topic of the course focuses on another societal or sustainability-related problem, challenging the students to learn how to take responsibility and design small but smart solutions that reduce the environmental impact. Consequently, the specific focus on the long-term use of reusable products was added only this academic year (2022-2023). Methodologically, we can compare the results of previous years with this year.

As can also be seen in Figure 2, the students receive our tools gradually from week 1 to week 4. In week 1, the students have to formulate an engagement regarding the specific single-use product they want to transform into a reusable product. Here, the introduction to product categories is given to inspire them. Week 2 handles the problem analysis, forcing students to understand the reasons why single-use products are most popular at this moment, but also how and when the product is used under what circumstances. Here, we include the detailing of the persona and the user journey of both the single-use and the reusable product to identify the barriers and opportunities. In week 3, the focus lies on ideation. We introduce the guiding questions to find opportunities for solutions and provide several brainstorming tools. The students learn to think outside the box and have to create 100 solutions. In week 4, the ideas are evaluated on quality, novelty, and appropriateness. Reusability criteria are included in the ecological trade-off, and the students are requested to create their own trade-off based on critical points identified with the user journey. Week 5 focuses on the further detailing of the chosen idea and week 6 includes the writing of (i) a design brief that can be used by an executive designer to further design the concept and (ii) a pitch video that is directed towards potential investors. Here, no specific tools are added. Nevertheless, students are invited to reflect on the identified barriers and opportunities as well as user journeys and personas in both the design brief and the pitch.

3.2 Questionnaire

After completing the course, the students (n=87) were requested to fill in an evaluation survey (November 2022). This survey consisted of both open and structured questions and questioned both the tools and the evaluation of the course (not further considered in this paper). The open questions were analysed using NVivo, and the structured questions were analysed with SPSS statistics.

The first block looked into the students' knowledge before the start of the course, the first question being 'How new was all the information you received during

the introductory lesson?' with five multiple-choice options ranging from 'I knew everything already' to 'Everything was new to me'. This was followed by an open question to clarify what exactly they learned, after which we asked what single-use product the student chose to tackle in this course (open question). The second block evaluated the usefulness of the tools. Regarding the user journey exercise, we asked from what perspective this was the easiest: either from the single-use product, the reusable alternative, or the combination and comparison of both. The following two questions were about the persona: a yes-no question about whether they think the persona helped them to put a clear focus, and an open question on how they used the persona in their own design process. Then, we asked in an open question what barriers they were able to identify from this exercise, followed by the opportunities for reuse. In the last question of this block, the students had to specify how they used the barriers and opportunities in their further design process.

The third block considered the tools for evaluation: the ecological trade-off and critical trade-off based on barriers and opportunities. The first question used a 5-point Likert scale (Not at all (1), very little (2), a little (3), a lot (4), very much (5)), asking to what extent each evaluation method helped them in selecting the final concept: ecological trade-off, their own trade-off, or a combination of both. This was followed by a yes-no question on whether they think the tools helped them to make their design even better. The next question was an open question on how they improved their designs with help of the trade-offs, and what aspects they focused on. The last question of the block asked for potential suggestions for improvement of the evaluation tools. The final designs were handled in the fourth block. First, they had to explain their final design, after which they had to state whether they were happy with it or not and further explain why. Then followed a multiple-choice question about the type of product they designed: a product that you have to buy for individual use, a product that works with a deposit system, or a product that is shared through a lease system. There was also an option 'other'. Then, the students could indicate whether they found it valuable to put the product in a larger system, and why. In the final open question of this block, the students had to explain why they thought their final design would lead to long-term behaviour change. The final block considered questions and suggestions to improve the course itself and is not included in this research paper.

3.3 Evaluation

To evaluate the results compared to previous years, in-depth reasoning was done with the teachers of this course: a team of three academics consisting of two professors and one PhD researcher from the Department of Product Development.

4 Results

4.1 General learning process

The students indicated they learned most new insights on (i) the impact and size of waste by single-use products, and (ii) how much material of such products is barely used or recycled. (iii) Knowledge of existing alternatives is also mentioned: what products do not have alternatives yet, the lack of knowledge on alternatives, and how many already exist. (iv) Others mentioned being surprised by the ecological footprint of drink cartons and paper bags as opposed to plastics. (v) The students also mentioned new insights in the design process: the impact that design can have, and what problems we need to give priority. More practically, the circular design principles to design for reuse were mentioned: avoiding glue connections, design for modularity, and the difficulties of designing for reuse.

4.2 Evaluation tools

Product categories

More than half of the students focussed on packaging, mostly of food (e.g., chips, cereal, fast food, pizza, candy, cup noodles, popcorn, butcher paper, cake, and salads). Also, packaging for medication (blister packs, vitamin boxes) and care products (make-up, deodorant, skincare, perfume boxes, shampoo bottles, toothpaste) came up. These products can be put under the category daily shopping, as well as at home. Also packaging for delivery (online shopping bags and boxes) and products to carry stuff (books, festival trays, shoe boxes, but also dog poop bags) were represented, and can be put in the category 'on the go'. Next to this, food wrapping products were chosen by +-10% (aluminium foil, cling film, and wrapping paper), as well as closing mechanisms for packaging, such as adhesive tape, Colson straps, bottle caps, and painter's tape. Also, waste bags came up. Desk items (ballpoint pens, markers) were chosen as well. They can all be put under the category 'at home'. One-tenth chose a product in the category 'intimate care' (band-aid, tampon applicator, wet wipes, and cotton swabs). By far, most students chose a 'daily shopping' product (60%), the other categories were underrepresented (10-15% per category). Interestingly, also labels from clothing were targeted by a few students, which do not fit into any of the categories.

Persona

45% of the students stated the persona helped them in the design process, while 55% revealed it did not help. This indicates that the integration of a meaningful persona should be improved. From the group that was positive about the persona, one-third

stated it helped to imagine the target group and their needs, as well as their habits and context. Some students were inspired by themselves for creating the persona since they considered themselves as difficult people to persuade to use an alternative. Several students specifically designed for their persona according to their specific barriers, although this group was smaller than expected (9%) since we specifically requested the students to take this into account in their design process.

User journey SUP vs. RP

When asked whether it was easier to construct the user journey either through the lens of the existing single-use products or the reusable product, 65,5 % of the students answered 'single-use product', while only 10,3% said 'reusable product'. 24,1% prefer the combination of both.

Identification of barriers and opportunities

Most of the barriers identified through the user journey exercise were related to the behaviour and habits of the user, such as having to keep the product with them, having to do extra steps after usage (e.g., cleaning), the overall user experience, the ease of use of and habits related to single-use products, in contrast to the need for adopting new behaviours. Also, perceptual and emotion-related aspects came across, such as hygiene (perception), feelings of shame, increased price, time investment and extra effort. Regarding product properties, typical advantages of single-use products as opposed to reusables were most frequently mentioned, such as low weight, aesthetic design, safety, and protection during transport. Finally, one-fourth of the respondents mentioned system barriers (e.g., accessibility, acceptance by e.g., butcher or baker, lack of knowledge) and barriers of the (service-) provider (e.g., regulatory constraints).

Among the opportunities for value creation, often properties of circular design were given, such as being sustainable and environmentally friendly. This shows that most students already consider making a product more sustainable as inherently positive and valuable. Other identified opportunities were no or less waste, more attractive design, and better functionality than single-use products. Certain barriers to reuse were translated into opportunities: price (in the long term), universal usage, and hygiene. Reusable products could also improve the user experience and simplify the usage steps. Next to this, more choice options, customisation, improved experience, and playful elements were seen as opportunities. For producers, new market opportunities were mentioned. Four students already touched upon the possibilities of a product-services system (extra services, deposit system). In general, the barriers that came up correspond with the product categories introduced in the first week.

Critical points and trade-off

In general, the combination of both evaluation methods was seen as the most fruitful (M 4.01), followed by their own trade-off based on critical points identified in the analysis (M 3.74) and the standard eco-evaluation (M 3,55). 81,6% of the students indicated that the trade-offs helped them to improve their designs.

4.3 Evaluation design

Usage of barriers and opportunities

Most students focused on removing the barriers from single-use products, and less on the potential opportunities of reusable products (although they frequently overlap). Approximately one-third of the students mentioned they took the barriers into account during the whole design process, by directly trying to solve the barriers in partial solutions, or by looking for solutions for each barrier separately. One student specifically mentioned using the user journey as a guide, and six students kept their persona in mind during the brainstorming phase. A few students mentioned linking back to the barriers during the design and selection phase. Typical improvements are extensions of functionalities, making the usage at least as good and convenient as the single-use product, improving transportation and storage, elongating the use, improving material, providing better service, universal usage, simplicity, improving recycling and decreasing waste.

Systems perspective

85% found it valuable to think further than just the product itself by putting it into its larger context/system. Some of the reasons why they found it valuable are 'it gives more context, you think more about those constraints as well', 'it was suddenly possible to develop an idea further that seemed unrealistic at first' and 'it helps to aim for more, for a change in lifestyle'.

4.4 Final designs

Half of the respondents designed a product for individual use, either fulfilling the same function as the single-use variant (e.g., refillable marker, fabric wrapping with Velcro, size-adjustable reusable chips bag) or adding extra functions (e.g., make-up pencil that can also remove make-up, reusable Nespresso cup with build-in dosage and tamper). Twelve students designed a product based on a lease system (e.g., reusable popcorn box provided by the movie theatre, reusable bag for delivery that is returned to the post office, reusable fast-food packaging, 'lease machine' instead of vending machine for umbrella's) and thirteen students designed a product that works with a deposit system (e.g., salad bowls and reusable biscuit packaging that

are returned in the supermarket, aluminium pizza boxes with deposit system). We link the answers to the question of why they think their design leads to long-term behaviour change with (design) strategies and interventions from literature. 'It makes the user more aware of the effects of pollution' (spillover effect [227]), 'there is no need for a big change in behaviour because of the way the product is designed', 'it will fit into people's existing behaviours and habits' (familiarity [103]), 'the product design creates an emotional bond with the product' (product attachment [256]), 'Because of the deposit system, people get money when they return it' (economic incentive).

4.5 Comparison with previous years

In comparison with previous years, the teachers of the course indicate that the new tools offer more support and guidance for the students, which results in more detailed solutions that have a higher potential to effectively be successful in replacing their single-use version. The practical support of the tools is especially helpful for inexperienced designers.

5 Discussion and conclusion

While two-thirds of the students preferred to make a user journey from the single-use perspective, it is important to note that thinking from the perspective of a 'potential' reusable product is a new and more challenging exercise for them. However, from the results of the course, we can conclude that it is valuable to investigate this way of thinking further. The students were free to choose a persona, we only intended to give inspiration by providing several examples of personas that fit into the different user clusters. This resulted in a varying quality of the chosen personas. Some were well thought-out and helped the students to define a target audience, while others were too general or vaguely described, hence they were not really considered in the final designs. The directions for the persona, and feedback towards the students, should be better followed up.

The participants of this study were only second-bachelor students of Product Development, and this course took place in the first semester. At that moment, they had only completed one year of study, which made them quite inexperienced. Some exercises were challenging for some, and several students did not always understand the assignments correctly. However, we very deliberately chose young students, since they had never been in contact with eco-design, design for behaviour, or product-service system design before. This way we could compare the results better with previous years. Also, students prove to be interesting subjects to test our tools

since they are less primed to use existing methods. This makes them more flexible in their thinking and generally more open to learning and using new methods and tools than senior designers.

It is difficult to make statements on the long-term use potential of reusable products that are not tested in the real world. However, by asking the students to evaluate their designs on their critical points and opportunities for long-term reuse, we can argue that the final designs are promising. It is interesting to see that several students looked into the whole system of the product's use instead of only the physical product and touched upon the concept of product-service systems. The survey could give the impression that these tools enable students to achieve a higher awareness of environmental problems. Obviously, this cannot directly be concluded as raising awareness on environmental issues and the correlating responsibility of the designer is an important part of the course in general. Nevertheless, using these kinds of tools enables the students to achieve more in-depth insights which might help them to effectively reach valuable solutions.

5.1 Implications for Sustainable Design Education

Although we did not evaluate the usability of the tools, teachers of sustainable design courses can gain insights and inspiration from our results and methodology. We identified some key takeaways for design educators: (i) It is important to emphasise the role and responsibility of the designer regarding the environmental impact and potential unintended consequences of their designs early in the learning process of students, and encourage them to adopt a systems perspective while facing design challenges. (ii) The dual approach of constructing user journeys from the perspective of both single-use and reusable products can help students identify design opportunities and challenges more effectively. (iii) It is crucial for students to consider the needs, habits, and contexts of their target audience when creating designs. Educators should also encourage students to design with specific personas in mind and address their unique barriers. However, it is important to facilitate this process of creating personas well to ensure the quality of the outcome. (iv) A combination of evaluation methods can lead to more well-rounded and effective design solutions. (v) Encourage students to explore various design approaches, including products for individual use, lease systems, and deposit systems. Highlight the importance of designs that align with users' existing behaviours and routines.

5.2 Conclusion

In this research, we tested out several tools and exercises based on our previous research on designing for long-term reuse during a Sustainable Design course. We

aimed to explore techniques to put our theory into design practice. Regarding the first research question (Q1) 'How are the tools evaluated by the students in their applicability and provision of new viewpoints?', we can conclude that the tools do provide new viewpoints for the students, but are not very applicable yet and need further iteration. (Q2) 'To what degree are the results facilitating long-term reuse, for example by providing a service with the product?': although we cannot put hard numbers on the potential for long-term reuse, we have several indicators (final design leans close to the identified barriers and opportunities, the implementation of a service or deposit system in the design solution, feedback to the specified persona) that show the potential of the final designs. From this point of view, we can conclude that the results are promising: In comparison with previous years, considerably more designs were product-service systems, and better targeted to specific types of users. Regarding the third research question (Q3) Does targeting specific users (aside from their demographic characteristics) and identifying critical points lead to innovative and sense-making results?', we argue the proposed solutions were overall definitely innovative while sense-making, mainly due to a variety of selection tools combined with a more targeted eco-evaluation and critical points and opportunities trade-off. Finally, the students reported that they learned new ways of reasoning to design for sustainability, which is a fixed target of this course, but also taking people's behaviour into account, which is newly introduced this year. From the teachers' perspective, the students also seemed to have a deeper understanding of the specific context and challenges than students in the same course in the previous years.

Future design

In order to succeed with this tool, a redesign is required to optimally transfer the generated theory into practical support for designers. In the future, we want to develop a 'lifetime journey' or 'routine journey', which is a combination of different possible lifetime scenarios including multiple user journeys, each depending on the nth time of use (since the first-time use will probably be different from the 2nd, 3rd, … 60th use). Also 'atypical' behaviour should be addressed here, which can be translated into incorrect usage, or using the product in a different way than intended. Examples are each time buying a new reusable product instead of reusing (using a reusable product as a single-use product, typically done with produce bags and sometimes coffee cups) [50] or reusing a product that is meant to be used only once (such as PET bottles). Besides this, the user's previous ecological behaviour, existing habits and practices, environmental concerns and ecological intentions *(user-related)*, the types of products (categories), the quality and functionality, the provided support *(product-related)*, and specific contexts, cultures and (social) environments *(context- related)* all have an influence on the course of the lifetime journey. It would be valuable to be able to anticipate as much as possible on these

variables in the development of a product, product-service system, service, or system solution to enable long-term use. Also related routines and practices that are in one way or another connected to the product usage can provide insights into possible barriers but also opportunities to sustainable repeated reuse, and should be further investigated.

Next to this, it is important to add a first (preliminary) step in developing solutions for reuse, by asking the question: is reuse desirable? This depends on several factors, ranging from the type of use (one-time or routine), the situation in which the product is used, to getting an abundance of products for free (e.g., tote bags) or the product having a very high break-even point (see LCA studies), making it nearly impossible to reuse the product beyond its break-even point. This part could mainly be used in the evaluation of a (potential) reusable solution.

Future research

We are planning to organise a workshop with fellow design researchers to further develop the tools and exercises. Future research should test them in the same sustainable design course for multiple years in a row, each time iterating the previous version. They could also be tested in smaller workshops with more experienced designers, i.e. professionals or design students.

Acknowledgements: Dirk Van Gogh

CHAPTER EIGHT

Development of a framework to assist designing for long-term reuse

1 Introduction

To make the findings applicable for designers, we synthesised all our data into a comprehensive schematic overview, from here on called 'framework'. We do not claim this to be a theoretical, behavioural, or predictive model. We constructed it with the main purpose of bringing together all the data and relationships between the data in order to assist designers and other practitioners in developing solutions for long-term reuse with a greater chance of success.

In this chapter, we elaborate on the creative process of developing the framework, the content of the framework and how to use it, and the iterations that were made based on expert evaluations. The framework is still a work in progress and a way to disseminate the research among practitioners, beyond the borders of the scientific world. Next to this, it aims to trigger both researchers and designers to experiment with it to enable further research and development.

2 How the framework was developed

By combining all the data and conclusions from the research done in this PhD (Chapters 1-7), we created an overview of the variables that influence the (long-term) use of reusable products. We schematised this data and made several iterations based on nuances we make in our papers and inspiration we took from behavioural models such as CADM, B-MAP, and COM-B. We then applied the final framework to the product categories (Chapter 2) and user clusters (Chapters 3-4) to help the user navigate the framework, and included different cases (Chapters 5-6) to serve as examples. We also linked the framework to a wide range of strategies that can concretely assist with developing interventions. We then presented the framework and opened a discussion with several design researchers (three professors and two fellow junior researchers) for evaluation.

With this framework, we aim to provide designers with a holistic perspective on the user, product, and context variables influencing user behaviour that must be considered while designing reusable products, ensuring a more comprehensive approach to foster long-term reuse.

2.1 Framework properties

Mindset and knowledge

In our framework, we emphasise the existence of some important user-related elements that are independent from any specific product, yet influence the likelihood of long-term reuse. These insights are mainly based on the findings discussed in Chapters 2 and 3. While they may not be product-specific, they can indirectly affect the potential for long-term usage. The two dimensions we highlight are general mindset and knowledge. **Mindset** encompasses an individual's ecological consciousness, their sense of responsibility regarding environmental issues, and their predisposition for throw-away or sustainable attitudes. On the other hand, **knowledge** is about problem awareness, awareness of needs and consequences, familiarity with existing alternatives, and knowledge of the impact of certain behaviours. We argue that knowledge can increase one's ecological mindset, and a cultivated ecological mindset can, in turn, enhance knowledge. Mindset is shaped by values, social norms, environmental concern, attitudes, green self-identity, and feelings of responsibility. Knowledge is dependent on education, media, advertising, visibility of sustainable products and lifestyles, and general misconceptions.

Product properties

There are also product-related prerequisites for making long-term reuse possible, independent of the user. We are talking about quality, functionality, and durability. **Quality** entails the product being free from defects, inconsistencies, or shortcomings. A high-quality product is more likely to stand the test of time and gain continued acceptance in the market. The **functionality** of a product refers to its ability to fulfil the promises it makes to the user and do what it is supposed to do. Ideally, it does this efficiently and effectively. In the context of long-term reuse, functionality is about providing a reliable and consistent experience over extended periods. Technical **durability** relates to the physical robustness of a product and its capacity to outlast its break-even point. A durable product can withstand wear and tear, environmental conditions, and frequent usage without significant deterioration in performance or appearance. Products designed for long-term reuse need to be built with materials that can resist degradation and damage.

Willingness, ability, routine

Based on Chapter 2, we integrated the pathway we defined towards long-term reuse, namely willingness (wanting), ability, and routine formation, into the framework. The variables that influence the potential success of each of these three phases, were complemented with data from Chapters 1, 4, 5, and 6. Figure 1 shows a simplified version of the framework including user, product, willingness, ability, and routine.

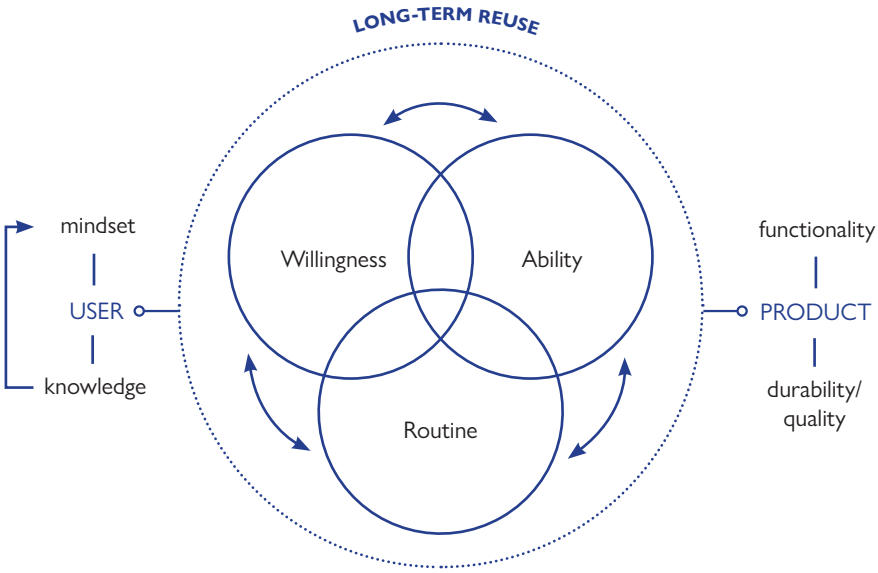


Figure 1. Simplified framework

Willingness usually stems from a positive sustainability-oriented mindset, financial incentives, other people using it (social encouragement), a product being more attractive or working better than a single-use variant, or a combination of those. It is closely tied to how potential users perceive the product, as factors such as safety, hygiene, material, and quality perception often act as barriers. Moreover, media discourse and narratives, prevailing social and cultural norms, and the visibility of alternatives all play significant roles in shaping this perception. Willingness to use represents the initial step towards adoption, which is a necessary precursor for long-term usage.

The variables that influence willingness are appearance, safety-, hygiene-, quality-, convenience-, and sustainability perception, attractiveness compared to SUP, subjective norms (including other people's behaviour, and feelings of shame and taboo), and price.

The user should have the **ability** to use the product. They need to be equipped with the necessary knowledge, skills (e.g., the user is aware of how the product works), and financial means to use the product (e.g., the user can afford expensive refills). The product should be available nearby (e.g., zero-waste supermarket), accessible, and accepted by the social environment. Also, the infrastructure that is needed to use the product (e.g., refill stations) has to be present. The product should function the way the user expects it to, it should be adapted to the needs of the user, and the user journey must be clear and executable.

Variables influencing ability are acceptance of other stakeholders (e.g., bakery, restaurant, supermarket, bar), accessibility (e.g., location), availability, infrastructure adapted and responding to the needs (e.g., cleaning facilities) and skills of the user (e.g., fit or size), the complexity of the user journey, user friendliness, and financial means (e.g., refill cost).

To eventually achieve sustained reuse, some sort of **routine** or practice formation is beneficial. In some cases (dependent on the user and product), this will be a daily or weekly fixed routine, while in other situations, it will be very irregular use. The aim is to use the product every time one would otherwise use a single-use variant. Barriers are often related to situational constraints (e.g., distraction or stress), time (e.g., being in a hurry, forgetting the product), a change in needs of the user, and mental and physical effort (e.g., having to think about the product, having to maintain it). The space and time in which the behaviour takes place are also key factors, as well as changes of environment or context. As we mentioned earlier, the quality and durability of the product to perform until beyond its break-even point have a key influence on the potential for routine formation.

Variables influencing routine formation are the ease of implementation in existing routines, SUP habit strength, persistence, mental and physical effort, work and family situation, change of context or environment, change of needs, satisfaction with product, market developments (newer, better products), and situational constraints (e.g., being late, or unforeseen circumstances).

Figure 2 shows the variables in detail.

Figure 2. Variables

2.2 Layers

The relative importance of variables within the framework can vary significantly between cases. Depending on the specific type of user and product considered, certain variables can be highlighted as potential critical points. This adaptability is a key feature of the framework, enabling designers to differentiate between cases, get a quick overview of (potential) critical points, and get specific directions towards more in-depth analysis. For this, we propose two layers: user, and category. Additionally, we involve a third layer, containing intervention strategies for tackling critical points. Through this link (best viewed on PC), the full framework and layers can be consulted:

www.uantwerpen.be/en/projects/reuse-lab/showcase-projects/research-projects/reusemotivation/

The link and QR code will direct you to a page with an interactive PDF, which serves as a mock-up for a potential future website. You will be able to click on several buttons (indicated with 'click me'), directing you to other pages. You can consult the four categories, four user clusters, an example for each category, and recommended strategies to tackle specific critical points. More detailed information on how to use the framework can be found in '3 How the framework is used'.

User

Based on the clustering variables and descriptors of the user clusters described in Chapter 3 (Figure 3), we highlight different parts of the framework (Figure 4). By doing so, we allow for a more precise assessment of how a reusable product aligns with the attitudes and requirements of specific users. Note that from here on, we changed the name 'situation-driven SUP users' to 'aspirers'. The user clusters are SUP avoiders, aspirers, apathetic, and SUP addicts.

The highlighted areas in Figure 4 can help designers better understand which factors to tackle first to reach their target audience, guiding them towards informed decisions and recommendations. Situational constraints, hygiene concerns, and persistent SUP habits are more prevalent in the SUP addict cluster (yellow), and the situation-driven SUP user (orange). For both groups, these situational constraints need to be tackled, but it is recommended to target the SUP addicts first in their mindset and willingness, which is already prevalent in the aspirer group. However, it is also possible to make them behave sustainably without creating willingness or a

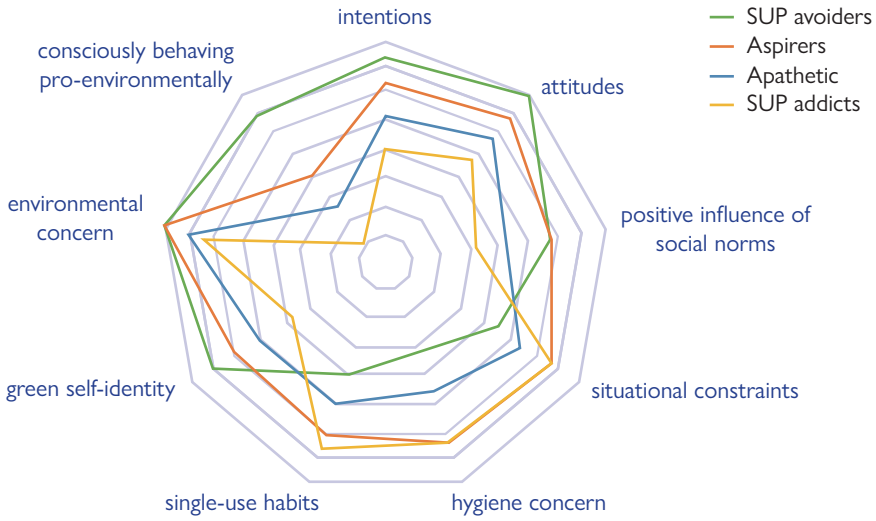


Figure 3. Cluster variables and descriptors

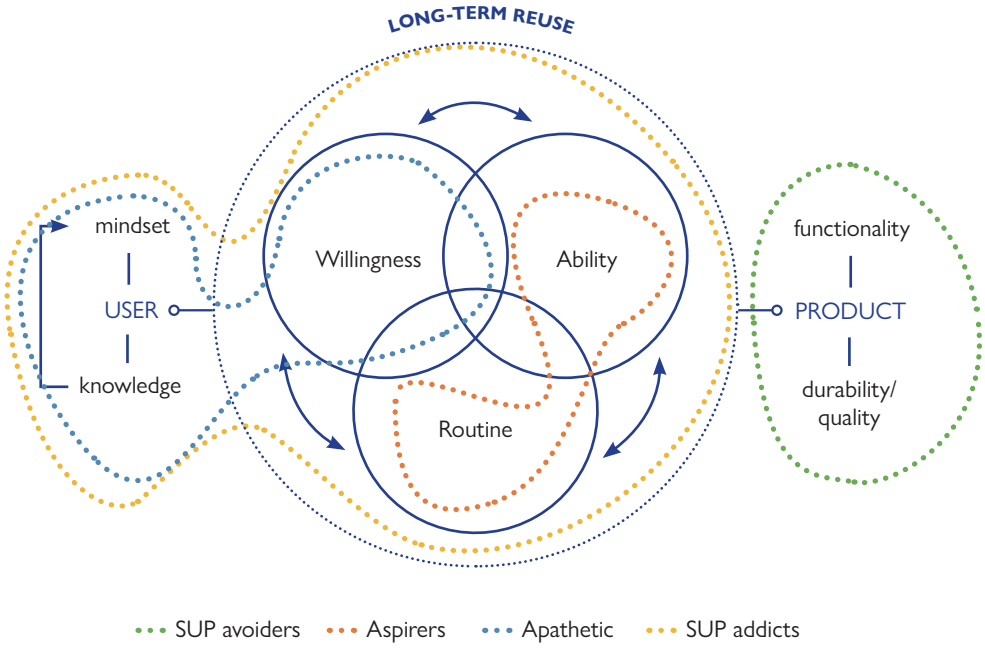


Figure 4. User layer indicating typical focus areas for the different clusters

positive mindset, namely through regulations or nudges (see 'intervention strategies' and 'discussion'). Apathetic (blue) experience less of these thresholds, but have rather low intentions and willingness, as well as attitudes, environmental concern, and ecological behaviour. It is beneficial to work on creating a willingness first, i.e. making the reusable product desirable. Alongside the SUP addicts, their primary pitfalls are situated in the mindset-willingness part. SUP avoiders (green) show the highest intentions, ecological behaviour, green self-identity, and experience the least barriers. When they encounter problems, it is mostly related to the product's function, quality, and durability.

Category

This iteration of the framework is tailored to the product categories determined in Chapter 2. It adapts the framework variables to suit the unique characteristics and contexts in which different product types operate. As a result, it provides a way to analyse specific products in a manner that considers typical critical points within their category. It is important to keep in mind that only **general** critical points are suggested. This does not mean that the other variables are not relevant, nor that the highlighted variables will automatically be the biggest barriers in a specific case. The framework only serves as guidance towards more targeted research. For 'intimate care' products, the main critical points are hygiene concerns, subjective norms, physical and mental ability, and infrastructure. For 'at home' products, these are functionality, practicality, and situational thresholds. The main critical points for 'daily shopping' products are habits, situational thresholds, and hygiene concerns, and for 'on the go' they are physical and mental ability, social and situational thresholds, and habits. These variations empower practitioners to apply the framework in a more targeted and context-specific way. By selecting the relevant layer based on the user and product characteristics, they can better identify the key factors that influence the long-term reuse potential of a product. This, in turn, helps in making informed decisions, optimising strategies, and promoting sustainable practices within the user and product contexts.

Strategies

The third layer of the framework involves linking the framework variables to various design, communication, and intervention strategies. These strategies serve as recommendations for addressing specific critical points. It is important to note that these are mere suggestions, and it is up to the designer to determine which strategies to employ and how best to combine them to achieve the desired outcomes. This approach means to encourage designers to explore new avenues and tailor their interventions to maximise the potential for long-term reuse. The proposed strategies can be found in Figure 5.

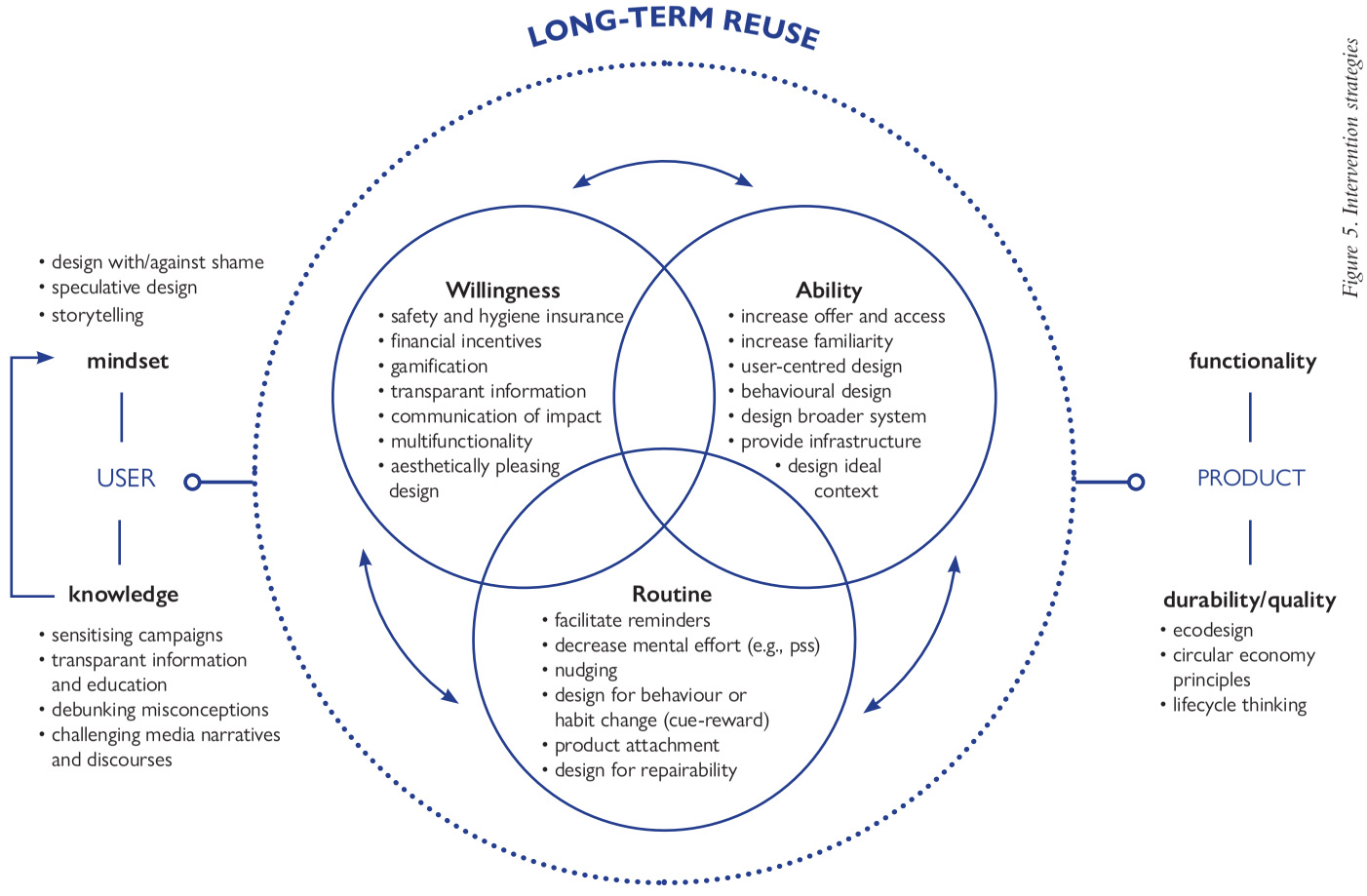


Figure 5. Intervention strategies

Recommendations per category

In Table 1, we show what a set of strategies and interventions could look like per category (simplified).

ON THE GO	Facilitate reminders Take away situational barriers (e.g., by means of a PSS)
DAILY SHOPPING	Increase offer, Increase accessibility
INTIMATE CARE	Remove concerns, increase knowledge, focus on the general mindset (using e.g., campaigns, storytelling, …)
AT HOME	Increase knowledge about the product offer, minimize effort from user, focus on practicality and multifunctionality

Table 1. Strategies and interventions per category

Recommendations per user cluster

Per cluster, we propose a set of general interventions in Table 2.

SUP AVOIDERS	Design qualitative solutions, increase offer and accessibility, enhance ability. **Make the behaviour possible.**
ASPIRERS	Increase offer and accessibility, remove situational barriers, facilitate reminders, nudge, encourage spillover effects. **Make the behaviour easier.**
APATHETIC	Focus on general mindset (using campaigns, storytelling, …), focus on the attractiveness of SUP alternatives. **Make the behaviour desirable.**
SUP ADDICTS	Focus on general mindset but beware of psychological reactance, decrease conscious decision making with regulations and bans. **Make the behaviour evident/normal.**

Table 2. Strategies and interventions per cluster

2.3 Examples

Based on the case studies discussed in Chapters 5 and 6, we also provide examples of specific products, such as the reusable coffee cup in the category 'on the go', the bread bag in the category 'daily shopping', and food huggers in the category 'at

home'. Several additional research activities were done in the category 'intimate care' that were not published for this thesis, but did provide us with valuable information on the critical points regarding reusable menstrual products, primarily the menstrual cup. This way, we can provide a concrete example within all four categories.

Coffee cups (on the go)

The barriers for reusable coffee cups found in Chapter 6 are forgetting the cup, inconvenience, spontaneity, size and weight, the inability to find a suitable cup, leaking, maintenance, the cup being too big for the machine, persistent stains, wear and tear over time, lack of possibility to use the cup at machines or in bars, and the mouthfeel of the material. Barriers found in Chapter 5 are hard-to-remove stains, the cup not being heat resistant, having to anticipate, forgetting the cup, unpractical folding, inconvenient lid, and concern for leaching chemicals (soft material). Motivators found in both chapters are easy cleaning, sustainability, aesthetics, better taste, easy to transport, keeps coffee warm, larger volume, and discounts.

Bread bags (daily shopping)

The barriers found in Chapter 5 are hard-to-clean material, the bag being too small for a larger bread, multiple bags needed, concerns about social acceptance, discomfort, and forgetting the bag. Motivators are ease of use, convenient roll-top, the possibility for multifunctionality (lunchbox), the bread bag having a convenient handle, the bread staying fresh longer, and easy and time-efficient cleaning.

Food hugger (at home)

The barriers found in Chapter 5 are that the food huggers are less suitable for jars, too small, not easily stretched, challenging to clean, not the right fit/size, risk of squashing, preformed shape, dirt or water remains after cleaning, sticky material, difficult to dry, hygiene doubts, not efficient, too much effort. Motivators are convenience, quick and easy usage, easy to fit into routine, and ready to use.

Menstrual cup (intimate care)

The critical points we distinguished for the menstrual cup are partly based on the master thesis of Karolien Bogaert, called 'Flowing Forward' [257]. She developed a platform and product-service system to enable menstruating people to try out different shapes and sizes of menstrual cups and discs. For her initial research, she analysed a lot of barriers to the adoption and sustained use of the menstrual cup by means of in-depth interviews (n=18) and a survey (n=345). The main barriers she found were hygiene perception, wear and tear, complicated user journey, finding the right fit/shape/firmness, feeling uncomfortable, prejudice, and lack of knowledge.

Next to this, we based ourselves on a speculative design workshop that we did alongside Drs. June Kyong Trondsen (NTNU) on reusable products related to bodily fluids (a workshop named 'PeePooPeriod'), in which we challenged shame, taboo, and social norms surrounding these types of products. The research highlighted the need for challenging norms and narratives, and the prevalence of shame and taboo surrounding bodily fluids. The paper 'Pee Poo Period. Exploring the intersection between shame, bodily fluids, and sustainable design' was presented at the Cumulus 2023 Conference in Antwerp, and has been published in the Conference Proceedings [258].

Finally, in a third research activity, the REuse lab took part in a circular museum project called 'MUCE' [259] with a 'Reuse Wall': a display cabinet presenting reusable alternatives to single-use products in different contexts, including the four product categories, the healthcare sector, and chemistry labs. Alongside the reuse wall, there were two tablets set up with a survey, questioning visitors' usage of a specific product, their intention to use it in the future, and their reservations and concerns regarding the product. Visitors were shown a few products in a row, with pictures and descriptions. The most frequently indicated concerns regarding menstrual cups were user-friendliness, hygiene, trustworthiness (effectiveness), impact on current habits, health, and time investment.

3 How the framework is used

The framework is not necessarily used according to a fixed step-by-step plan, but rather dependent on the starting point of the reuse case: (i) single-use product with no reusable solution yet, (ii) evaluation of a newly designed reusable product, or (iii) evaluation of an existing reusable product that is currently frequently discarded prematurely.

3.1 Is reuse desirable?

First, the 'problem' that forms the starting point for applying the framework (excessive SUP use in a certain context, or a reusable product that is not used beyond the break-even point) needs to be thoroughly analysed to make sure a reusable product would be the most desirable solution. Only then, the framework should be used. This means that it is important to consider whether there could also be an option for 'no use' (refuse) or using materials that can disappear (such as edible containers). For this, we base ourselves on the order of the Butterfly model of the Ellen McArthur Foundation [33], i.e. first refuse and reduce, then reuse, repurpose, and finally recycle.

3.2 Defining pitfalls and critical points

When tackling a reuse case which includes an existing reusable product or PSS (product-service system) that is not performing well, it is important to assess the unsustainable reuse as a way of diagnosing the current situation. The framework can assist with figuring out what the cause is of the premature discontinuation, by defining critical points. Before diving into an in-depth analysis of the product case, the following parts need to be covered.

Product preconditions

Is the break-even point technically not reachable? Does the product break down prematurely? Does the product show early wear and tear? If the answer to (at least) one of the questions is 'yes', then first and foremost the product needs to be redesigned to withstand long-term usage.

In what category is the case situated?

Defining in what category the case fits helps to get a first idea of the potentially critical points. These variables can then get extra attention during the analysis of the problem. In the interactive PDF, the most prominent variables are highlighted in a specific colour: red for 'intimate care', blue for 'on the go', green for 'daily shopping', and yellow for 'at home'. The same colours are used to give examples for each category. For each example, critical points, focus areas for each user group, and recommended strategies can be consulted.

Who is the user?

By defining what user cluster to target, the specific variation of the framework can be used for further analysis. In the interactive PDF, each cluster can be consulted with more information on their characteristics as well as the specific cluster variables. For each example, the specific focus area for each user group is highlighted.

3.3 Designing interventions

Eventually, with the third layer, concrete strategies and interventions can be selected to start designing. While designing, it is important to continuously return to the critical points, assessing whether they have been successfully targeted or not, constantly iterating.

3.4 Additional research

The (highlighted) variables can help the user of the framework to refine the in-depth analysis of their own case, and eventually fill in the framework as we did with the four examples. We do not steer or force towards a specific methodology but recommend using a systemic approach and getting inspiration from the methods used in this thesis: in-depth interviews, surveys, observations, and digital or non-digital diary studies.

4 Discussion and future research

We decided to include willingness as an important aspect of the framework, although we fully recognise that this step could be bypassed with nudging techniques, behaviour change strategies (ensuring the change), or by making the behaviour impossible (e.g., with bans). We argue that, even when applying these techniques, the user has to a certain extent agree and be aware of this. If the intervention is done against the user's will or without their consent, it ignores the concept of free will. This can be seen as manipulation (even if it is done for the 'greater good'). Moreover, it could lead to psychological reactance and resistance. We would also miss the opportunity for positive spillover effects. Therefore, we emphasise the importance of creating willingness in our framework.

We want to emphasise that this framework still needs critical evaluation in a systematic way. We deliberately chose to present it in this PhD, since we believe it is a valuable contribution both to design science and design practice. Future research should refine the content and test the usability of the framework. The framework should be applied to different conceptual and real-life cases and evaluated systematically, constantly being improved and iterated. The intention is to make the framework visually more appealing and understandable and to develop a web platform to enhance its usability, as well as enable the option for adding data from specific cases.

PART SIX

This last, concluding part, consists of two chapters.

Chapter 9 contains the discussion and conclusions in which we formulate answers to the research questions, present the most important contributions and implications of this PhD research, and end with limitations and future research.

Chapter 10 encompasses personal reflections on the process of doing a PhD and growth as a researcher, designer, and person.

Discussion and conclusions

Next to the adoption of reusable products, their long-term usage and implementation in routines are indispensable to have a positive impact on the environment. This thesis contributes to knowledge by investigating motivators and barriers to this long-term use, empowering designers to adopt a focused strategy in addressing them.

1 key findings

Below, we provide responses to the research questions through a series of propositions.

RQ1: What are the motivators and barriers to the long-term usage of reusable alternatives to single-use products? Or, in other words, why do people stop using SUP alternatives before their break-even point?

Based on the research described in Chapters 1 and 2, we generated a full overview of general (Table 1-3) as well as specific product-related barriers and motivators.

SUP ADVANTAGES	SUP DISADVANTAGES
quick and easy	waste
sterile, clean, hygiene	bad for environment
keeping products fresh	not degradable
cheap	less quality
easy disposal	feels less luxurious
not necessary to take with you	resource depletion
transparent	CO2 emission
attractive	
reuse as toys	
lightweight	
smaller portions	
tastes better	

Table 1. Advantages and disadvantages of single-use products

ADOPTION	
BARRIERS	MOTIVATORS
practicality	less waste
extra effort	more sustainable
hygiene concerns	price long-term
cost/ price short-term	convenient
personal preference	attractive
not believing in impact	trendy
social environment	
health and medical reasons	
lack of knowledge about impact	
not knowing product exists	
inconvenient	
time intensive	
quality concerns	
inaccessible	
lack of trust	
judgement from social environment	
not available	
not feeling responsible	
SUP habits (from childhood)	

Table 2. Barriers and motivators to the adoption of reusable products

LONG-TERM REUSE	
BARRIERS	MOTIVATORS
change of environment	good fit
change of habits	long-term attractiveness
effort to maintain lifestyle	(multi)functionality
weigh too much, take too much space	value compared to SUP
don't like it (personal preference)	good quality
hard to clean	better functionality than SUP
no room for it	easy to clean
costs too much	ergonomics
bad quality	aesthetics
unpractical	user friendly
price of refill	
unnecessary (not needed anymore)	
discomfort	
extra time investment	
extra effort	
showing wear & tear	
fear of being pedantic	

forgetfulness or spontaneous activity need for thinking in advance SUP habits hygiene concerns change of routine inconvenient location challenging work context lack of example lack of support from others	

Table 3. Barriers and motivators to long-term reuse

Based on this overview, we can conclude the following:

- **Proposition 1.1:** Successful adoption increases the likelihood of long-term usage. We break down the path to sustained long-term usage into three key conditions: the willingness to use, the ability to carry out the behaviour, and the establishment of a routine or practice.

- **Proposition 1.2:** Reasons to stop using reusable products before they reach their break-even point are dependent on product-, user-, and context variables that influence each other.

Below in Table 4, we combine the two propositions and present an overview of variables influencing long-term usage divided into willingness, ability, and routine.

	USER	PRODUCT	CONTEXT
WILLINGNESS	Sustainability mindset	Attractiveness or functionality compared to SUP	Financial incentives, trends, media, social norms
ABILITY	Skills, knowledge, financial situation	Functionality, complexity of user journey, adapted to needs of the user	Infrastructure, accessibility, availability, social acceptance
ROUTINE	Fit into existing habits, mental and physical effort, change of needs	Durability, perform beyond break-even point	Space and time, change of environment

Table 4. Variables influencing long-term reuse

RQ2: How do motivators and barriers to long-term reuse vary between types of products, contexts, and users?

Based on the research presented in Chapters 2, 3, and 4, we can conclude that:

- **Proposition 2.1:** Barriers and motivators to (long-term) use of reusable products vary between four clusters of users based on intentions and motivations to avoid SUP, the prevalence of certain barriers, and the previous usage of reusable products. The clusters are SUP avoiders, situation-driven SUP users (aspirers), apathetic, and SUP addicts.

- **Proposition 2.2:** Different types of users need or prefer different solutions, based on certain user, product, and context characteristics. For example, high green self-identity goes together with showcasing products or personalised items.

- **Proposition 2.3:** SUP avoiders use the most reusable products, followed by aspirers, apathetic and SUP addicts. People who already use many reusable products (i.e. SUP avoiders and aspirers) have a more accurate idea of what the biggest barriers are, and what they expect from these types of products.

- **Proposition 2.4:** Four product categories based on typical context-related barriers could be distinguished: intimate care, daily shopping, at home, and on the go.

- **Proposition 2.5:** Between the different product categories, the focus on certain barriers is different. Some barriers are more important in one category than another, such as shame/taboo/invisibility (product is relatively unknown) related to intimate care products versus forgetfulness/visibility/spontaneity with on the go products.

- **Proposition 2.6:** Daily shopping and on the go products are already more frequently used and in general better accepted in society than intimate care and at home products, which could be due to the latter being less visible in public and often made of softer, more fragile materials.

1.1 Clusters

Below, we present the four user clusters as described in Chapter 3 (Table 4).

SUP ADDICTS (20%)

We find the lowest intentions to avoid SUP among the segment of SUP addicts. They also express the lowest attitudes and subjective norms toward SUP alternatives. Their habits in using SUP and situational constraints on SUP alternatives appear significantly higher than in the other clusters, whereas their green self-identity and environmental concerns are lowest among all clusters, as is the frequency with which they consciously behave pro-environmentally. Although they score low on self-transcendence and conservation values, their self-enhancement and openness-to-change values are not significantly different from those held by SUP avoiders or the apathetic. In terms of demographics, their average age is not distinctive, but SUP addicts tend to be men with high incomes who reside mainly in the United States and Russia; Belgian consumers are underrepresented in this cluster.

SUP AVOIDERS (21%)

The SUP avoiders indicate the highest intentions to avoid SUP, along with the highest attitudes toward and subjective norms related to SUP alternatives. They have strongly abandoned the habit of using SUP, and neither contextual nor hygienic factors motivate them to keep using them. We find the highest green self-identity and environmental concern across all clusters, as well as the highest frequency of consciously behaving pro-environmentally. These consumers score higher on self-transcendence and conservation values than SUP addicts or the apathetic. Their self-enhancement and openness-to-change values are not significantly different though. In terms of demographics, their average age is not notably different from other clusters' (again, situation-driven SUP users are younger), but SUP avoiders are mostly women, highly educated, and of high income. They mainly reside in Belgium; U.S. and Russian consumers are underrepresented.

ASPIRERS (29%)

Aspirers or situation-driven SUP users indicate the second highest willingness to avoid SUP, attitudes toward SUP, subjective norms, green self-identity, environmental concern, and pro-environmental behaviour. They score high on self-transcendence and conservation values, as well as self-enhancement and openness-to-change values. Compared with SUP avoiders and the apathetic, situation-driven SUP users indicate habitual uses of SUP, hygienic concerns, and situational constraints with respect to SUP alternatives, which impede them from reducing their SUP usage intentions. Situation-driven SUP users are gender balanced and significantly younger than the other clusters, although the difference is rather small. They tend to have lower average incomes as compared to other clusters and mainly reside in the United States and Russia.

APATHETIC (31%)
Members of the apathetic cluster indicate the second lowest intentions, attitudes, subjective norms, pro-environmental behaviours, green self-identity, and environmental concern. Similar to SUP addicts, they score low on self-transcendence and conservation values. Their self-enhancement and openness-to-change values are among the lowest but not significantly different from those held by SUP addicts and SUP avoiders. Habits, situational constraints, and hygiene concerns do not seem to affect this cluster. In terms of demographics, their average age is not notably distinctive. They are mostly men, with slightly lower educational levels than other clusters but rather high incomes. They reside relatively equivalently across the three countries.

Table 4. Clusters and descriptions

1.2 Categories

Below, we present the four categories as described in Chapter 2.

CATEGORY	DESCRIPTION
Intimate care *(e.g., menstrual products, diapers, and reusable toilet paper)*	The most striking barriers are related to low willingness (mindset, safety perception, shame, unknown), which sometimes goes into conflict with sustainable values, and a high usage threshold: a new user journey, barriers related to the human body, and a need for personalization, which cause difficulties for long-term reuse. Context variables also cause thresholds, such as a lack of infrastructure (sanitary facilities, sterilization possibilities), which hinder the ability of the user to perform the behaviour. It is a very interesting product category since the potential impact is very high, especially for menstrual products such as the menstrual cup. *Main critical points: hygiene concerns, subjective norms, physical and mental ability, and infrastructure.*
Daily shopping *(e.g., produce bags, jars, tote bags, and refill bottles)*	Barriers are mostly practical and habitual, for example having to remember to take the product with you and having to break the habit of buying pre-packaged food. A lack of infrastructure opposes the ability of the user: often there is no shop nearby where you can use reusable jars, bags, etc. Willingness can be hindered by doubts about hygiene and safety, definitely for meat or fish packaging, and a convenience mindset. Also, the elaborate cleaning process can be a threshold. *Main critical points: habits, situational thresholds, and hygiene concerns.*

At home *(e.g., food huggers, refillable soap bottles, and reusable tea filters)*	These products are used inside of the home and do not need to be transported to any other location as part of the user journey. Their main barriers are related to the usage: users are sensitive to the extra time and effort the use of the product requires. Functionality and practicality are the most important factors here, and the products eventually need to become part of a routine. *Main critical points: functional, practical, and situational thresholds.*
On the go *(e.g., coffee cups, lunch boxes, food wraps, and reusable takeaway containers)*	In contrast with 'at home' products they are typically used on the road, in different locations, and transported from one place to another. They are also much more visible than 'at home' products, hence the users are more sensitive to opinions from other people. Also, it is not always possible to use them, since it depends on the willingness of the provider (e.g., coffee bar or takeaway restaurant). Other thresholds are mostly routine-related, and sensitive to the unplanned nature of its use. Users often forget the product because they did not know they would need it. Besides this, the weight and volume of the product can be perceived as annoying to carry around. *Main critical points: physical and mental ability, social and situational thresholds, and habits.*

Table 5. Categories and descriptions

RQ3: How can designers be supported by the results of this research in developing products/services/product-service systems that enable long-term reuse?

Based on the previous two research questions, a framework for designers was developed to synthesise the data we acquired and make it applicable to practitioners, as presented in Chapter 8.

- **Proposition 3.1**: Designers should thoroughly research the users they are designing for (based on the user clusters) and the type of product they want to design for long-term use (based on the product categories) before they start designing interventions.

- **Proposition 3.2:** Designers can use the framework to get an overview of the barriers their users can encounter regarding the long-term use of reusable products. The framework can assist designers in further user-centred research on specific cases and suggests (design) strategies to increase the potential success of their solutions.

- **Proposition 3.3:** An interdisciplinary approach is needed to create more of an intervention network from different disciplines and at different levels (e.g., communication, marketing, media, narratives, product and service design).

2 Other theoretical contributions

In this PhD research, apart from the general research questions discussed above, the following novelties were also generated.

2.1 The behavioural model

In the interviews, we investigated general barriers related to a whole range of products, which enabled us to distinguish different product categories to further investigate. For this, we constructed our interview guide based on the Comprehensive Action Determination Model (CADM) and went into barriers related to product, user, and context. With this qualitative study, we enhanced the CADM with other variables, resulting in a comprehensive framework that outlines the relative importance of factors that influence SUP avoidance intentions and reusable product usage. Though inspired by the initial model, we remodelled it slightly by using values and norms not as independent variables influencing behaviour through habits, situations, and intentions, but as a moderator. We revealed four user segments for whom the influence of habits, situations and intentions on behaviour may be different. The findings of our quantitative study (survey) reveal that attitudes and subjective norms related to SUP alternatives positively influence intentions to avoid SUP. Conversely, SUP habits, situational constraints, and hygienic concerns exhibit limited to no significant influence on these intentions, although they prove to be of significance in two distinct consumer segments—namely, SUP addicts and situation-driven SUP users.

2.2 Designing for cross-country user segments

With our cross-country study, we could confirm previous research that people tend to have individual attitudes, barriers, and motivators that are largely independent of demographic characteristics or the country they are residing in [201]. Although there are certain trends or tendencies regarding the influence of a country's culture, it is a misconception that all people from a country have the same perspective. When designing, it is preferred to look into the needs of the clusters instead of into demographics or countries.

2.3 Methodological perspective

We used a wide range of methods to investigate long-term reuse, allowing us to offer recommendations on effective approaches for analysing barriers, from intentions and first use to sustained, long-term usage. In-depth interviews prove to be suitable to examine intentions and self-reported past behaviour. To uncover barriers in the long term, observations and diary studies can offer valuable insights that are less easily obtained through interviews or surveys. By means of a digital platform, reminders and prompts can be sent to the user, thus enabling them to share real-time experiences and providing more accurate and concrete insights.

3 Comparison with prior studies

On the **product** level, barriers such as wear and tear, decreasing functionality, bad quality, and product aesthetics have been brought up in previous research as well [59,60]. Regarding the **user**, it has been shown before that it is important to design products according to the needs of the user [153], to focus on familiarity [154], and to take into account the context in which they are used, such as available infrastructure [77] and cultural barriers [35]. **Context** and settings can have a big influence on sustainable behaviour, in some cases even more prominent than TPB variables [260], which is in line with our research. In previous literature, the focus is often put on one sector, such as food packaging [59] or household products [20]. By investigating a wider range of products we could distinguish logical categories based on typical barriers and context, which can be valuable in more specific research in understanding reuse behaviour and designing new products. Mostly, the Theory of Planned Behaviour (TPB) has been used to explain SUP-related behaviour, pro-environmental behaviour, and reuse behaviour, more specifically single-use plastic bag consumption [67], SUP reduction intention [68], and the purchase of environmentally sustainable products [69]. We apply the Comprehensive Action Determination Model (CADM) [74] that has been previously used to explain waste prevention behaviour [75] and to develop strategies for reusable cup usage [76] to generate a more holistic overview of barriers to long-term use, including the influence of habits. While the majority of studies on reusable products focus only on the early adoption phase, we could show specific barriers to long-term reuse that differ from the results of prior studies. For example, our studies found that a change of context or environment influences long-term sustainable behaviour [79], and we add the aspect of 'routine formation' to willingness and ability, leaning more closely towards the field of product longevity. Studies on product longevity show that product attachment can be used to motivate people to use their products longer [20], but can also lead to product hibernation [91,92]. Our studies found little

influence of product attachment in the case of single-use and reusable products, but we argue it can be a useful method to stimulate long-term reuse.

To summarise (Figure 1), we contributed to literature by focusing specifically on the transition from single-use to long-term reuse within the field of product longevity, instead of the more common approach of addressing more complex, durable products such as domestic appliances. Besides this, we focus on a wide range of reusable products instead of one sector and apply a holistic approach by including user experiences within specific contexts. Regarding strategies for long-term (sustainable) behaviour, we include interventions that go beyond mere product design, emphasising the need for an interdisciplinary approach.

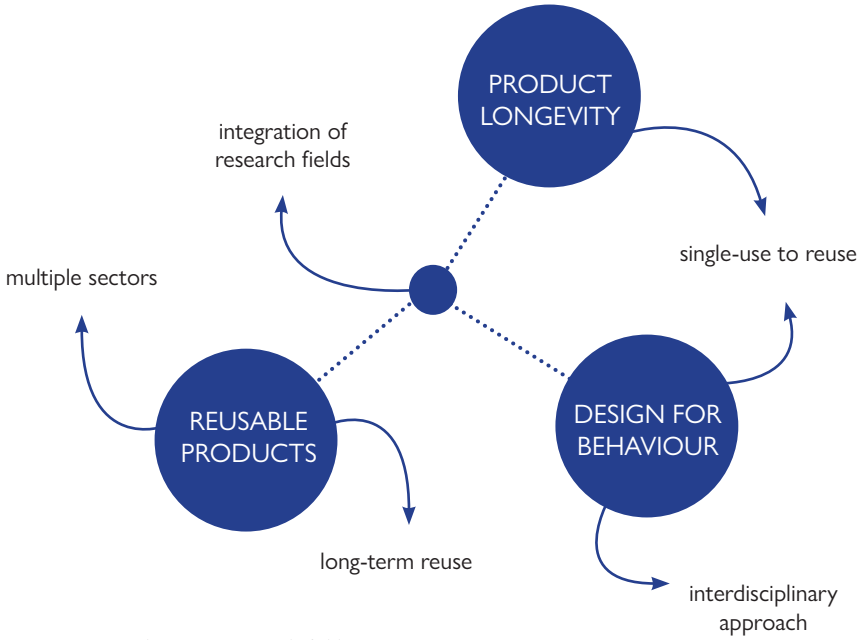


Figure 1. Contributions to research fields

4 Implications

4.1 For designers and industry

The framework presented in Chapter 8 offers guidance to companies and designers in creating solutions for long-term reuse. It is also meant to be built on further, like an open-source platform. By using the framework, designers can create a better picture of the long-term reuse situation and consequently increase the acceptance

and success of reusable products. In the long run, this framework might have a positive influence on the number of reusable products that are successfully used in people's daily lives as well as on the number of people that adopt reusable products. An example of a context in which the framework could be valuable to integrate is the Ubuntoo Platform, which was included in the research from Chapter 1 [124]. Industry can potentially be strongly impacted when elongated reuse becomes the norm. In an ideal situation, single-use products are gradually phased out until there is no market for these types of (consumer) products anymore. With the upcoming UN plastics treaty [52] and several bans on single-use products [25], this is becoming more and more a reality. This research and framework can support companies in addressing the user-centred aspect of transitioning towards business models based on long-term (re)use instead of single-use or business models based on planned obsolescence. It can also contribute to developing Corporate Social Responsibility (CSR) strategies, and encourage companies to take responsibility for the environmental impacts of their businesses. Next to this, the cross-country research and development of the clusters help define target groups, taking into account cultural aspects. Examples of companies working with business models based on reuse and taking social responsibility are Ecover (refill in-store) [261], Pieter Pot (online supermarket, return from home) [262], Brauzz (avoiding packaging waste) [263], and Loop (global platform for reuse) [264].

4.2 For researchers

The framework enables researchers to continuously incorporate new case studies and refine barriers. As an open-source database, it offers valuable information that can be harnessed in the creation of new (business) cases. For example, the REuse Lab at the University of Antwerp [265] can leverage and contribute to this framework with the purpose of co-creating novel reuse solutions in partnership with businesses. The framework forms a solid basis for further investigations in specific contexts and for specific products. For example, in the context of the Flemish 'Green Deal Anders Verpakt' [266], the aim of the REuse Lab is to support companies in the identification of ideal reusable packaging systems. At the moment of writing this thesis, a project is planned on medical reusable packaging as well as one for reusable six-pack packaging for beverages. In both projects, the framework will be used as a guiding model to execute the explorative research actions.

4.3 For design education

Teachers of sustainable design courses can gain insights and inspiration from the results and methodology described in Chapter 7 'Design for long-term reuse in

sustainable design education' and the framework presented in Chapter 8. Based on this research, we present the following learnings:

- It is beneficial to teach the students, early in their learning journey, a profound sense of the designer's role and responsibility concerning the environmental impact and potential unintended consequences of their designs. Therefore, students should be encouraged to embrace a systemic perspective when tackling design challenges.

- Adopting a dual approach by examining user journeys from the perspective of both single-use and reusable products can enhance students' abilities to identify design opportunities and challenges more effectively.

- The framework can assist students in considering the needs, behaviours, and contexts of their target audience when creating designs. Design educators can promote the practice of designing with specific personas related to the user clusters in mind, addressing their unique barriers.

- Employing a combination of a circular evaluation method and a weighed critical points trade-off can lead to more comprehensive and effective design solutions.

- Already during their education, it is good to make students explore a variety of design approaches and contexts, including products for individual use, lease systems, and deposit systems, and emphasise the importance of designs that align with users' existing behaviours and routines.

4.4 For users

The findings and framework can help users in finding their ideal user-product fit. We should not underestimate the impact of a good initial match between user and product on the environment, by avoiding early replacement because of discomfort, dissatisfaction, wrong size or fit, or a product that does not work well for the user in general. The user can identify themselves with certain clusters, and get recommendations in each product category, indicating specific barriers that are applicable to them. The more satisfied the user is with the product, the more chance for long-term reuse, and apart from good product/service/PSS design, this starts with a well-thought-out and substantiated user-product match. Furthermore, a better understanding of their own barriers and motivators might help users broaden their horizons and shift towards more sustainable habits.

5 Limitations

5.1 Research focus

Our focus on a broad range of consumer disposables and their alternatives was a very deliberate choice but brought some limitations. The barriers we identified often remained at a relatively superficial level, making it challenging to link them to specific types of products. For instance, the response 'I feel weird while using them' to a question about reusables' acceptability is highly contingent on the particular product and its intended use. Therefore, the inclusion of product categories made sense and helped us narrow down in subsequent research cycles.

To limit our research scope, we decided to focus on products that are individually owned rather than product-service systems (PSS), although we touched upon a cooperative system (Billie Cup) in Chapter 6. This approach allowed us to explore the primary obstacles that arise when users are responsible for all aspects, including maintenance, and provide recommendations for incorporating services to mitigate these barriers. Nevertheless, it would be interesting to do more comprehensive research into services and PSS that help decrease our use of disposable products in the long term.

The aspect of product repair did not come up that much, arguably because the research is about the longevity of simple products with low complexity. In the event of damage, the product is almost always disposed of or replaced entirely rather than attempting repair. However, an interesting avenue for further exploration is how even uncomplicated reusable products can be designed for repairability (e.g., after misuse) or upgraded for an extended lifespan. Additionally, some materials, such as fabric, can be quite easily repaired at home. Examples are bread bags, tote bags, or food wraps.

5.2 Results

The consumer clusters were constructed using factors such as intentions to avoid single-use products, environmental concern, attitudes, and previous ecological behaviour. They primarily centre around the chance of adopting reusable products, while the starting point of this research is to investigate the moment after people have already acquired the product and potentially decide to discontinue its use prematurely. One could argue that we should have focused more on the variables that influence long-term use only. We argue that an intention or willingness to acquire the product is the first step towards long-term reuse (e.g., buying the

product deliberately is very different from receiving it as a gift. In the first case, people usually have an intention to use the product, in the second situation, not necessarily). In other words, we conclude that in the end, people with different mindsets and attitudes towards the need to avoid single-use and environmental concern need different approaches to enable, nudge, guide, or steer them towards long-term reuse.

5.3 Research subjects

We focus on a broad range of people, but very much acknowledge that the 'average consumer' does not exist. We even emphasise this by creating clusters and pleading for targeted and differentiated approaches. However, we did not pay any attention to people who, for example, are disabled, have low incomes, or have special needs. So although we try to take different mindsets and situations into account, we are certainly not including everyone.

We also did not go very deeply into socioeconomic status, which would be of more importance with high-priced, larger appliances and their repair. Since we only focus on relatively cheap, simple products, socioeconomic status does not play as big a role. Also, according to Evans [46], it has little explanatory power. Nonetheless, we specifically included people with low income in the second research cycle to reach a wide range of profiles.

5.4 Behavioural models

In contrast to what we expected, habits, situational constraints, and hygienic concerns towards SUP alternatives do not significantly influence intentions to avoid SUP according to our research. This is not in line with a lot of previous research, which indicates the significance of situational and habitual constraints in plastic-avoiding intentions and behaviour [267,268]. However, these constraints play a crucial role in specific consumer segments, which take up around 60% of the total sample. Although the clusters will have probably averaged each other out, it would be interesting to repeat the study and complement it with more longitudinal research, and see if there are any different results regarding the significance of situational and habitual constraints, and hygiene concerns.

We looked into different models, such as CADM [74], which we eventually employed for our analysis, but also COM-B [269] and B-MAP [104]. We argue that for designers, these models can be very valuable, both for research and behavioural design. However, their explanatory and predictive power is not always very accurate

and there is a need for more pragmatic and applicable models. The translation of the B-MAP model into the Fogg behaviour wizard is a good example as well as the designer sustainable consumption roadmap [103]. However, these translations do not specifically assess the long-term usage of products. The maintenance aspect is often underexposed as opposed to initiation [270].

In our case, the behavioural models prove to be valuable to integrate into interview guides and questionnaires, in order to not forget important variables and have a checklist on all aspects of the behaviour. However, to synthesise the research into an applicable framework for designers, we realised their shortcomings and deliberately moved away from behavioural models in order to organise the results into a practical overview of typical barriers to long-term reuse.

5.5 Timing

Because this PhD started in March 2020, a substantial portion of the research inevitably had to be done during or right after the start of the COVID-19 pandemic. This could have influenced the research results and replicating some of the research activities could be valuable to compare influences during the pandemic, and a few years afterwards.

Due to the delay between planning, doing research, and analysing the data to generate conclusions, it was not always feasible to seamlessly continue one research cycle with insights from the previous one. In an ideal scenario, findings from each research cycle would naturally inform the next one. For example, the user clusters that we identified would have been very interesting to include in follow-up research.

5.6 Western view

The "Western view" in research refers to the perspective and approach often taken by scholars, researchers, and policymakers primarily from Western, industrialised countries. This perspective is influenced by the socioeconomic and cultural characteristics of these regions and within our research topic often has the following features: convenience-oriented consumerism, a focus on economic incentives, innovation, and technological solutions, and the emphasis on freedom of the consumer, in other words the 'right to consume'. It is just one perspective among many, and it may not fully capture the diversity of experiences and contexts worldwide. We addressed cultural differences by doing research in Belgium, the U.S.A. and Russia, but we must acknowledge the shortcomings of both Belgium and the U.S.A. being Western countries, and that most research was done in

cities. Other research activities were done in Belgium (Western context), and as researchers, it is unavoidable to have some cultural and normative standards which influence the direction that the research takes, and the terminology that is used towards respondents. Although we included some cross-cultural research, we suggest integrating other views into future research, doing research in different contexts, and collaborating with researchers from all over the world with different backgrounds and cultures. Additionally, for designers, it is important to be aware of their own cultural biases and how they influence the design process [271].

5.7 Validity and reliability

Reflecting on our research and initial stance in the introductory chapter, we highlight some key takeaways regarding validity and reliability below. We want to emphasise again that being objective in qualitative research is, in our view, never truly possible (hermeneutics – pure separation between object and subject is not possible), and subjects are always prone to all kinds of biases such as social desirability bias and self-report bias. We took this into account as much as possible. Moreover, we do not make claims on 'absolute truths' but acknowledge tendencies that we have interpreted from the findings. Besides this, we always compare and combine the results with previous research.

Researcher variability

Some interviews were done by students in the context of a course. This means that multiple researchers have carried out several parts of the research discussed in this thesis which highlights the issue of researcher variability. There can be variations in how the interviews were conducted, how questions were asked, and how responses were interpreted. This variability may have impacted the consistency and reliability of the data. To mitigate this, we provided a fixed interview guide, and the students were closely guided and followed up during the whole execution of the research. None of the transcription and (raw) data analyses were done by the students. All coding and interpretation were done by the author and supervisors.

6 Ethics

6.1 Working with human subjects

Whenever we worked with human subjects, ethical clearance was obtained from the Ethical Committee for the Social Sciences and Humanities (EA SHW) at the University of Antwerp. All respondents received an information form and consent form, ensuring their anonymity, and declaring their rights as research subjects.

Additionally, we maintained ongoing transparency by keeping participants informed about the progress of the study and any potential changes to the research protocol. We encouraged open dialogue and questions from participants, addressing their concerns promptly and comprehensively. We consistently used pseudonyms and secure data storage practices to protect their identities and personal information. In the reporting and dissemination of our research findings, we continued to ensure that the subjects' identities and sensitive information remain confidential.

6.2 Normative stance

One could argue that there is an ideological bias from our side, which influenced the direction the research took and the way the recommendations were formulated in the end. It is worth noting that, even though as scientists we strive to maintain objectivity through the scientific method, every researcher inherently carries their own perspective of the world, values, ideologies, and what they consider important. We firmly believe that being aware of these biases and maintaining a critical outlook can enhance the research and make it more relevant to the world. As researchers and designers, we support the notion that we hold a strong responsibility to contribute positively to the world, while carefully considering the implications of our actions and creations. This then raises the question: what is the common good, and who are we to define it? Over the past four years, we have engaged in ongoing conversations with fellow design researchers within our research group, as well as researchers from various other groups, universities, and countries, along with individuals from both design and non-design backgrounds among our acquaintances. These discussions have allowed us to refine our positions and remain aware of the normative aspects that inevitably influence our work.

6.3 Power and responsibility

We have to keep in mind our responsibility as designers as well, particularly when it comes to influencing behaviour. It makes us wonder why we should be in charge of nudging people and attempting to change their behaviours, even if, from our perspective, it is for the 'greater good'. What power do we have in influencing how people live their lives? These are questions you can ask marketers, politicians, or teachers as well. People are constantly influenced by external forces, often without even knowing it themselves. Society shapes our thoughts and defines what we perceive as 'normal' to a far greater extent than we ever realise. In this research, we investigated these influences and explored strategies on how to actively get past barriers engrained in society, such as feelings of shame or taboo, as well as prevailing ideas on sustainability and 'green' lifestyles. We also sought to strengthen motivators

and enablers, such as fostering collective awareness of the problems of pollution and waste, leveraging spillover effects, social encouragement, and increasing the availability of sustainable options in stores. Nevertheless, we must constantly remind ourselves of the power stance we take as designers, and the responsibilities that come with it. Because what gives us the authority to reshape how people think, behave, and act?

It is important to realise the detrimental effects unintended consequences of design can have on the world. A famous example is the 19th-century inventor Thomas Midgley Jr., who came up with the idea of putting lead in gasoline and invented CFCs, which were both banned because of their harmful effects on human health and the environment [272]. Another example, more related to this research, is Boyan Slat's 'Ocean Cleanup', which was discredited because of the potential impact the invention could have on marine life [273]. Or think of the paper straws, introduced following a single-use plastic straw ban, mentioned in the introduction of this thesis. They prove to be worse than plastic on several levels. We conclude that a holistic, systemic analysis of a problem and thorough investigation of the potential consequences are indispensable when designing interventions, definitely those aimed at environmental change.

7 Future research

7.1 User-centred research

Clusters

Future research can use the clusters to segment potential users and improve product-user match. They could be used to select participants for a longitudinal study with both existing and newly designed reusable products. The discovery that the influence of habits, situational constraints, and hygienic concerns are only emergent in some consumer segments highlights the necessity for further investigation. Future research could delve into the relationship between these variables and specific products for each cluster. Additionally, it would be interesting to link the four consumer segments that we have identified to a broader range of consumer characteristics and typical product usage behaviours, and investigate different settings, countries, and cultures.

Unconscious behaviour

The results of this research are almost entirely based on self-reported behaviour, while more research is needed on real-time, observed, unconscious behaviour. The influence of a change in environment or context would be very interesting to explore further. Future research could also investigate purchase behaviour, environmental

concern, and unconscious behaviour with bigger datasets gathered from e.g., mobile devices. However, it is important to take strong measurements regarding privacy protection, and always acquire consent and awareness of individuals contributing to these datasets. Additionally, the researcher should be aware of the risk of algorithmic bias and potential discrimination.

Social practice theory

Investigating the historical background of reuse practices can provide valuable insights to understand reuse behaviour better. A social practice perspective should complement the current research in order to enable (social) change towards a reusing society. It investigates certain behaviours not from an individual perspective, but focuses on the 'way of doing', which differs between cultures and even within families.

7.2 Design research

Framework

The framework can be integrated into an open-source platform, where researchers, companies and design practitioners can include their own data on certain reusable products. This way, more and more information will be connected, and the framework can be refined continuously. Also, the evaluation of several interventions can be included, creating an overview of what works and what does not, in what product category and for what type of user. Also, specific focus should be put on the implementation and usability of the framework. In addition to the user, more research should be done into other stakeholders' perspectives and barriers, and the feasibility of solutions from a complete value chain perspective. It would be very interesting and valuable to implement these insights into the framework. Case-based research is necessary to further investigate and refine the categories, and to gain insights on how designers can do their own analysis of a specific reusable product. Additionally, other reuse models and their impact on the barriers and enablers to prolonged reuse should be investigated, such as product-service systems or products in the sharing economy.

Tools

Further development of the preliminary tools would be interesting. The concept of a lifetime or routine journey can be further explored and elaborated to more accurately pinpoint critical points. Conducting workshops involving designers, design educators, students and practitioners can be employed to achieve this. Future research should test the (improved) tools in the same sustainable design course for multiple years in a row, each time iterating the previous version.

Interventions

Through experiments, interventions should be tested in the real world on their effectiveness in prolonging long-term reuse behaviour. Distinctions can be made between types of users (clusters) and products (categories) and this could in turn further refine the framework with best practices.

Product design

Additional insights are required to understand the particular product-related expectations for reusable products, such as the desired level of multifunctionality or customisation. Furthermore, there is a need to investigate the correlation between material flexibility, sensory experiences [274], and perceptions [275], and the acceptance of reusable products. When it comes to distinct categories of reusable products, like intimate care items, further research is essential to explore the impact of taboos and feelings of shame associated with bodily fluids within the context of sustainability. It may also be beneficial to replicate the same experiment with different types of products for a more comprehensive understanding.

7.3 REuseLab

This PhD research was executed within the context of the REuseLab [264], which currently includes other projects related to reuse and product lifetime extension as well. The knowledge acquired within this thesis will be used by fellow researchers within the lab, enabling them to expand and refine the framework, tailoring it to other contexts and user groups.

Fashion

Although fashion items are not meant to be single-use, the fast fashion industry actively promotes low quality and durability, and discarding clothes before reaching their break-even point. Lifetime extension could significantly decrease their environmental impact, and the framework could be employed and adjusted to the fashion sector in future research. Considering the act of maintenance, repair and deliberate lifetime extension (not throwing away, but actively keeping on using items), the concepts of willingness, ability, and routine prove to be valuable to take into account in the research and to form the basis for expanding the framework to fashion. In collaboration with Marie Das, a PhD student on the project 'Reuse in Style', a first explorative research action focused on willingness was published and presented at the ICED21 conference: Strategic design opportunities to increase sustainable fashion awareness and behaviour [276].

Medical sector

The reCure and REmedi projects within the REuseLab investigate the possibilities of reusable products in the healthcare sector. Although it differs from the consumer sector, the adoption and usage of reusable medical equipment have many similar barriers to the daily consumer goods investigated in this thesis. Consequently, it is valuable to consider the proposed framework in these projects as well. It is interesting to learn the similarities, as well as the differences due to the B2B context and distinct focus on hygiene and safety.

Reusable packaging

Many producers feel the pressure from the government to phase out single-use packaging, yet they remain hesitant towards reusable packaging due to uncertainties surrounding consumer reactions and the necessity to change established behaviours. A collaborative project with DW Reusables has recently started, wherein the REuseLab will monitor the acceptance of reusable alternatives to beer six-pack packaging, a product falling into the category of daily shopping items. To facilitate this monitoring, the framework will serve as a foundational tool, helping to comprehend user clusters in terms of willingness, ability, and routine, and exploring how strategic design interventions can foster a positive shift towards successful implementation.

Further research on consumer reusables

Building upon the insights gained from the REuseWall experiment at the Museum of Circular Economy (MUCE [258]), the REuseLab is currently writing a new research proposal to set up a citizen science research project. This proposal will use the developed framework as its basis and seeks to engage in a bottom-up exploration of addressing the identified barriers in the transition towards reusable products. Through a co-creative approach with citizens, ideally representing all clusters, the objective is to identify interventions that enable them to optimise their willingness, ability and routine formation towards reusable alternatives within the different product categories.

CHAPTER TEN

Personal reflections

In my opinion, one of the most important aspects of pursuing a PhD is reflecting upon what you did during the four years of research and what the implications are for you as a researcher, the scientific community, and society. Although we address this partially in the previous 'Discussion and conclusions' chapter, this section will delve deeper into my personal journey as a researcher, designer, and person.

1 Reflections on the research

1.1 Research questions

The overarching goal of this research was to tackle the issue of excessive single-use product consumption by promoting the long-term use of reusable alternatives. This initial research perspective led me to dismiss many other potential solutions for addressing the problem of waste and resource depletion caused by single-use products. For example, alternative approaches, such as challenging existing norms and systems on a more fundamental level, could lead to disposable products becoming obsolete without needing to replace them with another (reusable) product.

Moreover, when dealing with product packaging, often the environmental impact of the product itself outweighs that of the packaging. It is essential to acknowledge the preceding options in the waste hierarchy, namely refuse and reduce, and question whether the product for which we are designing a reusable container is genuinely necessary. It is important to remember that reusable packaging represents just one step on the journey towards genuine eco-friendliness. Therefore, before implementing any of the findings or utilising the framework or tools, it is crucial to address a fundamental question: 'Does reuse truly make sense?', because it is essential to assess whether a reusable product is a desirable solution in the first place.

However, this does not mean that the research questions of this thesis are not relevant. For many products, reuse would be the best option, as refusing or reducing their usage may not (yet) be feasible. We must acknowledge the reality of living in a

society that strongly depends on global connectivity and international trade. We rely on transporting products and food from all over the world, which is accompanied by a lot of packaging. I believe the research questions are complementary to the pursuit of systemic change. Considering the fact that reuse makes sense in specific situations, understanding how reuse can be effectively achieved beyond the break-even point creates valuable insights to support both society and the field of design science towards increased circularity.

1.2 Research methods

Having a master's degree in Product Development, going into research was not the most obvious path to take. While my education equipped me with some research skills, there was still much to explore regarding research methods and approaches. Also, the field of design research is rather new, which makes it interesting and exciting, but sometimes also complicated and confusing. Consequently, looking into all kinds of methods and disciplines ended up being an important part of my research process.

While exploring different pathways to tackle the research objectives, it was quite interesting to combine the different backgrounds and methods of my two promotors, prof. Els Du Bois and prof. Ingrid Moons. On the one hand, there was the designerly approach from Els, guiding me through the world of design-inclusive research and research in design context, and on the other hand, I had access to a wealth of information and insights from psychology and marketing through Ingrid. This proved to be a valuable and unique combination which helped me to approach my research questions in a meaningful and holistic way. I am grateful for being able to touch upon a wide variety of methods, allowing me to learn new research techniques and analysing skills.

In June 2022, I did a short research stay at the NTNU in Trondheim to explore the role of speculative design in the field of eco-design in a workshop with drs. June Kyong Trondsen, who investigates the role of shame in design from a speculative design perspective. We did a two-day workshop together with 8 participants, in which we combined our research perspectives. This proved to be not that easy, since our research approaches were rather different, but it provided me with very valuable insights and reflections on the challenges of combining speculative design with more classical eco-design and design for behaviour. It also gave me my first experience with doing workshops, and meeting professors and researchers from the Department of Design has broadened my vision.

1.3 Multidisciplinarity

I believe a multidisciplinary approach is valuable and necessary to approach (design) research problems holistically. However, as a PhD student, it is challenging to navigate this alone while still learning and developing. Besides this, PhD trajectories typically emphasise individual competence, which hinders collaborative effort. It would be interesting to explore how more collaboration during the research process can be achieved while simultaneously monitoring the growth and competence of the individual researcher. I believe that working together can provide new insights and skills. For example, although the collaborative research with June did not lead to the results we hoped for, it was a valuable learning experience, providing insights from a completely different perspective and contributing to my growth as a researcher.

2 Reflections on the process

2.1 The messiness of reality

I think of it as a perfect circle. It is something I have learned in science history and philosophy. Scientists from a few centuries ago were always looking for beauty, simplicity, the 'perfect circle', without any dents or imperfections. One formula, as short and clean as possible, to explain the world. I feel that, deep inside, I have had the same desire: finding the beautiful, clear answer to life, the universe, and everything. Finding out that it is just 42. And now we know everything! [277]

Of course, I know very well that this is not the way the world works. The messiness, complexity, the many different variables and stakeholders influencing the course of things that happen, the way things work and evolve,… Very early on I realised that navigating through this dense cloud of uncertainties and complexity is the only way to really handle my research questions, to not fall into the trap of considering my research problem in a vacuum. Definitely, with the subject of human behaviour, I realised the importance of seeing this in its context to get any idea of what it is like in real life. This is also why I included the product, user, and context focus. Of course, I realise that I only touched upon the surface of all possible contextual influences, and I am aware that there are endless ways to approach this. But it is a start.

2.2 Learning process

Impact

I had to learn the hard way (as many of my colleagues, I am sure) that doing a PhD is not in the first place about the impact you make on the world, but about learning to do research. Many of us start with an ideal to change the world. The moment you realise that that is probably not going to happen within these four years can be quite demotivating. On the other hand, it is reassuring to realise that that is not expected from you. Accepting that you are still learning, teaches you to be realistic and to keep going until the end. While I am writing the final parts of my thesis, I only now realise the growth I have experienced, but also the potential my research has to contribute to a more sustainable future. Doing the PhD has grounded me in a way. It taught me not to overestimate the impact I could or should make, but at the same time see the value in what I actually achieved.

But there is more. There is the impact this trajectory made on my personal development. There is the attention and value I put into the contact with my colleagues, trying to help each other or organising fun activities to do together, and the bond we created because we had to go through the same burden of pursuing a PhD. And finally, there is the impact I have had on my students, hopefully in a positive and motivating way.

Imposter syndrome

The imposter syndrome is a very real thing, and like many others, I struggled with aiming high until the end, while simultaneously doubting my work all the time. The constant hesitation and self-consciousness inevitably also affected work consistency, with the following questions on repeat: 'Is this the way to do it? Is this good enough? Shouldn't I wait a bit longer, until I am completely sure?' Usually, a deadline would help me out of this state, finally getting things done in the end. I am aware that my imposter syndrome is a result of perfectionism, and having very high expectations of myself. I am not even sure whether I completely got rid of it, even at this point. All I can do is be aware of it, not let it consume me, and be gentle for myself and others.

However, besides my own part in this, there is also the societal pressure and the performance economy, which are not exactly helpful, to say the least. From every direction, I hear other PhD students and peers experiencing the same thing. I believe it is necessary to tackle this problem on a larger scale level, lowering the excruciating expectations that are put on (young) people nowadays. The academic system needs some disruptive change. I refuse to believe it is necessary for PhD

students to be miserable half of the time in order to achieve success (this is not for everyone the case, I recognise that). Although I value the merits this trajectory brought me, I am also critical of the way this system sometimes seems to forget the fact that we are all human.

Why am I doing this?

Although in these four years, I never thought of quitting, I sometimes felt like the PhD was not for me, that I was not persistent or smart enough to do it. That it was, honestly, a bit boring, and way less interesting than any other activity I could pursue. Fun fact: I learned snowboarding, roller skating, longboarding, surfing, climbing, flying trapeze, and horse riding all during the four years of my PhD. I frequently reflected on this habit, this need to do all kinds of other stuff, to learn all these new things while doing the PhD. I believe it has something to do with rewards, and with recognition. The teacher would say: not bad for a beginner! And I had my portion of dopamine to get through the day.

The rewards of doing research come in very slowly. In the first year, there is virtually no reward at all. You just do research, hope the results are decent, and take a long time analysing. Only when your first (conference) paper is ready, submitted, and accepted, you finally get a bit of recognition for your work. Of course, the feedback from promotors also counts and is very valuable, but the actual reward, the recognition from outside, from the scientific community, is very rare. Then, nothing really happens, perhaps someone reads it, even cites it (dopamine!), and you just continue with the next cycle. How can a normal person endure this without the horse riding teacher complimenting them on their rhythm? Or just, something, someone, reassuring what you do has any meaning, any value.

Luckily, I am writing the very end chapter of my thesis right now, very eager to receive the biggest award of them all: obtaining the PhD. Will it all be worth it? Next to this personal achievement, I hope the framework can live on, be refined, and be used in the real world. Then, I am sure it will.

Growth

I believe that a combination of personal growth and persistence enabled me to finish this PhD. My research started simultaneously with the COVID-19 pandemic, where just 'surviving' seemed more important than thinking about future matters. However, during my PhD journey, I frequently reflected on what I did, whether it was what I wanted to do and how I wanted to do it.

In hindsight, I would have approached other people than my promotors or close colleagues earlier and more often for help, insights, or feedback. Looking back, I did a lot on my own, which I now realise is not necessary. I think this was due to a persistent belief that I had to do it all by myself, combined with a form of insecurity and anxiety to make myself vulnerable in a professional context. I commit to working on this in the future, as the concept of 'the lean PhD' [278] does not come out of nowhere, and iterations are necessary to improve your work, which includes asking for help from other people.

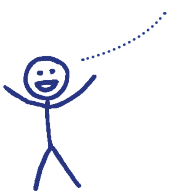
These last four years have taught me resilience, finding ways to handle stress, and the importance of proper time management (even though I still feel I have room to improve in this area). Perhaps perseverance was something I already had, an essential factor in preventing me from not giving up alongside the strong motivation to create a better, more sustainable world.

2.3 Future

As stated by the activist movement Scientists for Climate, 'Value-free science doesn't exist and science is inherently political', which raises another question: what is my role as a scientist in this world? All I can say is that I am thinking about this more and more lately. We will see what the future brings.

THE END

Congratulations! You made it!



Bibliography

[1] M. Miodownik, BBC - Plastics Watch - How did disposable products ever become a thing?, BBC (2023). https://www.bbc.co.uk/programmes/articles/nB9mTWPPJ4mDNS6wtV76bP/how-did-disposable-products-ever-become-a-thing (accessed October 24, 2023).

[2] Science history institute, History and Future of Plastics, Science History Institute (2023). https://www.sciencehistory.org/education/classroom-activities/role-playing-games/case-of-plastics/history-and-future-of-plastics/ (accessed October 25, 2023).

[3] L.M. Heidbreder, I. Bablok, S. Drews, C. Menzel, Tackling the plastic problem: A review on perceptions, behaviors, and interventions, Science of The Total Environment 668 (2019) 1077–1093. https://doi.org/10.1016/j.scitotenv.2019.02.437.

[4] Statista, Plastic production worldwide 2021, Statista (2021). https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/ (accessed June 22, 2023).

[5] Statista, Global plastics production forecast 2025-2050, (2020). https://www.statista.com/statistics/664906/plastics-production-volume-forecast-worldwide/ (accessed July 3, 2023).

[6] S. Singh, S.S.-L. Li, Bisphenol A and phthalates exhibit similar toxicogenomics and health effects, Gene 494 (2012) 85–91. https://doi.org/10.1016/j.gene.2011.11.035.

[7] R. Essel, L. Engel, M. Carus, R.H. Arens, Sources of microplastics relevant to marine pro-tection in Germany, Federal Environment Agency (Germany), Dessau-Roßlau, 2015.

[8] UNEP, Plastic Pollution, UNEP - UN Environment Programme (2022). http://www.unep.org/plastic-pollution (accessed October 25, 2023).

[9] M. Eriksen, M. Thiel, L. Lebreton, Nature of Plastic Marine Pollution in the Subtropical Gyres, in: 2016. https://doi.org/10.1007/698_2016_123.

[10] L. Lebreton, B. Slat, F. Ferrari, B. Sainte-Rose, J. Aitken, R. Marthouse, S. Hajbane, S. Cunsolo, A. Schwarz, A. Levivier, K. Noble, P. Debeljak, H. Maral, R. Schoeneich-Argent, R. Brambini, J. Reisser, Evidence that the Great Pacific Garbage Patch is rapidly accumu-lating plastic, Sci Rep 8 (2018) 4666. https://doi.org/10.1038/s41598-018-22939-w.

[11] X. Chang, Y. Fang, Y. Wang, F. Wang, L. Shang, R. Zhong, Microplastic pollution in soils, plants, and animals: A review of distributions, effects and potential mechanisms, Sci-ence of The Total Environment 850 (2022) 157857. https://doi.org/10.1016/j.scitotenv.2022.157857.

[12] S. Kühn, E.L. Bravo Rebolledo, J.A. van Franeker, Deleterious Effects of Litter on Marine Life, in: M. Bergmann, L. Gutow, M. Klages (Eds.), Marine Anthropogenic Litter, Springer International Publishing, Cham, 2015: pp. 75–116. https://doi.org/10.1007/978-3-319-16510-3_4.

[13] D. Gateuille, E. Naffrechoux, Transport of persistent organic pollutants: Another effect of microplastic pollution?, WIREs Water 9 (2022) e1600. https://doi.org/10.1002/wat2.1600.

[14] O. Setälä, V. Fleming-Lehtinen, M. Lehtiniemi, Ingestion and transfer of microplastics in the planktonic food web, Environmental Pollution 185 (2014) 77–83. https://doi.org/10.1016/j.envpol.2013.10.013.

[15] N.J. Beaumont, M. Aanesen, M.C. Austen, T. Börger, J.R. Clark, M. Cole, T. Hooper, P.K. Lindeque, C. Pascoe, K.J. Wyles, Global ecological, social and economic impacts of marine plastic, Marine Pollution Bulletin 142 (2019) 189–195. https://doi.org/10.1016/j.marpolbul.2019.03.022.

[16] IPCC, Chapter 3 — Global Warming of 1.5 oC, IPCC, 2023. https://www.ipcc.ch/sr15/chapter/chapter-3/ (accessed October 25, 2023).

[17] S. Naeem, R. Chazdon, J.E. Duffy, C. Prager, B. Worm, Biodiversity and human well-being: an essential link for sustainable development, Proceedings of the Royal Society B: Biological Sciences 283 (2016) 20162091. https://doi.org/10.1098/rspb.2016.2091.

[18] C.D. Golden, E.H. Allison, W.W.L. Cheung, M.M. Dey, B.S. Halpern, D.J. McCauley, M. Smith, B. Vaitla, D. Zeller, S.S. Myers, Nutrition: Fall in fish catch threatens human health, Nature 534 (2016) 317–320. https://doi.org/10.1038/534317a.

[19] Economist Impact, The rich world's plastic addiction has a social impact, (2023). https://impact.economist.com/sustainability/social-sustainability/the-rich-worlds-plastic-addiction-has-a-social-impact (accessed October 25, 2023).

[20] S. Kunamaneni, S. Jassi, D. Hoang, Promoting reuse behaviour: Challenges and strate-gies for repeat purchase, low-involvement products, Sustainable Production and Con-sumption 20 (2019) 253–272. https://doi.org/10.1016/j.spc.2019.07.001.

[21] C. Helbig, J. Huether, C. Joachimsthaler, C. Lehmann, S. Raatz, A. Thorenz, M. Faulstich, A. Tuma, A terminology for downcycling, Journal of Industrial Ecology 26 (2022) 1164–1174. https://doi.org/10.1111/jiec.13289.

[22] A. Franklin-Cheung, Is it possible to recycle plastics an infinite number of times?, Scien-ce Focus (2023). https://www.sciencefocus.com/science/is-it-possible-to-recycle-plastics-an-infinite-number-of-times (accessed October 21, 2023).

[23] A. Maisels, A. Hiller, F.-G. Simon, Chemical Recycling for Plastic Waste: Status and Per-spectives, ChemBioEng Reviews 9 (2022) 541–555. https://doi.org/10.1002/cben.202200024.

[24] OECD, Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options, Organisation for Economic Co-operation and Development, Paris, 2022. https://www.oecd-ilibrary.org/environment/global-plastics-outlook_de747aef-en (ac-cessed October 25, 2023).

[25] The European Union, Directive (EU) 2019/904 of the European Parliament on the re-duction of the impact of certain plastic products on the environment, 2019. https://eur-lex.europa.eu/eli/dir/2019/904/oj (accessed June 29, 2023).

[26] Directorate-General for Environment (European Commission), Turning the tide on sin-gle-use plastics, Publications Office of the European Union, LU, 2021. https://data.europa.eu/doi/10.2779/800074 (accessed October 25, 2023).

[27] I.D.L. Gómez, A.S. Escobar, The dilemma of plastic bags and their substitutes: A review on LCA studies, Sustainable Production and Consumption 30 (2022) 107–116. https://doi.org/10.1016/j.spc.2021.11.021.

[28] G.M. Zanghelini, E. Cherubini, R. Dias, Y.H.O. Kabe, J.J.S. Delgado, Comparative life cycle assessment of drinking straws in Brazil, Journal of Cleaner Production 276 (2020) 123070. https://doi.org/10.1016/j.jclepro.2020.123070.

[29] S. Boesen, N. Bey, M. Niero, Environmental sustainability of liquid food packaging: Is there a gap between Danish consumers' perception and learnings from life cycle as-sessment?, Journal of Cleaner Production 210 (2019) 1193–1206. https://doi.org/10.1016/j.jclepro.2018.11.055.

[30] H. Fetner, S.A. Miller, Environmental payback periods of reusable alternatives to single-use plastic kitchenware products, The International Journal of Life Cycle Assessment 2021 26:8 26 (2021) 1521–1537. https://doi.org/10.1007/S11367-021-01946-6.

[31] J.S.C. Viera, M.R.C. Marques, M.C. Nazareth, P.C. Jimenez, Í.B. Castro, On replacing sin-gle-use plastic with so-called biodegradable ones: The case with straws, Environmental Science & Policy 106 (2020) 177–181. https://doi.org/10.1016/j.envsci.2020.02.007.

[32] Ellen McArthur Foundation, Circular economy introduction, (2023). https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview (accessed October 25, 2023).

[33] Ellen McArthur Foundation, The butterfly diagram: visualising the circular economy, (2019). https://ellenmacarthurfoundation.org/circular-economy-diagram (accessed June 26, 2023).

[34] W. Stahel R., The performance economy, Springer, London, 2010.

[35] M. Ertz, R. Huang, M.-S. Jo, F. Karakas, E. Sarigöllü, From single-use to multi-use: Study of consumers' behavior toward consumption of reusable containers, Journal of Envi-ronmental Management 193 (2017) 334–344. https://doi.org/10.1016/j.jenvman.2017.01.060.

[36] Global Industry Analysts, Global Reusable Packaging Industry, 2023. https://www.reportlinker.com/p06032779/Global-Reusable-Packaging-Industry.html (accessed July 3, 2023).

[37] T. Herberz, C.Y. Barlow, M. Finkbeiner, Sustainability Assessment of a Single-Use Plas-tics Ban, Sustainability 12 (2020) 3746. https://doi.org/10.3390/su12093746.

[38] G. Blanca-Alcubilla, A. Bala, N. de Castro, R. Colomé, P. Fullana-i-Palmer, Is the reusable tableware the best option? Analysis of the aviation catering sector with a life cycle approach, Science of The Total Environment 708 (2020) 135121. https://doi.org/10.1016/j.scitotenv.2019.135121.

[39] H. Fetner, S.A. Miller, Environmental payback periods of reusable alternatives to single-use plastic kitchenware products, Int J Life Cycle Assess 26 (2021) 1521–1537. https://doi.org/10.1007/s11367-021-01946-6.

[40] N. van Nes, J. Cramer, Product lifetime optimization: a challenging strategy towards more sustainable consumption patterns, Journal of Cleaner Production 14 (2006) 1307–1318. https://doi.org/10.1016/j.jclepro.2005.04.006.

[41] C. Tassell, M. Aurisicchio, Refill at home for fast-moving consumer goods: Uncovering compliant and divergent consumer behaviour, Sustainable Production and Consumpti-on 39 (2023) 63–78. https://doi.org/10.1016/j.spc.2023.04.018.

[42] G. Cook, The Cotton Tote Crisis, The New York Times (2021). https://www.nytimes.com/2021/08/24/style/cotton-totes-climate-crisis.html (accessed October 28, 2023).

[43] B. Choate, B.Y. Davis, J. Verrecchia, Campus Bottled Water Bans, Not Always the Soluti-on, International Journal of Sustainability in Higher Education 19 (2018) 987–997. https://doi.org/10.1108/IJSHE-06-2017-0089.

[44] De Standaard, Van bouwvakkers tot fitgirls: hoe de Stanley-beker de hipste drinkfles van het moment werd, De Standaard (2024). https://www.standaard.be/cnt/dmf20240118_93765186 (accessed January 30, 2024).

[45] EPRS, Lifetime of electric and electronic products, Epthinktank (2022). https://epthinktank.eu/2022/02/10/right-to-repair-policy-podcast/lifetime-of-electric-and-electronic-products/ (accessed September 25, 2023).

[46] S. Evans, T. Cooper, Consumer influences on product life-spans, Longer Lasting Pro-ducts: Alternatives to the Throwaway Society (2010) 319–350.

[47] A.A. Horton, Plastic pollution: When do we know enough?, Journal of Hazardous Mate-rials 422 (2022) 126885. https://doi.org/10.1016/j.jhazmat.2021.126885.

[48] T. Cooper, The Significance of Product Longevity, in: Longer Lasting Products, Routledge, 2010.

[49] Dopper, Doppers bedrukken: Geef een persoonlijk, duurzaam cadeau met impact., Dopper (2023). https://dopper.com/nl/undefined/doppers-bedrukken (accessed No-vember 13, 2023).

[50] C. Tassell, M. Aurisicchio, PREVENTING THE OVERCONSUMPTION AND DISPOSAL OF RE-FILL AT HOME FAST-MOVING CONSUMER GOODS – INTERVENTIONS THAT SUPPORT CIR-CULAR CONSUMER JOURNEYS, Proceedings of the Design Society 3 (2023) 2935–2944. https://doi.org/10.1017/pds.2023.294.

[51] United Nations, Goal 12 | Ensure sustainable consumption and production patterns, (2023). https://sdgs.un.org/goals/goal12 (accessed October 26, 2023).

[52] V. Volcovici, In UN talks for a global plastic treaty, delegates to face off over production limits, Reuters (2023). https://www.reuters.com/business/environment/un-talks-global-plastic-treaty-delegates-face-off-over-production-limits-2023-11-12/ (accessed November 14, 2023).

[53] I. Horvath, Differences between "research in design context" and "design inclusive re-search" in the domain of industrial design engineering, Journal of Design Research 7 (2008) 61–83. https://doi.org/10.1504/JDR.2008.018777.

[54] D. Schwartz, B. Fischhoff, T. Krishnamurti, F. Sowell, The Hawthorne effect and energy awareness, Proceedings of the National Academy of Sciences 110 (2013) 15242–15246. https://doi.org/10.1073/pnas.1301687110.

[55] A.-M. Willis, Ontological Designing, Design Philosophy Papers 4 (2006) 69–92. https://doi.org/10.2752/144871306X13966268131514.

[56] J.P. Harnett, Ontological Design Has Become Influential In Design Academia – But What Is It?, Eye on Design (2021). https://eyeondesign.aiga.org/ontological-design-is-popular-in-design-academia-but-what-is-it/ (accessed October 28, 2023).

[57] D. Fraga, The manifesto of Ontological Design, Medium (2020). https://medium.datadriveninvestor.com/the-manifesto-of-ontological-design-7fdb19169107 (accessed October 28, 2023).

[58] P. Elf, B. Gatersleben, I. Christie, Facilitating Positive Spillover Effects: New Insights From a Mixed-Methods Approach Exploring Factors Enabling People to Live More Sustainable Lifestyles, Front Psychol 9 (2019) 2699. https://doi.org/10.3389/fpsyg.2018.02699.

[59] P.M. Coelho, B. Corona, R. ten Klooster, E. Worrell, Sustainability of reusable packaging–Current situation and trends, Resources, Conservation & Recycling: X 6 (2020) 100037. https://doi.org/10.1016/j.rcrx.2020.100037.

[60] X. Miao, L. Magnier, R. Mugge, Switching to reuse? An exploration of consumers' per-ceptions and behaviour towards reusable packaging systems, Resources, Conservation and Recycling 193 (2023) 106972. https://doi.org/10.1016/j.resconrec.2023.106972.

[61] S.C. Greenwood, S. Walker, H.M. Baird, R. Parsons, S. Mehl, T.L. Webb, A.T. Slark, A.J. Ryan, R.H. Rothman, Many Happy Returns: Combining insights from the environmental and behavioural sciences to understand what is required to make reusable packaging mainstream, Sustainable Production and Consumption 27 (2021) 1688–1702. https://doi.org/10.1016/j.spc.2021.03.022.

[62] Ellen McArthur Foundation, Reusable packaging business models, (2023). https://www.ellenmacarthurfoundation.org/reusable-packaging-business-models (ac-cessed November 16, 2023).

[63] E. Keller, J.K. Köhler, C. Eisen, S. Kleihauer, D. Hanss, Why consumers shift from single-use to reusable drink cups: An empirical application of the stage model of self-regulated behavioural change, Sustainable Production and Consumption 27 (2021) 1672–1687. https://doi.org/10.1016/j.spc.2021.04.001.

[64] J. Poole, Refill and reuse: Unilever launches Cif ecorefill, removing 1.5 million plastic spray bottles from shelves, ..Packaginginsights.Com/ (2019). https://pi.cnsmedia.com/a/737mRe4Y7JY= (accessed November 16, 2023).

[65] P. Sheeran, T.L. Webb, The Intention–Behavior Gap, Social and Personality Psychology Compass 10 (2016) 503–518. https://doi.org/10.1111/spc3.12265.

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

[67] D. Vina, L. Mayangsari, The application of theory of planned behavior in single-use plastic bags consumption in Bandung, J. Global Bus. Soc. Entrepreneurship (GBSE) 6 (2020) 124–137.

[68] L. Van, N.A. Hamid, M.F. Ahmad, A.N.A. Ahmad, R. Ruslan, P.F.M. Tamyez, Factors of Single Use Plastic Reduction Behavioral Intention, Emerging Science Journal 5 (2021) 269–278. https://doi.org/10.28991/esj-2021-01275.

[69] B. Kumar, Theory of Planned Behaviour Approach to Understand the Purchasing Beha-viour for Environmentally Sustainable Products, IIMA Working Papers (2012). https://ideas.repec.org//p/iim/iimawp/11469.html (accessed October 29, 2023).

[70] S. Michie, M.M. van Stralen, R. West, The behaviour change wheel: A new method for characterising and designing behaviour change interventions, Implementation Science 6 (2011) 42. https://doi.org/10.1186/1748-5908-6-42.

[71] A.L. Allison, F. Lorencatto, M. Miodownik, S. Michie, Influences on single-use and reusable cup use: a multidisciplinary mixed-methods approach to designing interven-tions reducing plastic waste, UCL Open Environment 3 (2021). https://doi.org/10.14324/111.444/ucloe.000025.

[72] K. Borg, A. Lennox, S. Kaufman, F. Tull, R. Prime, L. Rogers, E. Dunstan, Curbing plastic consumption: A review of single-use plastic behaviour change interventions, Journal of Cleaner Production 344 (2022) 131077. https://doi.org/10.1016/j.jclepro.2022.131077.

[73] A.L. Allison, D. Purkiss, F. Lorencatto, M. Miodownik, S. Michie, Improving compostable plastic disposal: An application of the Behaviour Change Wheel intervention develop-ment method, Frontiers in Sustainability 3 (2022). https://www.frontiersin.org/articles/10.3389/frsus.2022.968152 (accessed November 17, 2023).

[74] C.A. Klöckner, A. Blöbaum, A comprehensive action determination model: Toward a broader understanding of ecological behaviour using the example of travel mode choi-ce, Journal of Environmental Psychology 30 (2010) 574–586. https://doi.org/10.1016/j.jenvp.2010.03.001.

[75] A. Balundė, L. Jovarauskaitė, M.S. Poškus, Exploring adolescents' waste prevention via Value-Identity-Personal norm and Comprehensive Action Determination Models, Jour-nal of Environmental Psychology 72 (2020) 101526. https://doi.org/10.1016/j.jenvp.2020.101526.

[76] G. Song, Y. Lee, E.-C. Jung, Developing the '0U Cup': Promoting Ecological Behavior through a Cup-sharing Service System Based on the Comprehensive Action Determina-tion Model and Choice Architecture, Archives of Design Research 33 (2020) 5–16. https://doi.org/10.15187/adr.2020.08.33.3.5.

[77] J. Steinhorst, K. Beyerl, First reduce and reuse, then recycle! Enabling consumers to tackle the plastic crisis – Qualitative expert interviews in Germany, Journal of Cleaner Production 313 (2021) 127782. https://doi.org/10.1016/j.jclepro.2021.127782.

[78] T. Kurz, B. Gardner, B. Verplanken, C. Abraham, Habitual behaviors or patterns of prac-tice? Explaining and changing repetitive climate-relevant actions, WIREs Climate Chan-ge 6 (2015) 113–128. https://doi.org/10.1002/wcc.327.

[79] L. Herweyers, M. Das, S. Bevers, F. Dries, I. Moons, E. Du Bois, Barriers to the continued usage of alternatives for single-use plastics by students in student housing, Product Li-fetimes and the Environment (PLATE21) (2021). https://doi.org/10.31880/10344/10178.

[80] D.M. Evans, R. Parsons, P. Jackson, S. Greenwood, A. Ryan, Understanding plastic packaging: The co-evolution of materials and society, Global Environmental Change 65 (2020) 102166. https://doi.org/10.1016/j.gloenvcha.2020.102166.

[81] W. Poortinga, L. Whitaker, Promoting the Use of Reusable Coffee Cups through Envi-ronmental Messaging, the Provision of Alternatives and Financial Incentives, Sustaina-bility 10 (2018) 873. https://doi.org/10.3390/su10030873.

[82] Y. Luo, J. Zhao, Using behavioral interventions to reduce single-use produce bags, Resources, Conservation and Recycling 193 (2023) 106942. https://doi.org/10.1016/j.resconrec.2023.106942.

[83] P. Davies, A.E. Walker, J.M. Grimshaw, A systematic review of the use of theory in the design of guideline dissemination and implementation strategies and interpretation of the results of rigorous evaluations, Implementation Science 5 (2010) 14. https://doi.org/10.1186/1748-5908-5-14.

[84] S. Michie, A. Prestwich, Are interventions theory-based? Development of a theory co-ding scheme, Health Psychology 29 (2010) 1–8. https://doi.org/10.1037/a0016939.

[85] N.M.P. Bocken, S.W. Short, Towards a sufficiency-driven business model: Experiences and opportunities, Environmental Innovation and Societal Transitions 18 (2016) 41–61. https://doi.org/10.1016/j.eist.2015.07.010.

[86] L.M. Haase, L.N. Laursen, Designing for Longevity: Expert Strategies for Creating Long-Lasting Products, Routledge, 2023. https://www.routledge.com/Designing-for-Longevity-Expert-Strategies-for-Creating-Long-Lasting-Products/Haase-Laursen/p/book/9781032284668 (accessed October 24, 2023).

[87] P.B. Jensen, L.N. Laursen, L.M. Haase, Barriers to product longevity: A review of busi-ness, product development and user perspectives, Journal of Cleaner Production 313 (2021) 127951. https://doi.org/10.1016/j.jclepro.2021.127951.

[88] R. Mugge, J.P.L. Schoormans, H.N.J. Schifferstein, Design Strategies to Postpone Consumers' Product Replacement: The Value of a Strong Person-Product Relationship, Http://Dx.Doi.Org/10.2752/146069205789331637 8 (2015) 38–48. https://doi.org/10.2752/146069205789331637.

[89] H.N.J. Schifferstein, E.P.H. Zwartkruis-Pelgrim, Consumer-Product Attachment: Measu-rement and Design Implications, International Journal of Design 2 (2008) 1–13.

[90] S. Bellezza, joshua M. Ackerman, F. Gino, "Be Careless with That!" Availability of Pro-duct Upgrades Increases Cavalier Behavior toward Possessions, Journal of Marketing Research 54 (2017) 768–784. https://doi.org/10.1509/jmr.15.0131.

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

[92] Y. Choi, B. Kennedy, Understanding product hibernation periods with children's pro-ducts and exploring motivations for product care to encourage their reuse, Product Li-fetimes and the Environment (PLATE23) (2023). https://hdl.handle.net/10919/117257.

[93] V. Rizos, A. Behrens, W. Van der Gaast, E. Hofman, A. Ioannou, T. Kafyeke, A. Flamos, R. Rinaldi, S. Papadelis, M. Hirschnitz-Garbers, C. Topi, Implementation of Circular Eco-nomy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers, Sustainability 8 (2016) 1212. https://doi.org/10.3390/su8111212.

[94] L. Zhou, S.M. Gupta, Marketing research and life cycle pricing strategies for new and remanufactured products, Jnl Remanufactur 9 (2019) 29–50. https://doi.org/10.1007/s13243-018-0054-x.

[95] F. Poppelaars, C. Bakker, J. Van Engelen, Does Access Trump Ownership? Exploring Con-sumer Acceptance of Access-Based Consumption in the Case of Smartphones, Sustai-nability 10 (2018) 2133. https://doi.org/10.3390/su10072133.

[96] M. Hebrok, Design for longevity: taking both the material and social aspects of product-life into account, Journal of Design Research 12 (2014) 204–220. https://doi.org/10.1504/JDR.2014.064232.

[97] K. Niedderer, J. Mackrill, S. Clune, D. Lockton, G. Ludden, A. Morris, Creating Sustaina-ble Innovation through Design for Behavior Change: Full Report, University of Wolver-hampton, 2014. www.behaviourchange.eu.

[98] D. Lilley, Design for sustainable behaviour: strategies and perceptions, Design Studies 30 (2009) 704–720. https://doi.org/10.1016/j.destud.2009.05.001.

[99] J.F. De Medeiros, C.G. Da Rocha, J.L.D. Ribeiro, Design for sustainable behavior (DfSB): Analysis of existing frameworks of behavior change strategies, experts' assessment and proposal for a decision support diagram, Journal of Cleaner Production 188 (2018) 402–415. https://doi.org/10.1016/j.jclepro.2018.03.272.

[100] J.Z. Daae, C. Boks, Dimensions of behaviour change, Journal of Design Research 12 (2014) 145–172. https://doi.org/10.1504/JDR.2014.064229.

[101] J. Daae, L. Chamberlin, C. Boks, Dimensions of Behaviour Change in the context of De-signing for a Circular Economy, The Design Journal 21 (2018) 521–541. https://doi.org/10.1080/14606925.2018.1468003.

[102] S. Wendel, Designing for Behavior Change: Applying Psychology and Behavioral Econo-mics, O'Reilly Media, Inc., 2020.

[103] B.J. Fogg, J. Hreha, Behavior Wizard: A Method for Matching Target Behaviors with So-lutions, in: T. Ploug, P. Hasle, H. Oinas-Kukkonen (Eds.), Persuasive Technology, Sprin-ger, Berlin, Heidelberg, 2010: pp. 117–131. https://doi.org/10.1007/978-3-642-13226-1_13.

[104] B. Fogg, A behavior model for persuasive design, in: Proceedings of the 4th Internatio-nal Conference on Persuasive Technology, Association for Computing Machinery, New York, NY, USA, 2009: pp. 1–7. https://doi.org/10.1145/1541948.1541999.

[105] K.G. Volpp, G. Loewenstein, What is a habit? Diverse mechanisms that can produce sustained behavior change, Organizational Behavior and Human Decision Processes 161 (2020) 36–38. https://doi.org/10.1016/j.obhdp.2020.10.002.

[106] R.H. Thaler, C.R. Sunstein, Nudge: The Final Edition, 2012.

[107] A.T. Schmidt, B. Engelen, The ethics of nudging: An overview, Philosophy Compass 15 (2020) e12658. https://doi.org/10.1111/phc3.12658.

[108] M. Lehner, O. Mont, E. Heiskanen, Nudging – A promising tool for sustainable con-sumption behaviour?, Journal of Cleaner Production 134 (2016) 166–177. https://doi.org/10.1016/j.jclepro.2015.11.086.

[109] U.N.E. UNEP, Marine Plastic Debris and Microplastics: Global Lessons and Research to Inspire Action and Guide Policy Change, 2016. https://wedocs.unep.org/xmlui/handle/20.500.11822/7720 (accessed October 29, 2023).

[110] E. Beckman, The world of plastics, in numbers, The Conversation (2018). http://theconversation.com/the-world-of-plastics-in-numbers-100291 (accessed Octo-ber 28, 2023).

[111] C.J. Moore, Synthetic polymers in the marine environment: A rapidly increasing, long-term threat, Environmental Research 108 (2008) 131–139. https://doi.org/10.1016/j.envres.2008.07.025.

[112] European Commission, Single-use plastics: New EU rules to reduce marine litter, Euro-pean Commission - European Commission (2018). https://ec.europa.eu/commission/presscorner/detail/en/IP_18_3927 (accessed October 29, 2023).

[113] Q. Zhu, An Appraisal and Analysis of the Law of "Plastic-Bag Ban," Energy Procedia 5 (2011) 2516–2521. https://doi.org/10.1016/j.egypro.2011.03.432.

[114] S. Muralidharan, K. Sheehan, "Tax" and "Fee" Message Frames as Inhibitors of Plastic Bag Usage Among Shoppers: A Social Marketing Application of the Theory of Planned Behavior, Social Marketing Quarterly 22 (2016) 200–217. https://doi.org/10.1177/1524500416631522.

[115] R.U. Ayres, Life cycle analysis: A critique, Resources, Conservation and Recycling 14 (1995) 199–223. https://doi.org/10.1016/0921-3449(95)00017-D.

[116] V. Bisinella, P.F. Albizzati, T.F. Astrup, A. Damgaard, Life Cycle Assessment of grocery carrier bags, Danish Environmental Protection Agency., 2018. https://www2.mst.dk/Udgiv/publications/2018/02/978-87-93614-73-4.pdf.

[117] I. Ajzen, From Intentions to Actions: A Theory of Planned Behavior, in: J. Kuhl, J. Beck-mann (Eds.), Action Control, Springer Berlin Heidelberg, Berlin, Heidelberg, 1985: pp. 11–39. https://doi.org/10.1007/978-3-642-69746-3_2.

[118] J. Jansson, A. Marell, A. Nordlund, Green consumer behavior: determinants of curtail-ment and eco-innovation adoption, Journal of Consumer Marketing 27 (2010) 358–370. https://doi.org/10.1108/07363761011052396.

[119] P. Sheeran, T.L. Webb, The Intention–Behavior Gap, Social and Personality Psychology Compass 10 (2016) 503–518. https://doi.org/10.1111/spc3.12265.

[120] D.D. Cuzdriorean, S. Fekete, A.B. Vladu, Identifying the Promoters of Students' Sustai-nable Behaviour: An Empirical Study, The AMFITEATRU ECONOMIC Journal 22 (2020) 432–432.

[121] J. David Lee, A. Bahl, G.S. Black, D.C. Duber-Smith, N.S. Vowles, Sustainable and non-sustainable consumer behavior in young adults, Young Consumers 17 (2016) 78–93. https://doi.org/10.1108/YC-08-2015-00548.

[122] E.M. Rogers, A. Singhal, M.M. Quinlan, Diffusion of Innovations, in: An Integrated Ap-proach to Communication Theory and Research, 2nd ed., Routledge, 2008.

[123] L. McNeill, R. Moore, Sustainable fashion consumption and the fast fashion conun-drum: fashionable consumers and attitudes to sustainability in clothing choice, Inter-national Journal of Consumer Studies 39 (2015) 212–222. https://doi.org/10.1111/ijcs.12169.

[124] P. Schelstraete, V. Kini, Ubuntoo - Best Environmental Solutions Platform, Ubuntoo (2020). https://ubuntoo.com/ (accessed October 29, 2023).

[125] G.A. Giles, D.R. Bain, Materials and Development of Plastics Packaging for the Consu-mer Market, Sheffield Academic Press, 2000.

[126] R. Kumar, A. Verma, A. Shome, R. Sinha, S. Sinha, P.K. Jha, R. Kumar, P. Kumar, Shub-ham, S. Das, P. Sharma, P.V. Vara Prasad, Impacts of Plastic Pollution on Ecosystem Ser-vices, Sustainable Development Goals, and Need to Focus on Circular Economy and Po-licy Interventions, Sustainability 13 (2021) 9963. https://doi.org/10.3390/su13179963.

[127] P. Stegmann, V. Daioglou, M. Londo, D.P. van Vuuren, M. Junginger, Plastic futures and their CO2 emissions, Nature 612 (2022) 272–276. https://doi.org/10.1038/s41586-022-05422-5.

[128] A.L. Patrício Silva, J.C. Prata, T.R. Walker, D. Campos, A.C. Duarte, A.M.V.M. Soares, D. Barcelò, T. Rocha-Santos, Rethinking and optimising plastic waste management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment, Science of The Total Environment 742 (2020) 140565. https://doi.org/10.1016/j.scitotenv.2020.140565.

[129] S. Buranyi, The plastic backlash: what's behind our sudden rage – and will it make a difference?, The Guardian (2018).

[130] I. Johnston, Nine out of 10 people call for "plastic-free aisle" in supermarkets, finds survey, Independent (2017).

[131] J. Watts, Half of UK consumers willing to pay more to avoid plastic packaging, The Guardian (2019).

[132] Frost & Sullivan, Emerging Alternatives for Single-Use Plastics in Packaging, Research and Markets, 2019. https://www.researchandmarkets.com/reports/4900513/emerging-alternatives-for-single-use-plastics-in (accessed July 3, 2023).

[133] World Economic Forum, Nearly 9 in 10 People Globally Want a More Sustainable and Equitable World Post COVID-19, World Economic Forum (2020). https://www.weforum.org/press/2020/09/nearly-9-in-10-people-globally-want-a-more-sustainable-and-equitable-world-post-covid-19/ (accessed October 5, 2023).

[134] A.J. Heeren, A.S. Singh, A. Zwickle, T.M. Koontz, K.M. Slagle, A.C. McCreery, Is sustaina-bility knowledge half the battle? An examination of sustainability knowledge, attitu-des, norms, and efficacy to understand sustainable behaviours, International Journal of Sustainability in Higher Education 17 (2016) 613–632. https://doi.org/10.1108/IJSHE-02-2015-0014.

[135] L. Chang, J. Tan, An integrated sustainability assessment of drinking straws, Journal of Environmental Chemical Engineering 9 (2021) 105527. https://doi.org/10.1016/j.jece.2021.105527.

[136] M.H. Asif, T. Zhongfu, M. Irfan, C. Işık, Do environmental knowledge and green trust matter for purchase intention of eco-friendly home appliances? An application of ex-tended theory of planned behavior, Environ Sci Pollut Res 30 (2023) 37762–37774. https://doi.org/10.1007/s11356-022-24899-1.

[137] L. Li, Y. Zhang, An extended theory of planned behavior to explain the intention to use carsharing: a multi-group analysis of different sociodemographic characteristics, Trans-portation 50 (2023) 143–181. https://doi.org/10.1007/s11116-021-10240-1.

[138] B. Verplanken, S. Orbell, Reflections on Past Behavior: A Self-Report Index of Habit Strength1, Journal of Applied Social Psychology 33 (2003) 1313–1330. https://doi.org/10.1111/j.1559-1816.2003.tb01951.x.

[139] C. Tanner, CONSTRAINTS ON ENVIRONMENTAL BEHAVIOUR, Journal of Environmental Psychology 19 (1999) 145–157. https://doi.org/10.1006/jevp.1999.0121.

[140] S. Schwartz, J. Howard, A Normative Decision Making Model of Altruism, in: Altruism and Helping Behavior: Social, Personality, and Developmental Perspectives, Lawrence Erlbaum Associates, Hillsdale, 1981: pp. 189–211. https://www.semanticscholar.org/paper/A-Normative-Decision-Making-Model-of-Altruism-Schwartz-Howard/6c216e91935e53153633a8d07531ed03af4c269b (accessed July 11, 2023).

[141] C. Hollingworth, L. Barker, Behavioural Change Models: An overview of the two best behavioural change models and how to apply them, The Behavioural Architects, 2020. chrome-extensi-on://efaidnbmnnnibpcajpcglclefindmkaj/https://www.thebearchitects.com/assets/uploads/ip/TBA%20Articles/Behavioural%20Change%20Models_C.pdf.

[142] P. de Pelsmacker, P.V. Kenhove, Marktonderzoek: methoden en toepassingen, Pearson Education Benelux, Amsterdam, 2019.

[143] R. Collins, Keeping it in the family? Re-focusing household sustainability, Geoforum 60 (2015) 22–32. https://doi.org/10.1016/j.geoforum.2015.01.006.

[144] M.I. Alhojailan, Thematic analysis: a critical review of its process and evaluation, West East Journal of Social Sciences (2012) 39–47.

[145] J. Trondsen, C. Boks, Exploring the Role of Shame in Design Strategies, Proceedings of the Design Society 2 (2022) 2233–2242. https://doi.org/10.1017/pds.2022.226.

[146] T. Page, Product attachment and replacement: implications for sustainable design, In-ternational Journal of Sustainable Design 2 (2014) 265–282. https://doi.org/10.1504/IJSDES.2014.065057.

[147] T. Bhamra, D. Lilley, IJSE special issue: Design for Sustainable Behaviour, International Journal of Sustainable Engineering 8 (2015) 146–147. https://doi.org/10.1080/19397038.2015.1026666.

[148] R.H. Thaler, C.R. Sunstein, Nudge: The Final Edition, Penguin UK, 2012.

[149] K. Leismann, M. Schmitt, H. Rohn, C. Baedeker, Collaborative Consumption: Towards a Resource-Saving Consumption Culture, Resources 2 (2013) 184–203. https://doi.org/10.3390/resources2030184.

[150] J. Zachrisson, C. Boks, When to apply different design for sustainable behaviour strate-gies, in: Delft, The Netherlands, 2010. https://repository.tudelft.nl/islandora/object/uuid%3Af1efccdd-07bc-437d-bcbc-7a9d848b806d (accessed July 11, 2023).

[151] L. Herweyers, I. Moons, C. Barbarossa, P. De Pelsmacker, E. Du Bois, Understanding who avoids single-use plastics and why: A cross-country mixed-method study, Journal of Cleaner Production 414 (2023) 137685. https://doi.org/10.1016/j.jclepro.2023.137685.

[152] K. White, D.J. Hardisty, R. Habib, The Elusive Green Consumer, Harvard Business Re-view (2019). https://hbr.org/2019/07/the-elusive-green-consumer (accessed September 1, 2023).

[153] J. Clarkson, R. Coleman, Inclusive design, Journal of Engineering Design 21 (2010) 127–129. https://doi.org/10.1080/09544821003693689.

[154] Y. Tueanrat, S. Papagiannidis, E. Alamanos, Going on a journey: A review of the custo-mer journey literature, Journal of Business Research 125 (2021) 336–353. https://doi.org/10.1016/j.jbusres.2020.12.028.

[155] L.T. Sin, B.S. Tueen, 5 - Effective plastic design and packaging, in: L.T. Sin, B.S. Tueen (Eds.), Plastics and Sustainability, Elsevier, 2023: pp. 145–174. https://doi.org/10.1016/B978-0-12-824489-0.00004-0.

[156] K.D. Cox, G.A. Covernton, H.L. Davies, J.F. Dower, F. Juanes, S.E. Dudas, Human Con-sumption of Microplastics, Environ. Sci. Technol. 53 (2019) 7068–7074. https://doi.org/10.1021/acs.est.9b01517.

[157] R. Geyer, J.R. Jambeck, K.L. Law, Production, use, and fate of all plastics ever made, Sci-ence Advances 3 (2017). https://doi.org/10.1126/sciadv.1700782.

[158] OECD, Plastic leakage and greenhouse gas emissions are increasing, 2019. https://www.oecd.org/environment/plastics/increased-plastic-leakage-and-greenhouse-gas-emissions.htm.

[159] OECD, Improving Plastics Management: Trends, policy responses, and the role of inter-national co-operation and trade, 2018. https://www.oecd.org/environment/waste/policy-highlights-improving-plastics-management.pdf (accessed September 14, 2022).

[160] A. Cavaliere, S. Pigliafreddo, E. De Marchi, A. Banterle, Do Consumers Really Want to Reduce Plastic Usage? Exploring the Determinants of Plastic Avoidance in Food-Related Consumption Decisions, Sustainability 12 (2020) 9627. https://doi.org/10.3390/su12229627.

[161] J. Van Asselt, Y. Nian, M. Soh, S. Morgan, Z. Gao, Do plastic warning labels reduce con-sumers' willingness to pay for plastic egg packaging? – Evidence from a choice experi-ment, Ecological Economics 198 (2022) 107460. https://doi.org/10.1016/j.ecolecon.2022.107460.

[162] L.J. Axelrod, D.R. Lehman, Responding to environmental concerns: What factors guide individual action?, Journal of Environmental Psychology 13 (1993) 149–159. https://doi.org/10.1016/S0272-4944(05)80147-1.

[163] P. Roy, L. Ashton, T. Wang, M.G. Corradini, E.D.G. Fraser, M. Thimmanagari, M. Tiessan, A. Bali, K.M. Saharan, A.K. Mohanty, M. Misra, Evolution of drinking straws and their environmental, economic and societal implications, Journal of Cleaner Production 316 (2021) 128234. https://doi.org/10.1016/j.jclepro.2021.128234.

[164] S. Foteinis, How small daily choices play a huge role in climate change: The disposable paper cup environmental bane, Journal of Cleaner Production 255 (2020) 120294. https://doi.org/10.1016/j.jclepro.2020.120294.

[165] C.B.A. Romero, M. Laroche, G.M. Aurup, S.B. Ferraz, Ethnicity and acculturation of envi-ronmental attitudes and behaviors: A cross-cultural study with Brazilians in Canada, Journal of Business Research 82 (2018) 300–309. https://doi.org/10.1016/j.jbusres.2017.09.009.

[166] A. Chwialkowska, W.A. Bhatti, M. Glowik, The influence of cultural values on pro-environmental behavior, Journal of Cleaner Production 268 (2020) 122305. https://doi.org/10.1016/j.jclepro.2020.122305.

[167] T.R. Walker, E. McGuinty, S. Charlebois, J. Music, Single-use plastic packaging in the Canadian food industry: consumer behavior and perceptions, Humanit Soc Sci Com-mun 8 (2021) 1–11. https://doi.org/10.1057/s41599-021-00747-4.

[168] J. Wiefek, J. Steinhorst, K. Beyerl, Personal and structural factors that influence indivi-dual plastic packaging consumption—Results from focus group discussions with Ger-man consumers, Cleaner and Responsible Consumption 3 (2021) 100022. https://doi.org/10.1016/j.clrc.2021.100022.

[169] Y. Tao, M. Duan, Z. Deng, Using an extended theory of planned behaviour to explain willingness towards voluntary carbon offsetting among Chinese consumers, Ecological Economics 185 (2021) 107068. https://doi.org/10.1016/j.ecolecon.2021.107068.

[170] A.H. Eagly, S. Chaiken, The psychology of attitudes, Harcourt Brace Jovanovich College Publishers, Orlando, FL, US, 1993.

[171] M.H. Johe, N. Bhullar, To buy or not to buy: The roles of self-identity, attitudes, percei-ved behavioral control and norms in organic consumerism, Ecological Economics 128 (2016) 99–105. https://doi.org/10.1016/j.ecolecon.2016.02.019.

[172] N. López-Mosquera, F. Lera-López, M. Sánchez, Key factors to explain recycling, car use and environmentally responsible purchase behaviors: A comparative perspective, Re-sources, Conservation and Recycling 99 (2015) 29–39. https://doi.org/10.1016/j.resconrec.2015.03.007.

[173] P. Liu, M. Teng, C. Han, How does environmental knowledge translate into pro-environmental behaviors?: The mediating role of environmental attitudes and behavi-oral intentions, Science of The Total Environment 728 (2020) 138126. https://doi.org/10.1016/j.scitotenv.2020.138126.

[174] K. Borg, Media and Social Norms: Exploring the Relationship between Media and Plas-tic Avoidance Social Norms, Environmental Communication 16 (2022) 371–387. https://doi.org/10.1080/17524032.2021.2010783.

[175] K. Borg, J. Curtis, J. Lindsay, Social norms and plastic avoidance: Testing the theory of normative social behaviour on an environmental behaviour, Journal of Consumer Be-haviour 19 (2020) 594–607. https://doi.org/10.1002/cb.1842.

[176] E. Ari, V. Yılmaz, Consumer attitudes on the use of plastic and cloth bags, Environ Dev Sustain 19 (2017) 1219–1234. https://doi.org/10.1007/s10668-016-9791-x.

[177] B. Verplanken, ed., The Psychology of Habit: Theory, Mechanisms, Change, and Con-texts, Springer International Publishing, Cham, 2018. https://doi.org/10.1007/978-3-319-97529-0.

[178] C.A. Klöckner, B. Verplanken, Yesterday's Habits Preventing Change for Tomorrow? About the Influence of Automaticity on Environmental Behaviour, in: Environmental Psychology, John Wiley & Sons, Ltd, 2018: pp. 238–250. https://doi.org/10.1002/9781119241072.ch24.

[179] E.N. Çoker, S. van der Linden, Fleshing out the theory of planned of behavior: Meat consumption as an environmentally significant behavior, Curr Psychol 41 (2022) 681–690. https://doi.org/10.1007/s12144-019-00593-3.

[180] L.-M. Chuang, P.-C. Chen, Y.-Y. Chen, The Determinant Factors of Travelers' Choices for Pro-Environment Behavioral Intention-Integration Theory of Planned Behavior, Unified Theory of Acceptance, and Use of Technology 2 and Sustainability Values, Sustainabili-ty 10 (2018) 1869. https://doi.org/10.3390/su10061869.

[181] I. Moons, P. De Pelsmacker, An Extended Decomposed Theory of Planned Behaviour to Predict the Usage Intention of the Electric Car: A Multi-Group Comparison, Sustainabi-lity 7 (2015) 6212–6245. https://doi.org/10.3390/su7056212.

[182] B. Wang, Z. Yuan, X. Liu, Y. Sun, B. Zhang, Z. Wang, Electricity price and habits: Which would affect household electricity consumption?, Energy and Buildings 240 (2021) 110888. https://doi.org/10.1016/j.enbuild.2021.110888.

[183] E.F. Beitzen-Heineke, N. Balta-Ozkan, H. Reefke, The prospects of zero-packaging gro-cery stores to improve the social and environmental impacts of the food supply chain, Journal of Cleaner Production 140 (2017) 1528–1541. https://doi.org/10.1016/j.jclepro.2016.09.227.

[184] R. Kitz, T. Walker, S. Charlebois, J. Music, Food packaging during the COVID-19 pande-mic: Consumer perceptions, International Journal of Consumer Studies 46 (2022) 434–448. https://doi.org/10.1111/ijcs.12691.

[185] F. Haque, C. Fan, Prospect of microplastic pollution control under the "New normal" concept beyond COVID-19 pandemic, Journal of Cleaner Production 367 (2022) 133027. https://doi.org/10.1016/j.jclepro.2022.133027.

[186] D. Kasznik, Z. Łapniewska, The end of plastic? The EU's directive on single-use plastics and its implementation in Poland, Environmental Science & Policy 145 (2023) 151–163. https://doi.org/10.1016/j.envsci.2023.04.005.

[187] R.E. Dunlap, R.E. Jones, Environmental concern: conceptual and measurement issues, in: Handbook of Environmental Sociology, Greenwood Press, Westport, CT, 2002: pp. 482–524.

[188] U.A. Saari, S. Damberg, L. Frömbling, C.M. Ringle, Sustainable consumption behavior of Europeans: The influence of environmental knowledge and risk perception on envi-ronmental concern and behavioral intention, Ecological Economics 189 (2021) 107155. https://doi.org/10.1016/j.ecolecon.2021.107155.

[189] M. Sadiq, K. Bharti, M. Adil, R. Singh, Why do consumers buy green apparel? The role of dispositional traits, environmental orientation, environmental knowledge, and mo-netary incentive, Journal of Retailing and Consumer Services 62 (2021) 102643. https://doi.org/10.1016/j.jretconser.2021.102643.

[190] L. Fogt Jacobsen, S. Pedersen, J. Thøgersen, Drivers of and barriers to consumers' plastic packaging waste avoidance and recycling – A systematic literature review, Waste Ma-nagement 141 (2022) 63–78. https://doi.org/10.1016/j.wasman.2022.01.021.

[191] L. Whitmarsh, S. O'Neill, Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours, Journal of Environmental Psychology 30 (2010) 305–314. https://doi.org/10.1016/j.jenvp.2010.01.003.

[192] C. Barbarossa, P. De Pelsmacker, I. Moons, Personal Values, Green Self-identity and Electric Car Adoption, Ecological Economics 140 (2017) 190–200. https://doi.org/10.1016/j.ecolecon.2017.05.015.

[193][193] C. Barbarossa, P. De Pelsmacker, Positive and Negative Antecedents of Purchasing Eco-friendly Products: A Comparison Between Green and Non-green Consumers, J Bus Ethics 134 (2016) 229–247. https://doi.org/10.1007/s10551-014-2425-z.

[194] L. Steg, J.W. Bolderdijk, K. Keizer, G. Perlaviciute, An Integrated Framework for Encouraging Pro-environmental Behaviour: The role of values, situational factors and goals, Journal of Environmental Psychology 38 (2014) 104–115. https://doi.org/10.1016/j.jenvp.2014.01.002.

[195] S.H. Schwartz, Values: cultural and individual, in: A. Chasiotis, F.J.R. van de Vijver, S.M. Breugelmans (Eds.), Fundamental Questions in Cross-Cultural Psychology, Cambridge University Press, Cambridge, 2011: pp. 463–493. https://doi.org/10.1017/CBO9780511974090.019.

[196] H.-W. Chan, When do values promote pro-environmental behaviors? Multilevel evi-dence on the self-expression hypothesis, Journal of Environmental Psychology 71 (2020) 101361. https://doi.org/10.1016/j.jenvp.2019.101361.

[197] G. Grilli, B. Andrews, S. Ferrini, T. Luisetti, Could a mix of short- and long-term policies be the solution to tackle marine litter? Insights from a choice experiment in England and Ireland, Ecological Economics 201 (2022) 107563. https://doi.org/10.1016/j.ecolecon.2022.107563.

[198] J. Steinhorst, E. Matthies, Monetary or environmental appeals for saving electricity? –Potentials for spillover on low carbon policy acceptability, Energy Policy 93 (2016) 335–344. https://doi.org/10.1016/j.enpol.2016.03.020.

[199] M. Wolf, J. Emerson, D. Esty, A. de Sherbinin, Z. Wendling, Environmental Performance Index, Yale Center for Environmental Law & Policy, New Haven, CT, 2022. https://epi.yale.edu/ (accessed September 14, 2024).

[200] World Population Review, Plastic pollution by country, (2022). https://worldpopulationreview.com/country-rankings/plastic-pollution-by-country (ac-cessed September 14, 2022).

[201] J.B. Ford, Major Mistakes Made in Cross-Cultural Marketing Research, Projectics / Proyéctica / Projectique 21 (2018) 13–21. https://doi.org/10.3917/proj.021.0013.

[202] S.J. Vitell, R.A. King, K. Howie, J.-F. Toti, L. Albert, E.R. Hidalgo, O. Yacout, Spirituality, Moral Identity, and Consumer Ethics: A Multi-cultural Study, J Bus Ethics 139 (2016) 147–160. https://doi.org/10.1007/s10551-015-2626-0.

[203] R.A. Shweder, M.A. Sullivan, Cultural Psychology: Who Needs It?, Annual Review of Psychology 44 (1993) 497–523. https://doi.org/10.1146/annurev.ps.44.020193.002433.

[204] J. Hornikx, H. Hoeken, Cultural Differences in the Persuasiveness of Evidence Types and Evidence Quality, Communication Monographs 74 (2007) 443–463. https://doi.org/10.1080/03637750701716578.

[205] P. Sparks, R. Shepherd, Self-Identity and the Theory of Planned Behavior: Assesing the Role of Identification with "Green Consumerism," Social Psychology Quarterly 55 (1992) 388–399. https://doi.org/10.2307/2786955.

[206] L.M. López-Bonilla, J.M. López-Bonilla, From the new environmental paradigm to the brief ecological paradigm: a revised scale in golf tourism, Anatolia 27 (2016) 227–236. https://doi.org/10.1080/13032917.2015.1100128.

[207] R.E. Dunlap, K.D. Van Liere, A.G. Mertig, R.E. Jones, New Trends in Measuring Environ-mental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale, Journal of Social Issues 56 (2000) 425–442. https://doi.org/10.1111/0022-4537.00176.

[208] A. Hansla, A. Gamble, A. Juliusson, T. Gärling, The relationships between awareness of consequences, environmental concern, and value orientations, Journal of Environmen-tal Psychology 28 (2008) 1–9. https://doi.org/10.1016/j.jenvp.2007.08.004.

[209] K.G. Jöreskog, D.A. Sorbom, LISREL 8.54 and PRELIS 2.54 Scientific Software, (2006).

[210] C. Fornell, D.F. Larcker, Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics, Journal of Marketing Research 18 (1981) 382–388. https://doi.org/10.2307/3150980.

[211] R.P. Bagozzi, Y. Yi, On the evaluation of structural equation models, JAMS 16 (1988) 74–94. https://doi.org/10.1007/BF02723327.

[212] J.-B.E.M. Steenkamp, H. Baumgartner, Assessing Measurement Invariance in Cross-National Consumer Research, Journal of Consumer Research 25 (1998) 78–90. https://doi.org/10.1086/209528.

[213] B.M. Byrne, R.J. Shavelson, B. Muthén, Testing for the equivalence of factor covariance and mean structures: The issue of partial measurement invariance, Psychological Bulle-tin 105 (1989) 456–466. https://doi.org/10.1037/0033-2909.105.3.456.

[214] J.F. Hair, M.W. Celsi, D.J. Ortinau, R.P. Bush, Essentials of marketing research, McGraw-Hill, 2017. https://thuvienso.hoasen.edu.vn/handle/123456789/9930 (accessed October 30, 2023).

[215] A. Biswas, M. Roy, Green products: an exploratory study on the consumer behaviour in emerging economies of the East, Journal of Cleaner Production 87 (2015) 463–468. https://doi.org/10.1016/j.jclepro.2014.09.075.

[216] J.H. Lee, S.J. Hardman, G. Tal, Who is buying electric vehicles in California? Characteri-sing early adopter heterogeneity and forecasting market diffusion, Energy Research & Social Science 55 (2019) 218–226. https://doi.org/10.1016/j.erss.2019.05.011.

[217] A.R. Brough, J.E.B. Wilkie, J. Ma, M.S. Isaac, D. Gal, Is Eco-Friendly Unmanly? The Green-Feminine Stereotype and Its Effect on Sustainable Consumption, Journal of Consumer Research 43 (2016) 567–582. https://doi.org/10.1093/jcr/ucw044.

[218] Mei Plastic Vrij, Plasticvrij. En liefst niet enkel in mei | MVO Vlaanderen, (2021). https://www.mvovlaanderen.be/inspiratie/plasticvrij-en-liefst-niet-enkel-mei (accessed October 24, 2022).

[219] My bag plan, My bag plan, (2022). https://www.mybagplan.ca/ (accessed October 24, 2022).

[220] Greenpeace, Share your pics of ridiculous packaging!, Greenpeace Canada (2022). https://www.greenpeace.org/canada/en/story/466/share-your-pics-of-ridiculous-packaging/ (accessed October 24, 2022).

[221] D. Civancik-Uslu, R. Puig, M. Hauschild, P. Fullana-i-Palmer, Life cycle assessment of car-rier bags and development of a littering indicator, Science of The Total Environment 685 (2019) 621–630. https://doi.org/10.1016/j.scitotenv.2019.05.372.

[222] UNEP, From birth to ban: A history of the plastic shopping bag, UNEP (2021). http://www.unep.org/news-and-stories/story/birth-ban-history-plastic-shopping-bag (accessed November 24, 2022).

[223] UNEP, Visual Feature | Beat Plastic Pollution, (2022). http://unep.org/interactive/beat-plastic-pollution/ (accessed November 23, 2022).

[224] S.L. Wright, R.C. Thompson, T.S. Galloway, The physical impacts of microplastics on ma-rine organisms: A review, Environmental Pollution 178 (2013) 483–492. https://doi.org/10.1016/j.envpol.2013.02.031.

[225] Statista, Global packaging market shares by material, Statista (2022). https://www.statista.com/statistics/271601/packaging-materials-in-the-global-packaging-market-since-2003/ (accessed November 23, 2022).

[226] Statista, Europe: consumers concerned by packaging materials 2019, (2022). https://www.statista.com/statistics/1073096/consumers-concerned-by-packaging-materials-europe/ (accessed November 23, 2022).

[227] A. Maki, A.R. Carrico, K.T. Raimi, H.B. Truelove, B. Araujo, K.L. Yeung, Meta-analysis of pro-environmental behaviour spillover, Nat Sustain 2 (2019) 307–315. https://doi.org/10.1038/s41893-019-0263-9.

[228] T.L. Jones, M. a. J. Baxter, V. Khanduja, A quick guide to survey research, Ann R Coll Surg Engl 95 (2013) 5–7. https://doi.org/10.1308/003588413X13511609956372.

[229] Nester Research, Reusable Coffee Cup Market Size to Hit USD 24.85 Billion by 2031; Increased Online Food Delivery, Higher Usage of Reusable Cups and Rising Need to Re-duce the Plastic Use is to Elevate the Market Growth- Research Nester, GlobeNewswire News Room (2022). https://www.globenewswire.com/news-release/2022/10/14/2534750/0/en/Reusable-Coffee-Cup-Market-Size-to-Hit-USD-24-85-Billion-by-2031-Increased-Online-Food-Delivery-Higher-Usage-of-Reusable-Cups-and-Rising-Need-to-Reduce-the-Plastic-Use-is-to-Elevat.html (accessed October 31, 2023).

[230] European Commission, Behavioural study on consumers' engagement in the circular economy: executive summary, Publications Office of the European Union, LU, 2018. https://data.europa.eu/doi/10.2818/921596 (accessed October 31, 2023).

[231] E. Amasawa, T. Shibata, H. Sugiyama, M. Hirao, Environmental potential of reusing, renting, and sharing consumer products: Systematic analysis approach, Journal of Cleaner Production 242 (2020) 118487. https://doi.org/10.1016/j.jclepro.2019.118487.

[232] S.U. Rahman, Differences in horizontally individualist and vertically collectivist consumers' environmental behaviour: a regulatory focus perspective, International Journal of Business and Emerging Markets 11 (2019) 73–88. https://doi.org/10.1504/IJBEM.2019.097479.

[233] T.M. Singelis, H.C. Triandis, D.P.S. Bhawuk, M.J. Gelfand, Horizontal and Vertical Dimen-sions of Individualism and Collectivism: A Theoretical and Measurement Refinement, Cross-Cultural Research 29 (1995) 240–275. https://doi.org/10.1177/106939719502900302.

[234] G. Hofstede, National Cultures in Four Dimensions: A Research-Based Theory of Cultu-ral Differences among Nations, International Studies of Management & Organization 13 (1983) 46–74. https://doi.org/10.1080/00208825.1983.11656358.

[235] Hofstede Insights, Compare countries, (2022). www.hofstede-insights.com/fi/product/compare-countries/ (accessed November 27, 2022).

[236] M. Berg, C. Düvel, Qualitative media diaries: An instrument for doing research from a mobile media ethnographic perspective, Interactions: Studies in Communication & Cul-ture 3 (2012) 71–89. https://doi.org/10.1386/iscc.3.1.71_1.

[237] Grand View Research, Disposable Cups Market Size | Industry Report, 2021-2028, (2020). https://www.grandviewresearch.com/industry-analysis/disposable-cups-market (accessed August 22, 2023).

[238] Gitnux, The Most Surprising Coffee Cup Waste Statistics And Trends in 2023, (2023). https://blog.gitnux.com/coffee-cup-waste-statistics/ (accessed August 24, 2023).

[239] J.C. Kanniah, Why don't more people recycle their coffee cups?, Perfect Daily Grind (2021). https://perfectdailygrind.com/2021/06/why-is-recycling-single-use-coffee-cups-so-difficult/ (accessed August 24, 2023).

[240] M. Park, Defying Obsolescence, in: Longer Lasting Products, Routledge, 2010.

[241] E.M. Jepsen, P.J.N. de Bruyn, Pinniped entanglement in oceanic plastic pollution: A glo-bal review, Marine Pollution Bulletin 145 (2019) 295–305. https://doi.org/10.1016/j.marpolbul.2019.05.042.

[242] Environmental Audit Committee, Environmental Audit Committee 5th Special Report. Disposable Packaging: Coffee Cups, (2018). https://www.publicinformationonline.com/shop/172797 (accessed August 24, 2023).

[243] Billie Cup, One cup for All, BillieCup (2023). https://billiecup.com/nl/ (accessed August 24, 2023).

[244] S. Sandhu, S. Lodhia, A. Potts, R. Crocker, Environment friendly takeaway coffee cup use: Individual and institutional enablers and barriers, Journal of Cleaner Production 291 (2021) 125271. https://doi.org/10.1016/j.jclepro.2020.125271.

[245] J.V. López-Bao, A. Margalida, Slow transposition of European environmental policies, Nat Ecol Evol 2 (2018) 914–914. https://doi.org/10.1038/s41559-018-0565-8.

[246] E. Novoradovskaya, B. Mullan, P. Hasking, H.V. Uren, My cup of tea: Behaviour change intervention to promote use of reusable hot drink cups, Journal of Cleaner Production 284 (2021) 124675. https://doi.org/10.1016/j.jclepro.2020.124675.

[247] A. Mellick Lopes, A. Gill, D. Fam, Design and Social practice theory: A promising dialo-gue for sustainable living, Journal of Design Research 13 (2015) 327–347. https://doi.org/10.1504/JDR.2015.071462.

[248] M. Niimi, S. Wakes, M. McGuire, Design for sustainability: Addressing Food waste be-haviour through social practice approaches, 2014. http://hdl.handle.net/10523/4115.

[249] L. Kong, L. Wang, F. Li, G. Tian, J. Li, Z. Cai, J. Zhou, Y. Fu, A life-cycle integrated model for product eco-design in the conceptual design phase, Journal of Cleaner Production 363 (2022) 132516. https://doi.org/10.1016/j.jclepro.2022.132516.

[250] A. Marchand, S. Walker, Product development and responsible consumption: designing alternatives for sustainable lifestyles, Journal of Cleaner Production 16 (2008) 1163–1169. https://doi.org/10.1016/j.jclepro.2007.08.012.

[251] Y. Du, Q. Ye, H. Liu, Y. Wu, F. Wang, Sustainable Assessment Tools for Higher Education Institutions: Developing Two-Hierarchy Tools for China, Sustainability 15 (2023) 11551. https://doi.org/10.3390/su151511551.

[252] E. Manzini, C. Vezzoli, G. Clark, Product-service systems: using an existing concept as a new approach to sustainability, Journal of Design Research 1 (2001) 27–40. https://doi.org/10.1504/JDR.2001.009811.

[253] C. Vezzoli, A new generation of designers: perspectives for education and training in the field of sustainable design. Experiences and projects at the Politecnico di Milano University, Journal of Cleaner Production 11 (2003) 1–9. https://doi.org/10.1016/S0959-6526(02)00057-4.

[254] R. Trimingham, V. Lofthouse, E. Norman, T. Bhamra, N. Zanker, An integrated approach to sustainable design education, in: BARCELONA, SPAIN, 2008.

[255] L. Herweyers, E. Du Bois, I. Moons, TRASH TALK: WHO USES WHICH REUSABLE PRODUCT? USER INSIGHTS AND DESIGN OPPORTUNITIES FOR SINGLE-USE ALTERNATIVES, Internati-onal Conference on Design Engineering (ICED) 3 (2023) 3641–3650. https://doi.org/10.1017/pds.2023.365.

[256] R. Mugge, J.P.L. Schoormans, H.N.J. Schifferstein, 17 - PRODUCT ATTACHMENT: DESIGN STRATEGIES TO STIMULATE THE EMOTIONAL BONDING TO PRODUCTS, in: H.N.J. Schif-ferstein, P. Hekkert (Eds.), Product Experience, Elsevier, San Diego, 2008: pp. 425–440. https://doi.org/10.1016/B978-008045089-6.50020-4.

[257] K. Bogaert, Menstruatie van de toekomst: herbruikbare menstruatieproducten toegankelijker maken om lange termijn hergebruik te stimuleren, 2023. https://anet.be/record/opacuantwerpen/c:lvd:15392862.

[258] J. Kyong Trondsen, L. Herweyers, E. Du Bois, C. Boks, Pee poo period: exploring the intersection between shame, bodily fluids, and sustainable design, in: K. Vaes, J. Verlinden (Eds.), Connectivity and Creativity in Times of Conflict, Academia Press, 2023. https://doi.org/10.26530/9789401496476-081.

[259] MUCE - Muses United for Circular Economy, Muce (2022). https://muce.be/ (accessed November 8, 2023).

[260] D. Hill, A. Figueredo, W. Jacobs, Contextual influences on sustainable behavior, in: Psy-chological Approaches to Sustainability: Current Trends in Theory, Research and Appli-cations, Nova Science Publishers, Inc., 2013: pp. 269–293.

[261] Ecover, Ecover- Navullingen, Ecover België (2023). https://www.ecover.com/be-nl/ecover-producten/navullingen/ (accessed November 20, 2023).

[262] Pieter Pot, Pieter Pot | Verpakkingsvrije Boodschappen, Pieter Pot (2023). https://www.pieterpot.be/ (accessed November 20, 2023).

[263] Brauzz, Brauzz shop, (2023). https://brauzz.com/ (accessed November 20, 2023).

[264] Loop, Loop - A Global Platform for Reuse, (2023). https://exploreloop.com/ (accessed November 20, 2023).

[265] REuse Lab, University of Antwerp (2023). https://www.uantwerpen.be/en/projects/reuse-lab/ (accessed November 12, 2023).

[266] Green Deal Anders verpakt, Vlaanderen Departement Omgeving (2023). https://omgeving.vlaanderen.be/nl/green-deal-anders-verpakt-012 (accessed Novem-ber 12, 2023).

[267] Y. Sun, S. Wang, J. Li, D. Zhao, J. Fan, Understanding consumers' intention to use plastic bags: using an extended theory of planned behaviour model, Nat Hazards 89 (2017) 1327–1342. https://doi.org/10.1007/s11069-017-3022-0.

[268] H. Paterson, Plastic habits – an overview for the collection 'Plastics and Sustainable Earth,' Sustain Earth 2 (2019) 10. https://doi.org/10.1186/s42055-019-0017-6.

[269] D.F. Marks, The COM-B System of Behaviour Change: Properties, Problems and Pros-pects, Qeios (2020). https://doi.org/10.32388/U5MTTB.

[270] A.J. Rothman, Toward a theory-based analysis of behavioral maintenance, Health Psy-chol 19 (2000) 64–69. https://doi.org/10.1037/0278-6133.19.suppl1.64.

[271] D.Van Boxem, O'culo: serious game rond culturele bewustwording, 2023. https://anet.be/record/opacuantwerpen/c:lvd:15392553.

[272] R. Curly, Thomas Midgley, Jr. | American Chemist & Inventor, Britannica (2023). https://www.britannica.com/biography/Thomas-Midgley-Jr (accessed November 6, 2023).

[273] T. Stelling, De plasticvanger van Boyan Slat: ineffectief, peperduur en mogelijk een ramp voor het zeeleven, De Correspondent (2019). https://decorrespondent.nl/10638/de-plasticvanger-van-boyan-slat-ineffectief-peperduur-en-mogelijk-een-ramp-voor-het-zeeleven/cd942981-e62c-0c6d-12fe-2da54b878a3b (accessed November 6, 2023).

[274] A. Fenko, H.N.J. Schifferstein, P. Hekkert, Shifts in sensory dominance between various stages of user–product interactions, Applied Ergonomics 41 (2010) 34–40. https://doi.org/10.1016/j.apergo.2009.03.007.

[275] L.Veelaert, Express your material self: Experiential material characterization in product design, 2022.

[276] M. Das, L. Herweyers, I. Moons, E. Du Bois, STRATEGIC DESIGN OPPORTUNITIES TO INCREASE SUSTAINABLE FASHION AWARENESS AND BEHAVIOUR, International Conference on De-sign Engineering (ICED) 1 (2021) 2711–2720. https://doi.org/10.1017/pds.2021.532.

[277] D. Adams, The Hitchhiker's Guide to the Galaxy, Pan Macmillan, 2009.

[278] J. Kirchherr, The Lean PhD: Radically Improve the Efficiency, Quality and Impact of Your Research, Bloomsbury Publishing, 2018.

Publications

A1

L. Herweyers, E. Du Bois, I. Moons, Use - clean - repeat: Understanding user, product, and context to design for long-term reuse, Resources, Conservation and Recycling 204 (2024) 107511. https://doi.org/10.1016/j.resconrec.2024.107511.

L. Herweyers, I. Moons, C. Barbarossa, P. De Pelsmacker, E. Du Bois, Understanding who avoids single-use plastics and why: A cross-country mixed-method study, Journal of Cleaner Production 414 (2023) 137685. https://doi.org/10.1016/j.jclepro.2023.137685.

L. Herweyers, C. Catarci Carteny, L. Scheelen, R. Watts, E. Du Bois, Consumers' Perceptions and Attitudes toward Products Preventing Microfiber Pollution in Aquatic Environments as a Result of the Domestic Washing of Synthetic Clothes, Sustainability 12 (2020) 2244. https://doi.org/10.3390/su12062244.

E. Amato, F. Pfeiffer, N. Estoppey, D. Subotic, L. Herweyers, T. Breugelmans, M. Weyn, E. Du Bois, F. Dardenne, A. Covaci, R. Town, R. Blust, Field application of a novel active-passive sampling technique for the simultaneous measurement of a wide range of contaminants in water, Chemosphere 279 (2021) 130598. https://doi.org/10.1016/j.chemosphere.2021.130598.

P1

L. Herweyers, E. Du Bois, I. Moons, Trash talk: Who uses which reusable product? User insights and design opportunities for single-use alternatives, International Conference on Design Engineering (ICED) (2023) 3641–3650. https://doi.org/10.1017/pds.2023.365.

J. Kyong Trondsen, L. Herweyers, E. Du Bois, C. Boks, Pee poo period: exploring the intersection between shame, bodily fluids, and sustainable design, in: K. Vaes, J. Verlinden (Eds.), Connectivity and Creativity in Times of Conflict, Academia Press, 2023. https://doi.org/10.26530/9789401496476-081.

M. Das, L. Herweyers, I. Moons, E. Du Bois, Strategic design opportunities to increase sustainable fashion awareness and behaviour, International Conference on Design Engineering (ICED) (2021) 2711–2720. https://doi.org/10.1017/pds.2021.532.

Accepted: L. Herweyers, E. Du Bois, I. Moons, Unravelling Experiences, Barriers, and Design Strategies for Encouraging Reusable Takeaway Cup Usage. Design 2024 (2024), Cavtat, Dubrovnik, Croatia.

P3

L. Herweyers, I. Moons, E. Du Bois, A diary study set-up to identify thresholds for repeated usage of reusable products, Product Lifetimes and the Environment (PLATE23) (2023).

L. Herweyers, M. Das, S. Bevers, F. Dries, I. Moons, E. Du Bois, Barriers to the continued usage of alternatives for single-use plastics by students in student housing, Product Lifetimes and the Environment (PLATE21) (2021). https://doi.org/10.31880/10344/10178.

H1

M. De Boeck, J. Vleugels, K. Verlaet, J. Van Loon, L. Van Glabbeek, S. Smedts, S. Serneels, L. Herweyers, G. Bruyne, Prevention of Onycholysis During Cancer Treatment Using an Active Local Cooling Device: Comparison of Three Different Cooling Strategies:Volume I: Healthcare Ergonomics, in: 2019: pp. 214–221. https://doi.org/10.1007/978-3-319-96098-2_28.

L.Veelaert, E. Du Bois, L. Herweyers, I. Moons, Consumer's perception of plastics in everyday products in relation to their personality: Going Green - Ecodesign (2019):, Nara, Japan. pp. 61–77. https://doi.org/10.1007/978-981-15-6775-9_5.

Accepted: L. Herweyers, L. De Schepper, I. Moons, E. Du Bois, (2023) Design for Long-term Reuse in Sustainable Design Education. Going Green - Ecodesign (2023), Nara, Japan.

Acknowledgements

Here, at the very end of this PhD thesis, I would like to express my gratitude to all the people who made this endeavour possible.

First of all, I am grateful towards both of my promotors, **Els Du Bois** and **Ingrid Moons**. You are a fascinating duo, full of energy, ideas, and ideals, with the sincere goal of doing good for the world, something I appreciate and value a lot. You have been very open, approachable, and encouraging. I am proud of what I was able to reach with this PhD and what I could learn from you. Thank you for the opportunity and trust you gave me, and I hope we can keep in contact and work together in the future. Additionally, I appreciate the opportunity I got from the University of Antwerp and my promotors in pursuing a topic that I find interesting, and the freedom to approach this in the way I wanted.

I would like to thank the members of the doctoral committee (**Alexis Jacoby, Casper Boks, Ivo Dewit**) and jury (**Lise Magnier, Linda Nhu Laursen**) for showing interest in my research, taking the time to read my thesis and give thorough feedback to improve it. **Alexis**, thank you for your critical voice and constructive feedback, as well as your listening ear through some difficult times. **Casper**, thank you for regularly challenging me to take a step back and look at my research from a different viewpoint, and inviting me to Trondheim. **Ivo,** your optimistic and encouraging voice has really helped me get through these last months. I am incredibly grateful for your mental support, as well as your adequate reaction to some problems I encountered.

Thank you, **June Kyong Trondsen**, for making my research stay in Trondheim possible and our collaboration on the 'Peepooperiod' workshop. Apart from our professional work, I really enjoyed our adventures in Trondheim, Oslo, and Antwerp, and I sincerely hope we will continue to do things together in the future.

Elien Mathys, you were my first ever 'colleague friend', at the Department of Sociology, when we were both fresh out of school and ready to dive into academics. I am so, so proud that five and a half years later, we will both have obtained our PhD degrees. Although we were only working in the same place for 6 months, you always remained a close friend, for which I am very grateful.

Next, I want to thank **Dirk Van Gogh** for giving me the opportunity years ago to get a taste of doing research at KASK, and for the fruitful collaboration in the Sustainable Design course. **Linda Scheelen**, as my promotor for my master thesis, thank you for your guidance and support, enabling me to enrol in this research adventure. I also very much liked working together for Erasmus. I would like to thank **Dirk Van Rooy** and **Kristof Vaes** as well for the useful insights into behavioural psychology and design for behaviour, and the opportunity to present a bit of my research to the master students. Thank you **Gustaaf Cornelis** for your help with the philosophical reflection and **Wim Maes** for helping me choose the perfect blue, providing me with the fonts for my thesis, and being available last-minute on a weekend day.

Jochen Vleugels, I do not even know where to start. Without you, my life would definitely have been harder. Thank you for being a great colleague and always available to help me (and others) out. I really enjoy(ed) our walks and talks during and after the pandemic.

My five years as a researcher at Product Development started in the 3.07 office in the old building. **Lore Veelaert**, during my first year you have been my mentor, helping me out with all kinds of practical stuff, as well as providing mental support. Thank you. Also my other colleagues from back then, **Marieke, Thomas,** and **Shriram**, thank you for the pleasant first years. Jochen and **Muriel De Boeck** are the only ones 'left' from our office back then, thank you for having become long-term friends.

Esther Noëth and **Stine Moons**, thank you for the feedback, inspiration, and philosophy sessions, but also the many fun moments together. I see you both as great friends and I appreciate your help and understanding during the PhD journey.

Maud Gruyters, Marie Das, and **Paola Travella**, even though we have not been colleagues for that long, I have had some great moments and feel a valuable friendship with each of you. During the last year, we have had the opportunity to have many adventures together, which gave us room to get to know each other outside of work. I am very grateful for these chances. **Charlotte Harding**, thanks for the nice collaboration with the REuse Wall project, and **Lien Acke** for the talks during the last PhD-finishing months as my office neighbour and fellow finishing PhD student.

Of course, thank you to all my **junior researcher colleagues**. I hope there will be many teambuildings in the future like the one we did in the Ardennes last year.

Thank you **Patrick De Pelsmacker** and **Camilla Barbarossa** for the collaboration which led to my first journal paper within this PhD. I very much appreciate your advice and the time you put into my research.

Thanks to all the students who in one way or another contributed to this thesis: **Ella Adriaens, Sterre Bevers, Karolien Bogaert, Estelle Bohner, Doris Van Boxem, Free Dries, Maaike Dumon, Orin Gielen, Floor Goddeeris, Fien Huybrechts, Zinke Neyrinck, Anna Peštová, Sebastian Reyda, Meerten De Ryck, Lien De Schepper, Amber Schoetens, Renée Sommen**, and **Anastasia Vandoorne Fey**s.

Thanks to my family, especially my parents, **Koen** and **Kristin**, brother **Robin**, and sisters **Anthe** and **Febe** for the love and support, and for giving me an ego boost by relying on my proofreading skills. Thank you **Manon** for understanding the struggles of being a PhD student so well. **Greet** and **Guido**, my parents-in-law, thank you for genuinely being interested and curious about my research and progress, and for helping me out with translations.

Of course, I am grateful to all of my **friends** with whom I spent time outside of work, with a special shout-out to **Elisa** for writing an article about my research, helping me to reach a greater audience.

Lorens, my partner, thank you for your endless support, patience, trust, care, and love. You are the kindest person I know, and I am ever grateful to have you by my side.

Finally, I am grateful for Karelian pies, ramen, potatoes, and the fact that I do not have to eat bread and peanut butter every morning. And my Boc 'n' Roll of course (not sponsored).

Laure Herweyers (°1995) obtained a master's degree in Product Development before doing a PhD. Driven by a deep passion for sustainability and climate issues, her academic work focuses on eco-design, circular design, and fostering sustainable behaviour through design.

Contact: laure.herweyers@gmail.com